

New Entries to IPNI Library as References

1] IPNI. 2018. Research with Impact - Improving the Value of Loblolly Pine Forests through Fertilization. 7177.

Reference ID: 24531

Note: #24531e

Abstract: Loblolly pine is the most commercially important of the pine trees grown in the southern U.S. Unmanaged forests can take up to 50 years to mature, while managed stands can mature in as little as 20 years. Loblolly pine is very responsive to cultural treatments such as fertilization, thinning, and eliminating woody vegetation, yet little is known about how much extra wood and economic value can be gained from fertilization late in a rotation after thinning.

[2] Anonymous. (2018). InfoSawit Vol XII No 6 Juni 2018. pp 1 - 56.

Reference ID: 24532

Note: #24532e

[3] T. Oberthur, C.R. Donough, H. Sugianto, K. Indrasuara, T. Dolong, G. Abdurrohimi. (2018). Keberhasilan Intensifikasi Perkebunan Kelapa Sawit Dengan Best Management Practices: Dampak Terhadap Tandan Buah Segar Dan Hasil Minyak. Infosawit. 12(6) pp 46 - 48.

Reference ID: 24533

Note: #24533e > #24532e [Lampiran Teknis Metode Bunch Analyzes (BA)]

[4] COWI A/S. (2018). Feasibility study on options to step up EU action against deforestation: Part I: Background analysis: scale and trends of global deforestation and assessment of EU contribution: Part II: A potential EU initiative on deforestation: Possible Interventions. Luxemburg. pp 1 - 305.

Reference ID: 24534

Note: #24534e

Abstract: This study explores the feasibility of options to step up EU action against deforestation. Its results are presented in two reports: 'Part I: Background analysis and setting the scene: scale and trends of global deforestation and assessment of EU contribution' and 'Part II: A potential EU initiative on deforestation: possible interventions'. Part I analyses recent global and regional trends in deforestation and the linkages with the production and consumption of twelve key Forest Risk Commodities, with a focus on the role of the EU and its impacts. Further, the study reviews relevant EU policies, legislation and initiatives and ongoing international and regional efforts by private sector, governments and civil society. Building on the analytical insights gained in Part I, the Part II report makes suggestions on the framing of a possible EU initiative to tackle deforestation and its root causes and drivers. This includes specific objectives and a range of potential EU interventions tackling different dimension of the problem (supply and demand side drivers, as well as the role of finance & investments). All identified interventions are assessed against a shared set of assessment criteria: feasibility and effectiveness; political acceptance, technical complexity; and administrative costs. Given the complexity of the problem, any potential EU initiative should consider a package of interventions which addresses the

supply, demand and finance dimensions, building on and reinforcing existing EU action as well as government and private sector commitments on zero deforestation and other relevant international initiatives.

[5] R.D. Munson, J.P. Doll. (1959). The Economics of Fertilizer Use in Crop Production. *Advances in Agronomy*. Vol 11, pp 133 - 159.

Reference ID: 24535

Note: #24535e

Abstract: The need for commercial fertilizers to supplement the soil supply of available nutrients for crops has been amply demonstrated by agronomic research. Research workers in agronomy and agricultural economics, recognizing the importance of economics of fertilizer use for crop production, began cooperating on research projects designed to estimate the most profitable rates of plant nutrients for different soils. This research provided information that enabled the farmers to make more efficient use of fertilizer, thereby leading to an over-all increase of efficiency in agricultural production. Because of the interest in the economics of fertilizer use, the research has undergone rapid development in recent years. Therefore, the objectives, procedures, and terminology of this research may seem obscure to those who are not familiar with it.

[6] M. Barthel, S. Jennings, W. Schreiber, R. Sheane, S. Royston, J. Fry, Y.L. Khor, J. McGill. (2018). Study on the environmental impact of palm oil consumption and on existing sustainability standards. Luxemburg. pp 1 - 396.

Reference ID: 24536

Note: #24536e

Abstract: This report reviews environmental, social and economic aspects of palm oil production and consumption, and evaluates existing palm oil sustainability initiatives. There is clear evidence that the expansion of oil palm cultivation has resulted in deforestation, biodiversity loss, and net greenhouse gas (GHG) emissions. Oil palm has in some instances expanded onto land traditionally used by indigenous and local communities. Labour abuses, including child and forced labour, are reported on a regular basis, but the evidence on how commonplace such practices are remains incomplete.

Oil palm cultivation often provides a higher income for smallholders than other livelihoods, and thus contributes to the development of rural economies and to the overall economy of producing countries through its linkages. These economic benefits must be set against potential conflicts and the loss of ecosystem benefits, such as non-timber forest products.

These environmental and social impacts are not exclusive to oil palm. They would apply in differing degrees to other crops planted on the same land. Furthermore, other sources of vegetable oils, among which the most important is soybeans, occupy much larger areas per tonne of oil produced, and have their own environmental and social impacts. Among certification schemes, the ISCC (EU) certification system generally addresses the environmental objectives of a range of EU and UN policies, principally because of its stringent definition of High Carbon Stock forests. The RSPO certification system addresses to the largest extent policy objectives relating to human, land, and labour rights. The current ISPO standard least addresses the policy objectives under consideration in this study, with limited protection for forest, and MSPO occupies an intermediate position. The governance and transparency of those four schemes, hence their level of independence vis-à-vis relevant interest groups, also vary.

Although most producer countries have introduced environmental and social

regulations relating to palm oil, enforcement is often selective, incomplete or ineffective.

Europe remains the leading market for sustainably sourced palm oil, but progress on the growing number of voluntary initiatives and commitments has been slow. There is limited penetration of sustainable palm oil in India and China.

[7] COWI A/S. (2018). Feasibility study on options to step up EU action against deforestation: Inventory of existing EU policies, legislation and initiatives addressing the drivers of deforestation and forest degradation. Luxemburg. pp 1 - 102.

Reference ID: 24537

Note: #24537e

Abstract: This inventory of existing EU policies, legislation and initiatives has been developed as part of the Feasibility study on an EU Action Plan on deforestation, whose overall aim is to “define and assess policy options available to step up EU action on deforestation and forest degradation” (as per the European Commission’s Terms of Reference). For more background on the study please refer to the main report. This report presents the result of Task 1 of the study. The aim of Task 1, as per the ToR, is to conduct:-

‘a comprehensive mapping exercise of existing [and forthcoming] EU policy, legislation and initiatives that can address, directly or indirectly, the drivers of deforestation and forest degradation within and outside EU borders.’

The mapping exercise also covers selected Member State legislation, policy and initiatives and private sector initiatives.

Section 2 of this report describes the approach used to identify and present the elements of the inventory. Detailed results are presented in a printable Word document that lists the full inventory (printable on A4).

The inventory was prepared and completed as the first step of the study in 2016. It has not been further updated in the course of the study so the inventory reflects the state of play at the time of its completion (August 2016).

[8] M. Trankner. 2017. Magnesium, potassium and nitrogen deficiency-induced responses of crops and their impact on water-use efficiency: From poterin to plant scale. Faculty of Agricultural Sciences. Gottingen, Germany. PhD. pp 1 - 124. Georg-August-University Gottingen, Germany.

Reference ID: 24538

Note: S 2.5 #24538

[9] ISP, The Incorporated Society of Planters. (2017). Annual Report 2017 Laporan Tahunan. Annual Report. Kuala Lumpur. pp 1 - 150.

Reference ID: 24539

Note: S 35 #24539

[10] C. Lanaud, O. Fouet, T. Legavre, U. Lopes, O. Sounigo, M.C. Eyango, B. Mermaz, M.R. da Silva, R.G.L. Solorzano, X. Argout, G. Gyapay, H.E. Ebaiarrey, K. Colonges, C. Sanier, R. Rivallan, G. Mastin, N. Cryer, M. Boccara, I.B.E. Mousseni, K.P. Gramacho, D. Clement. (2017). Exploration of the *T. cacao* genome sequence to decipher the incompatibility system of *Theobroma cacao* and to identify diagnostic markers. 2017 International Symposium on Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24540

Note: #24540e > #24507e

Abstract: We explored the *Theobroma cacao* genome sequence to progress in the knowledge of the *T. cacao* incompatibility system. Cocoa self-compatibility is an important yield factor and has been described as controlled by a late gameto-sporophytic system involving several locus, and resulting in gametic non-fusion. In this work, we identified two different mechanisms controlling the *T. cacao* self-incompatibility system at two separate loci, located on chromosome one and four (CH1 and CH4). Both loci are responsible for gametic selection, but only one (the CH4 locus) is involved in the main fruit drop. The CH1 locus acts prior to gamete fusion and independently of CH4 locus. Fine mapping and genome wide association studies focused analyses of restricted regions without recombinant plants where several candidate genes were identified. Their expression analysis showed differential expression during incompatible or compatible reactions for some of them. Highly polymorphic SSR diagnostic markers, designed in the CH4 region identified by fine mapping, allowed the development of efficient diagnostic markers predicting self-compatibility and fruit setting according to allele or genotype presence. SSR alleles specific to self-compatible Amelonado and Criollo varieties were also identified allowing screening for self-compatible plants in cocoa populations

[11] ISP. (2017). The Planter Vol 93 No 1101 December 2017. pp 837 - 902.

Reference ID: 24541

Note: S serial #24541

[12] Y.L. Cheong, S. Baharuddin, E. Chaniago, L.H. Ooi. (2017). Herbicide Screening for the Control of *Rolandra fruticosa*. The Planter. 93(1101) pp 843 - 857.

Reference ID: 24542

Note: #24542e > S serial #24541

Abstract: Several herbicides were screened to determine their efficacy against an invasive weed, *Rolandra fruticosa*.

[13] M.K. Tang, V.N. Shylaja, N. Iswari. (2017). Revolutionising Biomass Management: 100 Years of Innovation. The Planter. 93(1101) pp 863 - 873.

Reference ID: 24543

Note: #24543e > S serial #24541 (reproduced from 13th ISP National Seminar 2017 Book, "100 Years of Oil Palm: Suring Forward".)

Abstract: Malaysia generates a big portion of its income from the agriculture sector. By far, the biggest contributor from this sector is the palm oil industry. Corresponding to its size, the palm oil industry also generates the largest amount of biomass as compared to other sectors. Over the past century, various technologies have been developed by the industry players to manage the biomass and other palm by-products sustainably. This paper presents the milestones that the palm oil industry has achieved from the pre-1970's up to today in revolutionising biomass management through innovative ventures and research.

[14] C & CI. (2017). C&CI: Coffee and Cocoa International November 2017 Vol 44 No 5. pp 1 - 50.

Reference ID: 24544

Note: S serial #24544

[15] C & CI. (2018). C&CI: Coffee and Cocoa International May 2018 Vol 45 No 2. pp 1 - 50.

Reference ID: 24545

Note: S serial #24545

[16] E. Tielkes. (2016). Journal of Agriculture and Rural Development in the Tropics and Subtropics 2016 Vol 117 No 1. pp 1 - 187.

Reference ID: 24546

Note: S 13 #24546

[17] E. Tielkes. (2016). Journal of Agriculture and Rural Development in the Tropics and Subtropics 2016 Vol 117 No 2. pp 189 - 343.

Reference ID: 24547

Note: S 13 #24547

[18] ISP. (2018). The Planter Vol 94 No 1103 February 2018. pp 75 - 128.

Reference ID: 24548

Note: S serial #24548

[19] S.B. Ng, V. Ng. (2018). Palm Fruit Oil: A Big Fat Controversy. The Planter. 94(1103) pp 79 - 88.

Reference ID: 24549

Note: #24549e > S serial #24548

Abstract: The well-known tagline: "Saturated fats cause heart disease" " Palm oil is a saturated fat". These smear campaigns are aimed at demonising tropical oils and specifically palm oil. The negative labelling had badly affected and stigmatised palm oil. This is a ploy used by the competitor to hide the harmful health problems caused by trans fats or "artificial saturated fats" they had produced, and through deceitful marketing, portrayed it as a natural saturated fat issue.

[20] P. Kalidas. (2018). Rugose Spiraling Whitefly - A New Pest of Oil Palm in India. The Planter. 94(1103) pp 93 - 98.

Reference ID: 24550

Note: #24550e > S serial #24548

Abstract: Rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin is found infesting oil palm plantation in West Godavari district of Andhra Pradesh, India in 2017. Adults are tiny sized white flies with brown colour bands on the wings. Presence of waxy filaments covering the eggs and immature stages on the undersurface of the leaves is the characteristic features of identity.

[21] S Paramanathan. (2018). Managing Problematic Soils for Oil Palm Cultivation. The Planter. 94(1103) pp 103 - 115.

Reference ID: 24551

Note: #24551e > S serial #24548 (reproduced from 13th ISP National Seminar 2017 Book, "100 Years of Oil Palm: Suring Forward".)

Abstract: Tropical soils when compared to temperate soils are considered to be problematic soils. This is mainly due to the differential effect of climate in tropical areas when compared to that in the temperate regions. Some tropical soils are especially problematic due to their unique characteristics and therefore require special management in order to obtain high and sustainable yields for a demanding crop such as oil palm.

[22] J. Poore, T. Nemecek. (2018). Reducing food's environmental impacts through producers and consumers. Science. UK. pp 987 - 992.

Reference ID: 24552

Note: #24552e

Abstract: Food's environmental impacts are created by millions of diverse producers. To identify solutions that are effective under this heterogeneity, we consolidated data covering five environmental indicators; 38,700 farms; and 1600 processors, packaging types, and retailers. Impact can vary 50-fold among producers of the same product, creating substantial mitigation opportunities. However, mitigation is complicated by trade-offs, multiple ways for producers to achieve low impacts, and interactions throughout the supply chain. Producers have limits on how far they can reduce impacts. Most strikingly, impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change. Cumulatively, our findings support an approach where producers monitor their own impacts, flexibly meet environmental targets by choosing from multiple practices, and communicate their impacts to consumers.

[23] IFA. (2018). Executive Summary - IFA 2030 Scenarios: Digging deeper, thinking harder, planning further. IFA Executive Summary. pp 1 - 5.

Reference ID: 24553

Note: #24553e

Abstract: As the world grows towards 10 billion people, creating greater natural resource constraints, and as new technologies change our lives and our possibilities more than ever before, the global fertilizer industry wishes to define its place in this future. To help do this, the International Fertilizer Association (IFA) embarked on a long-range strategic planning process using scenario planning methodologies. They focused on the most pressing issues facing the fertilizer industry as a way to extend thinking and test preparedness; a 'wind tunnel' for designing industry-wide and company-specific approaches that are informed, robust and anticipatory.

The world would be a very different place without fertilizers. Plants need light, carbon dioxide, water and essential nutrients, which can come from both organic and mineral fertilizers, in order to grow. Mineral fertilizers contain more concentrated, consistent and readily available nutrients than organic fertilizers and enable farmers to grow more on less land. Mineral fertilizers are produced from materials mined from naturally occurring nutrient deposits, or from the fixation of nitrogen from the atmosphere into plant-available forms. Mineral fertilizers thus serve as a crucial complement to organic fertilizers and it is estimated that without them, world agricultural production could fall by as much as half and it would not be possible to feed the global population. In other words, without mineral fertilizers, we could not sustain today's population of 7.6 billion, much less a population of 8.6 and 10 billion expected by 2030 and 2050.

The global fertilizer industry has undertaken tremendous investments over the last decades to increase production in order to ensure access to this vital input for the world's farmers. The consumption of fertilizers has grown nearly six-fold between 1961 and 2015 (from 32 to 184 million nutrient tons), to keep up with a population expanding from 3.1 billion to 7.4 billion during the same period. The industry has also vastly improved its production efficiency as well as emphasized the need for efficiency at the farm level by promoting effective plant nutrition based on the "4Rs" – applying the right nutrient, at the right rate, time and place.

[24] A. Gruere, M. Prud'homme. 2018. Medium-Term Fertilizer Outlook: 2018 - 2022. Berlin, Germany. pp 1 - 32. IFA.

Reference ID: 24554

Note: #24554e

[25] IFA. (2018). IFA Fertilizer Outlook 2018-2022 Production & International Trade and Agriculture Services IFA Annual Conference: 18-20 June 2018 Berlin Germany. IFA Annual Conference: 18-20 June 2018 Berlin Germany. Germany. pp 1 - 8.

Reference ID: 24555

Note: #24555e

Abstract: This Public Summary was prepared by the Agriculture and Production & International Trade Services, on the occasion of the 86th IFA Annual Conference held in Berlin (Germany) in June 2018. It draws on two reports that were available after the IFA Annual Conference to IFA members only: the IFA report "Medium-Term Outlook for World Agriculture and Fertilizer Demand: 2017/18-2022/23" and the IFA report "Medium-Term Outlook for Fertilizers and Raw Materials Global Supply: 2018-2022".

[26] R. Mikkelsen. 2018. Plant Nutrition Today - Summer 2018 Issue 2 No 4: Enhance Soil Health with Fertilizer. pp 1 - 2.

Reference ID: 24556

Note: #24556e

Abstract: We can agree that healthy soil is essential for sustainable and productive agriculture. While we have a general understanding of what soil health means, it can be difficult to define and even more difficult to agree on the best way to measure it. A definition certainly includes aspects of physical, chemical, and biological properties of soil

[27] T. Jensen. 2018. Plant Nutrition Today - Summer 2018 Issue 2 No 5: Subsurface Soil Compaction Restricts Rooting Depth and Access to Nutrients and Moisture. pp 1 - 2.

Reference ID: 24557

Note: #24557e

Abstract: Soil compaction is a problem that can often cause reduced crop yields without being easily noticed. It can restrict crop rooting depth and turn a normally deep productive soil into a less productive shallow soil.

[28] R.R.C. Espino, K.A. Tonogbanua, M.R.M. Espino, J.V. Ramos. (2017). DNA Profiling of Cacao (*Theobroma cacao* L.) Varieties in the Philippines Using Microsatellite Markers. 2017 International Symposium of Cocoa Research (ISCR). Peru. pp 1 - 12.

Reference ID: 24558

Note: #24558e > #24507e

Abstract: Fifteen (15) single sequence repeat (SSR) markers were used to construct a DNA profile of Philippine cacao varieties. This is as to assess the genetic similarity, genetic diversity and elucidate relationships between varieties/clones. A total of 50 accessions of cacao were collected from 10 provinces in the country composed of 20 varieties/clone. Of these, six (6) are National Seed Industry Council (NSIC) - registered. UPGMA similarity coefficients observed from the cluster analysis of the standard varieties ranged from 0.09 to 0.72, indicating that standard varieties is distinct from one another. The varieties with the highest similarity (72%) were between Criollo clones (Criollo Green and Criollo Red). At 0.22 similarity trinitarios composed majority

in one group. The mixing of other criollos with the trinitario group could be due to their genetic relationship where trinitarios are hybrids between Criollo and Amellonado. All of the primers characterized were highly polymorphic with values ranging from 0.6341 to 0.8702. Markers used were repeatable and sufficient and effective in detecting genetic similarities and establishing genetic profiles of the collection.

[29] S.R. Evangelista, M.G.C.P. Miguel, C.S. Cordeiro, C.F. Silva, A.C.M. Pinheiro, R.F. Schwan. (2014). Inoculation of starter cultures in a semi-dry coffee (*Coffea arabica*) fermentation process. *Food Microbiology*. 44, pp 87 - 95.

Reference ID: 24559

Note: H 8.1.5 #24559e

Abstract: The aim of this study was to evaluate the use of yeasts as starter cultures in coffee semi-dry processing. Arabica coffee was inoculated with one of the following starter cultures: *Saccharomyces cerevisiae* UFLA YCN727, *S. cerevisiae* UFLA YCN724, *Candida parapsilosis* UFLA YCN448 and *Pichia guilliermondii* UFLA YCN731. The control was not inoculated with a starter culture. Denaturing gradient gel electrophoresis (DGGE) was used to assess the microbial population, and organic acids and volatile compounds were quantified by HPLC and HS-SPME/GC, respectively. Sensory analyses were evaluated using the Temporal Dominance of Sensations (TDS). DGGE analysis showed that the inoculated yeasts were present throughout the fermentation. Other yeast species were also detected, including *Debaryomyces hansenii*, *Cystofilobasidium ferigula* and *Trichosporon cavernicola*. The bacterial population was diverse and was composed of the following genera: *Weissella*, *Leuconostoc*, *Gluconobacter*, *Pseudomonas*, *Pantoea*, *Erwinia* and *Klebsiella*. Butyric and propionic acids, were not detected in any treatment A total of 47 different volatiles compounds have been identified. The coffee inoculated with yeast had a caramel flavor that was not detected in the control, as assessed by TDS. The use of starter cultures during coffee fermentation is an interesting alternative for obtaining a beverage quality with distinctive flavor.

[30] D. Komes, A. Busic. (2014). Antioxidants in Coffee (Chapter 3). pp 25 - 32.

Reference ID: 24560

Note: H 8.1.5 #24560

[31] R.A. Rice. (2011). Fruits from shade trees in coffee: how important are they? *Agroforestry Systems*. 83(1) pp 41 - 49.

Reference ID: 24561

Note: H 8.1.5 #24561

Abstract: Agroforestry systems often receive attention and support in the literature for what is perceived as the benefits from multiple products associated with the trees that create the “forest” component of the setting. A comparison of small coffee growers’ use of fruits derived from the coffee agroforestry holding in Guatemala and Peru reveals that significant differences exist between these groups—not merely in the importance of the fruits themselves, but in the ways they are used. The overall importance of fruits from the coffee system accounts for a relatively small portion of the total value coming from the coffee area (about 10%), but the consumption and sales of the various products do generate needed income or sustenance for most farmers. The fate of fruits shows significant differences between the two countries. Whether at the farm level or on a per hectare basis, Guatemalan coffee farmers are more linked into a market economy and sell significantly more fruits than Peruvian farmers. The opposite is the case when on-farm consumption (use value) of the fruits

is compared. While the potential value of these products may be quite large (from \$95 to \$270/ha), we find that little gets consumed or sold, resulting in tremendous loss of potential benefits that could flow from these sources. Both groups lose more fruits than are sold or used, with Guatemalans foregoing more than three times the dollar value per hectare than Peruvians (\$151/ha vs. \$44/ha). Data about the economic context within which these growers and the fruits from coffee are found reveal possible reasons as to why we see the differences in use and exchange values realized in the two countries.

[32] R.H. Posada, M.S. de Prager, G. Heredia-Abarca, E. Sieverding. (2018). Effects of soil physical and chemical parameters, and farm management practices on arbuscular mycorrhizal fungi communities and diversities in coffee plantations in Colombia and Mexico. *Agroforestry Systems*. 92(2) pp 555 - 574.

Reference ID: 24562

Note: H 8.1.5 #24562

Abstract: Arbuscular mycorrhizal fungi (AMF) are essential for growth of coffee plants in acidic and phosphate deficient soils in Central and South America. We investigated the species richness of Glomeromycotean fungi in 9–13 years old coffee plantations in Colombia and Mexico. Fungal species richness was related to physical and chemical soil factors, soil aggregate stability, and farm management practices. Using morphological spore characteristics 85 AMF species were found. AMF species similarity within the plantations was 62–73 %, and the most regularly AMF species found in both countries were: *Acaulospora mellea*, *Acaulospora spinosa*, *Ambispora fennica*, *Diversispora aurantia*, *Dominikia aurea*, *Glomus brohultii*, *Rhizoglomus clarum* and *Rhizoglomus intraradices*. In both countries species richness was differently influenced by agronomic management intensity and soil parameter. In Colombia, where soils were more fertile with higher organic matter and soil pH than in Mexico, soil parameter explained the variations in species diversity, while in Mexico, agronomic management intensities explained the variations in species richness among sites. Soil aggregate stability slightly explains the AMF species richness in Colombia and Mexico. It can be concluded that the Glomeromycotean species richness is very high in older coffee plantations in Colombia and Mexico, and that agronomic inputs have positive effects on species richness in very acidic soils with lower organic matter contents, while in more fertile soils like in Colombia, soil parameter define more the AMF richness

[33] A.H. Youkhana, T.W. Idol. (2016). *Leucaena-KX2* mulch additions increase growth, yield and soil C and N in a managed full-sun coffee system in Hawaii. *Agroforestry Systems*. 90(2) pp 325 - 337.

Reference ID: 24563

Note: H 8.1.5 #24563

Abstract: One option to sustain full-sun coffee plantation is the use of a “cut-and-carry” system in which a stand of N-fixing trees is grown outside the coffee field and utilized as a source of mulch to capture the benefits of organic matter, nutrient additions, and continuous soil cover. The objectives of this study were to evaluate the potential of a cut-and-carry system of mulch additions from a multipurpose N-fixing tree for open-grown coffee in Hawaii to support high crop yield as well as improved soil organic matter and nitrogen. A stand of *Leucaena* variety KX2 trees were pollarded every 6 months, and the pollarded material was chipped and added to open-grown coffee plots. Approximately 65 Mg ha⁻¹ of mulch dry matter was added over a 3-year period, including ~27.5 Mg ha⁻¹ of C and ~530 kg ha⁻¹ of total N. Plots without mulch

addition were fertilized with equivalent amounts of inorganic N for comparison. Mulch decomposition averaged 64 % (weight basis) over the first year and followed first-order decay dynamics. Net N mineralization was positive by 3 months after addition. There was significant loss of all major biochemical components during the decomposition process. Mulching increased soil CO₂ efflux by 2.89 Mg ha⁻¹. Total soil C and N increased by 2.90 and 1.42 Mg ha⁻¹, respectively. Mulch addition significantly increased all measures of coffee growth and yield over 2 years, except for average bean weight. Where space is available or shade is undesirable, a cut-and-carry mulching system using *Leucaena-KX2* can increase soil C and N and achieve coffee yields similar to or greater than other full-sun systems.

[34] S.I. Mussatto, E.M.S. Machado, S.C.V. Martins, J.A. Teixeira. (2011). Production, Composition, and Application of Coffee and Its Industrial Residues. *Food and Bioprocess Technology*. 4(5) pp 661 - 671.

Reference ID: 24564

Note: H 8.1.5 #24564

Abstract: Coffee is one of the most consumed beverages in the world and is the second largest traded commodity after petroleum. Due to the great demand of this product, large amounts of residues are generated in the coffee industry, which are toxic and represent serious environmental problems. Coffee silverskin and spent coffee grounds are the main coffee industry residues, obtained during the beans roasting, and the process to prepare “instant coffee”, respectively. Recently, some attempts have been made to use these residues for energy or value-added compounds production, as strategies to reduce their toxicity levels, while adding value to them. The present article provides an overview regarding coffee and its main industrial residues. In a first part, the composition of beans and their processing, as well as data about the coffee world production and exportation, are presented. In the sequence, the characteristics, chemical composition, and application of the main coffee industry residues are reviewed. Based on these data, it was concluded that coffee may be considered as one of the most valuable primary products in world trade, crucial to the economies and politics of many developing countries since its cultivation, processing, trading, transportation, and marketing provide employment for millions of people. As a consequence of this big market, the reuse of the main coffee industry residues is of large importance from environmental and economical viewpoints.

[35] T.H.P. Nguyen, O. Vinnere Pettersson, P. Olsson, E. Liljeroth. (2010). Identification of *Colletotrichum* species associated with anthracnose disease of coffee in Vietnam. *European Journal of Plant Pathology*. 127(1) pp 73 - 87.

Reference ID: 24565

Note: H 8.1.5.2 #24565

Abstract: Twenty-three isolates of *Colletotrichum gloeosporioides*, five isolates of *C. acutatum*, two isolates of *C. capsici* and six isolates of *C. boninense* associated with anthracnose disease on coffee (*Coffea* spp.) in Vietnam were identified based on morphology and DNA analysis. Phylogenetic analysis of DNA sequences from the internal transcribed spacer region of nuclear rDNA and a portion of mitochondrial small subunit rRNA were concordant and allowed good separation of the taxa. We found several *Colletotrichum* isolates of unknown species and their taxonomic position remains unresolved. The majority of Vietnamese isolates belonged to *C. gloeosporioides* and they grouped together with the coffee berry disease (CBD) fungus, *C. kahawae*. However, *C. kahawae* could be distinguished from the Vietnamese *C. gloeosporioides* isolates based on ammonium tartrate utilization,

growth rate and pathogenicity. *C. gloeosporioides* isolates were more pathogenic on detached green berries than isolates of the other species, i.e. *C. acutatum*, *C. capsici* and *C. boninense*. Some of the *C. gloeosporioides* isolates produced slightly sunken lesions on green berries resembling CBD symptoms but it did not destroy the bean. We did not find any evidence of the presence of *C. kahawae* in Vietnam.

[36] V. Boreux, P. Vaast, L.P. Madappa, K.G. Cheppudira, C. Garcia, J. Ghazoul. (2016). Agroforestry coffee production increased by native shade trees, irrigation, and liming. *Agronomy for Sustainable Development*. 36(3) pp 1 - 9.

Reference ID: 24566

Note: H 8.1.5 #24566e

Abstract: Agroforestry systems usually include a high density and diversity of shade trees. Such systems often have a large diversity of fauna and flora and provide local and regional ecosystem services. Shade trees are, however, being removed to increase crop production in many tropical regions. There is little knowledge on the effect of shade trees on crop production in the context of trade-offs with other management practices. We therefore compared the benefits of exotic versus native shade trees on coffee production. We evaluated the importance of shade tree management for crop production in the context of management practices. Management practices included fertilization, liming, coffee pruning, weeding, and irrigation in 113 coffee agroforests in Kodagu, India, over a wide range of shade tree density, tree species diversity, and shade cover. We studied, in particular, *Grevillea* and non-*Grevillea* shade trees, the latter including mostly native tree species. Results show that a rise of 100 non-*Grevillea* shade tree per hectare increased production of berries by 5.6 % and larger beans by 6.25 %. Irrigation and liming increased berry production respectively by 16 and 20 %. These management interventions are likely to offset the relatively small negative effect of reducing shade density of non-*Grevillea* trees on coffee production. Recommendations based on an understanding of shade tree management alone can be misleading with regard to crop production.

[37] A. Chemura. (2014). The growth response of coffee (*Coffea arabica* L) plants to organic manure, inorganic fertilizers and integrated soil fertility management under different irrigation water supply levels. *International Journal of Recycling of Organic Waste in Agriculture*. 3(2) pp 1 - 9.

Reference ID: 24567

Note: H 8.1.5.1 #24567e

Abstract: A study was carried out to determine the effects of organic, inorganic fertilizers and integrated soil fertility management and irrigation levels (1,000, 750 and 500 ml per planting station) on coffee growth. There were no significant differences ($p > 0.05$) in girth, number of leaves and number of primaries due to the different soil fertility management options. Significant differences ($p < 0.05$) due to soil nutrient sources were observed in coffee height where inorganic fertilizer treatment resulted in tallest coffee plants (47.4 cm) and integrated soil fertility having the shortest coffee trees (42.8 cm) after 1 year. The highest irrigation level of 1,000 ml had the tallest plants with thickest stems while the lowest level had the shortest and thinnest plants ($p < 0.05$). No significant differences were observed in the number of leaves and number of primaries due to irrigation treatments. Results indicate that inorganic fertilizers are the most effective at high irrigation levels while organic manure performs better than inorganic fertilizers under low irrigation water levels.

[38] R. Cerda, C. Allinne, C. Gary, P. Tixier, C.A. Harvey, L. Krolczyk, C. Mathiot, E. Clément, J.-N. Aubertot, J. Avelino. (2017). Effects of shade, altitude and management on multiple ecosystem services in coffee agroecosystems. *European Journal of Agronomy*. 82 pp 308 - 319.

Reference ID: 24568

Note: H 8.1.5 #24568

Abstract: Agroforestry systems provide diverse ecosystem services that contribute to farmer livelihoods and the conservation of natural resources. Despite these known benefits, there is still limited understanding on how shade trees affect the provision of multiple ecosystem services at the same time and the potential trade-offs or synergies among them. To fill this knowledge gap, we quantified four major ecosystem services (regulation of pests and diseases; provisioning of agroforestry products; maintenance of soil fertility; and carbon sequestration) in 69 coffee agroecosystems belonging to smallholder farmers under a range of altitudes (as representative of environmental conditions) and management conditions, in the region of Turrialba, Costa Rica. We first analyzed the individual effects of altitude, types of shade and management intensity and their interactions on the provision of ecosystem services. In order to identify potential trade-offs and synergies, we then analyzed bivariate relationships between different ecosystem services, and between individual ecosystem services and plant biodiversity. We also explored which types of shade provided better levels of ecosystem services. The effectiveness of different types of shade in providing ecosystem services depended on their interactions with altitude and coffee management, with different ecosystem services responding differently to these factors. No trade-offs were found among the different ecosystem services studied or between ecosystem services and biodiversity, suggesting that it is possible to increase the provision of multiple ecosystem services at the same time. Overall, both low and highly diversified coffee agroforestry systems had better ability to provide ecosystem services than coffee monocultures in full sun. Based on our findings, we suggest that coffee agroforestry systems should be designed with diversified, productive shade canopies and managed with a medium intensity of cropping practices, with the aim of ensuring the continued provision of multiple ecosystem services.

[39] K.L. Tully, D Lawrence, S.A. Wood. (2013). Organically managed coffee agroforests have larger soil phosphorus but smaller soil nitrogen pools than conventionally managed agroforests. *Biogeochemistry*. 115 pp 385 - 397.

Reference ID: 24569

Note: H 8.1.5 #24569e

Abstract: The cultivation of crops in the presence of trees (agroforestry) and organic agriculture are management strategies thought to reduce nutrient losses to the environment and increase soil organic matter. Little is known, however, about the differences between organic and conventionally managed agroforests. This research examines how soil nutrient pools and mechanisms for nutrient retention may vary between these two different types of coffee agroforests. We determined variation in soil nutrient pools and nutrient retention capacity among (1) coffee farms in Costa Rica receiving mineral (conventional management) and organic inputs (organic management) and (2) different combinations of shade tree species. Soil nutrient pools and retention capacity were altered by fertilizer management. Soil nitrogen (N) and carbon (C) pools were significantly larger in conventional agroforests, but C:N ratios were similar among agroforests. Soil phosphorus (P) pools were significantly higher in organic agroforests. Overall, C and N concentrations were strongly positively correlated with oxalate-extractable aluminum concentrations. We did not observe

many strong species effects; however, soil cation exchange capacity was higher under Coffea–Musa combinations than under Coffea and N-fixing Erythrina combinations. Thus, mechanisms are in place to promote nutrient retention in agroforestry systems, but these mechanisms can be altered by management practices with consequences for long-term nutrient storage.

[40] S. Bhattarai, S. Alvarez, C. Gary, W. Rossing, P. Tittonell, B. Rapidel. (2017). Combining farm typology and yield gap analysis to identify major variables limiting yields in the highland coffee systems of Llano Bonito, Costa Rica. *Agriculture, Ecosystems & Environment*. 243 pp 132 - 142.

Reference ID: 24570

Note: H 8.1.5 #24570

Abstract: Yield variability in space and time is a well-known phenomenon in the highland coffee production systems of Costa Rica. Our objective was to systematically unravel variations and gaps in yields due to the combined effects of farm resources and major production variables in a region of premium quality highland coffee. We surveyed 40 coffee producing farms varying in size from small to large in Llano Bonito, Costa Rica to examine their diversity based on their resources. We further conducted an agronomic diagnosis and yield estimates in 97 individual measuring plots in 63 coffee fields over two cropping years (2013–2014 and 2014–2015). We categorized farm diversity through a resource endowment typology built by combining direct observation with the use of multivariate analysis and clustering techniques. This resulted in four farm types: large farms depending on external labour (Type 1, 25%), large farms with livestock (Type 2, 20%), small farms dedicated to coffee (Type 3, 38%), and small farms with an off-farm income (Type 4, 17%). We then analysed coffee yield variability and yield gaps through a boundary line approach. The mean yields for two cropping years fluctuated between 2.5 ± 0.18 and 1.6 ± 0.12 t ha⁻¹ on farm types 1 and 2 respectively. Though the yields did not differ strongly across farm types, there was a weak tendency ($p = 0.10$) towards yield variability between study years.

The combined use of farm typology and yield gap analysis revealed multiple farm-specific production variables that were significantly related to gaps in attainable yields. For any intervention to improve and stabilize yields in the future, the heterogeneity of farm orientation, management practices, production geographical context and soil properties must be given proper attention and integrated into crop, shade tree and soil management practices

[41] R.A. Flores, B.M.M.N. Borges, H.Jr. Almeida, R. De Mello Prado. (2016). Growth and nutritional disorders of coffee cultivated in nutrient solutions with suppressed macronutrients. *Journal of Plant Nutrition*. 39(11) pp 1578 - 1588.

Reference ID: 24571

Note: H 8.1.5.2 #24571

Abstract: The objective was to evaluate the effect of omitting macronutrients in the nutrients solution on growth characteristics and nutritional status of coffee. The treatments were complete nutrients solutions and solutions with nutrient omission: N (nitrogen), P (phosphorus), K (potassium), Ca (calcium), Mg (magnesium) and S (sulfur). The experiment was carried out under greenhouse conditions with 3 replicates in a completely random design. Plant height, number of leaves per plant, stem diameter, relative chlorophyll index, photosynthesis rate, stomatal conductance, transpiration, carbon dioxide (CO₂) concentration, dry matter, content levels of macronutrients in plant aerial part and root system, and nutritional disorders were

evaluated. Macronutrients suppression affected nutrients concentration in many plant parts, inducing the appearance of symptoms characteristic of each nutrient. The most limiting nutrients for coffee plants development were nitrogen and calcium, reflected in the lower dry matter accumulation and nitrogen the most required.

[42] E.B. Marinho, A.L. de Oliveira, D.B. Zandonadi, L.E.C. Benedito, R.B. de Souza, C.C. De Figueiredo, J.G. Busato. (2014). Organic matter pools and nutrient cycling in different coffee production systems in Brazilian Cerrado. *Agroforestry Systems*. 88(5) pp 767 - 778.

Reference ID: 24572

Note: H 8.1.5.1 #24572

Abstract: Agroforestry and organic systems have been used to reduce the negative effects that conventional coffee cultivation has on soils. In this work, ¹³C-CPMAS-NMR, Fourier transform infrared spectroscopy, elemental composition, classical humus fractionation and the soil fertility status were used to evaluate the impact of these three systems on a Latosol from the Brazilian Cerrado. Continuous input of tree residues promoted changes to the soil organic matter with increase in total organic carbon, humic acids (HA) and light organic matter, mainly in the topsoil. Available P and cation exchange capacity were also increased and the acidity status decreased in the agroforestry system. Moreover, HA from the agroforestry were enriched in O-alkyl C, O-di-alkyl C and alkyl C groups and the organic system resulted in HA richer in carboxyl groups. The conventional system resulted in greater aromatic and methoxyl participation, and lower phenol groups. HA from the agroforestry system were richer in easily degradable structures and the chemical fractionation demonstrated a decrease in both recalcitrant fractions, allowing for a more conservative and sustainable management of soil fertility. The modifications were not as evident in the organic system, probably due to the low organic fertilizer input.

[43] J.W. Munroe. 2013. Nutrient Availability in the Rhizosphere of Coffee: Shade-Tree and Fertilization Effects. Department of Geography. Toronto, Canada. Master of Science. pp 1 - 88. University of Toronto.

Reference ID: 24573

Note: H 8.1.5.1 #24573e

Abstract: Shade tree incorporation is beneficial in coffee cropping systems under sub-optimal conditions. This study was performed in lowland Costa Rica, at a 12-year-old experimental coffee farm. The main objective was to compare the effect of a nitrogen fixing shade tree, *Erythrina poeppigiana*, on nutrient availability in the rhizosphere of coffee under conventional fertilization. Accumulation of nutrients (mineral N, available P, and exchangeable base cations) in rhizosphere relative to bulk soil was greater under shade than full sun. Low nitrate availability in rhizosphere soil of full sun coffee was explained by root-induced acidification relative to bulk soil, as abundance of ammonia-oxidizing bacteria (AOB), which mediate nitrification, were positively correlated with pH. Organic fertilization enhanced AOB abundance and altered soil bacterial community structure relative to conventional fertilization. This study indicates clear effects of shade-tree presence on nutrient availability at the micro-scale, management of which is critical for stability of coffee agroforestry systems

[44] G. Abera, E. Wolde-Meskel, L.R. Bakken. (2014). Unexpected high decomposition of legume residues in dry season soils from tropical coffee plantations and crop lands. *Agronomy for Sustainable Development*. 34(3) pp 667 - 676.

Reference ID: 24574

Note: H 8.1.5 #24574

Abstract: Crop residues are essential fertilizer source of low-input farming systems in Sub-Saharan Africa. However, crop residues provide nutrients only if they decompose in the soil. Decomposition is assumed to be very low during the dry season due to the scarcity of water, but there are few quantitative knowledge on decomposition under such conditions. Therefore, we studied the decomposition of legume residues, haricot bean (*Phaseolus vulgaris* L.), and pigeon pea (*Cajanus cajan* L. (Millps) using litterbag experiments in two coffee and two crop land agroecosystems of southern Ethiopia. The residues were surface applied and subsoil buried under irrigated and non-irrigated conditions and were then retrieved after 30–180 days. We measured mass loss, decay rate constant (k), and C and N concentrations. Results demonstrate an unexpected high decomposition in seasonal dry soils, even when the litterbags were placed on the soil surface. Interestingly, 89 % of the initial N of pigeon pea and 85 % of haricot bean were released after 150 days, on the average. Thus microbial decomposition is unexpectedly high during the dry season. This finding has implications for the effect of plant residues on the supply of mineral N to crops growing during subsequent wet season.

[45] S.M. Bernas. (2011). Effect of Coffee Pulp Compost and Terrace on Erosion, Run off and Nutrients Loss from Coffee Plantation in Lahat Regency, South Sumatra. *Journal of Tropical Soils*. 16(2) pp 161 - 167.

Reference ID: 24575

Note: H 8.1.5 #24575e

Abstract: On some coffee plantations in Lahat Regency South Sumatra, in some places the farmers did not apply agricultural practices, such as tillage, conservation practices, and fertilizers. Many researches have been done to study about effects of organic fertilizer on soil nutrients content and plant growth as well as and the impacts of terrace on soil water content, run-off and erosion. However, there was less research in the highland area. Whereas the possibility of run off, erosion and nutrient leaching the high land area was high. Thus, it was important to apply terrace and organic coffee pulp in this farm. The aims of this research were to determine the effect of terrace and organic fertilizer on run off and soil erosion, nutrients loss and nutrient content in coffee leaves. Terrace system and organic fertilizer were applied on a one year old coffee plantation in Lahat Regency. Before the treatment applied, coffee pulp as organic fertilizer was decomposed in the chamber for about 2 months. The experiment was conducted in factorial in a Randomized Block Design with two factors. The first factor was coffee pulp compost (0, 3, and 6 Mg ha⁻¹), and the second factor was type of terrace (without, individual, and bund terraces). The size of each plot was 2 m width and 10 m length. Data was analysed by using LSD (Least Significant Different) test. The result shows that bund terrace reduced runoff and erosion significantly up to 79% (for run off water) and 78% (for eroded soil) compared to without terrace. Organic fertilizer did not affect run off and soil erosion. This may be caused by properties of coffee pulp compost which were fine particulates and the dosages of application were too low to cover soil surface. Bund terrace decreased significantly N, P, K nutrients in soil loss (sediment). The amount of N loss was reduced from 3.37 kg ha⁻¹ per four months (without terrace) to about 0.75 kg ha⁻¹ per four months (bund terrace). Terrace and organic fertilizer did not affect significantly nutrients content in the leaves, but P-

content was low without organic fertilizer addition. It is suggested to apply bund terrace and higher organic fertilizer dose on the coffee farm, and further experiments when harvesting the yield (berries) are needed for the second year old coffee farm.

[46] K.L. Tully, D. Lawrence. (2012). Canopy and leaf composition drive patterns of nutrient release from pruning residues in a coffee agroforest. *Ecological Applications*. 22(4) pp 1330 - 1344.

Reference ID: 24576

Note: H 8.1.5 #24576

Abstract: In a coffee agroforest, the crop is cultivated under the shade of fruit-bearing and nitrogen (N)-fixing trees. These trees are periodically pruned to promote flowering and fruiting as well as to make nutrients stored in tree biomass available to plants. We investigated the effect of canopy composition and substrate quality on decomposition rates and patterns of nutrient release from pruning residues in a coffee agroforest located in Costa Rica's Central Valley. Initial phosphorus (P) release was enhanced under a canopy composed solely of N-fixing, *Erythrina poeppigiana* compared to a mixed canopy of *Erythrina* and *Musa acuminata* (banana). Both initial and final N release were similar under the two canopy types. However, after five months of decomposition, a higher proportion of initial N had been released under the single canopy. Although patterns of decomposition and nutrient release were not predicted by initial substrate quality, mass loss in leaf mixtures rates were well predicted by mean mass loss of their component species. This study identifies specific pruning regimes that may regulate N and P release during crucial growth periods, and it suggests that strategic pruning can enhance nutrient availability. For example, during the onset of rapid fruit growth, a two-species mixture may release more P than a three-species mixture. However, by the time of the harvest, the two- and three-species mixtures have released roughly the same amount of N and P. These nutrients do not always follow the same pattern, as N release can be maximized in single-species substrates, while P release is often facilitated in species mixtures. Our study indicates the importance of management practices in mediating patterns of nutrient release. Future research should investigate how canopy composition and farm management can also mediate on-farm nutrient losses.

[47] F.K. Padi, O.K. Domfeh, A. Arthur, A. Ofori. (2017). Potential of recurrent selection for developing improved cocoa varieties in Ghana. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 12.

Reference ID: 24577

Note: #24577e > #24507e

Abstract: In the major cacao producing countries, recurrent selection using clones available through the International Cocoa Quarantine Centre, Reading, UK, remains an important approach to identifying new clones with good combining abilities for desired traits. In 2010, 56 clones derived from within-family selections for productive trees in eleven progeny trials evaluated over different time periods were used to design a trial at Tafo, Ghana. The clones T60/887, T85/799, PA 7 and PA 150 were included as standards. A single-tree randomisation approach was used with 15 trees per clone in each of four replicates. Excluding pods damaged by *Phytophthora* spp., average bean yields of the four standard clones over a period of three years (34 to 69 months after transplanting) ranged from 0.34 to 0.54 t/ha/year whereas those of the six most productive new clones ranged from 0.7 to 1.0 t/ha/year. The pod index for the new clones ranged from 18 to 24, compared with 19 to 30 in the standard clones. Individual bean sizes were in the range of 1.23 to 1.39 g for the six new clones compared with a

range of 1.21 to 1.32 for the standard clones. Expression of symptoms of CSSV disease among the selected clones following inoculation with severe CSSV strain 1A was comparable with those of the standard clones. Among seven of the clones tested for combining abilities with existing seed garden female clones, CRG 6035/103 and CRG 9006/106 showed good general combining abilities for juvenile tree vigour, precocity and bean yields, whereas CRG 3019/308 showed specific combining abilities with PA 121 and PA 150. Across farmers' plots in the Western Region of Ghana, seedling varieties developed using these new clones as males recorded higher seedling survival and better seedling vigour over those supplied from existing seed gardens. These results are evidence that further yield increments are attainable by selecting and crossing among cacao germplasm freely available in the international genebanks.

[48] C & CI. (2018). C&CI: Coffee and Cocoa International January 2018 Vol 44 No 6. pp 1 - 50.

Reference ID: 24578

Note: S serial #24578

[49] C & CI. (2018). C&CI: Coffee and Cocoa International March 2018 Vol 45 No 1. pp 1 - 50.

Reference ID: 24579

Note: S serial #24579

[50] ISP. (2017). The Planter Vol 93 No 1097 August 2017. pp 549 - 604.

Reference ID: 24580

Note: S serial #24580

[51] ISP. (2017). The Planter Vol 93 No 1100 November 2017. pp 757 - 816.

Reference ID: 24581

Note: S serial #24581

[52] L.J. Leao, Y.Y. Kwan. (2017). Advances in Oil Palm Breeding: Issues and Challenges. The Planter. 93(1097) pp 551 - 559.

Reference ID: 24582

Note: #24582e > S serial #24580

Abstract: Oil palm is the most efficient oil-bearing crop. However, its breeding cycle per generation requires at least a decade of meticulous work. In Malaysia, land under oil palm cultivation has increased by more than 50 per cent over the past 20 years. Price fluctuation in crude palm oil and fertiliser, further shrinkage of arable land and extreme labour shortage have propelled the demand for good quality planting materials as well as good crop management.

[53] S.H. Tey, Z.Y. Chen, Y.A. Liew, H.C. Ng, C.B. Teo, D. Subrmaniam, K.J. Goh. (2017). Emerging Digital Technologies and Tools for Application to Oil Palm Plantations. The Planter. 93(1097) pp 565 - 573.

Reference ID: 24583

Note: #24583e > S serial #24580 (reproduced from 13th ISP National Seminar 2017 Book, "100 Years of Oil Palm: Suring Forward".)

Abstract: This paper reviews how emerging digital technologies such as GPS receivers, satellite imagery and more recently unmanned aerial vehicles have been adopted for mapping, planning and monitoring in oil palm plantations. Developments

in the sensor and robotic technologies have also prompted us to pay attention to potential useful gadgets like agricultural drones, industrial exoskeleton and even personal self-balancing vehicles that can be adopted to reduce the burden on workers. A functional 10 litre-payload agricultural dusting drone has been widely used for paddy and vegetable farming worldwide. A 12 litre-payload drone has also been introduced but there are challenges to be overcome before it can be adopted for spraying in oil palm fields.

[54] S. Sivakumaran. (2017). Natural Rubber Industry Needs to Think and Act Out of the Box If it is to Survive and Flourish in the Decades to Come. *The Planter*. 93(1907) pp 579 - 585.

Reference ID: 24584

Note: #24584e > S serial #24580 (Article first published as 'NR Industry Think & Act Out of the Box for Survival' in Rubber Asia, 30th Anniversary Issue, June 2016 pp147-153

Abstract: The challenges facing the industry today are more intricate and not amenable to easy solutions. Hence there is need to think and act out of the box in certain areas if the NR industry is to survive over the next several decades.

[55] K.H. Chee. (2017). Oil Palm Weevil Pollination Revisited. *The Planter*. 93(1100) pp 761 - 771.

Reference ID: 24585

Note: #24585e > S serial #24581

Abstract: The weevils, *Elaeidobius kamerunicus* arrived in Southeast Asia from Cameroon over 30 years ago. Consequently, oil palm pollination has improved greatly resulting in a quantum jump in FFB yield. However, despite the presence of the weevil, there has been occurrence of poor fruit set in Malaysia and Indonesia on both newly matured and older palms in recent years causing major economic set back. The behaviour of *E. kamerunicus* in time and space was examined to uncover further research to restore the potential productivity of the oil palm. Existing information on other pollination insects are reviewed to facilitate a second introduction of pollination insects if necessary.

[56] C.M. Su, C.F. Bong. (2017). Effect of Different Insecticides on the Survival of the Oil Palm Pollinator, *Elaeidobius kamerunicus* (Coleoptera: Curculionidae) *The Planter*. 93(1100) pp 777 - 788.

Reference ID: 24586

Note: #24586e > S serial #24581

Abstract: This study investigated the effects of nine insecticides used in young mature oil palm plantations for bunch moth control and their effect on the survival of the oil palm pollinating weevils especially on the newly emerged young adult weevils from the spent male inflorescence spikelets.

[57] C.K.T. Then, H'ng W.C. (2017). Control of White Root Disease of Rubber with *Trichoderma*. *The Planter*. 93(1100) pp 793 - 799.

Reference ID: 24587

Note: #24587e > S serial #24581

Abstract: Three treatments were employed to evaluate the effectiveness of *Trichoderma* in controlling white root disease of rubber caused by *Rigidoporus lignosus*.

[58] N.E. Prabowo, L. Tohiruddin, T.H. Fairhurst, H.L. Foster, N. Evi Nafisah. (2002). Efficiency of Fertiliser Recovery by Oil Palm in Sumatra. 2002 International Oil Palm Conference, Nusa Dua, Bali, July 8 - 12, 2002. pp 282 - 290.

Reference ID: 24588

Note: H 8.1.1.1 #24588

Abstract: Because fertilizers are usually the most costly input in field management of oil palm, there is a strong incentive to improve the efficiency of fertilizer nutrient use by the crop. There is little published information on nutrient recovery roles for oil palm or on the factors that affect nutrient recovery efficiency.

[59] R.F. Schwan, G.H. Fleet. (2014). Cocoa and Coffee Fermentations. Secondary Cocoa and Coffee Fermentations. CRC Press Taylor & Francis Group. Florida, USA. pp 1 - 611.

Reference ID: 24589

Note: #24589

Abstract: Cocoa and coffee beans are some of the most traded agricultural commodities on international markets. Combined, they provide raw materials for a global industry valued in excess of \$250 billion. Despite this, few people know that microorganisms and microbial fermentation play key roles in their production and can have major impacts on product quality, safety, and value.

Cocoa and Coffee Fermentations explores the scientific principles behind cocoa and coffee fermentation. The book covers botanical and production backgrounds, methods of bean fermentation and drying, microbial ecology and activities of fermentation, the biochemistry of fermentation, product quality and safety, and waste utilization.

The book aims to optimize cocoa and coffee processing based on scientific evidence to enhance traditional processing methods that often give rise to inefficiencies and inconsistencies in product quality. It also aims to provide a better understanding of the complex microbial ecology in cocoa and coffee fermentations which involve interactions between species of yeasts, bacteria, and filamentous fungi.

Cocoa and Coffee Fermentations hopes to inspire further research linking the microbiology and biochemistry of cocoa and coffee bean fermentations with the development of better controlled fermentations, implementation of quality assurance programs, and ultimately improvement of the sensory attributes of the final product.

[60] C.H.J. Brando, M.F.P. Brando. (2014). Methods of Coffee Fermentation and Drying. pp 367 - 396.

Reference ID: 24590

Note: #24590e > #24589

[61] C.F. Silva. (2014). Microbial Activity During Coffee Fermentation. pp 397 - 430.

Reference ID: 24591

Note: #24591e > #24589

[62] D. Selmar, M. Kleinwachter, G. Bytof. (2014). Metabolic Responses of Coffee Beans During Processing and Their Impact on Coffee Flavor. pp 431 - 470.

Reference ID: 24592

Note: #24592e > #24589

[63] L.R. Batista, S.M. Chalfoun. (2014). Quality of Coffee Beans. pp 477 - 508.

Reference ID: 24593

Note: #24593e > #24589

[64] N.M. Guerrero, E.M. Moreno, O.M.C. Gavanzo, D.H. Duarte, E.A. Gutierrez. (2017). Mejoramiento genético de cacao en Colombia a través de selección varietal participativa: Genetic improvement of cocoa in Colombia through participatory varietal selection. 2017 International Symposium of Cocoa Research (ISCR). Peru. pp 1 - 11.

Reference ID: 24594

Note: #24594e > #24507e (Note: Journal is in Spanish)

Abstract: Colombia posee potencial en diversidad genética de cacao, en especial por ser parte del centro de origen de la especie y también por el desarrollo del cultivo a través del tiempo. La Federación Nacional de Cacaoteros – FEDECACAO -, mediante estrategias de mejoramiento participativo como base para la recuperación y salvaguardia de conocimientos, recursos genéticos y patrimonio social, ha generado procesos de conservación de germoplasma y de la diversidad genética en fincas con la búsqueda, recuperación, conservación y evaluación de nuevos genotipos promisorios. Desde los años 90, FEDECACAO inició el proceso de búsqueda, selección y evaluación de árboles sobresalientes en fincas de agricultores en todas las regiones productoras del país. Hasta el año 2016 la Federación ha seleccionado 116 árboles procedentes de 40 municipios, correspondientes a doce departamentos. El esquema establecido fue la evaluación regional de los genotipos seleccionados por ambientes y se obtuvo el registro de la Unidad de Fitomejoramiento en cacao. Se establecieron parcelas y experimentos con diseño experimental BCA, donde se evaluaron genotipos con características especiales; mediante variables relacionadas con componentes del rendimiento, respuesta a *Moniliophthora roreri.*, y perfil sensorial, en diferentes condiciones ambientales, durante 6 años. Los datos obtenidos en la evaluación fueron analizados mediante estadística descriptiva y multivariada. Los resultados obtenidos permitieron concluir que se debe continuar con la selección de genotipos con características especiales. En 2014 se obtuvo el registro comercial para 8 nuevos genotipos de cacao que poseen características de alto rendimiento, mayor tolerancia a monilia y calidad sensorial, en tanto que Fedecacao continua trabajando en la selección de genotipos de interés para el incremento de la productividad e incentivando nuevas selecciones de materiales promisorios con características de cacao fino de sabor y aroma.

[65] N.M. Guerrero, G. Gallego, P. Zapata, C. Quintero, D. Duarte, J. Tohme, O.D. Ramírez. (2017). Caracterización morfoagronómica y molecular de la colección de cacao de la Federación Nacional de Cacaoteros de Colombia: Morphoagronomic and molecular characterization of the cocoa collection of the National Cacao Federation of Colombia. 2017 International Symposium of Cocoa Research (ISCR). Peru. pp 1 - 12.

Reference ID: 24595

Note: #24595e > #24507e (Note: Journal is in Spanish)

Abstract: La identidad genética y las relaciones evolutivas en colecciones de germoplasma se han estudiado a través de marcadores moleculares, usados en el estudio, dando valor agregado en términos de información genética útil a los bancos de germoplasma. En cacao se han utilizado para establecer la identidad de los genotipos y su relación genética con los grupos establecidos, como base para programas de mejoramiento genético asistido por marcadores moleculares. Con los trabajos previos de selección de genotipos promisorios a través de mejoramiento participativo, la Federación Nacional de Cacaoteros caracterizó a nivel morfoagronómico 42 y molecular 70 genotipos, colectados en diferentes regiones productoras de Colombia, dentro de cultivos tradicionales en fincas de agricultores. La colección, establecida en condiciones de San Vicente de Chucurí, Santander (N 6° 52"57", W 73° 24" 46"), se caracterizó con 56 descriptores distribuidos de la

siguiente manera: de planta (2), hoja (12), flor (13), fruto (20) y semilla (9). Para la caracterización molecular se utilizó un chip de 96 SNP's bajo la plataforma Fluidigm®, siguiendo los protocolos previamente establecidos por CIAT. El procesamiento de las muestras y análisis de los datos se realizó entre FEDECACAO y el laboratorio de Biotecnología del Centro Internacional de Agricultura Tropical -CIAT- en Palmira, Colombia. Se utilizó el programa PowerMarker® 3.25 para realizar cálculos de parámetros descriptivos de variación genética y el programa NTSYS-pc para el análisis de agrupamientos y establecer las relaciones entre los individuos bajo estudio, con base en la distancia genética de Nei. Así mismo, se diagramaron los perfiles genéticos (Fingerprinting) de cada genotipo con el programa Flapjack. Basado en los resultados se evidencia la diversidad genética entre los genotipos evaluados y se ratifica la identidad de algunos comerciales para mejorar etiquetados. Se pudo verificar la relación existente entre genotipos seleccionados y parentales utilizados en programas de mejoramiento genético anteriores. La caracterización permitirá establecer futuros programas de mejoramiento genético para atender las necesidades de la demanda creciente de material para nuevas siembras y modernización del cultivo en Colombia.

[66] A. Mahabir, L.A. Motilal, D. Gopaulchan, A. Sankar, P. Umaharan. (2017). Identification of a core SNP panel for cacao identity and population analyses. 2017 International Symposium of Cocoa Research (ISCR). Peru. pp 1 - 11.

Reference ID: 24596

Note: #24596e > #24507e

Abstract: It is becoming increasingly easier to obtain genetic data from hundreds to thousands of single nucleotide polymorphisms (SNPs) in cacao (*Theobroma cacao* L.) plants. Yet, a consensus panel of SNPs for diversity, identity or population ancestry studies remains to be adopted by the cacao community. SNP panels were assembled based on major allele frequency (MjAF), polymorphism information content (PIC) and linkage group (LG) distribution. These panels were assessed on a test panel of 155 accessions to determine the minimum number and best combination of SNPs that could unambiguously separate reference cacao genetic profiles and simultaneously detect the correct population structure. Five designer panels, building on the results of the previous panels that achieved full resolution on the test case of 155 accessions were also assessed on a real world dataset of 1231 accessions. Increasing the number of SNPs generally resulted in improved resolution of genetic identities with concomitant reduction of synonymous groups. Retention of SNPs for panel inclusion relied on informativeness and PIC but did not need to be distributed equally among the ten chromosomes. A panel of 96 SNPs was suggested as a minimal core set of SNPs for adoption by the international cacao community.

[67] L.A. Motilal, D. Zhang, S. Mischke, L.W. Meinhardt, P. Umaharan. (2017). Candidate SSR tags for fruit and seed traits of *Theobroma cacao* L. in the International Cocoa Genebank Trinidad. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24597

Note: #24597e > #24507e

Abstract: Increasing yield is a prominent feature of crop breeding programmes including the economically important cacao (*Theobroma cacao* L.). As a tropical tree crop, the time and acreage needed for selection of improved varieties are limiting factors. Selection at an early seedling stage in a marker-assisted selection programme is desirable. Candidate molecular microsatellite markers were identified under an

association mapping approach for five fruit (fruit mass, husk mass, fruit length, fruit girth and fruit volume) and three seed (length, width and size of fresh peeled seeds) traits. Nine microsatellite markers (mTcCIR 19, 30, 40, 43, 57, 60, 126, 184 and 275) were consistently obtained under general and mixed linear models and explained between 4.68 – 12.87% of the observed variation. Markers mTcCIR60, mTcCIR126 and mTcCIR184 were most significantly associated with the reproductive traits. The adoption of these markers is recommended to the international cacao community.

[68] W.H. Céspedes-Del Pozo, R. Blas-Sevillano, D. Zhang. (2017). Assessing Genetic Diversity of Cacao (*Theobroma cacao* L.) Nativo Chucho in La Convencion, Cusco-Perú. 2017 International Symposium of Cocoa Research (ISCR). Peru, Lima. pp 1 - 8.

Reference ID: 24598

Note: #24598e > #24507e

Abstract: Perú is a megadiverse country with high biological, cultural, ethnic and historic richness, recognized as world center of genetic resources, being as a strategic for food security of its population MINAM, (2010). The Ministry of Agriculture declared; "Natural Patrimony of the Nation to the Peruvian Cocoa (*Theobroma cacao* L.)" and created the National Registry of Peruvian Cocoa Cultivars. Peru is one of the main origin centers of cocoa with high diversity and genetic variability; Native "Chuncho cocoa", "Porcelain of Piura", Nacional of Perú".

The Peruvian Amazon has a great genetic diversity of cocoa, one of them is "Chuncho cocoa", it is native to the province of La Convención in Cusco-Perú, where around 20 thousand hectares are cultivated, 60% are "Chuncho". The name comes from the place, since the area is inhabited by indigenous ethnic groups "Matsiguenga Chunchos", who probably domesticated this Cutivar (Bioversity, 2009).

To assess genetic diversity of Chuncho cocoa it was necessary to do bioprospection among the farmers' fields and native lands, located in the province of La Convención-Cusco 250 km), 51 morphological and agronomical descriptors were used to characterize 260 trees. 72 plants were selected by its superior agronomic characteristics to be the first genebank of Chuncho Cocoa, in fact there are several trees in this area waiting to be rediscovered.

The variability is in shape, size of seeds and fruits (all yellow), color of seeds (from whitish to almost black), tolerant to resistant against adverse factors.

35 sensorial profiles were encountered, Chuncho Cocoa has fine aroma and exceptional flavor; floral and fruity, sweet with low acidity, very low bitterness and astringency, herbal and nutty.

To do molecular prospection were used; 260 leaves samples of Native Chuncho Cocoa, 96 SNPs molecular markers, DNA Stool kit extraction and purification, DNA quantification by NanoDrop 2000 and genotyping by EP1™ System FLUIDIGM

60% of the samples are pure Chunchos, different population from the classification presented by Motamayor C. (2008), Chuncho is not Contamana. The result of Structure analysis confirmed that Chuncho Cocoa is indigenous to southern Peru, I can say the valley of Urubamba river in la Convención, Cusco-Perú is the center that originates cocoa.

To assess genetic variability and to know the characteristics of the Chuncho Cocoa will give us the basis for breeding, which will contribute to enhanced agricultural productivity, economic development, and food security for farmers involved in the cocoa value chain.

[69] P.V. García, L.F. García. (2017). Clasificación Intraespecífica de 14 Árboles Híbridos Seleccionados de Cacao (*Theobroma cacao* L.) Mediante Análisis de Conglomerados en Tulumayo: Intraspective Classification of 14 Hybrid Trees Selected From Cocoa (*Theobroma cacao* L.) by Analysis of Conglomerates in Tulumayo. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24599

Note: #24599e > #24507e (Note: Journal is in Spanish)

Abstract: Con el objeto de caracterizar morfológicamente y clasificar taxonómicamente 14 árboles híbridos de cacao mediante el análisis de conglomerados, se llevó a cabo un ensayo en el Centro de Investigación y Producción Tulumayo, perteneciente a la Universidad Nacional Agraria de la Selva, Tingo María-Perú. Se estudió 14 genotipos de cacao usando 15 descriptores morfológicos de flores, frutos y semillas (14 cualitativos y 1 cuantitativo), de la lista de descriptores de la Universidad de las Indias Occidentales (Trinidad y Tobago). Sólo para el número de óvulos/ovario (NOO), se utilizó la media, desviación estándar y el coeficiente de variación. Para el análisis de conglomerados, se eligió la distancia euclidiana, el método del ligamiento promedio, y la correlación cofenética, utilizando el programa PAST, v. 1.43. La caracterización morfológica de flores mostró una variación fenotípica de ligera a moderada; en cambio, para el NOO, la variación fue amplia. En los caracteres morfológicos de frutos y semillas se observó una mayor variabilidad cuyo polimorfismo dependió del carácter evaluado. Se formaron 3 grupos (I, II y III) y 1 entidad independiente a un nivel de afinidad de 1.0; siendo los grupos: ICS 95 x POUND 7, 20 con ICS 95 x ICS 6, 14; ICS 95 x U 58, 16 con U 68 x ICS 6, 11; IMC 67 x ICS 95, 1 con H 12 x ICS 6, 6; quienes exhibieron las menores distancias y mayores similitudes taxonómicas. Se sugiere complementar la clasificación taxonómica con una técnica de ordenación.

[70] N.D. Pokou, G.M. Tahi, B.B. Guiraud, R. Bhattacharjee, J.C. Motamayor. (2017). Assessment of genetic quality of Cacao seed gardens output using Single Nucleotide Polymorphism (SNPs) markers. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24600

Note: #24600e > #24507e

Abstract: The development and cultivation of improved planting material of cacao have greatly contributed to ensure efficiency of production and increasing farmer's income in producing countries. The use of improved planting materials is a major key towards ensuring sustainability of the cacao. In Côte d'Ivoire, improved plant material is released under hybrids seeds. Seed gardens are plots established using the parental genotypes of selected progenies in the aims of controlling the crosses to produced hybrids seeds for planting material. Genetic quality of seed gardens output have been the target of scientists for years through testing of different layouts. Now, seeds in Côte-d'Ivoire are produced in monoclonal seed gardens using hand pollination techniques to control the crosses between male and female parents on open flowers. However, little is known about the risk of non-recommended crosses in the seed gardens. In this study, 80 SNPs markers have been used to test 1288 parental trees in the mains seed gardens of Côte-d'Ivoire.

[71] A.A. Sankar, L.A. Motilal, D. Zhang, P. Umaharan. (2017). Genetic Diversity and Genetic Structure of Wild Cacao Collected in the Oriente using Single Nucleotide Polymorphisms. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24601

Note: #24601e > #24507e

Abstract: Cacao, the precious resource upon which a global multi-billion dollar industry depends is under threat from diseases such as Black Pod (a global scourge), Witches' Broom, and Frosty Pod. The latter two are confined to parts of the Americas but pose a threat in the entire cocoa world. Other major threats to cocoa production include adverse climate change predictions, aging trees, animal pests, and pollinator habitat loss. Due to these threats demand for the 'brown gold' that is cocoa has been predicted to outstrip supply in the not-too-distant future. What the cocoa industry needs may be locked in the genome of untapped germplasm such as the wild-type accessions collected during the London Cocoa Trade (LCT) Amazon project. The LCT accessions were held at the EEN station (thus the accession prefix: LCTEEN), but are now held at the Pichilingue station of INIAP in Ecuador, though some have been successfully transferred to the International Cocoa Genebank, Trinidad (ICGT) as part of the original project agreement. The original trees from which this collection arose may no longer exist due to the destruction of virgin forest in the Amazon. A timely intervention into the conservation of this collection is long overdue. Single Nucleotide Polymorphism (SNP) markers because of their high resolution have the capacity to provide valuable insight into the genetic constitution of these wild cacao accessions. The objectives of this research were to characterise available LCTEEN accessions with SNPs to create a genetic profile of the population and to use available geo-referencing information combined with the genetic information to assess spatial-genetic relationships. Results show LCTEENs are related to Purus, Nacional and Contamana populations and are good candidates for conservation.

[72] B.C. Garcia, F.E. Alcocer. (2017). Characterization Biosystems and Reproductive Biology of *Theobroma cacao* L. in Puyango Tumbes Binational Basin. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24602

Note: #24602e > #24507e

Abstract: Cocoa cultivation *Theobroma cacao* L. is currently gaining importance due to its good quality and high fat content, characteristics that favor the demand in the national and international market; however this interest is limited in Tumbes Region as in other productive regions of our country, because the variety of plantations is not defined, these are often crossed by pollination. For this reason, the biosystematic characterization and reproductive biology of cacao genetic material, adapted to ecological niches of the Tumbes Region, was carried out. Twenty minimal morphological characters (between qualitative and quantitative) were evaluated in flowers, fruits and almonds from 05 cocoa samples, using the descriptors of the Tropical Agronomic Research and Teaching Center (CATIE); It was determined that the intensity of pigmentation of the sepals, length of style, width / length of ear, depth of furrow, constitute the morphological characters of greater importance for the determination of the ecotypes under study. The samples of almonds under study, were treated, considering heading 1801 (cocoa beans, whole or split, raw or roasted). With regard to reproductive biology, it was determined that *T. cacao* presents a mechanism of natural cross-pollination (alogamia), confirming that when sexually reproduced occurs segregation and genetic recombination; It is determined that in the Tumbes

Region, there are traditional varieties, whose populations are heterogeneous, coming from: Trinitarios x Nacional, which despite being called "criollas", have been introduced from Ecuador. It is recommended to carry out pre-breeding activities (collection, characterization, evaluation, multiplication / regeneration, conservation) and effective methods of participatory genetic improvement.

[73] O. Sounigo, de Tchoua L.F., R. Bourgoing, T.F. Nsouga, D. Abolo, I.B. Efombagn, C. Cilas. (2017). Comparative assessment of agronomical performances of six commercial cocoa varieties in on farm progeny trials in Cameroon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24603

Note: #24603e > #24507e

Abstract: A long term participatory breeding program was launched in Cameroon in 2004, as a key component of a worldwide cocoa breeding project, funded by CFC. One activity within this program has consisted in setting up on farm progeny trials in order to assess the performances of commercial cocoa varieties, when tested in on farm conditions.

2,337 cocoa trees, belonging to six commercial varieties (six full-sib progenies issued from bi-clonal seed-gardens) were assessed in 11 progeny trial plots, set up in 2006, in two villages of Cameroon.

Cocoa yield data recorded during the period from 2011 to 2015 were analyzed and showed significant differences among progenies, ranging between 730 and 1,285 kg cocoa/ha/year.

In addition, 681 cocoa seedlings issued from seed-gardens (CV), have been planted simultaneously with 234 seedlings issued from pods collected in farmers' plots, in six progeny trial plots set up in 2007 in three villages of Cameroon.

149 of these farmers' seedlings were issued from pods collected on cocoa trees belonging to the traditional amelonado variety (named german cocoa) (GC), while 85 others were issued from pods collected on trees belonging to commercial varieties (half-sibs issued from commercial varieties) (FV).

Under the conditions of our trial plots (no permanent shade during the first ten years, because of the simultaneous planting of cocoa and shade trees), GC trees yielded significantly less (250 kg/ha/year) than FV (650 kg/ha/year) and CV trees (between 600 and 800 kg/ha/year).

The impact of these results on the future release of commercial cocoa varieties in Cameroon is discussed in this paper.

[74] O. Sounigo, M. Eyango, H.E. Ebaiarrey, N. Akongwni, I.B. Efombagn, C. Cilas, C. Lanaud. 2017. Assessing the impact of self-incompatibility on cocoa trees in Cameroon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. ICCO CIRAD.

Reference ID: 24604

Note: #24604e > #24507e

Abstract: Assess the impact of self –compatibility on several agronomical traits of cocoa trees.

In this study, the performances of self-compatible cocoa trees were compared to those of self-incompatible belonging to the same full-sib progenies.

[75] R.A. Ríos-Ruiz. (2017). Fitosanización como Estrategia Principal de Manejo Integrado de Enfermedades en Cacao en el Perú: Tres Décadas y Media de Estudios de Epidemiología y Eficiencia de Control - Phytosanitation as the Main Strategy for the Integrated Management of Diseases in Cocoa in Peru: Three Decades and a Half of Studies in Epidemiology and Control Efficiency. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24605

Note: #24605e > #24507e (Note: Journal is in Spanish)

Abstract: Las enfermedades fúngicas, y su manejo, limitan severamente la producción de cacao en el Perú. En ese contexto, la UNAS inició un programa sistemático y consistente de: levantamiento de enfermedades, estudios de biología de los patógenos, estudios epidemiológicos y de progreso, determinación de estrategias de control y evaluación de la eficiencia de medidas de control. Levantamiento de datos entre los años 1982-84 y 1987-89 identificó la Escoba de Bruja - EB (*Moniliophthora perniciosa*) y la Pudrición Parda - PP (*Phytophthora palmivora*) como las enfermedades más prevalecientes; sin embargo, este escenario cambió en los levantamientos de 1994-95 y 2005-06, que mostraron la Moniliasis - MO (*Moniliophthora roreri*) como la principal enfermedad, no raro causando pérdidas de 30 a 45% en la producción. Estudios de progreso; realizados entre los años 1988-90 para EB y PP, y entre los años 1993- 95/1996-98 (*Plantaciones híbridas*) y entre 2005-07/2014-2016 (plantaciones clonales) para MO; identificaron que la intensidad de EB en brotes, cojines florales y frutos fue mayor entre abril-setiembre, mientras que la presencia de PP en frutos presentó mayores incidencias entre diciembre-abril. Por otro lado, el apareamiento de MO en frutos ocurrió durante todo el año, siendo mayor entre enero-julio. Como las EB secas en el árbol y los frutos enfermos con PP y MO son importantes fuentes de inóculo, la estrategia de control prioritariamente debe contemplar la remoción del material afectado, o sea la Fitosanización. Definido esta estrategia, varios ensayos fueron efectuados para evaluar la eficiencia del control de EB, PP y MO. Entre los años 1988-90, el control de la EB fue satisfactorio cuando las escobas fueron removidas en setiembre y repase en diciembre o enero, así reduciendo los frutos enfermos y elevando la producción en 50%. Entre los años 1989-90, un ensayo de remoción de EB dos veces al año y remoción de frutos con PP demostró eficiencia técnica, dando como resultado mayor producción. Cuando se evaluó entre los años de 1995-96 dos frecuencias (7 y 14 días) de remoción de frutos con MO y PP, la remoción semanal redujo la incidencia de las enfermedades. En los años 1996-1998 y 2014-2015, la remoción semanal y la diferenciada (semanal de diciembre a mayo y a cada dos semanas de julio a noviembre) tuvieron efectos semejantes y redujeron la incidencia de la MO y aumentaron la producción. La fitosanización es eficiente y los servicios de extensión deben aplicarlas correctamente para que los productores la adopten masivamente.

[76] R. Laura, L. Llatas, Y. Cuchilla, S.H. Pastor. (2017). Participatory Model of Selection and Installation of a Seed Garden of Fine Cacao (*Theobroma cacao* L.) "Cacao Amazonas Peru" in the Amazon Region (Peru). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24606

Note: #24606e > #24507e

Abstract: The cacao is the main ingredient of chocolate and moves billions of dollars around the world each year, and it comes mainly from family farming. In Peru, more than 90,000 families benefit cultivating cacao in 16 of the 25 Regions that make up the country. The country contains a great diversity of types of cacao, many of which

have been classified as fine and flavored and are offered better prices in comparison to prices on the commodities stock market (London and New York). This presents a great opportunity to improve the family economy of the cacao farmers and at the same time, stimulate the conservation of genetic diversity. Given this opportunity and with the objective of providing mainly vegetative planting material properly cataloged with the denomination of origin (DO) "Cacao Amazonas Peru," a participatory cacao selection experience was started on a collection of 135 outstanding accessions representative of the Amazonas political region. The collection is located in the clonal gardens of the CEPROAA (Farmers Central Cooperative of Amazonas) at altitudes between 614 and 830 meters above sea level. The process of selection began with the validation of the morpho-agronomic characterization and the sensorial evaluation data of fruits to identify 10 clones with outstanding characteristics. The selection obtained was installed on the farm of a CEPROAA's partner farmer with a seed garden design of 1.5 hectares, maximizing the number of trees per selection. The 10 types of promising cocoa selected, were re-characterized with the same initial parameters and an analysis of the sensory profile of the beans was made to make available to the farmers, the fine chocolate industry, and researchers. During the process, participatory workshops were held with farmers in the area to highlight the value of having quality seed with known origin. This experience is serving as a model for the installation of more seed gardens in other regions of Peru, such as in Piura, offering a quick alternative to respond to the high demand for fine cocoa seed.

[77] M. Boccara, L.A. Motilal, C. Pierre, P. Umaharan. (2017). Caractérisation morphologique et moléculaire de variétés de Cacaoyer cultivées dans le département de la Grand 'Anse à Haïti: Morphological and molecular characterization of cocoa varieties cultivated in the Department of Grand Anse in Haiti. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 18.

Reference ID: 24607

Note: #24607e > #24507e (Note: Journal is in French)

Abstract: Le projet "Caractérisation morphologique et moléculaire de variétés de cacaoyer en Haïti" financé par le Catholic Relief Service et ses partenaires à Haïti, a été mené par le Cocoa Research Centre de l'Université des West Indies (CRC) en 2015/2016. Une enquête stratifiée a été réalisée dans 400 exploitations dans le département de la Grand' Anse, par une équipe locale. Une équipe du Cocoa Research Centre avait fourni une formation locale portant sur la stratégie et la collecte de données pour établir des fiches d'identité, des données de géolocalisation GPS et les protocoles d'échantillonnage de feuilles. Les observations et mesures portant sur les caractéristiques ont été réalisées sur les arbres, les fleurs, les fruits et les graines; des feuilles ont été récoltées sur chaque arbre choisi pour une caractérisation moléculaire. Un profil moléculaire de chaque échantillon de feuille a été obtenu en utilisant un set de 182 marqueurs SNP au laboratoire du CRC/UWI à St Augustine, Trinidad. Les analyses des profils SNP et des données d'observations morphologiques ont été réalisées au CRC. La diversité du cacaoyer échantillonné dans les fermes de la région d'étude est présentée en mettant l'accent sur leur origine, la diversité génétique, la conservation du germplasma et son utilisation dans le but de croisements.

[78] R.A. Susanti, P. Hadley, A. Daymond, P. Bastide, S. Lambert, K. Ingram, J.C. Motamayor. (2017). The Effect of Pruning on Photosynthetic Rate of Cacao Trees in a Novel Cropping System. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24608

Note: #24608e > #24507e

Abstract: An intensive growing system for cacao requires regular pruning to maintain canopy architecture. Frequent pruning has been recommended on cacao plantations to increase productivity but little research has been carried out to quantify the effect of such pruning on the physiological determinants of yield in cacao and photosynthesis in particular. In this study, the impact of pruning on photosynthesis was measured over three years, in trees of cacao clone (M01) maintained with one to four branches and either in trellis or conventional growing system. The impact of pruning and leaf age on photosynthetic rate was also investigated over one year where trees of two cacao clones (M01 and 45) were maintained in trellis system growing in an East-West orientation and a planting density of 2000 trees ha⁻¹.

Pruning increased light-saturated photosynthetic rate by 13.1-35.7%. In addition, mid-aged leaves had a higher photosynthetic rate compared with young and old leaves. No differences in photosynthetic rate were observed between the two clones.

Pruning increases canopy light transmission and light availability for interior leaves, therefore, increasing leaf photosynthetic rate. Photosynthetic rate may also be increased through an increase in the demand for carbohydrate by the pruned tree. By removing photosynthetically less efficient older leaves, pruning also improves the overall photosynthetic efficiency of the canopy and stimulates the tree to produce new growth.

[79] F. Ribeyre, O. Sounigo, X. Argout, C. Cilas, B. Efombagn, M. Denis, J.M. Bouvet, O. O. Fouet, C. Lanaud. (2017). The Genomic Selection of *Theobroma cacao*: a new strategy of marker assisted selection to improve breeding efficiency and predict useful traits in new populations. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24609

Note: #24609e > #24507e

Abstract: Genomic selection (GS) is a statistical approach that utilizes all available genome-wide markers simultaneously and phenotypic traits of a “training population” to estimate breeding values or total genetic values. For breeding programs, GS is a promising alternative to the traditional marker-assisted selection for manipulating complex polygenic traits often controlled by many small effect genes. A major interest of this method is also to be able to make predictions of trait values, from a training population, on trees only genotyped by molecular markers

The use of the appropriate statistical model remains one of the critical issues of the GS. The relative performance of biometrical models is expected to depend on the genetic background of the traits under assessment.

The objective of this study was to estimate the reliability of different models of genomic selection to predict two agronomic traits of cacao - yield and resistance to *Phytophthora* pod rot.

The study was performed on 287 trees present in a cacao farm plot in Cameroon, belonging to several full-sib progenies released to farmers as commercial varieties.

Each tree was genotyped, using more than 5,000 GBS (genotyping by sequencing) based on SNP markers, and assessed for the mean average of one bean, a trait contributing to cocoa yield, and the % of rotten, as a measure of resistance to

Phytophthora megakarya.

Two models were used: Best linear unbiased prediction model and Bayesian lasso model. Cross-validation was used to test their predictive ability. It is an assumption-free method using an estimation set for model training and an independent test set for prediction.

Predictive ability of models was good for both traits indicating that GS is a promising method to improve these cocoa traits. However, it was slightly higher for average weight of a bean ($R= 0.59$) than for % of rotten pods ($R= 0.42$).

[80] F. Doare, F. Ribeyre, C. Cilas. (2017). Le phénotypage du cacaoyer : comment estimer la granulométrie des fèves de cacao ? 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24610

Note: #24610e > #24507e (Note: Journal is in French)

Abstract: Le poids moyen des fèves de cacao est un caractère qui intéresse les industriels, mais ce caractère n'est généralement pas pris en compte dans les programmes de sélection. Des variétés ayant des fèves trop petites sont parfois éliminées des sélections; et, plus qu'un poids élevé des fèves, les industriels recherchent surtout une homogénéité de la granulométrie afin de faciliter le traitement des fèves, comme la torréfaction. Plusieurs travaux ont déjà indiqué que le poids (ou la taille) des fèves était un caractère très héritable chez l'espèce *Theobroma cacao* avec une héritabilité généralement supérieure à 0.5. Toutefois, les valeurs obtenues dans différents pays pour un même clone sont souvent très variables. Dans cette étude nous analysons l'effet de différents facteurs sur le poids des fèves. En dehors de l'effet clone, deux facteurs principaux ont un impact sur le poids des fèves: i) le nombre de fèves des cabosses : un bon remplissage des cabosses en fèves a tendance à limiter le poids des fèves alors que les cabosses mal remplies ont tendances à avoir des fèves plus lourdes, ii) la position des fèves dans la cabosse a une influence sur leur poids : les fèves issues des zones médiane et proche du pédoncule ont des fèves significativement plus lourdes que les fèves issues de la zone distale. Ces résultats nous conduisent à proposer des protocoles pour normaliser l'estimation des valeurs phénotypiques du matériel génétique. Afin d'obtenir une estimation fiable la granulométrie il est proposé: soit utiliser des fèves issus de pollinisations manuelles pour saturer les cabosses en fèves, soit utiliser systématiquement le nombre de fèves des cabosses en covariable. En normalisant cette mesure de la granulométrie, il sera plus facile de comparer les résultats issus de différents laboratoires. Les fèves de la zone distale des cabosses, ayant des tailles plus petites, devraient être traitées à part afin d'avoir des lots plus homogènes pour les traitements post-récoltes.

[81] C.J. Turnbull, A.J. Daymond, O. Gutierrez, P. Hadley, D. Livingstone, J.C. Motamayor, W. Phillips, P. Umaharan, D. Zhang. (2017). Adopting Reference Genotypes to Identify Off-types in Cacao Collections. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24611

Note: #24611e > #24507e

Abstract: It is important for researchers, curators and breeders to have confidence in data being generated by germplasm evaluation and breeding programmes, and one of the key concerns is the true identity of the plants being used. Mislabelling of cocoa accessions is a significant problem, with estimates as high as 30%. Naming errors will have a large, detrimental impact on conservation, breeding and research, since

mislabelled material is unlikely to exhibit the same genetic makeup or combination of traits as its true-to-type namesake. Farmers may also receive poorly performing material as a result of mislabelling. Data gathered from a mislabelled accession will result in misleading recommendations or conclusions, such as the genetic gain reported by breeding programmes.

Mislabelling events can also complicate the comparison of multiple data sets from different locations. It is particularly important to be able to link data to germplasm with confidence when combining the large trait evaluation and molecular analysis datasets necessary to identify and screen for key genes of interest.

The importance of correctly identifying material has been widely recognised for many years and several groups are currently generating genetic fingerprints using SNP markers. However, reliable identification of individuals will only be possible if a single genetic fingerprint is established as a reference for all others to be compared to and a core set of markers are consistently used. With this in mind, the Reference Genotype Working Group was formed in May 2016 with the aim of coordinating the verification of cacao germplasm.

This process has led to the development of an online tool to compare SNP profiles of individual trees and assign each a verification status; off-type, verified true-to-type or reference (original material if available). Although the tool can work with any number of SNP markers, the group have proposed a core set of widely-used markers to allow robust and consistent comparisons of profiles to be made across collections.

The verification status of accessions in a collection will be included in the International Cocoa Germplasm Database (ICGD) and made widely available to the cocoa community, with web pages created to highlight reference genotypes and compare other genetic fingerprints to these.

This paper describes the work of the Reference Genotype Working Group, initially focussing on the international collections and the International Cocoa Quarantine Centre (University of Reading), but with the intention to invite further collaboration from key partners and work towards the inclusion of other collections.

[82] B. Laliberte, M. Halewood. (2017). Cacao Genetic Resources: Policy Options for Enhanced Exchange and Benefit-Sharing. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24612

Note: #24612e > #24507e

Abstract: Conservation of cacao genetic resources and the facilitated access and sharing of derived benefits are key issues in ensuring that the genetic diversity contributes to the development of improved planting materials and addresses urgent priorities such as adaptation to climate change (particularly drought and high temperatures), pest and diseases and ensuring high quality and diversity of flavours in the cocoa production of tomorrow. The Global Strategy for the Conservation and Use of Cacao Genetic Resources, published by CacaoNet October 2012, provides a framework to ensure that cacao diversity provides direct benefits to the millions of small-scale farmers around the world.

There are only 2 international collections of cacao germplasm and they are maintained at CATIE in Costa Rica and at the Cocoa Research Centre (CRC) in Trinidad and Tobago with materials available in the public domain to all bona fide users under the Article 15 of the International Treaty on Plant Genetic Resources for Food and Agriculture (the ITPGRFA). The accessions are distributed using the Standard Material Transfer Agreement (SMTA) of the Treaty, which includes an Access and Benefit-Sharing (ABS) conditions. The International Cocoa Quarantine Centre at

Reading (ICQCR), UK ensures the safe movement of cacao germplasm between countries and regions. The rest of cacao genetic diversity is maintained in an estimated 35 national collections with over 24,000 accessions, in farmers' fields and in the wild, outside the scope of the multilateral system of access and benefit sharing created by the ITPGRFA and the application of Article 15 agreements like those signed by CATIE and CRC. As a result, access to those resources is subject to other national laws and policies, including those implementing the Nagoya Protocol for access and benefit sharing (which is a protocol to the Convention on Biological Diversity (CBD)). There is a lot of diversity in ex situ collections and in farmers' fields but their use in breeding is not optimised. And the lack of clear institutional legal and policy frameworks is an important constraint. The paper describes the current situation of exchange of cacao germplasm for conservation, research and crop improvement to enhance production and the key the constraints. It identifies incentives for partners to facilitate access to germplasm and the fair and equitable sharing of the benefits in a clear and transparent manner. It proposes approaches for stimulating the use of cacao genetic resources and ensure the involvement of decision-makers in formalizing agreements.

[83] G.M. Tahi, I.C. Trebissou, S.B. Guiraud, F. Ribeyre, P. Lachenaud, N.D. Pokou, K.F. N'guessan, P.N. Walet, R.A. Aka, K. Coulibaly, B.I. Kébé, M.E. Assi, B. Koné, E. Kassin, C. Cilas. (2017). Second Cycle De Selection Recurrente Du Cacaoyer (Theoboma Cacao L.) En Cote D'Ivoire: Parametres Genetique Chez les Deux Populations Constitutives Apres Treize Annees D'Observation: Second Cycle of Recurrent Selection of Cacao in Cote D'Ivoire: Genetic Parameters in Two Constituent Populations After 13 years of Observation. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24613

Note: #24613e > #24507e (Note: Journal is in French)

Abstract: L'amélioration génétique du cacaoyer en Côte d'Ivoire est basée sur un schéma de sélection récurrente et réciproque ayant comme critères de sélection, la production, le rapport production / vigueur, la résistance à *Phytophthora* et aux mirides, et la qualité technologique. Les deux populations de base sont constituées, d'une part de Forastero Haut-amazoniens (HA) et d'autre part de Forastero Bas-amazoniens (BA) et de Trinitario (T). Le programme est à son deuxième cycle de sélection. Le premier cycle a abouti à la sélection et à la diffusion de cinq croisements d'intérêt agronomique. Pour le second cycle, le choix des géniteurs a été réalisé par une sélection de type « individus/famille ». Les familles ont été sélectionnées sur leurs performances, mais aussi sur la base du comportement des géniteurs du premier cycle. Les individus, dans les familles retenues, ont été sélectionnés sur les mêmes critères que pour les familles, auxquels s'ajoutent deux autres, les dégâts cumulés de mirides et l'appréciation du sélectionneur. Dans chaque population, 40 géniteurs « améliorés » ont été choisis. Un factoriel incomplet 20 x 20 dans lequel, chaque géniteur a été croisé de manière déconnectée avec 4 autres, a ainsi été mis en place en 2000 à la Station de recherche de Divo, pour chaque population. Les arbres dans chaque essai ont été plantés suivant un dispositif en randomisation totale de parcelles mono arbre. Les caractères évalués sont la vigueur, le rendement potentiel annuel et le taux de cabosses pourries.

Après treize années de collecte de données, les résultats sur les paramètres génétiques (pourcentages d'additivité, aptitudes à la combinaison, corrélations, héritabilités et gains génétiques) sont présentés et discutés. Dans les deux populations, les pourcentages d'additivité dans la variance génétique sont

particulièrement élevés (78 à 90 %) pour le poids moyen d'une cabosse et relativement plus faibles (27 à 65 %) pour le rendement potentiel et le taux de cabosses pourries. Cela suggère des effets d'additivité importants pour la taille de la cabosse et des effets de dominance notables pour les deux derniers caractères. Un index de sélection combinant les quatre critères est construit pour améliorer l'efficacité de la sélection. Les listes des croisements et individus prometteurs au sein de chaque population sont fournies pour un taux de sélection de 1 %, dans la perspective de mettre en place des parcelles de validation des performances agronomiques de nouveaux hybrides et clones.

[84] R.G. Loor, F.M. Amores, S.A. Vasco, A.B. Eskes, J.G. Quiroz, C. Suárez, J.C. Motamayor, R.J. Schnell, J. Zambrano, D. Calderón, J.C. Jiménez, O. Tarqui, E. Rosenquist, C. Lanaud, O. Fouet, X. Argout, F. Valdez, P. Lachenaud, P. Costet, G.C. Quijano, M.M. Terán, I.C. Sotomayor, T. Casanova, C. Subia. (2017). Desarrollo de nichos específicos de cacao con alta productividad y calidad sensorial: experiencia ecuatoriana: Development of specific niches of cocoa with high productivity and sensory quality: Ecuadorian experience. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp -.

Reference ID: 24614

Note: #24614e > #24507e (Note: Journal is in Spanish)

Abstract: Uno de los pilares fundamentales en los que se basa hoy en día el desarrollo de la cacaocultura ecuatoriana, es el aprovechamiento de sus recursos genéticos disponibles. Con esta visión, desde el año 1995, se diseñaron nuevas estrategias de mejoramiento genético, con el objetivo de: a) obtener nuevos materiales genéticos con elevada producción y calidad organoléptica; y b) Potenciar el desarrollo de nuevos nichos de producción en áreas no tradicionales del cultivo. Para esto, un equipo multidisciplinario de trabajo ha venido combinando esfuerzos de investigación en las áreas de: mejoramiento convencional (cruzamientos), biología molecular, calidad organoléptica del grano (físico, químico y sensorial) y más recientemente también de tipo arqueológico, con el propósito de alcanzar los objetivos propuestos. El primer objetivo se empezó a cumplir desde el año 2009, con la liberación comercial de 4 clones altamente productivos: 2 para la Provincia de Manabí y 2 para la Provincia de Santa Elena, convirtiéndose esta última provincia a la época actual, en la región del país donde se evidencian los niveles más altos de producción de cacao fino por hectárea, en base al material genético liberado por INIAP. El resultado anterior, se consolidó en el año 2016, con la entrega para otra zona agroecológica de dos nuevos clones que inclusive superan en producción a nuestro referente territorial (el clon CCN-51). Al momento, se han obtenido nuevos resultados, con base en los cuales se planifica la entrega de dos nuevos clones de alta producción (2019) y que serán específicos para otra región cacaotera del Ecuador. El segundo objetivo también se está materializando con la identificación de zonas con potencial para la producción de nuevos cacaos especiales y de manera particular en la amazonia ecuatoriana, en donde se han realizado hasta el momento tres prospecciones en la región sur, con el propósito de aprovechar al máximo la diversidad natural presente en la zona. Este accionar ha permitido rescatar valiosos recursos genéticos que están siendo conservados en colecciones de campo, a partir de los cuales se están obteniendo resultados que permiten de manera preliminar avizorar en el mediano plazo, la entrega de nuevo material genético capaz de producir cacaos especiales con propiedades sensoriales diferentes al típico "Sabor Arriba" y en zonas no tradicionales del cultivo que reúnen condiciones agro-bioclimáticas y sociales con potencial para constituirse en nuevos y particulares nichos de

producción.

[85] A. Mata-Quirós, A. Arciniegas-Leal, W. Phillips-Mora, L.W. Meinhardt, D. Zhang. (2017). Understanding the Genetic Structure and Parentage of the Clonal Series of Cacao UF, CC, PMCT and ARF Preserved in the International Cacao Collection at CATIE (IC3). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24615

Note: #24615e > #24507e (Note: Abstract is in spanish but rest of journal is in english)

Abstract: La Colección Internacional de Cacao del CATIE fue creada en 1944 y conserva bajo el dominio público más de 1200 introducciones. Esta colección custodia 4 series de clones internacionales originadas en Costa Rica. Los clones UF fueron seleccionados por la United Fruit Co., principalmente a partir de materiales amelonados introducidos de Trinidad en 1913 y de tipo Nacional introducidos de Ecuador en 1928. Los clones CC (Centro de Cacao) fueron seleccionados por el Instituto Interamericano de Ciencias Agrícolas (IICA) entre 1957-1966. Son selecciones realizadas a partir de semillas de polinización abierta de clones UF o Matina y cruzamientos dirigidos que incluyen clones internacionales como EET-62, ICS-1, 6 y 39; Pound-12, SCA-6 y 12, etc. Los clones PMCT (Programa de Mejoramiento de Cultivos Tropicales) son selecciones del CATIE realizadas entre 1989 y 1992 a partir de árboles élitos de ensayos de campo y fincas de agricultores producto de cruzamientos entre clones internacionales. También incluyen genotipos acriollados colectados en Nicaragua, Belice y Costa Rica. Los clones ARF (Área de Recursos Fitogenéticos) fueron colectados por el CATIE en 1992 en Panamá, Belice, Honduras y Costa Rica. Además incluyen genotipos resistentes a mazorca negra seleccionados en ensayos interclonales del CATIE.

El estudio se realizó en el Sustainable Perennial Crops Laboratory (ARS-USDA) en Beltsville, MD. El objetivo fue analizar el parentesco y composición genética de 266 clones de cacao pertenecientes a las cuatro series mencionadas utilizando 48 marcadores SNP y 228 clones de referencia que representan la diversidad genética conocida de la especie. El grupo genético predominante en los clones fue Amelonado con una presencia que varió entre el 36,7% (Serie ARF) y el 55,6% (Serie CC). Los grupos Nacional y Criollo tienen una presencia del 22,8 y 21,3% en la Serie UF, pero fue menor al 13% en las demás series. El grupo Marañón aportó 17,4% a la serie ARF, mientras el grupo Contamana tuvo una importante presencia (8,2-10,6%) en las Series PMCT, ARF y CC debido al aporte de SCA-6 y SCA-12 en los cruzamientos. La presencia del 8,6% del grupo Iquitos en la serie ARF se deriva de la participación del clon IMC-67 en algunos de los cruces que le dieron origen a estos clones. Los grupos genéticos Guiana, Curaray y Purus tienen una escasa participación ($\leq 2\%$) en la composición de las series analizadas, excepto en el grupo ARF en donde el 7,8% de su composición proviene del grupo Purus.

[86] J.A. Chia-Wong, Márquez-Dávila.K.J., H. Cárdenas-Salazar, Hurtado-Gonzales. O.P., T. Huaman-Camacho, W. Cespedes-Del-Pozo, R.P. Saavedra-Arbildo, Y. Beraun-Cruz, M.S. Carranza-Cruz, B.A. Gutarra Castillo. (2017). Avances en el estudio de las bases genéticas y organolépticas del cacao fino o de aroma en el Perú: Advances in the study of the genetic and organoleptic bases of fine cocoa or aroma in Peru. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24616

Note: #24616e > #24507e (Note: Journal is in Spanish)

Abstract: Las variedades de cacao fino o de aroma en el Perú son utilizados para elaborar los mejores chocolates del mundo por sus exquisitas y poco comunes características organolépticas, Estas características permiten que el cacao peruano gane reconocimiento internacional y de ahí su gran valor económico. A pesar de esto, poco se sabe sobre los componentes genéticos y/o ambientales que contribuyen a la exclusividad de este valioso recurso económico. En el proyecto de investigación aplicada: “Estudio molecular de la diversidad genética de los cacaos aromáticos en el Perú con fines del fortalecimiento de su competitividad y aumento de la producción nacional de cacao de calidad”, financiado por Innóvate Perú del Ministerio de la Producción, se tiene como objetivos determinar la variabilidad genética y caracterización organoléptica de más de 100 tipos de cacao fino o de aroma que se cultivan a lo largo de las cinco principales regiones del Perú (Amazonas, Cusco, San Martín, Piura y Huánuco). Adicionalmente, la Universidad Nacional Agraria de la Selva en Tingo María y el Instituto de Investigaciones de la Amazonia Peruana en Tarapoto, hospedarán bancos de germoplasma y de propagación de esquejes para la difusión y estudios de estos valiosos recursos. Hasta inicios del 2017, ya se han recolectado más de 80 genotipos provenientes de las cinco regiones. Protocolos para análisis sensoriales que cumplan los más rigurosos estándares internacionales se han venido estableciendo. Por otro lado, técnicas de marcadores moleculares usando marcadores de DNA tipo SSR y SNPs, seguido por secuenciamiento de ADN, se vienen estableciendo. Estudios de asociación de fenotipo-genotipo formarán parte del conocimiento generado en este proyecto. Adicionalmente, estos conocimientos permitirán generar información genómica valiosa para salvaguardar nuestra biodiversidad nativa, otorgándole a los productores y sus asociaciones de herramientas para proteger sus recursos genéticos y a los potenciales mejoradores de cacao más luces en cuanto a la asociación genotipo-calidad. Se espera que a fin del proyecto, se cuente con los resultados de genotipificación de más de 100 genotipos de cacao fino o de aroma y mediante el resecuenciamiento se revelen SNPs particulares para cada grupo genético en cada región muestreada.

[87] D. Calderón, C. Subía, F. Fernández, R. Loor, O. Fouet, C. Lanaud. (2017). Identificación de árboles de cacao (*Theobroma cacao* L.) con potencial para el mejoramiento de los sistemas de producción en el sur de la Amazonía ecuatoriana: Identification of cacao trees (*Theobroma cacao* L.) with potential for the improvement of production systems in the south of the Ecuadorian Amazon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24617

Note: #24617e > #24507e (Note: Journal is in Spanish)

Abstract: La variabilidad existente dentro de las especies es la herramienta básica para los procesos de mejoramiento, la que se encuentra principalmente en sus respectivos centros de origen, como es el caso del cacao en la Amazonía ecuatoriana. Desde los años 60 – 70’s se han realizado varios estudios y prospecciones que han

permitido el establecimiento de bancos de germoplasma, los que actualmente se encuentran custodiados por el Departamento Nacional de Recursos Fitogenéticos del INIAP. Más recientemente, desde el año 2010 el Programa Nacional de Cacao, en coordinación con el CIRAD de Francia, en base a resultados científicos de interés para el Ecuador han realizado hasta el momento tres prospecciones al sur de la Amazonía. El material genético obtenido en la provincia de Zamora Chinchipe, se encuentra conservado y bajo evaluación en la Granja Experimental Domono (GED) de INIAP a 1100 msnm, para lo que fueron instalados un ensayo de clones (63) y un ensayo de híbridos (429). Al momento, los resultados en la GED evidencian materiales híbridos que superan significativamente los rendimientos registrados por los clones testigos (EET-103, CCN-51); los individuos híbridos identificados son: ZAMO3p19, ZAMO3p1, ZAMO5p9, los mismos que son considerados como promisorios para cabezas de clon adaptados a las condiciones de pie de cordillera y varios de ellos están usándose en el plan de mejoramiento por hibridación dirigida que actualmente lo desarrolla el Programa Nacional de Cacao en la Amazonía. Este accionar se ha complementado con la participación activa de comunidades Shuar y colegios agrícolas de la región, con quienes se ha extendido el rango de intervención hacia los cantones del Pangui – Zamora Chinchipe y Tiwintza – Morona Santiago, donde se realizaron talleres previos para la socialización y aprendizaje de la metodología de trabajo. Se han logrado coleccionar muestras foliares de 76 árboles para análisis genético que están siendo procesadas en los laboratorios de CIRAD, así también se obtuvieron varetas para clonación de todos los árboles y 97 mazorcas de 59 árboles para la obtención de híbridos. La multiplicación del material asegura la instalación de al menos un nuevo ensayo clonal y tres de descendencia híbrida que serán instalados próximamente en la región así como en las granjas experimentales, mientras que los resultados genéticos preliminares reflejan nueva e interesante variabilidad que ya está siendo usada en las estrategias de mejoramiento genético.

[88] B.D. Adewale, Sobowale, I. Olalekan, O.O. Adeigbe. (2017). Assessment of variability and stability of pod productivity in cocoa hybrids after a decade of pod production in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24618

Note: #24618e > #24507e

Abstract: Understanding the trend and stability of continuous productivity of the economic product of tree genotypes after years of establishment is key to their recommendation to farmers. Attention to this area in Cocoa is low in Nigeria. The present study was conducted in a hybrid trial plot established from beans whose pod productivity commenced in 2001. Pod yield of ten trees per plot of twenty genotypes laid out in randomized complete block design of five replications were monitored for four quarters in three consecutive years after a decade of continuous fruiting. A mixed model approach was employed for the data analysis; genotypes were random but quarters and years were fixed. The levels of the three factors differed significantly ($P < 0.001$) from the analysis of variance. The environment had the largest (87.01%) portion of the total variance. Only genotype by year and year by quarter interactions were significant ($P \leq 0.05$) in the experiment. Pod yield of the twenty cocoa genotypes ranged between 40 to 53 quarterly and between 161 to 213 annually; the corresponding least and highest occurred in T53/5 x N38 and T65/7 x T57/22 respectively. The first quarter (running from January to March) and 2012 mostly supported pod yields of the 20 genotypes. Regression coefficient (b_i) and Shukla stability variance (σ^2) differently and respectively identified T53/5 x T12/11 and

T12/11 x N38 as the most stable genotype in the experiment. Pod production varied in the different quarters and years, but the production potential of the 20 hybrids was all-round the year. Production trend of the genotypes for the three years of study was linear; suggesting that few years beyond a decade of cocoa establishment is still within the active productive years.

[89] A.K. Quaye, S. Konlan, A. Arthur, P. Pobee, J.A. Dogbatse. (2017). Media type and compost mixtures effect on growth and nutrient uptake of cocoa seedling at the nursery in Ghana. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24619

Note: #24619e > #24507e

Abstract: Efforts at improving cocoa (*Theobroma cacao* (L.) production in Ghana have been targeted at increasing yield with little attention to the production of quality seedlings and subsequent survival and field establishment. This experiment investigated the effectiveness of four media types, viz: Sawdust (SD), Cocopeat (CP), Rice husk biochar (RH) and Topsoil (TS) and four rates of compost; viz: 0g (Comp0), 200g (Comp1), 400g (Comp2) and 600g (Comp3) polybag⁻¹ on nutrient uptake and growth of cocoa seedlings. The treatments were arranged in a completely randomized design with four replicates. Foliar and residual nutrients were analyzed as well as growth and biomass production at 42 weeks after sowing. Results indicated that leaf area was significantly ($p < 0.05$) higher in RH (74.4 cm² to 133.2 cm²) than in TS (65.5 cm² to 98.1 cm²) across the compost rates. Seedlings foliar biomass was significantly ($p > 0.05$) higher in RH (6.4 g) than in SD. Plant nutrients uptake (NPK), was significantly ($p > 0.05$) higher in RH (10.0, 8.7 and 22.8 g plant⁻¹) than in SD (4.0, 3.3 and 8.5 g plant⁻¹). Seedlings raised in RH were significantly taller (38.5 cm) and bigger (6.6mm) than those raised in SD. Shoot and root biomass of seedlings in RH (9.3g and 3.5g) were higher than those in SD (4.2g and 2.3g). With respect to compost effects, foliar biomass and nutrient content increased with increasing rate of compost. Seedling height and girth as well as Shoot and root biomass all increased with increasing rates of compost. Residual N, Mg and Ca in the potting media were highest in CP (5.5 g Kg⁻¹, 12.8 Cmol(+) Kg⁻¹ and 28.5 Cmol(+) Kg⁻¹) and lowest in TS (2.3 g Kg⁻¹, 3.3 Cmol(+) Kg⁻¹ and 19.9 Cmol(+) Kg⁻¹ respectively). These residual nutrients increased significantly ($p < 0.05$) with increasing compost rate. The combined effect of RH with Comp3 significantly ($p > 0.05$) increased pH and available P of the potting media. Residual K was highest in CP with Comp3 (9.49 g Kg⁻¹) and lowest in TS with Comp0 (0.33 g Kg⁻¹). Rice husk biochar mixed with 400g and 600g of compost was the best potting media and produced robust seedlings with adequate foliar and residual nutrients which can support vigorous growth and survival in the field after planting out. Further evaluation of mixing TS, RH and compost at different ratios as a suitable potting media for raising cocoa seedling is recommended.

[90] R. Ramírez-Pisco, A.E. Ramírez-Montes, E.I. Leiva Rojas. (2017). Construcción del Modelo MNC (MUPV) V1 Para La Nutrición Del Cacao: Construction of the MNC Model (MUPC) V1 for the Nutrition of Cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24620

Note: #24620e > #24507e (Note: Journal is in Spanish)

Abstract: El empleo de los modelos para la producción agrícola, inició su desarrollo desde el mismo momento del descubrimiento de la agricultura, en donde el hombre con la observación del comportamiento del clima, logró descubrir el momento

oportuno de la siembra, a reconocer el crecimiento y desarrollo de las plantas y estar listo en el momento de la cosecha, generó estrategias para que los cultivos alcancen su producción año tras año. Sin embargo, aun después de transcurridos más de 7000 años se continúa en la búsqueda por descifrar el manejo de los cultivos y asegurar la nutrición, la producción de fibras, la generación de medicamentos y el confort de una población que cada día va en aumento. Para la construcción del modelo de nutrición en cacao, fue necesario el trabajo multidisciplinario a partir del año 2009, con el propósito de generar información de más de 40 variables de los componentes clima, suelo y planta. El modelo Manejo de la nutrición de cacao en Maceo, Urabá y Puerto Valdivia en su primera versión MUPV1 se concibió de carácter mixto, construido a partir de los conocimientos expertos, datos de investigación y análisis estadísticos, que permiten establecer los indicadores para alcanzar una producción potencial del cacao. El modelo contempla los limitantes que se deben superar para la producción del cacao, aun previo al establecimiento del cultivo. MNC-MUPV 1, toma en cuenta los principios de reposición y la ley del mínimo propuestos por Liebig desde 1840, junto con la ley de los rendimientos decrecientes de Mitscherlich, partiendo desde la interacción del medio edáfico, climático y vegetal. Se generó directamente en campo bajo sistemas productivos en las zonas de vida bh-T y bh-PM, que si bien son más complejos de analizar desde el punto de vista estadístico, se ajustan a las realidades de la producción de cacao en Colombia. El modelo MUPV1, brinda orientación a los productores de cacao, generando una mayor probabilidad de éxito para alcanzar la producción deseada.

[91] R.F. Schwan, A.E. Wheals. (2004). The Microbiology of Cocoa Fermentation and its Role in Chocolate Quality. *Critical Reviews in Food Science and Nutrition*. 44(4) pp 206 - 221.

Reference ID: 24621

Note: H 8.1.4 #24621e

Abstract: The first stage of chocolate production consists of a natural, seven-day microbial fermentation of the pectinaceous pulp surrounding beans of the tree *Theobroma cacao*. There is a microbial succession of a wide range of yeasts, lactic-acid, and acetic-acid bacteria during which high temperatures of up to 50°C and microbial products, such as ethanol, lactic acid, and acetic acid, kill the beans and cause production of flavor precursors. Over-fermentation leads to a rise in bacilli and filamentous fungi that can cause off-flavors. The physiological roles of the predominant micro-organisms are now reasonably well understood and the crucial importance of a well-ordered microbial succession in cocoa aroma has been established. It has been possible to use a synthetic microbial cocktail inoculum of just 5 species, including members of the 3 principal groups, to mimic the natural fermentation process and yield good quality chocolate. Reduction of the amount of pectin by physical or mechanical means can also lead to an improved fermentation in reduced time and the juice can be used as a high-value byproduct. To improve the quality of the processed beans, more research is needed on pectinase production by yeasts, better depulping, fermenter design, and the use of starter cultures.

[92] G.V. de Melo Pereira, E. Neto, V.T. Soccol, A.B.P. Medeiros, A.L. Woiciechowski, C.R. Soccol. (2015). Conducting starter culture-controlled fermentations of coffee beans during on-farm wet processing: Growth, metabolic analyses and sensorial effects. *Food Research International*. 75 pp 348 - 356.

Reference ID: 24622

Note: H 8.1.5 #24622e

Abstract: In this study, the potential use of *Pichia fermentans* YC5.2 as a starter culture to conduct controlled coffee bean fermentations during on-farm wet processing was investigated. Inoculated fermentations were conducted with or without the addition of 2% (w/v) sucrose, and the resultant microbial growth and metabolism, bean chemistry and beverage quality were compared with spontaneous (control) fermentation. In both inoculated treatments, *P. fermentans* prevailed over indigenous microbiota and a restricted microbial composition was observed at the end of fermentation process. The inoculation also increased the production of specific volatile aroma compounds (e.g., ethanol, acetaldehyde, ethyl acetate and isoamyl acetate) and decreased the production of lactic acid during the fermentation process. Sucrose supplementation did not significantly interfere with the growth and frequency of *P. fermentans* YC5.2 inoculum but maintained high levels of wild bacteria population and lactic acid production similar to the spontaneous process. In roasted beans, the content of sugars and organic acids were statistically ($p < 0.05$) similar for all the treatments. However, the inoculated fermentations were shown to influence the volatile fraction of roasted coffee beans by increasing the concentration of yeast derived metabolites compared to control. Sensory analysis of coffee beverages demonstrated that the use of the YC5.2 strain was favorable for the production of high-quality coffees with distinctive characteristics, e.g., intense perception of 'vanilla' taste and 'floral' aromas. In conclusion, the use of *P. fermentans* YC5.2 in coffee processing was shown to be a viable alternative to control the fermentation step and to ensure consistent quality of finished products.

[93] C.F. Silva, D.M. Vilela, C. de Souza Cordeiro, W.F. Duarte, D.R. Dias, R.F. Schwan. (2013). Evaluation of a potential starter culture for enhance quality of coffee fermentation. World Journal of Microbiology and Biotechnology. 29 pp 235 - 247.

Reference ID: 24623

Note: H 8.1.5 #24623e

Abstract: The coffee fermentation is characterized by the presence of different microorganisms belonging to the groups of bacteria, fungi and yeast. The objectives of this work were to select pectinolytic microorganisms isolated from coffee fermentations and evaluate their performance on coffee pulp culture medium. The yeasts and bacteria isolates were evaluated for their activity of polygalacturonase (PG), pectin lyase (PL) and pectin methylesterase (PME) and metabolites production. Among 127 yeasts isolates and 189 bacterial isolates, 15 were pre-selected based on their ability to produce PL and organic compounds. These isolates were strains identified as *Bacillus cereus*, *Bacillus megaterium*, *Bacillus subtilis*, *Candida parapsilosis*, *Pichia caribbica*, *Pichia guilliermondii* and *Saccharomyces cerevisiae*. When cultivated in Coffee peel and pulp media in single culture or two by two mixed inocula, different behavior concerning to PME, PL and PG were found. The two principal components PC1 and PC2 accounted for 45.27 and 32.02 % of the total variance. UFLA CN727 and UFLA CN731 strains were grouped in the positive part of PC1 being characterized by 1,2-propanediol, hexanoic acid, decanoic acid, nonanoic acid and ethyl acetate. The UFLA CN448 and UFLA CN724 strains were grouped in the negative part of PC1 and were mainly characterized by guaiacol, butyric acid and citronellol. *S. cerevisiae* UFLACN727, *P. guilliermondii* UFLACN731 and *C. parapsilosis* UFLACN448 isolates are promising candidates to be tested in future studies as coffee starter cultures.

[94] G.V. de Melo Pereira, V.T. Soccol, S.K. Brar, E. Neto, C.R. Soccol. (2017). Microbial ecology and starter culture technology in coffee processing. *Critical Reviews in Food Science and Nutrition*. 57(13) pp 2775 - 2788.

Reference ID: 24624

Note: H 8.1.5 #24624e

Abstract: Coffee has been for decades the most commercialized food product and most widely consumed beverage in the world, with over 600 billion cups served per year. Before coffee cherries can be traded and processed into a final industrial product, they have to undergo postharvest processing on farms, which have a direct impact on the cost and quality of a coffee. Three different methods can be used for transforming the coffee cherries into beans, known as wet, dry, and semi-dry methods. In all these processing methods, a spontaneous fermentation is carried out in order to eliminate any mucilage still stuck to the beans and helps improve beverage flavor by microbial metabolites. The microorganisms responsible for the fermentation (e.g., yeasts and lactic acid bacteria) can play a number of roles, such as degradation of mucilage (pectinolytic activity), inhibition of mycotoxin-producing fungi growth, and production of flavor-active components. The use of starter cultures (mainly yeast strains) has emerged in recent years as a promising alternative to control the fermentation process and to promote quality development of coffee product. However, scarce information is still available about the effects of controlled starter cultures in coffee fermentation performance and bean quality, making it impossible to use this technology in actual field conditions. A broader knowledge about the ecology, biochemistry, and molecular biology could facilitate the understanding and application of starter cultures for coffee fermentation process. This review provides a comprehensive coverage of these issues, while pointing out new directions for exploiting starter cultures in coffee processing

[95] L. Jr. Lima, M.H. Almeida, M.J.R. Nout, Zwietering M.H. (2011). *Theobroma cacao* L., "The Food of the Gods": Quality Determinants of Commercial Cocoa Beans, with Particular Reference to the Impact of Fermentation. *Critical Reviews in Food Science and Nutrition*. 51 pp 731 - 761.

Reference ID: 24625

Note: H 8.1.4 #24625e

Abstract: The quality of commercial cocoa beans, the principal raw material for chocolate production, relies on the combination of factors that include the type of planting material, the agricultural practices, and the post-harvest processing. Among these, the fermentation of the cocoa beans is still the most relevant since it is the process whereby the precursors of the cocoa flavor arise. The formation of these precursors depends on the activity of different microbial groups on the beans pulp. A comparison of fermentations in different countries showed that a well-defined microbial succession does not always take place and that the role of *Bacillus* spp. in this process remains unclear. Considering the overriding importance of the fermentation to achieve high quality commercial cocoa beans, we discuss the need of addressing the impact of the farming system, the ripeness state of the pods, and the role of microbial interactions on the fermentation in future research. In addition, the problem of high acidification cocoa beans, aspects dealing with the volatile fraction of the flavor, and the cocoa butter properties, all were identified as critical aspects that need further investigation. The standardization of the microbiological methods and the application of metagenomic approaches would magnify the knowledge in this domain.

[96] M. Kleinwächter, D. Selmar. (2010). Influence of drying on the content of sugars in wet processed green Arabica coffees. Food Chemistry. 119 pp 500 - 504.

Reference ID: 24626

Note: #24626e

Abstract: When wet processed coffee beans are dried, the resulting decrease in the water potential induces various metabolic responses. This study was aimed at elucidating the impact of these reactions on the composition of sugars, representing potential aroma precursors. Wet processed green coffees were dried under defined conditions, and the relevant sugars were analysed. Special emphasis was put on the influence of the drying regime, i.e. continuous dryings and such interrupted by pauses in order to mimic sun dryings.

The contents of fructose and glucose decreased significantly within the first day of drying. This diminution for the first time proves that the lower contents of glucose and fructose generally present in wet processed coffee beans in comparison to dry processed ones are – at least in part – due to metabolic processes and are not related to the leaching of sugars into the process water in the course of wet processing.

[97] S. Knopp, G. Bytof, D. Selmar. (2006). Influence of processing on the contents of sugars in green Arabica coffee beans. European Food Research and Technology. 223 pp 195 - 201.

Reference ID: 24627

Note: #24627e

Abstract: Quantitative analyses of low molecular sugars in green coffees (*Coffea arabica* L. var. Acaià) that were processed in parallel either by the traditional wet or the traditional dry method, revealed a close correlation between the kind of post-harvest treatment and the contents of fructose and glucose. While in washed coffee beans (wet processing) only low amounts of these both hexoses were present, those in unwashed coffees (dry processing) were significantly higher. Model-processing experiments in the laboratory confirmed these findings. Moreover, a comparison with the untreated controls revealed that the low levels of both sugars are the consequence of a decrease in the case of wet processing, whereas they remained unchanged or even increased in the case of dry processing. Further minor sugars are also affected by post-harvest treatment. The amounts of galactose, arabinose and mannose show a similar arrangement as those for glucose and fructose, although their overall concentration is about 100-fold lower. Sucrose, the major low molecular sugar in green coffee beans, is not significantly affected by coffee processing. The influence of an active seed metabolism on the observed alterations of the sugars concentrations is discussed.

[98] M. Crafac, M.B. Mikkelsen, S. Saerens, M. Knudsen, A. Blennow, S. Lowor, J. Takrama, J.H. Swiegers, G.B. Petersen, H. Heimdal, D.S. Nielsen. (2013). Influencing cocoa flavour using *Pichia kluyveri* and *Kluyveromyces marxianus* in a defined mixed starter culture for cocoa fermentation. international Journal of Food Microbiology. 167 pp 103 - 116.

Reference ID: 24628

Note: H 8.1.4 #24628e

Abstract: The potential impact of aromatic and pectinolytic yeasts on cocoa flavour was investigated using two defined mixed starter cultures encompassing strains of *Pichia kluyveri* and *Kluyveromyces marxianus* for inoculating cocoa beans in small scale tray fermentations. Samples for microbial and metabolite analysis were collected at 12–24 hour intervals during 120 h of fermentation. Yeast isolates were grouped by

(GTG)₅-based rep-PCR fingerprinting and identified by sequencing of the D1/D2 region of the 26S rRNA gene and the actin gene. Pulsed Field Gel Electrophoresis (PFGE) was conducted on isolates belonging to the species *P. kluyveri* and *K. marxianus* to verify strain level identity with the inoculated strains. Furthermore, Denaturing Gradient Gel Electrophoresis (DGGE) was performed to follow yeast and bacterial dynamics over time including the presence of the bacterial inoculum consisting of *Lactobacillus fermentum* and *Acetobacter pasteurianus*. Yeast cell counts peaked after 12 h of fermentation with the predominant species being identified as *Hanseniaspora opuntiae* and *Hanseniaspora thailandica*. *P. kluyveri* and *K. marxianus* were found to compose 9.3% and 13.5% of the yeast population, respectively, after 12 h of fermentation whilst PFGE showed that ~88% of all *P. kluyveri* isolates and 100% of all *K. marxianus* isolates were identical to the inoculated strains. Despite never being the dominant yeast species at any stage of fermentation, the un-conched chocolates produced from the two inoculated fermentations were judged by sensory analysis to differ in flavour profile compared to the spontaneously fermented control. This could indicate that yeasts have a greater impact on the sensory qualities of cocoa than previously assumed.

[99] G.V. de Melo Pereira, V.T. Soccol, A. Pandey, A.B.P. Medeiros, J.M.R.A. Lara, A.L. Gollo, C.R. Soccol. (2014). Isolation, selection and evaluation of yeasts for use in fermentation of coffee beans by the wet process. *International Journal of Food Microbiology*. 188 pp 60 - 66.

Reference ID: 24629

Note: H 8.1.5 #24629e

Abstract: During wet processing of coffee, the ripe cherries are pulped, then fermented and dried. This study reports an experimental approach for target identification and selection of indigenous coffee yeasts and their potential use as starter cultures during the fermentation step of wet processing. A total of 144 yeast isolates originating from spontaneously fermenting coffee beans were identified by molecular approaches and screened for their capacity to grow under coffee-associated stress conditions. According to ITS-rRNA gene sequencing, *Pichia fermentans* and *Pichia kluyveri* were the most frequent isolates, followed by *Candida glabrata*, *quercitrusa*, *Saccharomyces* sp., *Pichia guilliermondii*, *Pichia caribbica* and *Hanseniaspora opuntiae*. Nine stress-tolerant yeast strains were evaluated for their ability to produce aromatic compounds in a coffee pulp simulation medium and for their pectinolytic activity. *P. fermentans* YC5.2 produced the highest concentrations of flavor-active ester compounds (viz., ethyl acetate and isoamyl acetate), while *Saccharomyces* sp. YC9.15 was the best pectinase-producing strain. The potential impact of these selected yeast strains to promote flavor development in coffee beverages was investigated for inoculating coffee beans during wet fermentation trials at laboratory scale. Inoculation of a single culture of *P. fermentans* YC5.2 and co-culture of *P. fermentans* YC5.2 and *Saccharomyces* sp. YC9.15 enhanced significantly the formation of volatile aroma compounds during the fermentation process compared to un-inoculated control. The sensory analysis indicated that the flavor of coffee beverages was influenced by the starter cultures, being rated as having the higher sensory scores for fruity, buttery and fermented aroma. This demonstrates a complementary role of yeasts associated with coffee quality through the synthesis of yeast specific volatile constituents. The yeast strains *P. fermentans* YC5.2 and *Saccharomyces* sp. YC9.15 have a great potential for use as starter cultures in wet processing of coffee and may possibly help to control and standardize the fermentation process and produce coffee beverages with novel and

desirable flavor profiles.

[100] D. Selmar, G. Bytof, S.-E. Knopp. (2008). The Storage of Green Coffee (*Coffea arabica*): Decrease of Viability and Changes of Potential Aroma Precursors. *Annals of Botany*. 101 pp 31 - 38.

Reference ID: 24630

Note: #24630e

Abstract: † Background and Aims When green coffee is stored for a prolonged time the coffee quality decreases distinctively. Apart from well-known 'off-notes' that arise from undesired oxidations of lipids, a typical 'flattening' of the cup quality is detectable. In order to elucidate the biological causes for this phenomenon, differentially processed coffees (wet, dry, semi-dry processing), were stored under standard conditions for 2 years and analysed comprehensively.

† Methods Wet-processed coffee was stored either as parchment coffee, where the endocarp remained around the beans or as hulled beans. Viability of coffee seeds was estimated using the tetrazolium-test of seed viability. Changes in concentration of free amino acids and soluble carbohydrates were analysed by HPLC.

† Key Results Whereas all other coffees lost viability within the first 6 months of storage, coffee beans stored within the parchment remained viable for >1 year. Glucose and fructose decreased slightly in the course of storage and glutamine content declined significantly. However, the changes observed in sugar and amino acid content were not correlated with the viability of the coffee beans. Consequently, neither typical metabolic reactions occurring within living cells nor characteristic post-mortem reactions could be responsible for the observed changes. As a result of post-mortem reactions in re-imbibed seeds, a characteristic bluish-green colour developed, putatively due to the oxidation of chlorogenic acids and subsequent reactions with primary amino compounds. This coloration might be an appropriate marker to substantiate if coffee seeds had been stored for an expanded time and putative quality losses were not relevant so far.

† Conclusions It is suggested that loss of viability is relevant for the aroma flattening. As neither metabolic nor postmortem reactions were responsible for the observed changes, it is concluded that Maillard reactions that occur during storage might be the cause of the decrease in potential aroma precursors.

[101] S.R. Evangelista, M.G.C.P. Miguel, C.F. Silva, A.C.M. Pinheiro, R.F. Schwan. (2015). Microbiological diversity associated with the spontaneous wet method of coffee fermentation. *International Journal of Food Microbiology*. 210 pp 102 - 112.

Reference ID: 24631

Note: H 8.1.5 #24631e

Abstract: The evaluation of the microbiota present during coffee wet fermentation was done in two distinct regions of Minas Gerais, Brazil: one farm in the South of Minas Gerais (Lavras=L) and another farm in the savannah region (Monte Carmelo=MC). The yeast population ranged from 2.48 to 4.92 log CFU/g and from 2 to 4.81 log CFU/g, the mesophilic bacteria population ranged from 3.83 to 8.47 log CFU/g and from 5.37 to 7.36 log CFU/g, and the LAB population ranged from 2.57 to 5.66 log CFU/g and from 3.40 to 4.49 log CFU/g in the L and MC farms, respectively. *Meyerozyma caribbica* and *Hanseniaspora uvarum* were the dominant yeasts in coffeewet fermentation at L farm, and *Torulasporea delbrueckii* was the dominant yeast at MC farm. The species *Staphylococcus warneri* and *Erwinia persicina* were the predominant bacteria at L farm, and *Enterobacter asburiae* and *Leuconostoc mesenteroides* were the dominant species at MC farm. Lactic acid was the principal

acid detected, reaching 2.33 g/kg at L farm and 1.40 g/kg at MC farm by the end of the process. The volatiles composition was similar for roasted coffee from the two different regions and furans, acids, and alcohol were the main groups detected. Temporal Dominance Sensation (TDS) analyses showed that the coffee beverage from L farm was dominated by citrus and herbaceous sensory characteristics, while the coffee from MC farm was dominated by citrus, herbaceous, and nuts sensory characteristics. Evaluating the microbiota in these two regions was important in improving the knowledge of the microbial species present during coffee wet fermentation in Brazil.

[102] D.M. Vilela, G.V.M. Pereira, C.F. Silva, L.R. Batista, R.F. Schwan. (2010). Molecular ecology and polyphasic characterization of the microbiota associated with semi-dry processed coffee (*Coffea arabica* L.). Food Microbiology. 27 pp 1128 - 1135.

Reference ID: 24632

Note: #24632e

Abstract: This work was aimed at isolating and identifying the microbiota present during the semi-dry method of coffee processing using polyphasic methods and to evaluate microbial diversity with PCR-DGGE. Samples of *Coffea arabica* L. were collected during different processing stages in southern Minas Gerais, Brazil. The bacterial and fungal isolates were phenotypically characterised and grouped according to the ARDRA technique, in which the 16e23S and ITS1-5.8S regions of the rDNA were sequenced for species identification. The bacterial counts varied from 3.7 to 7 log CFU g⁻¹. The yeast counts ranged from 3.4 to 6.9 log CFU g⁻¹, and the filamentous fungal population varied from 2 to 3.7 log CFU g⁻¹. *Bacillus subtilis*, *Escherichia coli*, *Enterobacter agglomerans*, *Bacillus cereus* and *Klebsiella pneumoniae* were the predominant bacteria detected during the processing of the coffee, and *Pichia anomala*, *Torulaspora delbrueckii* and *Rhodotorula mucilaginosa* were the dominant yeasts. All of the yeast and bacterial species detected by PCR-DGGE were isolated using culture-dependent methods, with the exception of one uncultivable bacterial species. *Aspergillus* was the most common genus among the filamentous fungal isolates. The use of polyphasic methods allowed a better characterization of the microbiota that is naturally present in semi-dry processed coffee.

[103] C.F. Silva, L.R. Batista, L.M. Abreu, E.S. Dias, R.F. Schwan. (2008). Succession of bacterial and fungal communities during natural coffee (*Coffea arabica*) fermentation. Food Microbiology. 25 pp 951 - 957.

Reference ID: 24633

Note: #24633e

Abstract: Bacteria, yeasts and filamentous fungi were isolated during natural coffee processing. Bacteria were isolated in greater numbers at the beginning of the fermentation, when the moisture of the coffee beans was around 68%. Gram-positive bacteria represented 85.5 of all bacteria isolated, and *Bacillus* was the predominant genus (51%). Gram-negative species of the genera *Serratia*, *Enterobacter* and *Acinetobacter* were also found. Approximately 22% of 940 randomly chosen isolates of microorganisms were yeasts. *Debaryomyces* (27%), *Pichia* (18.9%) and *Candida* (8.0%) were the most commonly found genera, and these three genera tended to appear more often as the fruit was fermented and dried. *Aspergillus* was the most abundant genus besides *Penicillium*, *Fusarium* and *Cladosporium*, with 42.6% of the total fungi isolates. The genera and species identified included members known to have pectinase and cellulase activities. Of the 10 organic acids analyzed and

quantified in coffee beans, acetic and lactic acids may have been generated by microbial activity. Butyric acid was not detected in any sample.

[104] E. Djan, S.T. Lowor, J. Dogbatse, F. Owusu-Ansah, F.K. Padi. (2017). A possible role of potassium in mediating cacao seedling responses to soil water stress. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24634

Note: #24634e > #24507e

Abstract: Moisture stress is one of the key constraints to establishment of cocoa, particularly on degraded soils as in the case of replanting after removal of aged cocoa tree stocks. Potassium (K) availability has been found to be critical for survival to water stress in many crop species. In two separate experiments, 13 cacao seedling varieties were evaluated under four levels of applied potassium (0, 1, 2, or 3 g/plant of muriate of potash) to identify any differential physiological mechanisms in the responses of cocoa progenies to applied potassium that may lead to improvement in drought tolerance. In the first experiment, four varieties known in Ghana for their field tolerance to water stress were evaluated whereas in the second experiment, 10 varieties were used. Thirty days after K application, water was withheld from three-month old pot-grown seedlings for a period of 31 days. Measurements were taken on plant growth, dry matter partitioning and various physiological parameters. Water stress significantly impacted on all measured traits from 8 days after stress imposition leading to reduced leaf membrane stability and leaf chlorophyll fluorescence. Leaf polyphenol and proline contents however increased. Though liberal application of K under well-watered conditions tend to negatively impact plant function, K application was beneficial for growth and integrity of physiological functions following water stress. Under water stress, K-treated plants had increased root and shoot biomass, higher leaf water content, higher chlorophyll fluorescence and reduced electrolyte leakage from leaves leading to improved vigour. In the first experiment, there was little evidence for variety x K interaction for specific traits, but the expression of a particular physiological function appeared to have been influenced by the parentage of the varieties. Varieties having Scavina parentage showed reduced membrane stability relative to those with PA 7 parentage, but relative water contents were in the reverse order in these varieties under water stress. Leaf total polyphenol increased much more in the varieties with Scavina parentage than those with PA 7 parentage. The results suggest that different mechanisms may account for their putative drought tolerance. In the second experiment, significant interaction of variety and potassium for the studied traits suggests that not all varieties may benefit from the possible drought mitigation influences of applied potassium.

[105] A.J. Daymond, K. Acheampong, A. Prawoto, S. Abdoellah, G. Addo, P. Adu-Yeboah, A. Arthur, N.C. Cryer, Y.N. Dankwa, F. Lahive, S. Konlan, A. Susilo, C.J. Turnbull, P. Hadley. (2017). Mapping Cocoa Productivity in Ghana, Indonesia and Côte d'Ivoire. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24635

Note: #24635e > #24507e

Abstract: In order to obtain an understanding of farm practices and drivers of on-farm cocoa yields, a survey and a programme of regular crop monitoring was conducted across a range of farms in the top three cocoa-producing countries: Côte d'Ivoire, Ghana and Indonesia. For each country, groups of farms were sampled from key cocoa-growing regions or provinces and their physical characteristics were mapped

(120 farms in Indonesia, 96 in Ghana and 48 in Côte d'Ivoire). Farm practices were determined by a farmer interview and crop development on selected trees from each farm was observed every six weeks over a period of four years in Ghana, three years in Indonesia and one year in Côte d'Ivoire.

Farms in Ghana and Côte d'Ivoire were older and larger than those in Indonesia. In all three countries, planting density varied considerably (276 to 3626 trees ha⁻¹ in Ghana, 556 to 1848 trees ha⁻¹ in Côte d'Ivoire and 272 to 2598 trees ha⁻¹ in Indonesia) and often deviated from recommendations. Trees on all of the farms in Ghana and Côte d'Ivoire were seed derived, whilst a mixture of seed-derived and clonal material was cultivated in Indonesia. A larger proportion of farms (96%) were owner-operated in Indonesia compared with Côte d'Ivoire and Ghana (58% and 69%, respectively). Soil analyses in Ghana and Indonesia showed that nutrient levels were below threshold levels on many farms, illustrating the need for fertiliser applications to be matched to local conditions.

Considerable farm-to-farm variation in yield was recorded for each country. For example, in Ghana 30 and 10-fold differences in yield were observed between farms for the years 2012/13 and 2013/14, respectively. Geographical variation in yield was much greater in Indonesia, where cocoa cultivation is spread over a larger area than in Ghana and Côte d'Ivoire. Farm to farm variation within each country was partially explained by a number of common factors. These included planting density (many farms were planted below recommendations), whether or not the farmers fertilise their farms and whether or not they sprayed fungicides. In Ghana, insufficient soil phosphorus was another factor underlying yield variation between farms.

Overall, the results of this study demonstrated the potential for yield improvement on existing cocoa farms, without significant expansion of the area cultivated, through husbandry practices (such as gap-filling/ replanting of low density farms), targeted fertiliser application and carefully timed pest and disease control.

[106] E.E. Gutierrez, E.I. Leiva, R. Ramírez. (2017). La Poda y La Producción de Cacao (*Theobroma cacao* L.): Pruning and Production of Cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24636

Note: #24636e > #24507e (Note: journal is in spanish)

Abstract: Among the cultural practices for the management of the cultivation of cocoa stands out the pruning, work widely reported in the literature, but it is ambiguous when there are no criteria for its implementation and there are no indicators to evaluate its result. The relationship between pruning and the vegetative and reproductive behavior of cocoa was studied in 8-year-old trees in universal clones CCN 51 and ICS 95, located in the tropical humid forest life zone (bh-T). The treatments corresponded to reference (-h), adequacy (b), b-25%, b-50% and b-75% pruning of the canopy. In the reference treatment (-h) apical pruning was carried out leaving the trees at 4 m height, leaves were removed from the productive area until 1 m, the adaptation pruning was carried out from the reference management; from the adaptation pruning, three pruning intensities were performed corresponding to the elimination of 25%, 50% and 75% of the canopy. The pruning affected the leaf area index with significant differences between treatments in each clone, the reproductive variables presented significant differences in fruits of 2 to 4 months and the weight of fermented and dry grain presented significant differences between the clones and treatments, the weight of fermented and dry cocoa bean is significantly reduced by increasing pruning intensity. It is as well as, the treatment reference that counts on the greater foliar area that is related to increases in the retention of flowers, cucumbers, fruits of 2 to 4 months and

tendency to the increase of harvestable fruits, with low index of ear and greater index of grain.

[107] P.E. Aikpokpodion. (2017). Agronomic Implication of the Competitive Adsorption Between NH_4^+ and K^+ in a Selected Cocoa Growing Soil in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24637

Note: #24637e > #24507e

Abstract: Nutrient deficiency is a major factor contributing to the downward trend in cocoa production in Nigeria. The most available and commonly used fertilizer in Nigeria comes as compound fertilizer (N:P:K; 15:15:15). When NH_4 is used as N source in compound fertilizer, there is the possibility of chemical interactions between K^+ and NH_4^+ in soil solution due to similarities in their chemical properties. In order to appraise the impact of chemical interactions between K^+ and NH_4^+ on potassium bioavailability, subsamples were equilibrated in solution containing only potassium ions and other subsamples equilibrated in solution containing ammonium and potassium ions. Potassium adsorption was significantly higher in soil treated with K solution than soil treated with K- NH_4 solution. The study showed that, application of N: P: K fertilizer that has NH_4 as its N source could result in the reduction of potassium storage capacity of the soil for plant use

[108] A. Marín, E.I. Leiva, R. Ramirez. (2017). La Sostenibilidad del Cultivo de Cacao (*Theobroma cacao* L.) y la Respiración del Suelo en Colombia: The Sustainability of Cocoa Cultivation (*Theobroma cacao* L.) and Soil Breathing in Colombia. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24638

Note: #24638e > #24507e (Note: journal is in spanish)

Abstract: Entre los parámetros empleados para estimar la sostenibilidad de un sistema agrícola productivo, se propone la dinámica de la materia orgánica, tomando como indicador el balance entre la respiración del suelo y la materia orgánica aportada. La producción de CO_2 en el suelo es un indicador de la actividad biótica y es considerado para evaluar su salud y calidad. Con la cuantificación del CO_2 que respira el suelo es posible estimar la materia orgánica que se descompone y que debe ser restituida para asegurar la sostenibilidad del sistema. Se cuantificó la respiración del suelo en cultivos de cacao localizados en las zonas de vida bosque húmedo tropical (bh-T) en planicies aluviales del Urabá Antioqueño y en bosque húmedo premontano (bh-PM) en relieve colinado del Magdalena Medio en Colombia. Los tratamientos correspondieron a parcelas fertilizadas y sin fertilizar cultivadas con los clones CCN-51, ICS-95, FSV-41, FCH-8 y LUKER-40 con seis años, bajo manejo tradicional campesino, en donde la hojarasca permanece cubriendo el suelo todo el año. La fertilización estuvo compuesta por una mezcla órgano-mineral que se aplicó cada tres meses, ajustada a los requerimientos nutricionales del cultivo. La respiración del suelo fue mayor en el bosque húmedo Tropical (bh-T), con valores que oscilaron entre 15,07 y 80,21 $\text{Kg CO}_2 \text{ ha}^{-1}$. En el bosque húmedo premontano (bh-PM) osciló entre 21,10 y 61,10 $\text{Kg CO}_2 \text{ ha}^{-1}$. Así, es necesaria la aplicación de materia orgánica para asegurar la sostenibilidad del sistema productivo.

[109] E.I. Leiva- Rojas, R. Ramírez- Pisco. (2017). Acumulación y Extracción de Nutrientes en el Cultivo del Cacao (*Theobroma cacao* L.). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24639

Note: #24639e > #24507e (Note: journal is in spanish)

Abstract: La producción potencial del cultivo de cacao es regulada por la disponibilidad de minerales en el suelo además, es afectada por factores climáticos y edáficos, para estos últimos se cuenta con protocolos de diagnóstico tanto de sus propiedades físicas como químicas, que aportan parte de la información necesaria para recomendar la aplicación de los nutrientes demandados, aunado a los requerimientos nutricionales del cultivo. Los nutrimentos necesarios para la producción incluyen la cantidad de minerales extraídos en su crecimiento vegetativo y los exportados en la cosecha. Comúnmente la aplicación de nutrientes puede ser deficitaria o excesiva respecto a la cantidad que es removida por el cultivo, para la suplementación racional y sostenible de minerales o fertilizantes y enmiendas es indispensable conocer la cantidad de nutrientes acumulados y los retirados en los granos de cacao. Se colectaron árboles completos, incluida la raíz, para cuantificar su biomasa y con los análisis químicos de cada parte del material se calculó la acumulación de nutrientes. El muestreo se realizó en plantaciones de 4, 10, 15, 20 y 30 años, en las zonas de vida bosque húmedo tropical (bh-T), bosque seco tropical (bs-T) y bosque húmedo premontano (bh-PM). En el sitio de cada árbol se tomaron muestras de suelo para su correspondiente análisis químico. Se concluyó que el modelo de crecimiento es distinto según la zona de vida, con mayor acumulación de fitomasa en bh-T y la más baja en bs-T. La concentración de nutrientes en las hojas es mayor que en las demás partes del árbol, con valores de N: 1,4 a 2.2%, K: 1.2 a 2.2%, Ca: 0,8 a 2%, Mg: 0,33 a 0,9%, P: 0,13 a 0,20% y S: 0,07 a 0,27 %. El orden de extracción es $N \geq K \geq Ca > Mg > P > S$, y cambia dependiendo de la edad del cultivo. El grano extrae el K en mayor cantidad. La secuencia de acumulación de nutrientes en las hojas es: $N = Ca > K > Mg > P > S$, en el fuste es $K > Ca \geq N > Mg > P > S$. Sin embargo, el contenido de minerales en el suelo no siempre tiene relación directa con los nutrientes acumulados en el árbol.

[110] C. Hernández, E.I. Leiva, R. Ramírez. (2017). Dinamica Estomatica en Cacao (*Theobroma cacao* L.): Stomatic Dynamics in Cocoa (*Theobroma cacao* L.). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24640

Note: #24640e > #24507e (Note: journal is in spanish)

Abstract: La actividad estomática está relacionada con la fotosíntesis, la transpiración y la conductancia, procesos que a su vez están regulados por la cantidad de agua y aire disponible en el suelo, la temperatura ambiente y la radiación. Los estomas desempeñan un papel vital en el mantenimiento de la homeostasis de la planta y son los responsables del intercambio gaseoso. El propósito de esta investigación fue caracterizar la dinámica estomática y relacionarla con los cambios en luminosidad y estado hídrico del suelo. El estudio se realizó en el departamento de Antioquia, municipio de Maceo en la zona de vida bosque húmedo premontano (bh-PM) y Chigorodó en la zona de vida bosque húmedo tropical (bh-T), en clones de cacao CCN 51, ICS 95 y FSV 41, las variables climáticas contempladas correspondieron a temperatura, radiación y precipitación, se registró la humedad volumétrica del suelo y en las hojas se cuantificó el intercambio gaseoso durante todo el día, se tomaron improntas de los estomas cada dos horas. Se evidenció que el cacao es hipoestomático, con 229-262 estomas por mm² y que durante las 24 horas

del día el mayor número de estomas abiertos se observó entre las 10 am y las 2 pm y se incrementa cuando hay mayor contenido de humedad en el suelo. Algunos clones responden al incremento de PAR, presentando las mayores tasas de asimilación de CO₂ a las 12 m, cuando los valores de radiación oscilan alrededor de los 1600 $\mu\text{mfotones.m}^{-2}.\text{s}^{-1}$. Después de las 2 pm aumentó el cierre estomático y se relacionó con el descenso de los valores de asimilación en las horas de la tarde.

[111] C.R. Donough, M. Ng, C. Lai. (1993). Pamol's Approach to Quality Control in Controlled Pollination for DxP Seed Production. *The Planter*. 69(805) pp 163 - 175.

Reference ID: 24641

Note: S serial #24641e (NOTE: available in hardcopy The Planter 1993 Vol 1 in serial shelf bound copy) Paper presented in ISP Semnar on 'Advances in Cocoa & Oil Palm in Meeting Future Challenges' 16-17 June 1992, Lahad Datu, Sabah.

Abstract: DxP seed production involves two basic operations:-

- (a) Collection of pollen from selected pisifera palms, and
- (b) Using the pisifera pollen to pollinate female inflorescences of selected dura palms, thus resulting in the desire DxP cross.

Strict quality control is absolutely necessary at all stages of the operation in order to ensure purity of the DxP crosses, failing which contamination will occur. This contamination is apparent from the level of dura palms within the DxP population. Oil yield is lowered as a result of these duras and, depending on the severity of contamination, losses can be substantial. Contamination can also result in illegitimate tenera palms which cannot be distinguished from legitimate teneras of DxP crosses by fruit, but their yield potential is lower, Pamol's quality control procedures for controlled pollination work are described. Fruit type surveys in 1987 and early 1988 plantings of Pamol DxP show that these procedures have resulted in virtually pure DxP hybrids.

[112] IOPRI. (2018). The 6th Quadrennial IOPC International Oil Palm Conference 2018, 17-19 July 2018, Medan, Indonesia. The 6th Quadrennial IOPC International Oil Palm Conference 2018. Medan, Indonesia. pp 1 - 66.

Reference ID: 24642

Note: #24642e (note: Proceedings contain abstracts only)

[113] H. Sugianto, S. Primananda, E. Yuliadi, P.G. Gan, P.V.V. Ho, Y.L. Lim, C. Donough, T. Oberthür. (2018). Variation within Typical Management Blocks in an Oil Palm Plantation & Implications for Precise Crop Management. The 6th Quadrennial IOPC International Oil Palm Conference 2018, 17-19 July 2018, Medan, Indonesia. pp 1 - 4.

Reference ID: 24643

Note: #24643e > S 8.1.1 #24642e (note- Poster and manuscript available)

Abstract: In commercial oil palm plantations in Indonesia, the smallest unit of management is a 'block' which is typically 25-40ha in size. Such a block is typically 1km long and 250-400m wide, and is managed uniformly i.e. crop management practices (including fertilizer application) are implemented evenly within each block. Research on use of remote sensing for site-specific management in oil palm has shown that there is variation within each block. But actual measurements in existing commercial blocks are rare. Results are reported here from actual field measurements in 10 typical commercial oil palm blocks in Central Kalimantan. There is considerable variation in soil properties and plant tissue nutrient concentrations within the blocks. Yield and growth also showed similar variations within blocks. Variation in growth

measured on individual palm basis showed variation across both the length and width of the blocks. Analysis showed that current sample size used for determination of plant tissue nutrient concentrations is also adequate for establishment of block average values for palm growth parameters. Such knowledge of within-block variations is essential for better management of performance in oil palm plantations. In recent years, there is a trend to amalgamate blocks into larger management units as big as 100-125ha each. Given the within-block variations reported here, this would be counter-active towards precise crop management, and will likely counter-act efforts to improve performance.

[114] S.M. Abd Malik, C. Donough. (2018). Growth and Nutrient Use Efficiency in Commercial-Scale Oil Palm Pre-Nursery Stage. The 6th Quadrennial IOPC International Oil Palm Conference 2018, 17-19 July 2018, Medan, Indonesia. Indonesia. pp 1 - 5.

Reference ID: 24644

Note: #24644e > S 8.1.1 #24642e (note- Poster and manuscript available)

Abstract: The oil palm is a very precocious crop, which can come into maturity as early as 25 months from field planting, with peak yield at four years thereafter. The planting of uniformly good and healthy seedlings is one prerequisite for this. Oil palm seedlings are typically grown for one year in a nursery before field planting, commonly in two-stage nurseries comprising a pre-nursery (PN) stage followed by a main nursery (MN) stage. Standard fertilizer programs are commonly used in oil palm nurseries. Plastic pot trays (PPT) are increasingly being used in oil palm PN stage in place of conventional polybags (CPB), due to savings in soil, space and labour. Proper nutrition is essential for the PPT system. We investigated effects of three different fertilizer rates on PN oil palm seedlings grown using PPT and CPB. Results indicate that fertilizer application rates can be lower than current practice. CPB seedlings were generally slightly larger. Both protocols suffered high nutrient loss, indicating a need for improved irrigation. Nutrient performance indicators need more detailed study

[115] Y.L. Lim, R. Wandri, J. Gerendas, H. Sugianto, C. Donough, T. Oberthür. (2018). An Update on Oil Palm Nutrient Budgets. The 6th Quadrennial IOPC International Oil Palm Conference 2018, 17-19 July 2018, Medan, Indonesia. pp 1 - 5.

Reference ID: 24645

Note: #24645e > S 8.1.1 #24642e (note- Poster and manuscript available)

Abstract: Information on nutrient contents in tenera oil palm above-ground biomass components is essential for estimating oil palm nutrient demand and corresponding fertilizer requirements in commercial oil palm operations. Available information is from just a few publications, with differences in research methods and small sample sizes, and conditions in the field experiments do not fully represent the range of actual conditions in areas of commercial cultivation. IPNI Southeast Asia conducted a 4-year fertilizer trial in Kalimantan, Indonesia, using whole commercial blocks (Donough et al., 2014) which has generated a large dataset on nutrient contents of tenera oil palm fresh fruit bunches, and annual fronds and trunk growth. Results derived from this dataset are compared to available information and updates the current knowledge base on oil palm nutrient budget for mature tenera planting material.

[116] V. C. Adaigbe, J. A. Odebiyi, A. A. Omoloye, C. I. Aisagbonhi, Iyare O. (2011). Host location and ovipositional preference of *Elaeidobius kamerunicus* on four host palm species. *Journal of Horticulture and Forestry*. 3(5) pp 163 - 166.

Reference ID: 24646

Note: #24646e

Abstract: The response of the oil palm pollinating weevil *Elaeidobius kamerunicus* Faust (Coleoptera: Cucurlionidae) to the inflorescence of different palm species was tested in a choice, non-choice and a four arm- olfactometer bioassay. Weevils preferred significantly the inflorescence of oil palm (*E. guineensis* Jacq) for oviposition. In both choice and non-choice tests using mated adult females, significantly more eggs were laid on oil palm than coconut, livingstonia and royal palms. *E. kamerunicus* is able to locate its host plant by olfactory stimuli. These experiments support the hypothesis that pollen-seeking insects use pollen odour cues to locate its oviposition site.

[117] IOPRI, MPOB, ISOPA. (2018). Standard Operational Procedure for Ganoderma Disease Management in Endemic Area. Secondary Standard Operational Procedure for Ganoderma Disease Management in Endemic Area. IOPC. Medan. pp 1 - 20.

Reference ID: 24647

Note: S 8.1.1.4 #24647

Abstract: Ganoderma disease is one of the most common diseases found in oil palm plantation in Southeast Asia. This soil-borne disease is also the most difficult to control, particularly in endemic area where the source of inoculum is abundant.

[118] S.K. Ng. (2012). Agromac's Clonal Oil Palms. Secondary Agromac's Clonal Oil Palms. Agromac Sdn Bhd. Malaysia. pp 1 - 66.

Reference ID: 24648

Note: S 8.1.1 #24648

Abstract: The firm prospects of enhancing oil yields of the oil palm (*Elaeis Guineensis* Jacq.) by 30% or more via propagating vegetatively top elite individuals within a progeny led to the establishment of many commercial tissue culture laboratories in the eighties in Malaysia and Indonesia.

[119] KLKB. (2014). KLK Mini-Conference for Managers and Assistants, 24-26 February 2014, Venue-AARSB. KLK Mini-Conference for Managers and Assistants, 24-26 February 2014, Venue-AARSB. Kota Damansara, Selangor.

Reference ID: 24649

Note: S 8.1.1 #24649

[120] ISP. (2018). The Planter Vol 94 No 1104 March 2018. pp 139 - 196.

Reference ID: 24650

Note: S serial #24650

[121] C.L. Chong. (2018). Malaysian Oil Palm Industry - Environmental Concerns and Present Scenario: Part 1: Environment Crossroad. *The Planter*. 94(1104) pp 147 - 160.

Reference ID: 24651

Note: #24651e > S serial #24650

Abstract: From an environment point of view, the global oil palm industry is at a crossroad. Organisations in the industry are finding it increasingly difficult to meet the new criteria introduced by the Roundtable on Sustainable Palm Oil (RSPO), in addition

to the high cost of implementation of RSPO and certification and the low premium of certified oil. Malaysia and Indonesia have established and implemented, or in the process of establishing their own domestic version of sustainable palm oil, i.e. Malaysian Sustainable Palm Oil (MSPO) and Indonesian Sustainable Palm Oil (ISPO). This is in line with their own national objective of controlling the destiny of their national oil palm industry rather than being subjected to external control which may clash with their national social responsibilities. Part 1 of this two part article outlines the majority of organisations implementing environment sustainability schemes that may impact the oil palm industry. The impacts are dictated by the concerns of overseas consumers and buyers of palm oil products, which in turn, are dependent on their national requirements and the influence of regional non-government organisations (NGOs). The impacts of MSPO and ISPO are explored in slightly greater depths as these are implemented on a national scale by their respective national organisations on their indigenous oil palm industry. The impasse faced by RSPO is also highlighted.

[122] C.L. Chong. (2018). Malaysian Oil Palm Industry - Environmental Concerns and Present Scenario: Part 2: An Alternative Future Environmental Direction. *The Planter*. 94(1104) pp 165 - 171.

Reference ID: 24652

Note: #24652e > S serial #24650

Abstract: In part 1, the presently available environmental schemes applicable to the oil palm industry have been outlined. At present environmentally speaking, the Malaysian oil palm industry is attempting to secure recognition for the Malaysian Sustainable Palm Oil (MSPO) Certification Scheme which is based on a Malaysian standard drawn up by the industry. This move was spearheaded with the support from industry organisations and members facilitated by MPOB. The MSPO scheme will be mandatory for the Malaysian oil palm industry in the near future and is parallel to the Indonesian Sustainable Palm Oil scheme (ISPO). This paper advocates the establishment of a national scheme for environmentally friendly oil palm products based on the ISO 14000 family of standards. With this proposed claim, Malaysian palm oil and oil palm products can then be marketed or branded as environmentally friendly products. As the ISO 14000 family of standards fully supports the environmental sustainability aspect, products accepted as being environmentally friendly can be deemed to be produced sustainably. Since the scheme is based on the ISO 14000 family of standards and independently certified as such by independent third party assessors, this scheme will have a good chance of being accepted by overseas consumers and buyers of Malaysian palm oil and oil palm products.

[123] M.R. Chandran. (2018). Certified Sustainable Palm Oil: Multiple Standards. *The Planter*. 94(1104) pp 175 - 179.

Reference ID: 24653

Note: #24653e > S serial #24650

Abstract: The emergence and presence of numerous sustainability benchmarks and standards for palm oil intensify the need for the sector to transform itself so that sustainable practices become institutionalised over time.

[124] Z. Xu, Z. Guan, T.S. Jayne, R. Black. (2018). Factors influencing the profitability of fertilizer use on maize in Zambia. *Agricultural Economics*. 40(2009) pp 437 - 446.

Reference ID: 24654

Note: #24654e

Abstract: Fertilizer use remains very low in most of Africa despite widespread

agreement that much higher use rates are required for sustained agricultural productivity growth. This study uses longitudinal farm survey data to estimate maize yield response functions in a relatively high-potential zone of Zambia to determine the profitability of fertilizer use under a range of small-farm conditions found within this zone. The theoretical framework used in this study incorporates agronomic principles of the crop growth process. We generalize the asymmetric production models and define a concept of yield scaling factors. The model distinguishes different roles of inputs and non-input factors in crop production. We estimate the effects of conventional production inputs as well as of household characteristics and government programs on maize yield. The results indicate that recommended fertilizer application rates in the two specific years were often unprofitable, given observed price conditions and the yield response to fertilizer. However, there was substantial variability in yield response to fertilizer based upon the rate of application, the timeliness of fertilizer availability, the use of animal draught power during land preparation, and whether the household incurred the death of an adult member in the past three years. These modifying factors, as well as variations in input and output prices due to proximity to roads and markets, substantially affected the profitability of fertilizer use on maize.

[125] Z. Xu, Z. Guan, T.S. Jayne, R. Black. (2009). Food Security Research Project No 39: Factors Influencing the Profitability of Fertilizer Use on Maize in Zambia. Secondary Food Security Research Project No 39: Factors Influencing the Profitability of Fertilizer Use on Maize in Zambia. Michigan State University (MSU). Lusaka, Zambia. pp 1 - 26.

Reference ID: 24655

Note: #24655e

Abstract: Fertilizer use remains very low in most of Africa despite widespread agreement that much higher use rates are required for sustained agricultural productivity growth. This study estimates maize yield response functions in agro-ecological Zone IIA, a relatively highpotential zone of Zambia, to determine the profitability of fertilizer use under a range of small farm conditions found within this zone.

The theoretical framework used in this study incorporates agronomic principles of the crop growth process. The model distinguishes different roles of inputs and non-input factors in crop production. We estimate the effects of conventional production inputs as well as household characteristics and government programs on maize yield for households in the dominant acrisols soil type.

Results indicate that even within this particular soil type within Zone IIA, the maize-fertilizer response rate in the two specific years varied widely across households. The main factors explaining the variability in maize-fertilizer response rates were the rate of application, the timeliness of fertilizer availability, the use of animal draught power during land preparation, and whether the household incurred the death of an adult member in the past three years. These modifying factors, as well as variations in input and output prices due to proximity to roads and markets, substantially affected the profitability of fertilizer use on maize. Fertilizer use on maize tended to be unprofitable at full commercial fertilizer prices for farmers who received fertilizer late and who were located in relatively remote areas.

[126] J. Ma, Y. Liu, W. He, P. He, P.M. Haygarth, B.W.J. SurrIDGE, Q. Lei, W. Zhou. (2018). The long-term soil phosphorus balance across Chinese arable land. *Soil Use and Management*. 34(3) pp 306 - 315.

Reference ID: 24656

Note: #24656e

Abstract: Quantifying temporal and spatial variation of soil phosphorous (P) inputs, output and balance across Chinese arable land is needed for better P management strategies. Here we address this challenge by using a soil P budget to analyze the soil P balance in arable land across the whole of China, for the period 1980-2012. Results indicated that the total P input to soil increased from 22.5 kg P/ha in 1980 to 79.1 kg P/ha in 2012. However, the total P output from soil only increased from 17.9 kg P/ha in 1980 to 36.9 kg P/ha in 2012. Therefore, the average net soil P surplus in China increased from 4.6 kg P/ha in 1980 to 42.1 kg P/ha in 2012. The study found great variation in soil P balance across different regions. Soil P balance varied between regions with the order of southeast (SE) > north central (NC) and the middle and lower reaches of Yangtze River (MLYR) > southwest (SW) > northwest (NW) > northeast (NE). Phosphorus accumulated in agricultural soil across China could theoretically meet crop P demands for approximately 4.8 - 12.0 years, depending on the bioavailability of P stored in soils. Increasing the return rates of manure and straw could substantially reduce the demand for fertilizer P. This paper represents a basis for more targeted, regionally informed P fertilizer recommendations in Chinese soils.

[127] K. Atzmanstorfer, T. Oberthur, P. Laderach, R. Whitsed, L. Collet, G.E. Quiñonez. (2006). Probability Modeling to Reduce Decision Uncertainty in Environmental Niche Identification and Driving Factor Analysis: CaNaSTA Case Studies. pp 33 - 43.

Reference ID: 24657

Note: #24657e

Abstract: Hillside agro-ecosystems have a complex spatial and temporal distribution of natural resources. Farmers generally possess a vast body of knowledge about environmental resources on their farms but this knowledge is largely based on locally observable features rather than generalized knowledge. The lack of process-based knowledge concerning agro- ecosystem function creates uncertainty that obstructs sound decision-making under conditions of rising economic and ecologic pressure in many developing countries. Since the past decade, Precision Agriculture provides tools to reduce uncertainty caused by environmental variation. By describing spatial and temporal variation of the environment, Geographic Information Systems help to detect suitable crops for specific environmental niches and support farmers to find optimal management practices for their plot of land. Hence Precision Agriculture helps to raise the economic benefits of farming, ensures consistent product quality and reduces negative environmental impacts caused by inappropriate management practices. A spatial decision support system called CaNaSTA was developed to aid the decision making process of crop adoption in tropical agriculture. Using Bayesian probability statistics, CaNaSTA integrates trial data, spatial data and expert knowledge and provides maps, tables and graphs analyzing and interpreting the probability distributions of spatial phenomena. The International Centre for Tropical Agriculture (CIAT) has applied CaNaSTA to three case studies related to tropical agriculture. The first case study identifies niches for specialty coffee production, the second analyses the potential of cowpea (*Vigna unguiculata* (L.) Walp.) for tropical hillside environments in Colombia. Finally, Canasta was applied to a non-crop related area by performing a study of carbon concentration in tropical soils.

[128] J. Mathews, R.A. Barasa, H. Batubara, A. Ardiyanto. (2016). Impact of Assisted and Natural Weevil Pollination in Young Matured Oil Palm in West Kalimantan. 100th Year Celebration of Indonesian Oil Palm Research Institute, 6th International Seminar IOPRI-MPOB for current research and Pests, Ganoderma and Pollination for higher productivity. Medan, Indonesia. pp 1 - 9.

Reference ID: 24658

Note: #24658e (Note- Conference Paper and Poster is included and entered as #24568)

Abstract: An experiment was conducted from March 2014 to September 2015 on young matured palms of 2011 plantings of P.T.Bumitama Gunajaya Agro, Seriam Jaya Estate, in West Kalimantan for a comparative study on the impacts of natural weevil and manual assisted pollinated on female inflorescences and bunches of oil palm. A total of 710 female inflorescences pollinated manually for a period of 13 months was compared with 709 natural weevil (*Elaeidobius kamerunicus*) pollinated female inflorescences of the palms planted in moderately deep Sulfaquepts soil. Measurement taken in the field for a period of 12 months from October 2014 to September 2015 for harvested fresh fruit bunches indicated that the average bunch weight in assisted pollinated treatment of 9.95 kg per bunch was about 39.39% higher when compared to the natural weevil pollinated bunches of 7.19 kg per bunch. The fruit to bunch ratio by weight measured in 208 samples of naturally pollinated bunches was 56.14%, which was 19.12% lower when compared to the same number of bunches measured in the assisted pollinated bunches, which was 66.87%. The kernel to bunch ratio of 7.01% in the assisted pollinated treatment was 17.82% higher than the naturally pollinated bunches of 5.95 %. The overall mean oil to bunch ratio in assisted pollinated bunches was 29.30% against the natural pollinated bunches of mean 24.40%, an increment of 20.09% in assisted pollinated bunches was observed. The natural pollinated bunches showed distinct seasonal variation in the fruit to bunch ratio, from May 2015 to July 2015 bunches exhibited low fruit to bunch ratio. The experiment indicates that the efficiency of natural pollinator weevils have to be more active to improve yields in Borneo. An extra expected income of Rp 8.7 juta per hectare per year has been calculated in assisted pollination with an operation cost of 2.3 juta per hectare. The weevil population introduced in 1981 in South East Asia, climate in Kalimantan Island, high sex ratio in oil palm progenies on the pollination at young matured age is also discussed in this paper.

[129] J.A. Jansen, C.S. Wortmann, M.A. Stockton, C.K. Kaizzi. (2013). Maximizing Net Returns to Financially Constrained Fertilizer Use. *Agronomy Journal*. 105(3) pp 573 - 578.

Reference ID: 24659

Note: #24659e

Abstract: Financial constraints commonly limit fertilizer use by smallholder farmers as they strive to maximize net returns on their investments. Fifteen crop–nutrient response functions, including six crops, were derived from the results of 80 trials conducted in Uganda. The net return to nutrient application for typical fertilizer use costs and grain prices in Uganda was greatest for a small amount of N applied to dry bean (*Phaseolus vulgaris* L.), followed by N applied to rice (*Oryza* spp.), P applied to groundnut (*Arachis hypogaea* L.) and soybean [*Glycine max* (L.) Merr.], and then N applied to maize (*Zea mays* L.) and grain sorghum [*Sorghum bicolor* (L.) Moench]. Net returns were less for the remaining nine response functions. The Uganda Fertilizer Optimization Tool was developed for Uganda to maximize net returns to fertilizer use for finance-limited crop management. It considers the area of each crop to be planted,

fertilizer costs, expected grain value, and the money available for investment. The tool optimizes across response functions to provide the crop–nutrient–rate combinations expected to maximize net returns. In an example with 1 ha each of the above six crops and US\$170 available for fertilizer use, the optimized net return was US\$1918 compared with US\$676 and US\$804 for US\$170 of fertilizer applied to maize and rice, respectively, at rates to maximize net returns per hectare. This approach to fertilizer use of maximizing net returns on investment can gradually enable much increased fertilizer use because of the relatively high returns on investment compared with traditional fertilizer use recommendations.

[130] M. Kouakou, N'K. Hala, A.A.M. Akpessa, Y. Tuo, M. Dagnogo, K.E. Konan, H.K. Koua. (2014). Comparative Efficacy of *Elaeidobius kamerunicus*, *E. plagiatus*, *E. subvittatus* (Coleoptera: Curculionidae) and *Microporum* spp. (Coleoptera: Nitidulidae) in the Pollination of Oil Palm (*Elaeis guineensis*). Journal of Experimental Biology and Agricultural Sciences. 2(6) pp 538 - 545.

Reference ID: 24660

Note: #24660e

Abstract: Pollination capacity of *Elaeidobius kamerunicus* Faust, *E. plagiatus*, *E. subvittatus* and *Microporum* spp., was highlighted by the quantitative and qualitative analysis of the transported pollen grains and by controlled entomophilous pollination. The quantity and quality of pollen grains transported by adults of different species and the pollen grain which reached to the female inflorescence were evaluated by counting under a binocular microscope. Controlled pollination was conducted by releasing adult insects of different species on bagged female inflorescences. The fruit set and parthenocarpic were counted one month after fertilization. Results of the study revealed that *E. kamerunicus* species carries more pollen than the other three species (317 grains / individual) and this was followed by *E. plagiatus* (174 grains / individual). The males of both species carry significantly more pollen than their respective females. Quantities of pollen carried by *E. subvittatus* and *Microporum* spp did not differ significantly. *E. kamerunicus* and *E. plagiatus* carried pollen of very good quality (respective germination rate 92.7% and 77.1%). While *E. subvittatus* was transported pollen of medium quality (germination 53.87%) and *Microporum* spp vehicle pollen of poor quality (germination rate 26.8%). For the three beetles of the genus *Elaeidobius*, a significant correlation was found between the rate of fruit set and the number of individuals released on the female inflorescence of palm oil. Finally, for the same number of individuals released, *E. kamerunicus* is the species that provides the best rate of fruit set, followed by *E. plagiatus*.

[131] T. Auffray, B. Frerot, R. Poveda, C. Louise, L. Beaudoin-Ollivier. (2017). Diel Patterns of Activity for Insect Pollinators of Two Oil Palm Species (Arecales: Areaceae). Journal of Insect Science. 17(2) pp 1 - 6.

Reference ID: 24661

Note: #24661e

Abstract: The pollination of two oil palm species, *Elaeis guineensis* Jacquin and *Elaeis oleifera* Cortes (Arecales: Areaceae), depends on a mutualistic relation with insects, which use male inflorescences as a brood site, and visits female inflorescences lured by the emitted odor, which is similar to that of males. Although the activity of visiting the inflorescences by these insects is critical for the adequate natural pollination of the host plant, their activity is poorly documented. In the present study, we determine the diel activity of two specialized pollinator weevils (Coleoptera: Curculionidae) on inflorescences of their respective host-palm: *Elaeidobius*

kamerunicus Faust specialized on *E. guineensis*, and *Grasidius hybridus* O'Brien and Beserra specialized on *E. oleifera*. The average timing of activity was studied by using passive interception traps. Then the pattern and the duration were refined by using aspiration trapping within the active period for each insect species at the male and female inflorescences. All the experiments were conducted in an Ecuadorian oil palm plantation, located close to Amazonian forest. *E. kamerunicus* and *G. hybridus* were found to be the pollinators of *E. guineensis* and *E. oleifera*, respectively. The two species differed in their diel pattern of activity: *E. kamerunicus* was active in the morning and *G. hybridus* during a short period at dusk. For both palm species, insect visits were synchronous on both male and female inflorescences. The synchronicity is discussed as a strategy to maintain the relation mutualistic between partners. These findings increase our understanding of the oil palm pollination system.

[132] K.N. Ponnammam, R.S.N. Pillai, A. Sajeebkhan, A. Vijayan. (2003). Evaluation of the pollination efficiency of different bio-types of *Elaeidobius kamerunicus* in the oil palm plantations in different agro-eco systems. ICAR Publications. Kerala. pp 1 - 45.

Reference ID: 24662

Note: #24662e

[133] D.C. Forero, P. Hormaza, H.M. Romero. (2012). Phenological growth stages of African oil palm (*Elaeis guineensis*). Annals of Applied Biology. 160 pp 56 - 65.

Reference ID: 24663

Note: #24663e

Abstract: The aim of this paper was to study the phenology of commercially cultivated representative genotypes of the *Elaeis guineensis* Jacq. species in two Colombian growing areas. The frequency of observations was daily, weekly or monthly depending on the stage of development under evaluation, over an 18-month time period. Observations were made on pre-nursery and nursery plants and on three- to five-year-old palms starting from the zero leaf (spear leaf), through development of inflorescence, and ending with maturity and harvesting of fruit bunches. Stem observations were made on different age palms of the same cultivars. The duration of each phenological stage was measured in terms of days. The phenological growth stages were coded according to the BBCH scale (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie), consisting of three digits, because of the inclusion of intermediate stages between the principal and secondary stages in order to provide more accurate details on each development stage.

[134] S. Bandung. (2015). *Elaeidobius kamerunicus*: Penyerbukan dan fruitset. Buletin Entomologi. pp 5 - 7.

Reference ID: 24664

Note: #24664e (note: Journal is in malay)

Abstract: Penyerbukan adalah jasa yang dihasilkan oleh serangga-serangga yang hidup dan makan dari pollen yang ditawarkan oleh serangga. Adalah *Elaeidobius kamerunicus* Faust yang memiliki jasa sedemikian besar, sehingga minyak sawit menjadi salah satu tulang punggung ekspor di luar minyak bumi dan gas. *E. kamerunicus* (Coleoptera:Curculionidae) merupakan serangga yang berperan penting dalam proses penyerbukan kelapa sawit ini. Pelepasan kumbang *E. kamerunicus* di Indonesia pada tahun 1982 secara signifikan meningkatkan produktivitas kelapa sawit dari 40% ke 60%.

[135] Y. Tuo, H.K. Koua, N'K. Hala. (2011). Biology of *Elaeidobius Kamerunicus* and *Elaeidobius Plagiatus* (Coleoptera: Curculionidae) Main Pollinators of Oil Palm in West Africa. European Journal of Scientific Research. 49 pp 426 - 432.

Reference ID: 24665

Note: #24665e

Abstract: The pollination of the oil palm is assured mainly by the insects. The most effective are *Elaeidobius kamerunicus* and *Elaeidobius plagiatus*. Declining populations of pollinating insects in the palm oil plantation is often the cause of the low yields observed in the production of seeds. The study of the biology of these beetles has been conducted in the laboratory (27.43 ± 0.74 ° C and 75.16 ± 2.54 HR). The average of life expectancy was of 32.02 ± 12.43 days for *Elaeidobius plagiatus* and 59.18 ± 8.53 days for *Elaeidobius kamerunicus*. The total cycle time was 10.27 ± 0.34 and 8.38 ± 0.12 days respectively for *E. kamerunicus* and *E. plagiatus*. The number of eggs laid by female is of 57.64 ± 8.29 eggs for *E. kamerunicus* against 29.56 ± 5.29 for *E. plagiatus*. Knowledge of the biology of these insects is vital for better management of oil palm yields.

[136] I. Pradiko, F. Hidayat, N.H. Darian, H. Santoso, Winarna, S Rahutomo, E.S. Sutarta. (2016). Distribusi Perakaran Kelapa Sawit dan Sifat Fisik Tanah pada Ukuran Lubang Tanam dan Aplikasi Tandan Kosong Sawit Yang Berbeda: Root Distribution of Oil Palm and Soil Physical Properties in Different Planting Hole and Empty Fruit Bunches Application. Jurnal Penelitian Kelapa Sawit. 24(1) pp 23 - 28.

Reference ID: 24666

Note: #24666e (Note: Journal is in Malay)

Abstrak: Penelitian ini dilakukan untuk mengetahui distribusi perakaran dan faktor fisik tanah pada ukuran lubang tanam standar (0,6 m x 0,6 m x 0,6 m), sedang (1 m x 1 m x 0,6 m) dengan aplikasi tandan kosong sawit (TKS) sebanyak 400 kg/lubang tanam dan 740 g urea/lubang tanam, dan besar (2,8 m x 2,8 m x 1 m) dengan aplikasi TKS sebanyak 400 kg/lubang tanam dan 740 g urea/lubang tanam. Penelitian ini merupakan penelitian demonstrasi plot (demplot) menggunakan desain penelitian rancangan acak kelompok (RAK) non faktorial dengan tiga perlakuan ukuran lubang tanam yaitu lubang tanam standar, sedang, dan besar dengan tiga kali ulangan. Hasil penelitian menunjukkan bahwa total akar tanaman kelapa sawit pada lubang tanam standar, sedang, dan besar berturut-turut adalah $28,60 \text{ gram/dm}^3$; $26,69 \text{ gram/dm}^3$; dan $24,47 \text{ gram/dm}^3$. Ukuran lubang tanam tidak berpengaruh nyata terhadap distribusi akar primer, tetapi berpengaruh nyata terhadap distribusi akar sekunder dan tersier. Tanaman kelapa sawit pada lubang tanam besar memiliki distribusi akar sekunder dan tersier yang lebih tinggi (hingga 40%) dibandingkan lubang tanam lainnya. Peningkatan permeabilitas dan porositas serta penurunan bulk density tanah cenderung meningkatkan distribusi akar, khususnya akar tersier. Sementara itu, peningkatan kadar air tanah tidak diikuti dengan peningkatan distribusi akar sekunder dan tersier, karena kedua jenis akar tersebut lebih banyak berada di lapisan tanah atas. Pengolahan tanah yang lebih baik, salah satunya melalui pembuatan lubang tanam besar, dapat memperbaiki sifat fisika tanah sehingga dapat meningkatkan perkembangan akar sekunder dan tersier.

Abstract: This study was conducted to determine the root distribution and to analyze soil physical factors that affect roots development in different size of planting hole; standard (0.6 m x 0.6 m x 0.6 m), medium ((1 x 1 m x 0.6 m) with 400 kg empty fruit bunches (EFB)/hole and 740 g urea/hole, and big (2.8 mx 2.8 mx 1 m) with 400 kg EFB/hole and 740 g urea/hole. This study employed demonstration plot that used a

non factorial randomized block design (RBD) with three treatments (standard, medium, and big hole) and three replications. The results showed that total distribution of oil palm roots in standard, medium, and big planting hole are respectively 28.60 g /dm³; 26.69 g/dm³; and 24.47 g/dm³. Types of planting hole did not significantly affect primary root, but significantly affected secondary and tertiary root distribution. In big planting hole, oil palm has highest secondary and tertiary roots distribution than the others (up to 70%). Increasing of permeability, porosity, and decreasing of soil bulk density tends to increase root distribution, especially tertiary. Meanwhile, increase on soil water content is not followed by secondary and tertiary distribution, since both root types more distributed in the upper soil layer. Better soil tillage; through big planting hole, can improve soil properties and optimizing development of secondary and tertiary roots.

[137] J. Yue, Z. Yan, C. Bai, Z. Chen, W. Lin, F. Jiao. (2015). Pollination activity of *Elaeidobius kamerunicus* (Coleoptera: Curculionoidea) on oil palm on Hainan Island. Florida Entomologist. 98(2) pp 499 - 505.

Reference ID: 24667

Note: #24667e

Abstract: *Elaeidobius kamerunicus* Faust (Coleoptera: Curculionidae), the pollinating weevil, is the most efficient insect pollinator of oil palm, *Elaeis guineensis* Jacq. (Arecales: Arecaceae). In this experiment, the pollinating activity of *E. kamerunicus* was observed in an oil palm field in Hainan, China, in order to further understand the dynamics of the weevil's behavior on inflorescences. Both male and female inflorescences emitted an anise-like fragrance. Female inflorescences appeared to reward the weevils with copious nectar production, whereas male inflorescences appeared to do so with both nectar and pollen. The number of weevils visiting an inflorescence was assessed by the use of a sticky trap encircling it, and by counting the weevils present on samples of spikelets of inflorescences. The weevil population peaked on the 3rd day of anthesis on male inflorescences, and on the 2nd day of anthesis on female inflorescences. Weevil activity recorded on the day of highest abundance during anthesis revealed an inactive period during 07:00–08:00, substantial activity during 11:00–12:00, and peak activity during 17:30–18:00. The number of female adult weevils was always much greater than the number of males, both on male and on female inflorescences. Separation of anthesizing male inflorescences into 7 consecutive stages each 1 d long and use of sticky traps baited with anthesizing male flowers that were placed around inflorescences on the plant were optimal techniques for obtaining reliable data on the numbers of pollinating weevils. To increase the population of *E. kamerunicus* in Hainan, some steps should be taken including releases of adult weevils in oil palm plantations, and control of the weevil's predators and parasites, such as rats and harmful nematodes.

[138] R. Whitsed, R. Corner, S. Cook. (2011). A model to predict ordinal suitability using sparse and uncertain data. Applied Geography. 32(2011) pp 401 - 408.

Reference ID: 24668

Note: #24668e

Abstract: We describe the development of the algorithms that comprise the Spatial Decision Support System (SDSS) CaNaSTA (Crop Niche Selection in Tropical Agriculture). The system was designed to assist farmers and agricultural advisors in the tropics to make crop suitability decisions. These decisions are frequently made in highly diverse biophysical and socioeconomic environments and must often rely on sparse datasets.

The field trial datasets that provide a knowledge base for SDSS such as this are characterised by ordinal response variables. Our approach has been to apply Bayes' formula as a prediction model.

This paper does not describe the entire CaNaSTA system, but rather concentrates on the algorithm of the central prediction model. The algorithm is tested using a simulated dataset to compare results with ordinal regression, and to test the stability of the model with increasingly sparse calibration data. For all but the richest input datasets it outperforms ordinal regression, as determined using Cohen's weighted kappa. The model also performs well with sparse datasets. Whilst this is not as conclusive as testing with real world data, the results are encouraging.

[139] J.H. Cock, P. Jones, T. Oberthur. (2008). Homologue and avocados: What will grow on my farm? *Acta Horticulturae*. pp 1 - 17.

Reference ID: 24669

Note: #24669e

Abstract: In horticulture one of the foremost questions is "What can be grown in a specific site?" Homologue was developed to answer this question. The hypothesis supporting development of "homologue" is that if similar sites to those where a particular crop grows well can be identified these sites are also likely to be suitable for that crop. The homologue software package was developed to determine the similarity of sites in terms of climate. A particular feature of homologue is that it does not require a large number of sites: with just one site it is possible to determine other similar sites on a global basis. Avocado (*Persea Americana*) was used as a test crop to determine whether Homologue was capable of identifying sites suitable for a crop and also for individual crop cultivars. We conclude that homologue is capable of identifying not only suitable sites for a crop, but that it may also be used to determine suitable sites for a particular cultivar.

[140] P. Jones, A. Jarvis, G. Hyman, S. Beebe, D. Pachico. (2007). Climate Proofing Agricultural Research Investments. *SAT eJournal*. 4(1) pp 1 - 29.

Reference ID: 24670

Note: #24670e

Abstract: The case for impending climate change is now proven. Governments can decide, by their action or inaction, to what extent the change will occur; the International Agriculture Research Community (IARC) will have no say in this whatsoever. It is up to the IARC to try to maintain objectives in the face of the possible scenarios. In this paper we discuss the various types of agricultural research projects in terms of their time to fruition and the expected longevity of their results. We look at the information requirements for ensuring that project products have the necessary lifetimes to justify the investments in the research. We show that strategies differ depending on the type of research that is undertaken. Basic research into genetic traits and capacities within the available germplasm has to be planned in the long term with outcomes in mind. The vulnerability of the populations and agricultural systems that use developments from this basic research now places its priority setting in a changing climate and world concept. Ensuring that the germplasm is available for use has taken on a critical new importance with recent studies. Germplasm banks comprise a small fraction of what we will be relying on for the future. Well over 90% of useful genetic variability may still be in the wild. This has to be considered carefully in setting out research objectives. Plant breeders, who will put together the results of the basic research into useful packages, now have an uncertain target to aim for when regarding future climate conditions. They may not be able to choose their testing sites in present

climates to target agricultural populations that will be using their products in the future. Agronomic and agricultural development projects face the most difficult task. How do we develop stable farming systems in an environment that is not only unstable, but also changing so slowly that the farmers cannot see, or even envisage, the changes. These are some examples of the problem. The paper sets out to categorise the types of research and information that will be necessary at all levels. We draw on experience from the CGIAR system and from CIAT in particular. We show that a number of software tools have been developed that can address some of these problems.

[141] IPI. (2018). e-ifc No 53 June 2018. 53 pp 1 - 48.

Reference ID: 24671

Note: #24671e

[142] F.M. Gebrehawariyat, W. Haile, T. Mamo, I. Zipori, E. Sokolowski. (2018). Response of Teff [*Eragrostis tef* (Zucc.) Trotter] to Potassium Fertilizer Application in Four Districts of North Shewa, Ethiopia. e-ifc. 53(June 2018) pp 3 - 15.

Reference ID: 24672

Note: #24672e > #24671e

Abstract: Teff [*Eragrostis tef* (Zucc.) Trotter] is a cereal crop species unique to Ethiopia, where it is an important staple crop. It is grown on more than 3 million ha of land. In recent decades, soil fertility has significantly declined in Ethiopia. While nitrogen (N) and phosphorus (P) are traditionally applied by teff growers, potassium (K) has been ignored due to the perceived notion that soils in Ethiopia provide all K requirements. However, recent studies have led to opposite conclusions. Teff K requirements, and its response to K application, have seldom been addressed.

The objectives of the present study were to examine teff response to rising K application rates on Vertisols in four regions in the Ethiopian Central Highlands: Sululta, Mulu, Bereh, and Moretena Jiru. Potassium was applied at rates of 0, 30, 60, 90, and 120 kg K₂O ha⁻¹ along with urea + NPSZn blend applied at 64 kg N ha⁻¹ and 20 kg P₂O₅ ha⁻¹.

Generally, crop performance and yield parameters displayed significant increases up to K application range of 60-90 kg K₂O ha⁻¹, with grain yield rising by 26-30% at Moretena Jiru; 21-50% at Bereh; 36-82% at Sululta; and 60-130% at Mulu. Crop yields were between 1-3 Mg ha⁻¹. The large differences between regions may be attributed to the teff genotype cv. Dega at Moretena Jiru and cv. Konchu at the other regions, and to soil fertility traits that require further exploration.

Economically, the incentive of local teff growers to choose an appropriate K application rate would emerge from the expected increment in the marginal profit although this differed considerably between regions, being positive up to 30, 60, 90, and 120 kg K₂O ha⁻¹ at Moretena Jiru, Bereh, Mulu, and Sululta, respectively. Potassium application significantly increased N, P, and K concentrations in grains and straw, indicating that K was a principal limiting factor in teff crop development. Consequently, the uptake rates of these nutrients rose significantly, which indicates a possible need to increase their application rates when K is adequately supplied.

In conclusion, the potential of K supply to substantially enhance teff productivity is significant but largely depends on local soil traits that should be thoroughly examined in advance.

[143] C.F. Ozkan, D. Anac, N. Eryuce, E.L. Demirtas, F.O. Asri, D. Guven, M. Simsek, N. Ari. (2018). Effect of Different Potassium and Sulfur Fertilizers on Onion (*Allium cepa* L.) Yield and Quality. e-ifc. 53 pp 16 - 24.

Reference ID: 24673

Note: #24673e > #24671e

Abstract: Onion (*Allium cepa* L.) is the most widely cultivated species of the genus *Allium*. It is rich in many essential nutrients and sulfur (S)-containing compounds considered important for human health. While potassium's (K) role in plant nutrition is well established, K fertilization practices still suffer from low agronomic efficiency. Recently, crop S requirements have gained special attention, particularly in *Allium* species. Polyhalite is a sedimentary marine mineral, consisting of a hydrated sulfate of K, calcium (Ca) and magnesium (Mg) at rates of 14, 48, 6, and 17% of K₂O, SO₃, MgO, and CaO, respectively. The objective of this study was to compare the effects of polyhalite, potassium sulphate (SOP), and potassium chloride (MOP) fertilizers on onion bulb yield, nutrient uptake, and on bulb quality properties. An equal dose of 270 kg K₂O ha⁻¹ was applied as MOP, SOP, polyhalite, and a mixture of polyhalite and SOP, and these were compared against a control which applied nitrogen (N) and phosphorus (P) fertilizers. While MOP increased bulb size and yield by 28%, S fertilizers contributed additional yield increases ranging from 12 to 22% compared to the control. The major effect of all of the fertilizers was that they improved K availability during the onion crop cycle. Polyhalite application resulted in the highest yield, probably due to its slow-release character, providing constant soil K availability throughout the crop cycle. High rates of S application did not correlate with high yield or quality. While polyhalite's advantageous agronomic efficiency was obvious, suitable rates of application remain subject to economic considerations.

[144] H.K. Patro, G. Sahoo, B. Behera, A.K. Senapati, N.K. Awasthi, S.K. Bansal, S.N. Jena, N. Prusty, A. Panda. (2018). Effects of Potassium Application Regime on Productivity and Drought Tolerance Parameters of Groundnut (*Arachis hypogaea* L.) in Odisha, India. e-ifc. 53 pp 25 - 35.

Reference ID: 24674

Note: #24674e > #24671e

Abstract: Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in India but its productivity is poor due to factors such as high soil acidity, low fertilizer use, imbalanced fertilizer practices, and frequent crop failures due to recurrent low soil moisture. Groundnut farmers in India, and Odisha in particular, often ignore the high potassium (K) requirements of this crop, which results in low yield and quality, as well as declining soil fertility. Appropriate K application management, therefore, needs to be addressed in order to meet groundnut K demands throughout the season.

The objectives of the present study were: to determine an appropriate K dose for rabi groundnut crops to suit the growing conditions in Odisha; to compare between basal and split K application; and to establish a well-founded fertilization recommendation for Odisha groundnut farmers. Three K doses (40, 60, and 80 kg K₂O ha⁻¹) were examined through basal and split application (basal and at bloom) versus unfertilized control and farmers' practice (18; 48; 36 kg ha⁻¹ of N; P₂O₅; K₂O, respectively) altogether comprising eight treatments. Physiological indicators of water stress, drought resistance, and yield components were determined during crop development over two growing seasons in 2014 and 2015.

In most parameters studied, there was a significant advantage to the split K application at the highest dose tested. Due to an increased number of fertile pods per plant, pod yield was 30% higher than under control conditions, in addition to greater kernel weight

and higher shelling rates. It may be concluded that split K application is far better for groundnut crops. Nevertheless, further research is required to determine K uptake rates, K agronomic efficiency, and consequently, the appropriate K dose under the conditions characterizing the groundnut production system in Odisha.

[145] CIMMYT. (1988). From agronomic data to farmer recommendations: An economics training manual. Secondary From agronomic data to farmer recommendations: An economics training manual. International Maize and Wheat Improvement Center. Mexico. pp 1 - 87.

Reference ID: 24675

Note: #24675e

[146] V.V. Bhaskar, K.K. Rao. (2018). Analysis of Bunch Quality in Oil Palm Hybrid Cross Combinations under Krishna-Godavari Zone of Andhra Pradesh, India. International Journal of Current Microbiology and Applied Sciences. 7(5) pp 2488 - 2493.

Reference ID: 24676

Note: #24676e

Abstract: The present study comprising of eleven hybrid cross combinations of oil palm was carried out at Horticultural Research Station, Vijayarai, West Godavari district of Andhra Pradesh to evaluate bunch quality of oil palm hybrid cross combinations under Krishna-Godavari zone of Andhra Pradesh. The eleven tenera hybrid cross combinations of oil palm used were 128D x 291P, 124D x 266P, 18D x 32P, 35D x 291P, 65D x 111P, 104D x 98P, 82D x 266P, 109D x 291P, 115D x 291P, 148D x 98P and 220D x 98P and planted at a spacing of 9 m x 9 m in square system of planting in a randomized block design and replicated thrice under supplemented tube well irrigation. Bunch analysis has revealed that hybrid cross combination 115D x 291P has recorded significantly highest bunch weight (26.0 kg), fruit weight per bunch (16.0 kg), per cent of fruit weight to bunch (76.0%), per cent of moisture content of the fruit (58.7%), per cent of oil from wet mesocarp (53.08%) and per cent of oil from bunch (24.87%) coupled with significantly highest number of bunches per palm per year (8.5) and yield of fresh fruit bunches (26.5 t/ha). Based on the data analysis of yield and bunch quality parameters of different dura x pisifera cross combinations it could be concluded that 115D x 291P followed by 109D x 291P have been identified as precocious in bearing coupled with fresh fruit bunch yield and bearing good quality parameters.

[147] IPNI. (2018). Better Crops With Plant Food Vol. 102 (No. 3). pp 1 - 28.

Reference ID: 24677

Note: #24677e

[148] I.A. Ciampitti, F. Salvagiotti. (2018). Soybeans and Biological Nitrogen Fixation: A review. Better Crops With Plant Food. 102(3) pp 5 - 7.

Reference ID: 24678

Note: #24678e

Abstract: A review of 60 studies reporting on biological N fixation (BNF) in soybean was done to study the limits to which BNF can satisfy plant N demand. This review confirmed that BNF could satisfy plant N demand up to 200 kg N/ha. The N-gap (plant N uptake minus fixed N) widened rapidly if plant N demand exceeded 370 kg N/ha, which suggested the need for additional N under conditions of high yield potential. The partial N balance (fixed N minus N removed in seeds) was negative on average but

approached neutral or positive values when BNF contributed at least 58% of plant N uptake.

[149] V. Nosov, N. Tishkov, V. Makhonin. (2018). Adapting Fertilization Strategies for High Soybean Productivity in Southern Russia. *Better Crops With Plant Food*. 102(3) pp 8 - 11.

Reference ID: 24679

Note: #24679e

Abstract: Soybean field experiments conducted in Southern Russia found an advantage for short duration varieties over intermediate duration varieties in years with midseason crop stress caused by drought and high temperatures. Short duration varieties were found highly responsive to both starter and foliar fertilizers.

[150] J. Zhang, P. He. (2018). Field-Specific Fertilizer Recommendations for Better Nitrogen Use in Maize. *Better Crops With Plant Food*. 102(3) pp 12 - 14.

Reference ID: 24680

Note: #24680e

Abstract: China is emphasizing a need to optimize nutrient management for maize to secure high yields without jeopardizing the environment. Nutrient Expert (NE)-based fertilizer management in summer maize production systems in north-central China significantly increased grain yield and nitrogen use efficiency, and lowered greenhouse gas emissions.

[151] T.M. Maaz, A. Eagle. (2018). PART 2: Effects of 4R Management, Climate, and Soil Variables on Nitrogen Losses. *Better Crops With Plant Food*. 102(3) pp 15 - 17.

Reference ID: 24681

Note: #24681e

Abstract: Climate, soil, and 4R Nitrogen (N) management impact N losses in measurable ways. However, nitrous oxide (N₂O) emissions and nitrate (NO₃⁻) leaching respond differently to changes in fertilizer management and environmental conditions. Strategies that target multiple pathways may be necessary to combat N losses.

[152] R. Mikkelsen. (2018). Nanofertilizer and Nanotechnology: A quick look. *Better Crops With Plant Food*. 102(3) pp 18 - 19.

Reference ID: 24682

Note: #24682e

Abstract: There is more talk and publications about nanofertilizers in recent years, but these materials are still new for many agronomists. Because these fertilizers are still in the early stage of development, a brief review of their potential is useful.

[153] T. Tiemann, M.A. Tin, D.D. Nguyen, M.T. Tran, M. Fisher, E.M. de Paulo, T. Oberthür. (2018). Crop Nutrition for Vietnamese Robusta Coffee. *Better Crops With Plant Food*. 102(3) pp 24 - 27.

Reference ID: 24683

Note: #24683e

Abstract: Coffee remains one of the most significant sources of income for many farmers in the Central Highlands of Vietnam, but at the same time, yields have been declining or stagnant. Field insights indicate that farmers attempt to counter this trend by experimenting with varying, often increasing amounts of currently available fertilizers. These changes have not worked but have increased production costs markedly. Not to mention that imbalanced fertilizer dressings cause collateral effects

of increased contamination of offsite water resources. Robusta coffee systems in the Central Highlands of Vietnam have potential for improvement that can be realized by closing knowledge gaps on balanced crop nutrition, and at the same time, extending access to appropriate nutrients.

[154] L.P. Watson. (2018). Fertilizer Placement Influences Profit: A look back to 1938. *Better Crops With Plant Food*. 102(3) pp 24 - 25.

Reference ID: 24684

Note: #24684e

Abstract: Six fertilizer placement demonstrations with potatoes in eastern North Carolina in 1937 proved that fertilizer placed to not injure seedlings, yet within ready access to feeder roots, will result in better crop stands and yields. The improved practice placed fertilizer in a band method to each side and slightly below the seed-piece level. The average yield increase was 15.2 barrels of No.1 grade potatoes per acre over the check plot, which was fertilized by the old method of placing the fertilizer in the drill and mixing it with the soil before planting the seed.

[155] K.A. Macintosh, D.G. Doody, P.J.A. Withers, R.W. McDowell, D.R. Smith, L.T. Johnson, T.W. Bruulsema, V. O'Flaherty, J.W. McGrath. (2019). Transforming soil phosphorus fertility management strategies to support the delivery of multiple ecosystem services from agricultural systems. *Science of the Total Environment*. 649(2019) pp 90 - 98.

Reference ID: 24685

Note: #24685e

Abstract: Despite greater emphasis on holistic phosphorus (P) management, current nutrient advice delivered at farmscale still focuses almost exclusively on agricultural production. This limits our ability to address national and international strategies for the delivery of multiple ecosystem services (ES). Currently there is no operational framework in place to manage P fertility for multiple ES delivery and to identify the costs of potentially sacrificing crop yield and/or quality. As soil P fertility plays a central role in ES delivery, we argue that soil test phosphorus (STP) concentration provides a suitable common unit of measure by which delivering multiple ES can be economically valued relative to maximum potential yield, in \$ ha⁻¹ yr⁻¹ units. This value can then be traded, or payments made against one another, at spatio-temporal scales relevant for farmer and national policy objectives. Implementation of this framework into current P fertility management strategies would allow for the integration and interaction of different stakeholder interests in ES delivery on-farm and in the wider landscape. Further progress in biophysical modeling of soil P dynamics is needed to inform its adoption across diverse landscapes.

Highlights

- P management decisions still remain largely focused on agricultural production.
- However, managing soil P fertility is central to the delivery of multiple ES.
- No operational framework exists to manage P fertility for multiple ES delivery.
- Soil test P can be used to attribute economic value and trade ES relative to yield.
- Modifications are needed to current P fertility management strategies to deliver ES.

[156] J.M. Mogollóna, A.H.W. Beusen, H.J.M. van Grinsven, H. Westhoek, A.F. Bouwman. (2018). Future agricultural phosphorus demand according to the shared socioeconomic pathways. *Global Environmental Change*. 50 pp 149 - 163.

Reference ID: 24686

Note: #24686e

Abstract: A spatially explicit, two-pool soil phosphorus (P) model was used to analyze cropland P dynamics and fertilizer demand based on future crop production as projected in the shared socioeconomic pathways (SSPs). The model was initialized with historical data on P inputs and uptake, which governed the soil P accumulation up to present day. In contrast to existing scenario studies, the model accounts for both soil characteristics relevant to P retention and changing land use. At the global scale, crop uptake and the fraction of the applied P fertilizer that is directly taken up by plant roots govern the P quantities present in the soil. Despite the differences in the storylines among the SSPs, the quantitative implementation results in estimates for crop production and P inputs that are quite similar, which contrasts with the stark divergence in terms of population and incomes. In addition to global fertilizer P inputs in croplands increasing from 14.5 Tg P yr⁻¹ in 2005 to 22–27 Tg P yr⁻¹ in 2050, this study also estimates that 4–12 Tg P yr⁻¹ would be needed in 2050 in global intensively managed grasslands to maintain fertility. Our new model approach can pinpoint the contribution of area expansion and crop yield improvement toward the total production, whereby the latter is shown to contribute 100% to 69%, depending on the scenario.

[157] Universidad de Antioquia, University of Antioquia. (2016). Vitae Vol 23 (Supl 1) 2016. 23 pp 1 - 289.

Reference ID: 24687

Note: #24687e

[158] E.A.G. Rodríguez, N.M. Guerrero, O.M.G. Díaz, O. Gavanzo. (2017). Fenología en fase vegetativa del cacao: Una aproximación para el manejo inteligente del cultivo: Phenology in the vegetative phase of cocoa: an approach for the intelligent management of the crop. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 4.

Reference ID: 24688

Note: #24688e > #24507e (Note: journal is in Spanish)

Abstract: Los factores climáticos, principalmente irradiación y temperatura, en ausencia de condiciones de estrés, son determinantes en el comportamiento fenológico del cacao e indirectamente en las estrategias para el manejo inteligente del cultivo. En tal sentido, en Santander – Colombia (700 msnm, 7° 15' 17,0" N; 73° 08' 38,1" W), se estudió durante 82 semanas el comportamiento fisiológico y productivo de 8 clones de cacao (ICS 1, ICS 39, ICS 60, ICS 95, EET 8, TSH 565, CCN 51 e IMC 67.) en una plantación de 20 años. Las variables analizadas fueron: estado de la yema (1- latente, 2- brotada, 3- alongada), floración (%), rendimiento (Kg.ha⁻¹ por año) y pérdidas asociadas a *M. royeri* (%). La normalidad de los datos fue evaluada, se realizó análisis de comparación de promedios ($P > 0,05$) y Tukey ($P > 0,05$). En la brotación ($p \leq 0,5$) los materiales con mayor actividad fueron ICS 1 (1,83), seguido de CCN 51 (1,65); en los demás materiales no hubo diferencia. Se identificó que la intensidad de la brotación fue mayor en los periodos comprendidos entre marzo - abril y septiembre - octubre; con menor intensidad entre mayo y agosto. Se registraron dos periodos de reposo vegetativo, entre las semanas 46 a la segunda del año siguiente; y entre la semana 8 a la 14, ambos con una duración promedio de dos meses, excepto en CCN 51 e ICS 60 que permanecieron activos. La floración, entre los ocho clones, fue diferente ($p < 0,001$), siendo mayor en CCN 51 (31,0 %) y EET 8 (28,20 %) y menor en TSH 565 (16,05 %), seguido de IMC 67 (14,98 %) e ICS 95 (16,25 %). La fructificación fue continua durante el periodo de evaluación; sin embargo ICS 39 (entre semana 36 a 40) y EET 8 (28 a 38) e ICS 60 (16 a 22) evidenciaron épocas de mínima formación.

[159] M.O. Opoku-Agyeman, G.J. Anim-Kwapong, F. Owusu-Ansah. (2017). Evaluation of cacao in fruit tree species' shade system in Ghana. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 13.

Reference ID: 24689

Note: #24689e > #24507e

Abstract: A study was undertaken in 2008 at Afosu, Ghana, to evaluate impact of fruit species shade tree density and complementarities in a cacao farm ecosystem on resource availability, soil carbon stock and cacao standing biomass and to assess the cost effectiveness of the tree species' diversification. The study contributes information on system productivity and ecosystem resilience, in a controlled study of agro-ecosystem and economic benefits of a multi-strata cacao/diversified tree system. Two each of *Allanblackia parviflora*, *Ricinodendron heudelotii*, *Persea americana* and *Tetrapleura tetraptera* integrated as a mixed stand into cacao at shade tree density of 92, 69 and 44 trees ha⁻¹ for three evaluated treatments and 37 trees ha⁻¹ of mix *Terminalia ivorensis* and *T. superba* as control. These treatments were planted in a randomized complete block design with four replications. Seventy-eight months after transplanting cacao, no significant treatment differences were recorded for dry cacao bean yield. Fluctuating mean annual dry cacao bean yields of 312, 241, 775 kg ha⁻¹ for 2014/15, 2015/16, 2016/17 crop years respectively were recorded for the three-year period. LAI and percent ground cover recorded statistically different values, ranging from 0.53-0.7 and 0.28–0.42 respectively. Shade tree biomass estimated in fragments (above-ground and root) recorded significant treatment differences that also contributed to significant carbon stock differences with values of 49.25 - 73.96 Mg Cha⁻¹. Significant differences were recorded in the carbon content of above-ground parts of cacao trees. Treatments did not differ in soil carbon stock. Differences in total carbon stock values resulted from tree (cacao and shade) biomass treatment differences. No significant treatments impact was recorded on pH, OM, N, P, K, Mg and Ca in April 2016 soil samples. Results from the study showed ample space was still available for exploitation by the competing tree species and therefore optimal spatial arrangement for the system could not be determined at this stage.

[160] A. Arthur, A.A. Afrifa, J.A. Dogbatse. (2017). Assessment of soil fertility status of cocoa farms around the Ankasa National Park in the Jomoro District of the Western Region of Ghana. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 8.

Reference ID: 24690

Note: #24690e > #24507e

Abstract: The Western Region currently produces over 50 per cent of Ghana's cocoa. Information on the fertility status of soils within the cocoa growing region and possible fertilizer recommendations do not exist. Since cocoa yield is generally related to the fertility status of the soil, a study was conducted to evaluate the fertility status of soils supporting growth of cocoa around the Ankasa National Park area in the Western Region. The soils were sampled at two depths, 0 - 15 cm and 15 - 30 cm on 40 different cocoa farms and analysed for selected fertility characteristics. Analyses of the top soil showed a mean soil pH of 4.91±0.06 which is considered to be moderately acidic. This range is outside the optimum range required for sustainable and competitive cocoa production. Mechanical analyses of the soil indicate very high percentage of sand around 70 per cent, clay mineral of 20 per cent and 10 percent silt which enhances percolation and leaching of basal cations. Exchangeable Ca and Mg were therefore generally below threshold. Organic carbon status of the soils averagely ranged between 0.78-2.68 % with a mean of 1.53±0.07 which was low. Mean available

phosphorus, 11.31 ± 0.5 mgkg⁻¹ was below the optimum and phosphorus is the most limiting nutrient that will affect cocoa yield. In general, nutrient levels were higher in the top soils than the sub soils. The evaluation showed that the soils suffer from multi-nutrient deficiency. It is concluded that nutrient levels of the soils are low to very low, and will not support good cocoa growth and yield. Application of fertilizers rich in calcium, magnesium and phosphorus will improve on the soil reaction (pH) which will subsequently bring most of the trace elements into solution at their right levels. Additionally, the farmers are encouraged to invest in fertilization using available organic materials or residues generated from the farms or locality to produce organic manure.

[161] A.A. Afrifa, J.A. Dogbatse, A. Arthur. (2017). Using integrated plant nutrient management strategy for sustainable and competitive cocoa production in Ghana. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 10.

Reference ID: 24691

Note: #24691e > #24507e

Abstract: Cocoa production in Ghana is becoming less sustainable and less competitive because of several years of continuous low input cocoa cultivation that depends mainly on nutrient reserves of newly cleared forest thus resulting in the degradation of soil resource base. The necessity for external plant nutrient replenishment resulted in the introduction of recommended cocoa fertilizers like Asaase Wura, Cocofeed, Cocoa Master, Cocoa Sett, Sidalco liquid fertilizers, Nutrismart, Natural Asontem, poultry manure and cocoa pod husk ash as an initial solution to the fertility problem. For an efficient intervention to the existing problem, it is important to monitor the levels of degradation of cocoa soils in the different ecological zones and cropping systems. A study was therefore, conducted by sampling and analyzing eight hundred soil samples from the depths of 0-15 and 15-30 cm of different soil groups - Acrisols (75%), Lixisols (10%), Ferrasols (9%) and Nitisols (3%) of the Ghana cocoa belt, within five cocoa regions namely Eastern, Ashanti, Western North, Western South and Central Regions. Additionally, nutrient analyses of different parts of the cocoa plant were undertaken. Analyses of the parts of the crop indicated that nutrient losses through the beans which are exported needed to be replaced especially nitrogen (2.81%) which is the highest. The results also showed the need to increase the levels of the basal cations in these soils to enrich the base saturation of these soils. It could be noted from the fertilizers recommended for use in the country that, N and basal cations are lacking in some of the formulations whilst others have these elements. The paper concludes on the need to integrate the fertilizers that contains N and basal cations especially calcium to meet the standard ratio of K:Ca:Mg of 2:17:8 with those lacking these elements in order to increase the level of N and basal cations in the soil thereby increasing yields and also enriching the base saturation of the soil. Also for cocoa farmers to adopt the integrated application of all these tested fertilizers annually to ensure balanced nutrient supply for sustainable and competitive cocoa production from the Ghana cocoa belt.

[162] L. Bagny Beilhe, N. Mezatio, J.L. Tamesse. (2017). Diversity of cocoa pollinators in Cameroon. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 5.

Reference ID: 24692

Note: #24692e > #24507e

Abstract: The studies on cacao pollinators diversity and their efficiency in pollination dated back from 70's and 80's did not bring to a general consensus. Who are the true pollinators of cocoa? How do the pollinators vary according to agro ecological

conditions in the plots? Considering the disparity of knowledge on the main pollinators' families and ecology it is not possible to design systems with the most favorable habitats conditions for the pollinators communities, neither to quantify precisely losses due to the absence of some pollinators. Here we propose to analyze potential pollinators fauna and their pollination activities in a Cameroonian plantation. Insect traffic on cocoa flowers were followed up under different shade conditions with different litter characteristics. Many methods (i.e. direct observation or by a community approach through global fauna collection) in the plot contributed to establish a functional diversity of pollinators insects and to characterize pollination activities. A high diversity of insects visit cocoa flowers (Formicidae, Milichidae, Psilidae). Most of them spend less than one minute on the flower without exploring the interior of the flower. Species from Ceratopogonidae family were not found visiting the cocoa flowers. The addition of banana stem rot in the litter increase the abundance of some species (like ants) but decreases overall species richness and modify pollinators functional diversity.

[163] H.A. Cordoba, P. Bermeo, E. Torres. (2017). Caracterización de la comunidad microbiana cultivable presente en suelos cacaoteros en una zona productora de Colombia, como contribución al manejo de la fertilidad del suelo: Characterization of the cultivable microbial community present in cocoa soils in a production area of Colombia, as a contribution to the management of soil fertility. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 8.

Reference ID: 24693

Note: #24693e > #24507e (Note: journal is in Spanish)

Abstract: En Colombia, el cultivo de Cacao (*Theobroma cacao*) tiene un alto potencial agronómico. Sin embargo, presenta una baja productividad como resultado, en parte, a un manejo ineficiente de la fertilización. Programas de fertilización fundamentados en los requerimientos nutricionales del cultivo, en el conocimiento del papel que cumple la comunidad microbiana en el ciclaje de nutrientes y del efecto que casusa la fertilización sobre esta comunidad, permitirá contar con planes de fertilización más efectivos que aumentarían la productividad del cultivo de manera sostenible. Este proyecto tiene como objetivo realizar la caracterización morfológica y molecular de la comunidad microbiana cultivable asociada a la degradación de celulosa, solubilización de fosfastos (fosfato tricálcico, de hierro y aluminio) y fijación de nitrógeno libre en suelos y compost presentes en dos fincas cacaoteras ubicadas en el municipio de Nilo, Cundinamarca. Para ello, se colectaron muestras compuestas de suelo rizosférico de plantas de cacao provenientes de una finca con fertilización convencional o química y otra orgánica. Se determinó el logUFC por gramo seco de suelo como medida indirecta de la abundancia de microorganismos encontrada en cada muestra; se aisló y caracterizó los morfotipos aislados de bacterias y hongos encontrados en medios selectivos y se determinó su actividad enzimática cualitativa celulolítica y solubilizadora de fosfatos. La identificación molecular fue llevada a cabo para los morfotipos de bacterias y hongos que presentaron mayor potencialidad usando el marcador 16S e ITS1-4 del gen rADN, respectivamente. Se encontró que la abundancia de bacterias celulolíticas y hongos solubilizadores de fosfatos fue mayor en el suelo con manejo orgánico y el compost presentó la mayor diversidad y abundancia de microorganismos celulolíticos. Del total de 63 hongos con potencial de degradación de celulosa, *Fusarium* sp. obtuvo el mejor resultado con un factor de hidrólisis de 2.3. De un total de 38 hongos potenciales solubilizadores de fósforo, *Ustilaginpoidea* sp., presentó el mejor resultado con factor de solubilización en fosfato tricálcico de 1.5. Respecto a bacterias fijadoras de nitrógeno, la abundancia de

morfotipos fue mayor en la finca orgánica, aunque sin diferencias significativas, siendo el género *Bacillus* sp. el potencial fijador. Este estudio permite resaltar el papel de la microbiota nativa en el ciclaje de carbono, fósforo y nitrógeno, así como su contribución a la fertilidad natural de suelos cacaoteros y la productividad del cultivo.

[164] T. Wibaux, P. Bastide, D. Snoeck, J.C. N'Guessan Kouame, P. Jagoret. (2017). L'hétérogénéité de production entre cacaoyers en Afrique de l'Ouest et Centrale : Réflexions sur des voies d'intensification de la culture cacaoyère Africaine: Production heterogeneity between cocoa trees in West and Central Africa: Reflections on intensification of African Cocoa growing. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 9.

Reference ID: 24694

Note: #24694e > #24507e (Note: journal is in French)

Abstract: En Afrique de l'Ouest et Centrale, la culture du cacaoyer repose encore très largement sur l'utilisation de plants issus de semences, aux origines plus ou moins contrôlées. Malgré le constat communément admis que ce type de matériel végétal peut présenter une forte hétérogénéité, les problèmes liés à la variabilité de performance individuelle des arbres au sein des populations sont rarement abordés. En Côte d'Ivoire, premier producteur mondial de cacao, le brassage génétique résultant de la diffusion de semences hybrides et l'utilisation importante de leurs descendances libres par les producteurs semblent avoir amplifié cette hétérogénéité. Des questions se posent aujourd'hui quant à l'impact de cette variabilité au champ sur les performances globales des plantations et leur potentiel d'intensification.

A partir d'observations de la variabilité de production au sein de populations de cacaoyers issus de semences en Côte d'Ivoire et au Cameroun, nous proposons une étude visant à caractériser et à comparer l'hétérogénéité de production au sein de populations de cacaoyers dans différents cas de figure.

L'impact de l'hétérogénéité de production intra-population face aux stratégies actuelles d'intensification des systèmes de cacaoculture africains est discuté. Des premiers éléments de réponse ouvrent la voie vers de nouveaux critères d'évaluation des impacts des innovations techniques dans une démarche d'intensification écologique de la cacaoculture. Des voies d'étude de l'hétérogénéité de production au sein de verger dans différents contextes agroécologiques sont proposées.

[165] L.T. Phelan. (2017). Business Sustainability & Improved Soil and Water Management Practices in Cocoa Production Systems. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 12.

Reference ID: 24695

Note: #24695e > #24507e

Abstract: This paper argues that it is critically important for the global cocoa and chocolate industry to promote smallholder farmers' adoption of 'improved' soil and water management practices (SWMPs), given that their capacity to adapt to and mitigate the impacts of increasing temperatures, changing precipitation patterns, and frequent extreme weather events on production directly impacts the vulnerability or resilience of the cocoa value chain to climate change. As the management of soil and water resources is typically constrained by policy, market, institutional and governance challenges, information asymmetries, and farmers' mindsets and levels of knowledge, this paper explores the extent to which the adoption and continued use of 'improved' SWMPs is contingent on farmers' perception of costs incurred relative to benefits derived. Taking the view that industry has a key role to play in enhancing the long-term sustainability of cocoa production against a backdrop of growing concern over

climate change, and uncertainty regarding water availability and future climatic suitability of current cocoa growing areas, it offers original insights into how industry could facilitate farmers' adoption of 'improved' SWMPs. This paper argues that, in doing so, the industry could move towards closing the yield gap in a manner more compatible with its objective of realising 'climate-friendly' production; reduce its corporate ecological, carbon, and water footprint; adopt a sourcing strategy which is more ethical, and socially- and environmentally sustainable; and enhance its resilience and that of smallholder farmers - the primary link in the cocoa value chain - to climate change.

[166] E. Arévalo-Gardini, A. Farfán-Pinedo, C. Arévalo-Hernández, C. Baligar-Virupax. (2017). Selección de genotipos y/o accesiones de cacao silvestres y domesticados tolerantes a la acidez del suelo en el Perú: Selection of genotypes and/or accessions of wild and domesticated cacao tolerant to soil acidity in Peru. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 6.

Reference ID: 24696

Note: #24696e > #24507e (Note: journal is in Spanish)

Abstract: La acidez del suelo y toxicidad de aluminio son los factores más limitantes del crecimiento y productividad en los suelos ácidos del mundo. Alrededor de 70% del territorio peruano está compuesto por suelos ácidos. Con la finalidad de seleccionar genotipos de cacao tolerantes a acidez del suelo, se establecieron dos ensayos bajo condiciones de vivero en las estaciones experimentales del Instituto de Cultivos Tropicales, ubicado en la provincia y región San Martín, coordenadas geográficas 06°30'28" latitud sur y 76°00'18" longitud oeste, altitud de 333 m.s.n.m. Se cultivaron en macetas 60 genotipos y/o accesiones de cacao domesticados y silvestres, por un periodo de seis meses; siendo sometidas a dos tratamientos (Tratamiento 1: sustrato con pH= 4.7 y saturación de aluminio a 30 % y tratamiento 2: sustrato con pH= 5.8 y saturación de aluminio □ 0.25 %), para evaluar los efectos de la acidez de suelo y saturación de aluminio sobre el crecimiento, composición química y estrés fisiológico. En ambos tratamientos se mantuvo el suelo a capacidad de campo (33 Kpa) cercano al potencial hídrico de la planta.

Del total (60) genotipos en estudio el 60% son considerados tolerantes a suelos ácidos, entre ellos destacan ICS-1, ICS-95 (Colección internacional), CEPEC 2002, BS-01(colección Brasil), ICT-2142, ICT-1026 (colección ICT), AYP-22, PAS-91 (colección silvestre), entre otros; el 33% presentan tolerancia media, destacan POUND-12, UF-667 (colección internacional), PAS-105, PAS-100 (colección silvestre), ICT-1092 (colección ICT), entre otros y el 7% de genotipos considerados no tolerantes a suelos ácidos; UNG-73, AYP-20, UGU-126 y UNG-76 (colección silvestre). Los resultados mostraron que las variables conductancia estomática y biomasa seca total son los factores más importantes en la clasificación de cacao como tolerantes, moderadamente tolerantes y sensibles a la acidez del suelo. Por lo tanto, estas variables son cualidades o características de las plantas, confiables en la selección de genotipos y/o accesiones de cacao tolerantes a la acidez del suelo. A partir de los resultados obtenidos, la magnitud de absorción y transporte de nutrientes esenciales en los genotipos de cacao están influenciados por el nivel de toxicidad de aluminio en el crecimiento y la capacidad de los genotipos de cacao para tolerar la toxicidad de aluminio.

[167] S. Saj, P. Jagoret. (2017). Traditional cacao agroforestry in Central Africa can provide both respectable yields and levels of ecosystem services. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 8.

Reference ID: 24697

Note: #24697e > #24507e

Abstract: Since it moved toward - and tried to apply - intensive production patterns, cacao cultivation in Sub-Saharan Africa represents a major driver of deforestation. In Cameroon, most cacao is still cultivated in low-input traditional agroforests (CAFS). Such systems are still criticised for their presumed low cocoa production and seemingly economic and ecological inefficiency of their associated tree community (ATC). Yet, these household systems proved to be sustainable on the long run and marginally threaten forest land when compared to other producing regions or agricultural systems.

We studied a cAFS' 100-year chronosequence and checked for three ecosystem services they provide: (i) cacao production; (ii) carbon (C) storage in tree biomass and (iii) tree species conservation. Within this chronosequence we also studied a large array of associated trees densities (ATD) to better appreciate the role of competition on the services studied. We used, among other variables, basal area (BA) of the different components of the systems to gauge interspecific competition, functional group dynamics and cacao trees productive abilities.

Yields were highly depending on the age of the plot, the BA of the ATC and the structure of the cacao stand. Very long-term production seemed achievable if the BA of the cacao stand remained under 40% of CAFS' total BA. High accessible yields underlined a good production potential which was mitigated by interspecific competition. Yet, for a given level of competition some associated functional groups of the ATC were consistently related to higher cacao yields. Furthermore, CAFS were able to combine high levels of tree species richness with long-term conservation abilities and C storage. However, tree species conservation potential depended on ATD and remained difficult to appraise. C storage was highly dependent on large trees and not systematically mitigated by ATD - underlining the possible "uncoupling" of tree species conservation and C sequestration in those systems.

ATD reduction emphasised consistent shifts of functional traits / groups that are to alter CAFS functioning and ATC diversity of uses. Thus, a "rough simplification" - as regularly advocated to alleviate the competition between cacao stands and ATC - is most likely to impair traditional CAFS ecosystem sustainability. We argue that cacao productivity in these systems can be raised combining consistent rejuvenation and densification practices with site-specific intensification in terms of inputs and/or manpower. Such intensification would not compulsorily include ATD reduction and therefore would, at least partly, facilitate the preservation of some of the ecosystem services supported.

[168] L. Armengot, P. Barbieri, C. Andres, J. Milz, M. Schneider. (2017). Comparing productivity and profitability of agroforests and monocultures in Bolivia 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24698

Note: #24698e > #24507e

Abstract: The global demand for cacao has increased. To meet this demand, the cultivated area has been expanded in tropical forest areas and production has intensified by replacing traditional agroforestry systems with monocultures. This has led to a loss of biodiversity in cacao growing areas. The implementation of more sustainable agricultural practices for cacao production such as organic farming and

agroforestry systems depends on the profitability of such practices for the farmers. In this study, the productivity and profitability of agroforestry and full-sun monocultures (with 2 years of temporary shade with plantains) under organic and conventional farming are compared for the first five years of a newly established long-term trial in Alto Beni, Bolivia. Cacao and by-crops (plantain/banana) yields, costs, revenues, and labour demand were registered, and the return on labour, i.e. the return per working day, were estimated for each system.

The results showed that yields of cacao were about 40% higher in the monocultures compared to the agroforestry systems. But the revenues derived from the sales of banana and plantains economically overcompensate for this difference. So, the return on labour across the years was roughly twice as high in the agroforestry systems compared to the monocultures, even though agroforestry systems were more work demanding than monocultures, mainly because the time needed to manage the shade trees. Efforts for developing and making markets accessible for the farmers to sale by-crops such as bananas or plantains is then capital to ensure the profitability of the agroforestry systems.

Comparing organic and conventional management, cacao yields and return on labour were similar under both managements in the agroforestry systems. But in the monocultures, cacao yields were nearly 50% lower under organic farming. However, the return on labour was similar. This was mainly due to the lower cost of the organic management. These might have a strong implication for smallholder farmers, who usually hold limited savings and lack of access to credit. In addition, organic management was not more work demanding than conventional management.

[169] F. Ribeyre, C. Cilas, N. Motisi, P. De Reffye. (2017). Influence de la pollinisation sur le remplissage des cabosses du cacaoyer: Influence of pollination on the number of beans per cacao pod. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 6.

Reference ID: 24699

Note: #24699e > #24507e (Note: journal is in French)

Abstract: The production of cocoa, in number of fruits produced, and in number of seeds per pod is variable characters and rarely inheritable in cacao. Environmental factors therefore influence these characters. In this work, we aim to determine the mechanisms that explain the distribution of the number of beans per pod for a given clone.

We used a three-factor model adapted from Ph de Reffye's (1978) work: the number of effective pollen grains, the number of fertile eggs and the abortion of pods according to their filling. The selected Bayesian approach allows to consider the five parameters of the model as random variables. The model is applied to 10 clones planted in Togo in the same site (Zozokondji). The number of beans per pod was counted for each of the 300 pods harvested per clone.

The observed distributions of the number of beans per pod have different shapes depending on the clones. The model allows to correctly adjust the number of seeds per pod for each clone. The results show that the estimated parameters for each of the distributions are different depending on the clones. The three factors limit seed production per pod but are of variable importance depending on the clones.

The model provides access to parameters that are difficult to measure, such as the scarcity of pollen. The binomial distributions correspond to clones that have few pods poorly filled and for which pollen does not appear to be a limiting factor. Other distributions, more spread out or bimodal, correspond to clones for which the model estimates that effective pollen is rare. Our model shows that pollination is a factor

limiting the filling of pods for 8 of the 10 clones studied.

[170] L.F. Garcia, D.J. Davila, P.V. Garcia. (2017). Conservacion de la viabilidad de la semilla de cacao (*Theobroma cacao* L.) mediante deshidratacion y conservacion en frio: Conservation of feasibility of cocoa seed (*Theobroma cacao* L.) through cold dehydration and conservation. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 3.

Reference ID: 24700

Note: #24700e > #24507e (Note: journal is in Spanish)

Abstract: El ensayo se realizó con el objetivo de evaluar el efecto de la deshidratación de la semilla de cacao conservada en frío en la prolongación de la viabilidad del embrión del clon CCN-51. Las semillas se acondicionaron adecuadamente determinándose el peso fresco y humedad inicial promedio de dos muestras de 20 semillas. Las otras muestras se colocaron en la estufa a 35°C por distintos periodos de tiempo hasta obtener los contenidos de humedad finales (tratamientos). Los cuatro contenidos de humedad y tiempos de deshidratación fueron: T1 = 43.1% de H° y 0 h.; T2 = 39.2% de H° y 6.5 h, T3 = 30.5% de H° y 13 h y T4 = 22.8% de H° y 15 h. Las evaluaciones de la viabilidad de la semilla en laboratorio de cada tratamiento se hicieron a: 0, 30, 60, 90 y 120 días a una temperatura de 26±2°C, de conservados en un freezer a 15°C. Los resultados muestran que a los 90 días (3 meses) de conservación, los tratamientos T2 (39.2% de H°) y T3 (30.5% de H°), exhibieron 90% y 87% de germinación, respectivamente. A los 120 días (4 meses) de conservación, las semillas de los tratamientos T2 (39,2% de H°) y T3 (30,5% de H°), exhibieron porcentajes de germinación relativamente altos (83% y 83%), respectivamente; en cambio, los tratamientos T1 (43,1% de H°) y T4 (22,8% de H°), solo exhibieron 37% y 47% de germinación, respectivamente. En futuros ensayos se sugiere incluir un inhibidor hormonal que induzca la dormancia del embrión y prolongue la viabilidad de la semilla de cacao conservada en frio.

[171] O. Deheuvels, L. De Waal, L. Bagny Beilhe. (2017). How habitat heterogeneity affects pollinator's communities in cocoa-based agroforestry systems? 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 5.

Reference ID: 24701

Note: #24701e > #24507e

Abstract: In the humid tropics, a significant amount of the agricultural landscape where cocoa (*Theobroma cacao*) is grown is managed as agroforestry systems. As pressure to intensify cocoa production is increasing, the current worldwide trend for the intensification of cocoa production aims at significant reductions of the shade canopy. However, this trend implies losing the potential to produce valuable ecosystem services. Among those services, pollination is a limiting factor of cocoa production that has been investigated in the 70's and 80's essentially by trapping methods. The genus *Forcypomia* sp. is acknowledged to be the main insect responsible for cocoa pollination, when other insects such as ants and *Trips* sp. would play a secondary role. Regulation and habitat provision for cocoa pollinating insect communities are poorly documented in the literature. Most pollinating species are known from trapping methods in the immediate surroundings of the tiny cocoa flowers and no study has succeeded so far in observing and describing the insects actually visiting the inside of the cocoa flowers. In this investigation, we characterized habitats for pollinating insects at plot scale, in a 1.5 ha cocoa-based agroforestry system located in the Peruvian Amazon. Local climate, topography, leaf litter's biomass, composition and water content, cocoa trees and associated plant diversity and

structure, were described, as well as farmer's practices. Based on habitats characterization, we compared the pollinating insects' communities of two contrasted habitats within the same plot. We used a digital video recording system that allowed us to monitor and record all insects visiting cocoa from 6:30 am to 05:30 pm during the main flowering season. Each habitat was sampled in 2 or 3 different locations when possible and 20 to 30 flowers were monitored in each repetition, resulting in a total amount of 180 monitored flowers. Our results showed that the diversity and the frequency of insects visiting cocoa flowers are influenced by habitat quality. The heterogeneity of habitat often found in cocoa-based agroforestry system is mostly due to farmer's practices relying on opportunistic shade management. Pollinating insects' communities do not always rely specifically on the *Forcypomia* genus but rather depend on habitat quality. These results open good perspectives for the ecological intensification of cocoa production in Agroforestry Systems.

[172] M. Notaro, M. Martinet, R. Vaca, C. Schloeggel, P. Costet, C. Gary, O. Deheuvels. (2017). Participatory design of sustainable cocoa-based agroforestry systems – a methodological approach in the Dominican Republic. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 10.

Reference ID: 24702

Note: #24702e > #24507e

Abstract: Most of the cocoa production worldwide comes from small farms where cocoa is family-grown, often on highly diversified and small plots known as agroforests. In the Dominican Republic, the majority of cocoa is produced in such systems where undescribed cocoa cultivars are associated with more than 40 other plant species. These highly diversified and shaded cocoa orchards are the current strategy of a highly vulnerable and ageing population of farmers with low income and poor education level. As most of the next generation of farmers has already fled to the cities or has found a job in the flourishing tourism sector, there is an urgent need for solutions to make cocoa production attractive again. Government's strategies for cocoa intensification traditionally rely on genetic improvement and capacity building on crop, pests and disease management, both having proved to fail because of a lack of knowledge about actual farmers' practices and strategies. On the other hand, a recent alliance between Research and chocolate manufacturers has led to an innovative program for the design of sustainable cocoa-based agroforestry systems. The design methodology relies on a participatory approach based on the identification, quantification and ranking of the products generated by the current cocoa-based AgroForestry Systems (SAFc). The farmers' strategy of diversification where timber and fruit trees are cultivated with cocoa trees on the same plot, together with other annual and multiannual crops, is the basis of the participatory approach. Workshops with focus groups are conducted to deal with every aspect of cocoa production, from soil quality management to cocoa and shade plants management. These workshops lead to define a panel of options, or prototypes, where cocoa varieties are associated with a productive shade canopy linked to markets, in a design that allow an acceptable cocoa yield level together with other sources of income. The panel of agroforestry prototypes produced in these participatory workshops is finally tested for its economic resilience under different climate and prices scenario, before being implemented in the field. This innovative program seeks transforming the cocoa production sector in the Dominican Republic by making the cocoa based AFS an attractive alternative for the next generation of farmers.

[173] W. Niether, L. Armengot, C. Andres, M. Schneider, G. Gerold. (2017). Modifying micro-environmental growing conditions for the cacao tree by shade tree pruning. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24703

Note: #24703e > #24507e

Abstract: Cacao production systems are characterized by the occurrence of associated trees, the total stem density, the number of species, and the ecosystem services they provide. In a long term field trial in Alto Beni, Bolivia, comparing five cacao production systems, we monitored microclimatic differences at 1 m height between a cacao monoculture and two types of agroforestry systems with a fallow as a natural control. Cacao trees were spaced 4 by 4 m and associated trees were placed between the cacao rows in the agroforestry systems. Tree management included a regular cacao and shade tree pruning. We analyzed the effects of the main annual pruning on canopy openness, light and throughfall reduction, temperature fluctuations and vapor pressure deficits within the stand by comparing monocultures and agroforestry systems.

In agroforestry systems, trees reduced the radiation reaching the understory cacao tree due to their canopy cover, and intercepted precipitation. Under the agroforestry canopy it was cooler and the trees were less exposed to vapor pressure deficits.

The annual main pruning increased the canopy openness in an agroforestry system from 10 % to 31 %, photon flux density from 15 % to 63 % of total above canopy radiation and throughfall rate to the same level as in the monoculture while the stem density and tree species number of the agroforestry systems were maintained as before pruning. On the other hand, temperature fluctuations were not buffered anymore and vapor pressure deficit increased as high as in the monoculture.

Canopy openness decreased with increasing stem number. A high stem density and a closed canopy cover can cause light deficiency for the cacao tree, when radiation is reduced below the necessities for full photosynthesis. And that, in turn, affects productivity and yield. Pruning is an effective practice to manage the microclimatic conditions within the cacao production system without decreasing the number of stems in a stand. Especially under the viewpoint of climate change with increasing temperature and changes in precipitation patterns in cacao producing countries, agroforestry systems will provide less stressful conditions for the cacao tree and by pruning the light requirements can be managed. But the pruning intensity has to be adapted to local and seasonal climatic conditions to manage the ecosystem services of a shade tree canopy in favor of the cacao without losing its buffering function.

[174] M.K. Mera, R. Ramirez, E.I. Leiva. (2017). Importancia de la hojarasca en el cultivo de cacao (*Theobroma cacao* L.): Importance of leaf litter in the cultivation of cocoa (*Theobroma cacao* L.). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24704

Note: #24704e > #24507e

Abstract: Es ampliamente reportada la importancia de la hojarasca en los cultivos, en especial en el caso del cacao, sin embargo, la información cuantitativa del aporte de materia orgánica, de nutrientes, de carbono y las distintas funciones que cumple la hojarasca en el suelo, son ambiguas e insuficientes. La descomposición de la hojarasca es un proceso principalmente biótico influenciado por diversos factores, entre los que se encuentra la precipitación, temperatura, calidad de la hojarasca y poblaciones de macro y microorganismos. Se estableció la dinámica de la hojarasca bajo el cultivo de cacao durante 14 meses, en las zonas de vida bh-T (Uraba,

Colombia) en los genotipos LK-40, FCH-8 y CCN-51 y 13 meses en bh-PM (Maceo, Colombia), en FSV-41, FCH-8 y CCN-51, donde se estimó la tasa de descomposición y el aporte de nutrientes de la hojarasca. Para estimar la descomposición de la hojarasca se utilizó el método de contenedores de descomposición, los cuales medían 30 x 30 cm, con apertura de 7 mm de diámetro, se distribuyeron al azar por genotipo. Se cuantificó el contenido de nutrientes N, P, S, Ca, Mg, K, Fe, Mn, Cu, Zn, B, la respiración del suelo de acuerdo a la metodología propuesta por Alef et al (1995), se consideró la resistencia a la penetración, la humedad volumétrica del suelo y el carbono total. El aporte de hojarasca bajo un cultivo de cacao de 3 años en bh-T fue de 4 t.ha⁻¹ .año⁻¹ y en un cultivo de 5 años en bh-PM de 6 t.ha⁻¹ .año⁻¹, la hojarasca presentó un tiempo medio de descomposición en la zona de vida bh-T de 379.63 días, el aporte de nutrientes por la hojarasca al suelo fue en la zona de vida bh-T de 57.0 kg N, 6.3 kg P, 3.4 kg S, 76.2 kg Ca, 25 kg Mg, 24.1 kg K, 4.4 kg Fe, 2.1 kg Mn, 0.04 kg Cu, 0.4 kg Zn, 0.2 kg B y en bh-PM de 68.8 kg N, 4.9 kg P, 4.5kg S, 100 kg Ca, 33.2 kg Mg, 35.9 kg K, 1.6 kg Fe, 2.1 kg Mn, 0.04 kg Cu, 0.3 kg Zn, 0.4 kg B.

[175] C. Subía, C. Caicedo, D. Calderón, L.T.J. Pico, Y. Vargas, F. Fernández, N. Paredes, A. Vera, A. Díaz, S. Bastidas, D. Sotomayor, L. Lima, J. Intriago, C. Congo, M. Sánchez. (2017). Establecimiento de un ensayo en sistemas agroforestales de cacao con diferentes niveles de manejo en la amazonía ecuatoriana: Establishment of a trial in cocoa agroforestry systems with different levels of management in the Ecuadorian Amazon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp -.

Reference ID: 24705

Note: #24705e > #24507e

Abstract: Frente al cambio climático, pérdida de la biodiversidad, fragilidad de los suelos agrícolas, baja productividad de cultivos y pobreza en la región amazónica ecuatoriana, los sistemas agroforestales se presentan como una alternativa sostenible para la producción agrícola de las especies de mayor interés, entre las que se destaca el cacao al ser originario de la zona y por la importancia que representa como fuente de ingresos económicos a los agricultores. Se ha demostrado que la producción de cacao bajo sistemas agroforestales requiere de un manejo diferenciado respecto de los cultivos intensivos que se realizan principalmente en la Región Litoral del país, por lo que se propuso el establecimiento de un ensayo para evaluar cinco tipos de sistemas agroforestales con cuatro niveles de manejo agronómico. El experimento se sembró con los clones EET-103 y EET-95 a finales del 2015 en los predios de la Estación Experimental Central de la Amazonía del INIAP a 250 msnm que cubre una superficie aproximada de 9 hectáreas, se aplicó el Diseño de Bloques Completos al Azar con arreglo en franjas donde el cruce de los arreglos agroforestales con los manejos resultan en un total de 20 tratamientos con tres repeticiones, siendo la unidad experimental de 1296 m². Este estudio se realiza de forma multidisciplinaria con el objetivo de evaluar el comportamiento de las diferentes especies componentes de los sistemas agroforestales e interacciones bióticas y abióticas, por lo que se propuso evaluar variables edáficas, flujo de nutrientes, comportamiento de plagas y enfermedades, servicios ecosistémicos, rendimientos, calidad de la producción y el análisis económico. Los sistemas agroforestales resultaron de la combinación del cultivo de cacao con una especie forestal *Cedrelinga cateniformis*, con una especie frutal *Bactris gasipaes*, con una especie de servicio *Erythrina* spp, con la especie forestal combinado con una especie de servicio más un testigo a libre exposición solar, los que una vez establecidos fueron aplicados los diferentes niveles de manejo correspondientes a bajo orgánico, orgánico intensivo, medio convencional que se

refiere al manejo recomendado por INIAP para la zona y un manejo intensivo denominado alto convencional. En el ensayo se partió del análisis de suelo por parcela que resultó en la homogeneidad del suelo, para lo que se aplicó la fertilización de arranque y se han realizado básicamente labores de control de malezas, podas de formación del cultivo principal y manejo de los dos tipos de sombra, usándose el cultivo de plátano como sombra temporal.

[176] E.I. Leiva-Rojas, L. Sigindioy, R. Ramirez-Pisco. (2017). Dinámica hídrica del cacao (*Theobroma cacao* L.): Water Dynamics of Cocoa (*Theobroma cacao* L.). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24706

Note: #24706e > #24507e

Abstract: El cacao requiere de permanente aporte hídrico para mantener sus procesos fisiológicos y asegurar la productividad del cultivo. La literatura presenta que el cacao es particularmente sensible a la carencia de humedad y se manifiesta con marchitez y en casos extremos secamiento y pérdida de hojas. Por lo general, los países que producen alto volúmenes de grano, la precipitación anual es de 1500 mm y se presenta un período seco de dos a tres meses. El objetivo de la investigación fue conocer la dinámica hídrica en la relación suelo-cacao como herramienta para la toma de decisiones en el manejo del agua de este cultivo bajo las condiciones de bosque húmedo tropical (bh-T) en la región de Urabá Colombia. Se evaluaron árboles de ocho años de edad, seleccionando la hoja número 4 completamente sana de una rama terminal para cuantificar temperatura, transpiración (E), déficit de presión de vapor (VPD) y radiación fotosintéticamente activa (PAR) con el medidor de intercambio gaseoso CIRAS-3 PP Systems. Además, se midió humedad volumétrica del suelo y evaporación con el método del microlisímetro, se registró precipitación, temperatura, evapotranspiración de referencia, humedad relativa y radiación. Los resultados evidenciaron que, en época seca correspondiente a febrero con balance hídrico negativo, el clon ICS-95 alcanza hasta 3.23 mmol H₂O m⁻² s⁻¹, mientras que el CCN-51 transpira hasta 2.99 mmol H₂O m⁻² s⁻¹. En la época lluviosa julio y septiembre ambos clones disminuyen la transpiración, el clon CCN-51 con valores entre 2.26 y 2.37 mmol H₂O m⁻² s⁻¹, y el ICS-95 presenta mayor transpiración y variabilidad entre 2.52 y 3.65 mmol H₂O m⁻² s⁻¹. Con respecto a la evaporación se encontró que en el periodo seco se evaporó una lámina de 6.88 mm y en la época lluviosa 1.32 mm
Palabras clave: requerimiento hídrico, transpiración, evaporación, humedad del suelo.

[177] B.D. Adewale, D.R. Ojo, A.B. Nduka. (2017). Cocoa vegetative propagation in Nigeria: a search for other suitable rootstock clones. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 14.

Reference ID: 24707

Note: #24707e > #24507e

Abstract: The most suitable rootstock (from reports) for clonal cocoa propagation in West Africa has been F3 Amazon. A contest of this assertion would be necessary owing to the availability of many cocoa genetic resources in West Africa. Hence, the present research investigated the suitability of five other cocoa clones along with F3 Amazon as rootstock for three hybrid cocoa clones as scions. The factorial in Completely Randomized Design experiment had three replications. Pod and bean characters (Pod length, Pod girth, Pod weight, Pod thickness, Number of beans per pod and Weight of wet beans per pod) of the six clones were significantly ($P < 0.01$) different, moreover, some juvenile vegetative characteristics measured at intervals equally differed significantly ($P < 0.01$) too. Top grafting survival ranged between 15%

(F3 Amazon and CRIN Tc2) and 94% (WACRI and CRIN Tc1). Rootstock receptivity for the three scions ranged between 33% (F3 Amazon) and 73% (N38). Number of active nodes after top grafting was between one and three. CRIN Tc1 had the highest (75%) compatibility with the six clones. Furthermore, significant ($P < 0.05$) differences equally existed among the eighteen union combinations for three periodic intervals of leaf counts. In this experiment, three other clones (WACRI_S1, N38 and T101/15) had higher receptivity for union and regeneration of CRIN Tc1, CRIN Tc2 and CRIN Tc3 compared to F3 Amazon. This result approves the efficiency of other clones as better rootstock for top grafting in cocoa and formally informs that they could be alternative rootstocks (where they are available) for cocoa vegetative propagation instead of F3 Amazon.

[178] E. Arévalo-Gardini, M. Canto, J. Alegre, O. Loli, A. Alberto Julca, V. Baligar. (2017). Influence of agroforestry systems with cacao on soil properties (physical, chemical and microbiological) in Peruvian Amazon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24708

Note: #24708e > #24507e

Abstract: Growing cacao in agroforestry system generates an intensive productive use of the land and maintaining and improving the properties of tropical soils, and which play an important role in improving cocoa production and fertility of degraded tropical soils. A long term study was established in the EE “El Choclino”/Instituto de Cultivos Tropicales – ICT, Tarapoto, San Martin - Peru, with the objective to evaluate the impact of improved natural agroforestry systems (INAS) and in improved traditional agroforestry system (ITAS) planted with cacao genotypes on soil physical, chemical and biological (fungus and nematodes) properties. Both systems of cacao production were installed on area with 30-years of secondary forest. Field experiment consist of 10 cacao genotypes (ICS-95, UF-613, CCN-51, ICT-1112, ICT-1026, ICT-2162, ICT-2171, ICT-2142, H-35, U-30) and one spontaneous hybrid. After removal of the surface organic layer, Samples for soil an soil microbiological community analysis were taken at 0-20 cm depth in 2004 before the installation of the management systems and in 2012, the samples for fungus and nematodes community analysis were preserved in frozen at $-20\text{ }^{\circ}\text{C}$. Bulk density, porosity, and soil moisture content at field capacity and wilting point varied significantly during the years of assessment, under cocoa genotypes assessed. Soil pH, CEC, exchangeable Mg and sum of bases were highest in the INAS, than the ITAS. In both the systems, SOM contents, extractable P and K and exchangeable K, Mg and Cu and Al saturation, increased with years of cultivation. However, overall improvement of SOM and soil nutrient status was much higher in the ITAS than INAS. The levels of physical and chemical properties of soil under cocoa genotypes show a marked difference in both systems. The soil fungi and nematode diversity index varied significantly during the years of assessment under the systems assessed. The fungal communities showed significant changes due to soil disturbance influenced by the installation of INAS and ITAS with cacao genotypes. The population of soil nematodes associated to the Cacao was very varied, predominating the genus *Meloidogyne*, *Helicotylenchus* and *Pratylenchus*, while the population of non - phytopathogenic nematodes consisted of genera of the orders *Dorylaimida* and *Rhabditida*. Overall the edaphic conditions with a sandy loam texture, 60% sand, strongly acidic reaction, low organic matter ($<1.5\%$), and annual average temperatures of $26.4\text{ }^{\circ}\text{C}$, played a significant role in the observed soil fungal diversity parameters and functional fungal groups and were favorable for development of nematode population.

[179] I. Cortes. (2017). Poda coronal en el manejo integrado de la moniliasis en cacao criollo: Coronal pruning in the integrated management of moniliasis in cacao criollo. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24709

Note: #24709e > #24507e (Note: journal is in spanish)

Abstract: Cacao is one of the main crops of agricultural exports and is a generator of jobs, Of the 130 thousand hectares of cocoa that provide occupation around 450 thousand people, however productivity is greatly affected each campaign because of the high severity of the disease. Moniliasis of cocoa caused by the fungus (*Moniliophthora roreri*), causing economic losses greater than 50% to 80% of the production, its devastating effects have caused abandonment of the cacao areas of the Creole cocoa groups, an effect that puts the native genetic material in Peru as well as cocoa activity for fine aroma chocolate. The different strategies of traditional or chemical control are not sustainable economically, environmentally and socially. During five years, the experimental phase of the technology was developed, followed by three years of the validation phase (2004-2011) generated as a technological alternative to the conditions of the cocoa agroecosystem. It was developed through the integrated management of the disease, which allowed reduction of the severity of the disease, increase crop yield and environmental sustainability. The objective of this research is to determine the complementary integration of three management components which were integrated in a sequential, complementary and compatible manner, all established on an ecological, agronomic and socioeconomic basis in order to reduce the high severity of the disease moniliasis. This investigation allowed to evaluate the effect of the complementary integration of the developed components being. % reduction in the severity of the Moniliasis disease, in the increase of productivity, as well as the profitability analysis, performance risk analysis, cost risk analysis and sensitivity analysis comparatively with traditional management. There was significant significant difference in yield from 531 Kilos to 931 kg of dry cocoa Hectarea year, respectively. the average direct return obtained with the improved technology was 95.56%, and that is higher than that obtained with the control technology that only reached on average 53.11%, the incidence was reduced by 85% with the complementary integration research, being economically profitable.

[180] Y. Jaimes, C. González, J. Rojas, F. Ribeyre, C. Cilas, E.L. Furtado. (2017). Estructura poblacional y dinámica espacial y temporal de la monilia en diferentes ambientes: Population structure and spatial and temporal dynamics of the monilia in different environments. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24710

Note: #24710e > #24507e (note: Journal is in spanish)

Abstract: La monilia (*Moniliophthora roreri*) es la principal enfermedad biótica de T. cacao en Colombia. Se requiere conocer aspectos básicos de la biología del patógeno para generar estrategias de manejo. Se analizó la diversidad genética y estructura poblacional de 186 aislamientos de *M. roreri* procedentes de siete departamentos de Colombia utilizando 13 microsatélites. Se encontraron 152 genotipos multilocus (MLG) y poblaciones clonales de acuerdo al índice de asociación estandarizado (IA). Esto sugiere que monilia presenta recombinación asexual o parcial debido a la parasexualidad. Se reconocieron dos grupos genéticos entre los aislamientos mediante el método de agrupamiento bayesiano, diferenciándose por origen geográfico y altitud. En cuatro localidades se monitoreó la incidencia de la enfermedad a clones con diferentes grados de susceptibilidad en el tiempo y la parte espacial en

el CI La Suiza de Corpoica, entre julio de 2013 a mayo de 2015. Para el análisis temporal y espacial se empleó el modelo lineal generalizado con distribución de quasi-Poisson con función de ligación logarítmica. Se encontró relación significativa entre clones y localidades. El clon SSC61 presentó la mayor intensidad de la enfermedad y en San Vicente los menores niveles de la enfermedad en todos los materiales. De acuerdo al test I de Moran se evidenció una autocorrelación espacial de la enfermedad. La epidemia de monilia varía de acuerdo con la localidad, variedad y localización en el campo. Por ello, las prácticas de manejo se deben ajustar según los microambientes y la distribución de los materiales en el lote.

[181] G.K. Awudzi, R. Adu-Acheampong, S.K. Ahadzi, A.J. Daymond. (2017). Reassessment of the temporal distribution and damage of *Bathycoelia thalassina* (Herrich-Schaeffer) on cocoa in Ghana. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24711

Note: #24711e > #24507e

Abstract: In Ghana, insecticides are mainly used to control mirids the most important insect pest on cocoa. However, recent field observations show that *Bathycoelia thalassina* has also become a key pest. The present study was conducted to assess the current distribution and damage levels of *B. thalassina* with a view to developing an appropriate strategy for their control. Pest assessment involved visually inspecting *B. thalassina* inhabiting sites on cocoa trees to hand-height and recording their numbers between the hours of 6:30am and 9:00am. Immature but ripened pods, occasionally deformed were characterized as *B. thalassina* damaged pods. Ten farmers' farms were selected in each of Ashanti and Eastern regions of Ghana between January 2012 and April 2013. Three experimental plots at the Cocoa Research Institute of Ghana (CRIG) were also observed from September 2014 to September 2016. *B. thalassina* was present throughout the year in both the farmers' and CRIG plots. Peak population and damage occurred in April to June and again in September. Incidence of *B. thalassina* on hybrid cocoa was significantly higher than on the traditional Amelonado variety on some farmers' farms ($p < 0.01$). The occurrence of the pest all year round might partly be explained by the presence of pods on hybrid varieties throughout the year given that *B. thalassina* are pod feeders. A significant positive relationship was observed between rainfall and number of *B. thalassina* per tree ($r^2 = 0.35$, $p = 0.001$). High *B. thalassina* numbers and symptoms of their damage on pods between April and June suggest that the current recommendations for the spraying of insecticides on cocoa need revision and should include treatments in the first half of the year. Regular monitoring of pest numbers would also enable a more targeted pest control.

[182] G.A. Ameyaw, N. Chingandu, O. Domfeh, H.K. Dzahini-Obiatey, O.A. Gutierrez, J.K. Brown. (2017). Variable detection of cacao swollen shoots disease-associated badnaviruses by PCR amplification. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24712

Note: #24712e > #24507e

Abstract: Diagnosis of cacao swollen shoot disease (CSSD) is currently accomplished through visual symptom inspection, and indexing suspect-infected trees by grafting to a susceptible cacao indicator host. Much attention has now shifted to the use of polymerase chain reaction (PCR) amplification for reliable CSSD detection to complement ongoing resistance breeding research and strain diversity studies on

the virus. This study assessed the detection efficiency of eight novel PCR primer pairs designed based on sequence alignment of seven full-length CSSD associated badnaviruse genomes available in the GenBank database. Results from the PCR amplification indicated that detection was variable by primer pair, at 25% to 34% efficiency, for the 81 samples assessed. Phylogenetic analyses of the sequenced PCR products grouped the isolates into three major geographical groups (Ghana, Togo and Ivory Coast), albeit, with some outliers and majority (60%) of the samples clustering into CSSV group B. Pairwise distance analysis of the movement protein locus, using the Sequence Demarcation Tool, delineated three CSSD badnaviral species, based on the ICTV species cut-off, at $\geq 80\%$. The MP locus is a region of high diversity and so provides additional information about the extent of diversification within this viral region that can help understand distribution of MP-variants. It must however be pointed out that, it is not the taxonomically informative region for demarcation of badnavirus species. Sequences of two samples (isolates) collected from the Asankragwa and Boako districts in the Western region of Ghana where rapid decline has been observed recently were distinct from previously described CSSD isolates. The results indicate that greater-than-expected genomic variability occurs among CSSD-associated badnavirus isolates in Ghana, and underscore the need for elucidating the extent of genomic variability of the predominant CSSD-associated badnaviruses. This is to enable reliable diagnostics development for disease management and research objectives that have become essential to abate the current pandemic and devise long-term control strategies.

[183] M.Y. Meriam. (2017). Rat and squirrel management using wire mesh trap in cocoa area at CRDC Tawau and Madai Sabah Malaysia 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24713

Note: #24713e > #24507e

Abstract: More than 60 species of vertebrate reported as pest of cocoa worldwide. Some of them become a serious pest and give an impact on cocoa yield. Among them, mammalian pest in a rodent group such as rats and squirrels, are responsible for severe attack. The losses on cocoa yield are varied and differ from one country to another. It was estimated about up to 90 % due to the mammalian pest if left under control. This study was carried out at two Cocoa Research and Development Centre (CRDC) Tawau and Madai. This study was carried out using caught marked and release (CMR) technique by conventional method using wire mesh trap. From this study it was found that in the cocoa area size about only 1 ha, there were estimated about 40 rats and 33 squirrels when the first caught is only 9 rats and 22 squirrel respectively. Only less than 10 % of the total traps set up manage to caught the animals. In cocoa germplasm area at CRDC Tawau, trap set up using jackfruit bait is preferred by the rats and squirrel. Meanwhile, at CRDC Madai trap set up using palm oil as bait is preferred by the rat and squirrel. Generally, most of the rat caught in the trap set up on the ground and the squirrel trapped in the trap set up on the cocoa branch.

[184] A.J. Daymond, M.J. End, C.J. Turnbull, A.C. Wetten, P. Hadley. (2017). Safe movement of cocoa germplasm. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24714

Note: #24714e > #24507e

Abstract: In order to access sufficient genetic diversity for cocoa breeding it is often

necessary to import new genotypes. However, it is vital that such movement takes place within a quarantine framework to avoid introduction of pests and diseases. Safe movement procedures for cocoa germplasm are particularly important as many pests and pathogens of cocoa are confined to particular geographical regions.

The International Cocoa Quarantine Centre at the University of Reading (ICQC,R) is the main hub for global movement of cocoa germplasm. The centre has been in operation since 1985 and has worked closely with the international genebanks to provide a safe transit route for germplasm to institutes working on cocoa in over thirty different countries. Rigorous testing procedures include virus indexing through a combination of graft testing and laboratory screening using a suite of PCR primers. Approximately 400 accessions are currently held at the ICQC,R, with current lists and further information available on the centre's website (www.icgd.reading.ac.uk/icqc/), which has links to the International Cocoa Germplasm Database (ICGD) enabling recipients of material to access associated data.

The Technical Guidelines for the Safe Movement of Cacao Germplasm document, based on the original FAO/IPGRI Technical Guidelines, was updated extensively in 2010 by the CacaoNet Safe Movement Working Group to take into account a broader range of pest and disease threats. Subsequent revisions were made in 2014 and 2017. The guidelines serve as a reference point for the cocoa community and include information on the geographical spread of pests and diseases and sub-sections on particular pests and diseases that have been written by experts within those fields. Information includes physical symptoms, biology of the pathogen or insect pest and recommended quarantine measures.

The guidelines have been published on-line and in physical form in English, French and Spanish under the umbrella of CacaoNet and will continue to be updated to incorporate new knowledge as it becomes available.

[185] O.E. Cabezas, J.L. Gil, R. Gómez, C. Dávila, S. Morón, C. Ramírez. (2017). Estado fitosanitario en la producción de cacao (*Theobroma cacao* L.) en la región de Huánuco (Perú): incremento del impacto de *Carmenta foraseminis* Eichlin: Phytosanitary status in the production of cocoa (*Theobroma cacao* L.) in the Huanuco region (Peru): increased impact of *Carmenta foraseminis* Eichlin. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24715

Note: #24715e > #24507e (Note: This journal is in spanish)

Abstract: La región Huánuco representa el 4.8% de la producción nacional de cacao, siendo antes del 2015, las enfermedades en frutos uno de los principales factores que reducían en 20 a 42% los rendimientos; mientras que el daño por insectos plaga eran considerados no significativos. Desde fines del 2015, la presencia de un perforador de frutos, denominado localmente “Mazorquero del cacao”, ha adquirido gran importancia al causar el deterioro de los granos en las mazorcas cosechadas. Desde el 2016, en fincas de productores se evalúa la distribución, incidencia y daños causados por el “mazorquero” y enfermedades en mazorcas verdes y cosechadas. En una prospección de 165 fincas de 63 comunidades pertenecientes a las provincias de Leoncio Prado y Huamalíes, se determinó un 93% de ocurrencia del “mazorquero”, con 20 a 70%, de infestación en las mazorcas cosechadas; mientras que las enfermedades sólo representan el 10 a 20%. Las provincias de Puerto Inca, Marañon y Pachitea, que concentran el 1.4% de la producción en la región; aún son zonas libres del “mazorquero”. Este insecto plaga corresponde a la especie *Carmenta foraseminis* Eichlin (Lepidoptera, Sesiidae), reportado en Venezuela y Colombia como el “perforador del fruto de cacao”. La infestación en frutos se inicia a los 2.5 meses de

edad y la duración de su ciclo biológico es de 54 a 72 días. Se ha evaluado la pérdida de granos en daños directos e indirectos; la pérdida de granos por fruto a causa del daño directo es de 5 a 13%, mientras que el 70 a 90% se pierde a consecuencia del daño indirecto ocasionado por el ingreso de agua de lluvia, hongos, bacterias y otros insectos a través de los orificios de salida dejados por los adultos de *C. foraseminis*. Como estrategias inmediatas de control se han implementado podas en árboles de sombra y plantas de cacao, cosechas oportunas y tratamiento de los restos de cosecha; con estas prácticas se logra reducir la infestación en tre 10 a 15% en frutos cosechados, en la mayoría de los casos estos porcentajes corresponden sólo a daños directos. Con la finalidad de plantear un Manejo integrado de plagas (MIP) se están realizando estudios de sus enemigos naturales y ensayos de campo para evaluar la eficiencia de control de *Beauveria bassiana*, *Bacillus thuringiensis*, productos repelentes e insecticidas de baja toxicidad.

[186] R. Adu-Acheampong, G. Awudzi, R. Sem, P. Tagbor , S.W. Avicor. (2017). Habitat adaptation and population of nymphal and adult stages of two cocoa mirid species (*Distantiella Theobroma* [DIST.] and *Sahlbergella singularis* Hagl.). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24716

Note: #24716e > #24507e

Abstract: This paper describes part of a detailed study of the habitat and feeding-site adaptation and population of different life stages of two important cocoa mirid species, *Distantiella theobroma* (Dist.) and *Sahlbergella singularis* Hagl. (Hemiptera: Miridae). The study was conducted from 1981 to 2015 in the Eastern Region of Ghana (6.24.676 N, 0.52.074 W). The insects have low population densities, but strong environmental and habitat adaptability. They easily reach damaging population levels when environmental conditions are suitable. In field studies across a block of 8 ha plot in 34 years, 17,892 *D. theobroma* and 31,143 *S. singularis* in total were sampled with significant variability in dominance detected in habitat affinity between the two species. Nymphs were the most frequently detected stage (93.2%), and significant differences in abundance were detected in habitat preference. The old perception that *D. theobroma* had strong habitat affinity for pods than *S. singularis* could not be established in the present study. In contrast, 63.3% *S. singularis* and 54.7% *D. theobroma* were recorded on pods. Of all the samples collected on pods, green unhardened tissue (chupons), fan branches and trunks, mirids were present in the following order; pods (60.1%) > chupons (30.8%) > fan branches (5.1%) > trunks (4.0%). The widespread occurrence of *S. singularis* on different tissues reflects their broad habitat affinity and environmental range. Mirid numbers decreased with decreasing moisture and rising temperature. Peak populations occurred in January to March and August to December, but the two species were most abundant in September. The consistent low field observations of *D. theobroma* suggest that newer cocoa varieties are likely to contribute substantially to *D. theobroma* suppression, at least during the time period of the study when newer insecticide formulations were being widely applied nationwide for mirid control. For *S. singularis* that were relatively well represented across different parts of the plants, conventional insecticide application which is the main method of control may be fruitful when application is purposefully targeted at the pods and chupons.

[187] G.M. Ten Hoopen, M. Ndoungué, S. Petchayo Tigang, Z. Techou, C. Nembot, D. Fontem. (2017). *Trichoderma asperellum* PR11 soil treatments for *Phytophthora megakarya* control. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24717

Note: #24717e > #24507e

Abstract: Many *Phytophthora* species have a soil borne phase in their natural life cycles even though disease expression often occurs on aerial plant parts. In Cameroon, black pod rot of cacao (*Theobroma cacao* L.), is caused by *P. megakarya*. Primary inoculum of *P. megakarya* is located in the soil and with the onset of the rainy season, through rain splash, cacao pods become infected. From there the repeated cycles of pod infection and sporulation are at the origin of losses that can reach up to 80% when no control measures are in place. Thus, if this soil borne inoculum could be eliminated or prevented from reaching cacao pods, losses from black pod could be reduced considerably. In Cameroon, successful biological control of black pod rot has been obtained with the use of *Trichoderma asperellum* PR11 applications directed at cacao pods. The objective of this project therefore, was to investigate the possibility of using *T. asperellum* PR11 in soil applications in order to reduce black pod disease incidence due to *P. megakarya*.

The study was undertaken in a farmer's field near Nkolbisson, Centre region of Cameroon. *Trichoderma asperellum* PR11 was applied on a three weeks basis over two consecutive production seasons. A water only and a fungicide, Ridomil Gold 66 WP (6 % metalaxyl-M & 60 % CuO) treatment were used as controls. Weekly data collection consisted of counting all healthy and diseased pods. For each treatment, six replicate plots each containing 16 cocoa trees were used.

The absolute number of rotten pods and percentage pod rot was lower for *T. asperellum* treated plots when compared with the water control yet higher than the fungicide control, albeit these differences were not significant. There was however, a significant difference between treatments with regard to disease progression over time. Given that *T. asperellum* applications directed at cacao pods have shown efficiency in controlling black pod rot, the use of soil applications of *T. asperellum*, which slows disease progression, should therefore lead to additive effects when both control strategies are employed simultaneously.

[188] C. Nembot, P. Takam Soh, Z. Ambang, G.M. ten Hoopen, Y. Dumont. (2017). On the use of mathematical modelling to study the impact of phytosanitation on cocoa black pod disease caused by *Phytophthora megakarya*. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24718

Note: #24718e > #24507e

Abstract: Cocoa black pod rot, due to several *Phytophthora* spp., like *Phytophthora megakarya*, is the most important disease worldwide and the main cocoa disease in Africa, responsible for yield losses up to 50-80% in the absence of control measures. In this paper, we show how the use of Mathematical modelling and analysis can be helpful to better understand the mechanisms behind black pod rot epidemics and, also to identify gaps in our knowledge. Although black pod rot of cocoa is of major concern and much attention has been dedicated to it, there are still many questions regarding the factors that govern disease dynamics. For instance the relative importance of the two different sources of inoculum (primary and secondary) and spore dispersal dynamics are not well understood. In an attempt to provide answers to these (or some of these) questions, a temporal compartmental model has been developed and study,

that allows to investigate the impact of phytosanitary pod removal on cocoa black pod epidemics. Using the model analysis, we highlight two thresholds, related to the model's parameters, that drive all possible dynamics of the system, and show the relative importance of some compartments in the disease dynamics. Numerical simulations are also provided to illustrate our results and discuss the impact of sanitary harvest.

[189] L. Dongo, N. Chingandu, J.K. Brown. (2017). Molecular genomic diversity of previously undescribed cacao swollen shoot badnaviruses in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24719

Note: #24719e > #24507e

Abstract: Cacao swollen shoot disease (CSSD) is caused by a complex of badnaviruses and is a major pathogen infecting cocoa in West Africa, causing as much as 100% yield loss. The shortage of knowledge about these viruses, their distribution, and genomic variability has precluded the development of molecular diagnostic tools, essential for breeding programs aimed at developing cocoa tolerant or resistant genotypes. To characterize the genomic variation of CSSD badnavirus isolates in Nigeria, forty-nine cocoa leaf samples exhibiting virus-like symptoms were collected from the Oyo, Osun and Ondo states. CSSD-badnavirus presence was confirmed in 32 of 49 leaf samples (65.3%) by PCR amplification of a 577 bp region of the intergenic region (IR). The phylogenetic analysis resolved four clades, two well-supported and two unsupported major clades. About 29% were found to be closely related to those previously sequenced from Ghana and Ivory Coast (GenBank accessions), but none were related to the three published Togo isolate sequences. Two thirds of the isolates (60 of 84; 71%) from Nigeria grouped into a single clade composed of two groups or strains of a predicted, new CSSD-badnavirus species, thus far uniquely found in Nigeria. For all isolates combined, there was no apparent relationship between genotype and symptoms or geographical location of collection site, indicating genomic variability is distributed in cacao at the collection sites studied. The isolates that grouped with previously described CSSD badnaviruses are possibly the result of introductions of viral genotypes because of germplasm exchange among the three countries (Nigeria, Ghana and Cote d'Ivoire) during regional international germplasm projects. The full-length genome sequence was determined for selected isolates within the unique clade, revealing a previously unidentified species. The new species shared 70-75% nucleotide identity with other known CSSD badnaviruses, based on pairwise distance analysis of the taxonomically informative viral RT-RNase H region. The inability to PCR-amplify isolates from all symptomatic samples suggests the possible association of additional, undiscovered CSSD badnavirus-like isolates and/or other non-badnaviruses with symptomatic trees in Nigeria, highlighting the need for extensive studies to understand the full extent of CSSD badnavirus variability and other virus-like pathogens. This is the first report of a previously undescribed badnaviral genome associated with CSSD symptoms in cacao in Nigeria, herein designated, Cacao red vein-banding virus.

[190] I.S. Cantos, O.T. Freire, G.P. Monserrate, F.A. Puyutaxi, R.L. Solorzano, T.C. Mendoza, J.C. Motamayor. (2017). Selección de genotipos de cacao (*Theobroma cacao* L.) de alto rendimiento y con tolerancia a las principales enfermedades que afectan al cultivo en Ecuador: Selection of high-yielding cacao (*Theobroma cacao* L.) genotypes with tolerance to the main disease affecting the crop in Ecuador. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24720

Note: #24720e > #24507e (**Note: Journal is in spanish**)

Abstract: Se ejecutaron tres esquemas de cruzamientos para obtener progenies que permitan la selección de genotipos de cacao con alto rendimiento y tolerantes a las enfermedades. Los parentales se seleccionaron con base a criterios de productividad y sanidad a partir de colecciones vivas disponibles en la EET-Pichilingue y dos antiguas poblaciones híbridas en el mismo sitio (más de 50 años de edad). La primera población de progenies se obtuvo cruzando genotipos Alto amazónicos x Alto amazónicos; la segunda población se obtuvo cruzando genotipos de cacao de tipo Nacional x Alto amazónicos, mientras que la tercera provino del cruce entre genotipos de cacao tipo Nacional x Nacional. Al final se evaluó una población compuesta por 698 genotipos clonales de cacao, obtenidas de plántulas seleccionadas a partir de las poblaciones de progenies derivadas de los esquemas de cruzamientos antes mencionados. La evaluación se condujo en el periodo 2007-2013, los resultados permitieron la selección de plántulas híbridas y el desarrollo de al menos un par de clones (INIAPT 384 e INIAPT 484) dotados de precocidad, alta productividad y aceptable tolerancia a las enfermedades. Otros se han seleccionado por su valor como parentales para futuros planes de mejoramiento genético porque muestran un bajo nivel de afectación por escoba de bruja vegetativas (INIAPT 527, INIAPT 560 e INIAPT 526), otros a Moniliasis y escobas de bruja en el fruto (INIAPT-281, INIAPT-535, INIAPT-469, INIAPT-640, INIAPT-258 e INIAPT-647). El clon INIAPT 484 es auto compatible y cuenta con una capacidad rendimiento parecida a la de la variedad comercial CCN 51 en las zonas cacaoteras en que han sido comparados. Sus padres son cacaos silvestres Alto amazónicos y está dotado de un perfil sensorial muy particular. Los planes para entregarlo como una nueva variedad comercial en beneficio del sector cacaotero del Ecuador se encuentran avanzados. Este trabajo se cumplió dentro del marco del Convenio técnico-financiero INIAP-USDA/MARS que abarcó el periodo 2002-2013.

[191] E. Muller, S. Ravell, A. Wetten, J. Allainguillaume, F. Abrokwah, K. Kouakou, H.K. Dzahini-Obiatey. (2017). A next generation sequencing approach to elucidate CSSV species profiles. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 14.

Reference ID: 24721

Note: #24721e > #24507e

Abstract: Cacao swollen shoot virus (CSSV) is a member of the family Caulimoviridae, genus Badnavirus and is naturally transmitted to *Theobroma cacao* by several mealybug species. The virus is restricted to West Africa, while the cacao tree originates from the Americas, and has therefore most probably an indigenous origin on the West African subcontinent. The resultant disease has caused enormous economic damage in Ghana since the 1930's but was restricted to small areas in Togo and Côte d'Ivoire until recently. Now, renewed outbreaks in the main producing areas in Côte d'Ivoire, Ghana and Togo, cause serious yield losses and tree death. CSSV populations in West African countries are genetically structured into several different groups according to the diversity in the first part of ORF3 corresponding to

the movement protein. To unravel the extent of isolate diversity we used Illumina HiSeq technology and reconstructed 21 new complete genomes corresponding to the different groups of CSSV sequences. In this way we were able to compare the partial sequences of the RTase region (recognised as the taxonomical region by ICTV using a 20% threshold of nucleotide divergence to denote separate species), and thereby identifying nine different CSSV species. These results will now be used to improve the detection of all badnaviruses present in cacao leaf samples, a vital tool in efforts to halt the spread of the disease and confirm the healthy status of new plantations.

[192] S.O. Agbeniyi, D.O. Adeniyi, B.A. Ogundeji. (2017). Impact of climate change on timing and frequency of fungicide application for the control of phytophthora pod rot of cacao in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 13.

Reference ID: 24722

Note: #24722e > #24507e

Abstract: Cocoa production is an important economic activity in growing ecologies of Nigeria. the tree *Theobroma cacao* is prone to many diseases, among which pod rot caused by *Phytophthora* species is major and resulted into economic losses if not managed. Hence, an effective crop protection strategy is a main factor in cacao production in Nigeria. A regular application of copper- based fungicides during cropping season is being practice by farmers, but impact of climate change on the efficacy of these fungicides in management of *Phytophthora* pod rot is of majr concern. Field trials were conducted in 2014, 2015 and 2016 in Ibadan, Oyo State (Lat. 7.216oN, Long. 3.852oE) Nigeria. The study was conducted by application of copper-1-oxide 60% + metalaxyl 12% WP between May and October each year with three spray regime (fortnight monthly-spray, monthly-spray and no spray application). The regression statistics of the three weather parameters and black pod disease incidence indicates strong relationship and high R-square value; weather parameters significantly affect the black pod incidence in cocoa season in the trial location. Generally, there was a positive correlation between black pod incidence and relative humidity ($r= 0.19, 0.53$) except in year 2016 which recorded a negative linear correlation ($r= -0.19$). Negative correlation ($r= -0.54$) was recorded between black pod incidence and temperature in year 2014 and 2015, while it was positive ($r=0.53$) in 2016. The linear relationship between black pod disease and rainfall shows a negative correlation (-0.42). Effect of weather vis-à-vis relative humidity, temperature and rainfall was established both in temporal and spatial distribution of pod rot incidence in cocoa production. The effect of fungicide application on cocoa production was not significant and environmental factors influencing development of *Phytophthora* pod rot were both positively and negatively correlated in the trial location.

[193] R.A. Rios-Ruiz. (2017). Fitosanización como estrategia principal de manejo integrado de enfermedades en cacao en el Perú: tres décadas y media de estudios de epidemiología y eficiencia de control: Phytosanitation as the main strategy for integrated management of cocoa disease in Peru: three and a half decades of epidemiology and control efficiency studies. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24723

Note: #24723e > #24507e (Note: Journal is in spanish)

Abstract: Las enfermedades fúngicas, y su manejo, limitan severamente la producción de cacao en el Perú. En ese contexto, la UNAS inició un programa sistemático y consistente de: levantamiento de enfermedades, estudios de biología

de los patógenos, estudios epidemiológicos y de progreso, determinación de estrategias de control y evaluación de la eficiencia de medidas de control. Levantamiento de datos entre los años 1982-84 y 1987-89 identificó la Escoba de Bruja - EB (*Moniliophthora perniciosa*) y la Pudrición Parda - PP (*Phytophthora palmivora*) como las enfermedades más prevalecientes; sin embargo, este escenario cambió en los levantamientos de 1994-95 y 2005-06, que mostraron la Moniliasis - MO (*Moniliophthora roreri*) como la principal enfermedad, no raro causando pérdidas de 30 a 45% en la producción. Estudios de progreso; realizados entre los años 1988-90 para EB y PP, y entre los años 1993- 95/1996-98 (plantaciones híbridas) y entre 2005-07/2014-2016 (plantaciones clonales) para MO; identificaron que la intensidad de EB en brotes, cojines florales y frutos fue mayor entre abril-setiembre, mientras que la presencia de PP en frutos presentó mayores incidencias entre diciembre-abril. Por otro lado, el apareamiento de MO en frutos ocurrió durante todo el año, siendo mayor entre enero-julio. Como las EB secas en el árbol y los frutos enfermos con PP y MO son importantes fuentes de inóculo, la estrategia de control prioritariamente debe contemplar la remoción del material afectado, o sea la Fitosanitización. Definido esta estrategia, varios ensayos fueron efectuados para evaluar la eficiencia del control de EB, PP y MO. Entre los años 1988-90, el control de la EB fue satisfactorio cuando las escobas fueron removidas en setiembre y repase en diciembre o enero, así reduciendo los frutos enfermos y elevando la producción en 50%. Entre los años 1989-90, un ensayo de remoción de EB dos veces al año y remoción de frutos con PP demostró eficiencia técnica, dando como resultado mayor producción. Cuando se evaluó entre los años de 1995-96 dos frecuencias (7 y 14 días) de remoción de frutos con MO y PP, la remoción semanal redujo la incidencia de las enfermedades. En los años 1996-1998 y 2014-2015, la remoción semanal y la diferenciada (semanal de diciembre a mayo y a cada dos semanas de julio a noviembre) tuvieron efectos semejantes y redujeron la incidencia de la MO y aumentaron la producción. La fitosanitización es eficiente y los servicios de extensión deben aplicarlas correctamente para que los productores la adopten masivamente.

[194] M.M. Ndoungué Djeumekop, L. Blondin, C. Herail, G.M. Ten Hoopen, C. Neema. (2017). Combining field epidemiological information and genetic diversity to understand phytophthora megakarya dispersion in young cocoa plantations in Cameroon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24724

Note: #24724e > #24507e

Abstract: *Phytophthora megakarya* is the most virulent *Phytophthora* species reported on cacao (*Theobroma cacao*) in Africa. Previous studies have shown that it disperses mainly through rain splash from soil to pod where infection occurs. However, this mechanism takes place in already infected cacao plantations. How *P. megakarya* arrives in disease free plantations and what determines subsequent successful establishment are largely unknown. Disease monitoring with molecular tools can help to better understand dispersal mechanisms. The objective of this work is to identify the introduction pathways of *P. megakarya* in young cocoa plantations that could help predict and prevent further spread.

This study was carried out in Central-Cameroon on four cacao plantations, located in two distinct agro-ecological regions and established in 2006 on lands free of primary inoculum. These plantations were monitored on a weekly basis, from 2009 to 2016, for the presence of *P. megakarya*. As soon as first infections occurred, we started to collect *P. megakarya* in the field and from the surrounding environment. A total of 182

P. megakarya strains were isolated and genotyped using 14 polymorphic SSR markers.

Results indicate that disease incidence was relatively low from 2009 to 2016 and restricted to areas most conducive for disease development. The sampled *P. megakarya* populations showed limited genetic diversity. Thirty Multilocus Genotypes were obtained for all habitats but just one was constant over the years. Based on the spatial disease pattern observed in field and the occurrence of MLGs, it appears that the single constant MLG is the founder genotype which could be the main responsible for disease spread. The number of genotypes shared between the studied plantation and its surrounding environment suggests that inoculum originates primarily from neighboring cocoa plantations. Run-off water seems to be an important dispersal mechanism. The implications of these findings for *P. megakarya* control are discussed.

[195] E. Arévalo-Gardini, G.P. Sánchez-Torres, E. Flores, K. Markes, B. Leon-Ttacca, D. Zhang, L. Meinhardt, V. Baligar. (2017). Comportamiento de los clones de cacao de la colección del ICT frente a *Moniliophthora roreri* en Tarapoto, Peru: Behaviour of cocoa clones from the ICT collection in front of *Moniliophthora roreri* in Tarapoto, Peru. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24725

Note: #24725e > #24507e (Note: Journal is in spanish)

Abstract: La diversidad del cacao es la base fundamental para la búsqueda de resistencia a las enfermedades importantes como la moniliasis [*Moniliophthora roreri* (MR)], en la EE “El Chocloino” del Instituto de Cultivos Tropicales – ICT en Tarapoto con el objetivo de determinar el nivel de resistencia a MR, 39 genotipos de cacaos elites del ICT, provenientes de campo de productores de las provincias de Mariscal Cáceres y Tocache en el Departamento de San Martín, Perú; un genotipo susceptible EET-400 (control) y otro resistente ICS-95 (control), fueron sometidos a inoculaciones manuales de MR. Los genotipos seleccionados están distribuidos en bloques completamente al azar (DBCA) con tres repeticiones, cada genotipo es un tratamiento, en cada uno de ellos se obtuvieron tres frutos por polinización manual con polen del genotipo IMC-67, los frutos después de la polinización protegieron con bolsas plásticas hasta los tres meses de edad. El inóculo de MR se obtuvo a partir de frutos en estado de mancha, los que fueron lavados y desinfectados con hipoclorito de sodio al 2% por cinco minutos, luego se enjuagan con agua destilada estéril, después se cortan en rodajas de un centímetro de espesor; las rodajas se ponen dentro de placas petri y se incuban a temperatura ambiente para favorecer la esporulación. Las esporas se colectan en placas petri estériles para su transporte al campo. Los frutos obtenidos para la inoculación manual previamente son lavados con agua destilada estéril, luego en el centro del fruto se inocula MR por el método del alfiler a una concentración de 10^6 ufc.cc⁻¹, luego se protegen con bolsas poniendo un algodón con agua en su interior para mantener la humedad. A los 60 días de la inoculación se evalúa la severidad externa con una escala de 0=fruto sano, a 5= fruto esporulado. La severidad interna fue medida por la escala de 0= 0% de necrosis y 5 > 80% de necrosis interna; después de las evaluaciones los genotipos fueron clasificados de acuerdo a la severidad interna en: resistentes (0 - 1.25), moderadamente resistentes (1.26 - 2.50), moderadamente susceptible (2.51 - 3.75) y susceptible (3.76 - 5.0). Con los datos obtenidos se realizan el ANVA respectivo y las medias se comparan con Scott & Knott ($P \leq 0.05$). Del total de genotipos evaluados: 46.2% fueron resistentes, 30.8% como moderadamente resistentes, 17.9% como moderadamente susceptibles y 5.1% susceptibles.

[196] J.M. Barnett, R. Luxton, J. Keily, S. Tyler, S. Andrews, V. Mfegue, A. Wetten, M. Gilmour, J. Allainguillaume. (2017). Rapid and cost effective 'on-site' detection of cacao swollen-shoot virus (CSSV). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 3.

Reference ID: 24726

Note: #24726e > #24507e

Abstract: The UK chocolate industry is worth >£4 billion per year and demand is ever increasing. Most of the cocoa beans imported and consumed in the UK come from West Africa, where Cacao Swollen Shoot Virus disease (CSSD) has been identified as the main disease threat to productivity. Currently infected trees are identified by observation of characteristic leaf changes eg. red-vein banding and chlorosis and or the presence of swollen stems and roots. However it can take months to years for these symptoms to appear, during which time the infection is spread by the mealybug insect vector Pseudococcidae to surrounding trees. Immunoassays developed to detect Cacao Swollen Shoot Virus (CSSV) in infected leaves have not proved to be sensitive enough due to the high background interaction with plant material. Current laboratory tests available to confirm CSSV infection involve detection of CSSV viral DNA using polymerase chain reaction (PCR) technology (Dzahini-Obiatey, 2010 and Oro et al., 2012) this can currently only be performed in a laboratory environment by specialist staff.

The work presented is the strategy and progress of a multidisciplinary project that aims to develop a unique biosensor system for detection of presymptomatic CSSD, that is applicable as a field-based system. This will be achieved by developing an inexpensive novel assay system and integrated hand-held device for the detection of CSSV strain New Juaben, viral coat protein. The sensor is based on the novel arrangement of layers of porous materials through which the sample and reagents will flow. The basis of the assay is a novel immobilized binding reagent and a highly efficient reporter system. This is a platform technology with a range of possible adaptations and this is the first of many possible applications across the agri-food, environmental and biomedical fields. The assay developed will be validated in collaboration with the local branch of WCF Ghana-CocoaAction a private-public sector initiative.

[197] L. Armengot, J. Riedel, J. Milz, M. Schneider. (2017). Monitoring pest and diseases under different production systems in a long-term trial in Bolivia 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24727

Note: #24727e > #24507e

Abstract: Pest and diseases might strongly affect cacao production. Agroforestry systems are thought to have higher pod losses due to diseases compared with monocultures due to for instance higher air humidity and less aeration. The aim of this study is to compare the incidence of pest and diseases in different cacao production systems. The study was performed in 2016 in a long-term trial established in Bolivia between end 2008 and beginning of 2009 (www.systems-comparison.fibl.org). Five different systems were compared, i.e., monoculture and agroforestry systems under organic and conventional management and one successional agroforestry system with organic management.

Frosty pod rot (*Moniliophthora roreri*), one of the most important fungal diseases in the study area, was monitored every two weeks during the harvesting season, from April to October. All the infected pods by frosty pod rot were registered, and were cut to avoid the spread of the spores. The stage of the disease as well as the size of the

infested pods were recorded. At harvest, the incidence of other pest and diseases at pod level, was registered. Harvest was done regularly every two weeks.

The results show a very low percentage of pods affected by pests and diseases, about 10% in all the systems. Frosty pod rot was the most important disease, i.e., about 70% of the infested pods were affected by it. Approximately 80% of the pods diseased by frosty pod rot were cut before they entered the sporulation stage and most of them (70%) had a size between 7 and 15 cm.

Witches broom (*Moniliophthora perniciosa*) was the second most important disease, and it was followed by black pod (*Phytophthora*) and pods eaten by birds or mammals. The incidence of the mirid (*Monalonion disimulatum*), which was quite high in the study area some years ago was almost negligible.

The relative total number of pods affected by pests and diseases did not differ between production systems. The same results were found for the pods affected by frosty pod rot, which means that the more humid microclimatic conditions of the agroforestry systems are not promoting its spread and the sporulation of the spores. In the successional agroforestry systems there were more pods eaten by birds or small mammals, which indicates that this system supports the presence of these animals. In conclusion, good management practices (well-pruned cacao and shade trees), and especially a regular and early control of pests and diseases are essential to prevent high pod losses.

[198] W.P.N. Guessan, C.N. Gouamené, K.F. N'Guessan, A.R. Aka, G.M. Tahi, K. Coulibaly, K.E. Kassin, M.E. Assi, S.B. Guiraud, B.I. Kébé, B. Koné. (2017). La chenille *Achaea catocaloides* Guenee (Lepidoptera: Erebidae), une nouvelle menace pour la cacaoculture en Côte d'Ivoire: The caterpillar *Achaea catocaloides* Guenee (Lepidoptera; Erebidae), a new threat to cocoa farming in Ivory Coast. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24728

Note: #24728e > #24507e (Note: Journal is in French)

Abstract: Le cacao est un produit stratégique pour la Côte d'Ivoire qui en est le premier producteur mondial. La production nationale s'établit autour de 1 900 000 tonnes au cours de la campagne 2016-2017 ce qui représente 40 % de l'offre mondiale. Ce produit génère près de 38 % des recettes à l'exportation, et représente plus de 14 % du Produit Intérieur Brut. Cependant, la cacaoculture est sujette à nombreuses contraintes dont la forte pression des maladies et ravageurs. Les insectes nuisibles les plus dommageables sont les mirides et les foreurs des tiges qui causent 30-40% des pertes de production et contribuent à la dégradation du verger. Concernant les maladies, la principale est la pourriture brune des cabosses, due à *Phytophthora* spp. et responsable de pertes de production de 10-45%. Aussi, à toutes ces affections graves, s'est ajoutée la recrudescence du swollen shoot dans le verger cacaoyer ivoirien depuis 2003 dans les régions de Bouaflé et Sinfra. En plus des contraintes ci-dessus, en 2016, une invasion de chenilles a été signalée dans la zone de Taabo, Djékanou et Hiré (centre de la Côte d'Ivoire). Des travaux ont été réalisés en vue d'identifier l'espèce en cause, de déterminer la distribution géographique, évaluer les dégâts et faire les recommandations. Les travaux réalisés ont consisté en des entretiens avec des producteurs de cacao et des prospections dans des plantations de cacao, des collectes d'échantillons de chenilles pour observations au laboratoire. Comme résultats obtenus, la chenille observée a été décrite et identifiée. Il s'agit de *Achaea catocaloides* Guénée. Cette chenille s'attaque d'abord aux feuilles. Une chenille peut consommer une feuille entière de cacaoyer en 12 heures. Elle s'attaque également aux fleurs, aux chérelles et à un degré moindre aux cabosses.

Après 14 jours, une plantation de cacaoyer peut être entièrement détruite. La chenille a été observée dans 8 sous-préfectures réparties dans 5 départements et 3 régions de production de cacao. Les superficies atteintes par les attaques de cette chenille et entièrement traitées sont estimées à 20 368 ha. En dehors du cacaoyer, la chenille s'est attaquée au caféier, bananier, maïs et arachide autour des plantations de cacaoyer. Pour lutter contre cette invasion, une stratégie de gestion cette invasion a été élaborée. Quelques causes majeures qui auraient entraîné l'apparition et les fortes pullulations de cette chenille dans le verger de cacaoyer ivoirien sont discutées.

[199] W. Phillips-Mora, A. Mata-Quirós, A. Arciniegas-Leal. (2017). Generation of cacao clones with durable resistant against frosty pod rot (*Moniliophthora roreri* (cif. & par.)). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24729

Note: #24729e > #24507e

Abstract: Cacao diseases are responsible for substantial losses at global scale, now fostered by the unprecedented effects of climate change. In a perennial crop such as cacao mostly grown by small farmers with limited resources, breeding for resistance to pathogens must have top priority worldwide and the durability of resistance must become central to sustainable disease management.

CATIE is developing a strategy for the generation and deployment of varieties with durable resistance against *Moniliophthora roreri*, the causal agent of moniliasis or frosty pod rot (FP), the most devastating disease in tropical America. The strategy is based on the sequential accumulation of FP resistant genes with different geographic and genetic origin into single varieties (pyramiding). This takes advantage of the polygenic and predominantly additive nature of FP resistance in cacao. CATIE is applying a holistic approach to enhance cacao performance and durability of resistance by simultaneously generating genotypes that combined FP resistance with agronomic relevant traits such as high yield, good quality and resistance to black pod rot (*Phytophthora palmivora*).

Screening for resistance to FP began at CATIE in the early 1980's when a reliable inoculation method was consolidated. The method has been the cornerstone for the routine evaluation/selection of clones resistant/tolerant to FP. So far, 278 clones have been rated as resistant or moderately resistant. They belong or are related to the ten genetic groups described by Motamayor et al. in 2008. Since most of these clones originated in areas where FP was absent, it is probable that non-specific genes are responsible for FP resistance in cacao, and thus, they could protect the plant against other pathogens.

The Nacional, Criollo and Marañon genetic groups were the most important sources of FP resistant genes in the first stages of CATIE's breeding program. Some of the resulting clones were released for farmer use in Central America and Mexico starting in 2007. They are mainly planted in polyclonal layouts that maximizes cross-pollination among the inter-compatible clones and reduce the natural pressure and impact of FP. It has been pointed out that resistant genes will last longer in cultivar mixtures than in pure stand simply owing to reduced exposure to the pathogen.

The current plant breeding approach at CATIE utilizes classical breeding techniques to incorporate into the Program novel resistant genes from other genetic groups. CATIE's efforts have global relevance in view of the growing threat of the spread of FP into other continents.

[200] M.E. Leandro-Muñoz, P. Tixier, W. Phillips-Mora, S. Maximova, J. Avelino. (2017). Effects of microclimatic variables on the onset of symptoms and signs of *Moniliophthora roreri* for three cacao clones in a range of incomplete resistance. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 20.

Reference ID: 24730

Note: #24730e > #24507e

Abstract: Moniliophthora Pod Rot (MPR), caused by the fungus *Moniliophthora roreri* (Cif.) Evans et al is one of the main limiting factors of production in Latin America. Combating MPR is difficult due to the time-consuming and high cost recommended practices. This limitation is due to the current insufficient information on the biology and epidemiology of the pathogen. This research aims to compare MPR development, symptoms onset of the disease and fungal sporulation for three cacao clones in a range of incomplete resistance—Pound-7 (highly susceptible), CC-137 (moderately resistant) and CATIE-R4 (highly resistant)—and understand the influence of different microclimatic variables on this development. A total of 10,054 pods of 5-10 cm length were labelled during 55 weeks. Pods were observed throughout their lifetime: healthy, diseased with no sporulation, diseased with sporulating lesions, harvested. Incidence curves were built for all of the 55 generations of pods observed. Generations with nonconventional clonal behavior were selected in order to illustrate our hypothesis that environment, especially climate, could affect cacao's incomplete resistance to MPR. Differences in resistance among these clones lie in the number of resistant genes accumulated; however, the resistance of the three may be affected under certain environmental condition. Then, using GLMM, GLM and AIC surfaces we determined the specific period (when and for how long) where each microclimatic variable better explained the disease development. These new variables were combined in a complete GLMM and GLM, where only significant variables were retained. Water-related variables and temperature determine the symptoms expression for the susceptible clones, while, for the resistant clone CATIE-R4, only temperature showed up as explicative variable due to low numbers of CATIE-R4 pods showing symptoms. According to our models, there are two important events where resistance strategies could be developed for the cacao resistance strategy: fungal germination and penetration, where PAMP-triggered immunity (PTI) could be activated; and the symptoms onset, where the effector-triggered immunity (ETI) could occur. Success of these two events responds to the effect of humidity and temperature, respectively. We considered that none of the clones presents PTI as a defense mechanism against spore germination and penetration. Host resistance mechanisms resulting from the ETI are triggered internally and against colonization, where temperatures influence the success of these strategies. CATIE-R4 resistance strategy consists of the interruption of fungal colonization as an ETI strategy. This interruption also avoids fungal reproduction since the fungus has difficulties sporulating over CATIE-R4 pods, causing inoculum suppression.

[201] Phosagro. 2018. PhosAgro - Optimal plant nutrition for healthy diets: Product Catalogue: Sales Guideline. PhosAgro. Moscow, Russia. PhosAgro.

Reference ID: 24731

Note: S 32 #24731

[202] R.F. Zanin, M.P. Corso, C.S.G. Kitzberger, Maria Brígida dos Santos Scholz, Marta de Toledo Benassi. (2016). Good cup quality roasted coffees show wide variation in chlorogenic acids content. *LWT - Food Science and Technology*. 74 pp 480 - 483.

Reference ID: 24732

Note: H 8.1.5 #24732

Abstract: Chlorogenic acids (CGAs), of which the main representative is 5-caffeoylquinic acid (5-CQA), contribute to the quality and health benefits of coffee. However, excessive amounts of CGAs have been associated with a reduction in coffee cup quality. This paper describes the content of CGAs and 5-CQA in roasted coffees produced with different post-harvest processing (natural and pulped) methods and obtained from coffee quality contests in different Brazilian regions. These coffees differed in cup quality but the roasting degree was standardized. The amounts of CGA and 5-CQA were determined by HPLC. The CGA content ranged from 19.7 to 35.2 g/kg, and the 5-CQA content ranged from 8.0 to 16.4 g/kg. Overall, 5-CQA comprised 38–50% of the total CGA. No relationships between the chlorogenic acid levels and post-harvest process, location and/or cup quality were observed. Even when comparing roasted arabica coffees from different regions of Brazil and under different post-harvest processing, there was a wide variation in the total CGA (180%) and 5-CQA content (205%) for coffees with good cup quality with a similar roasting degree. Therefore, it is possible that coffees with good cup quality may also have a high CGA content.

[203] K. Velmourougane. (2011). Effects of wet processing methods and subsequent soaking of coffee under different organic acids on cup quality. *World Journal of Science and Technology*. 1(7) pp 32 - 38.

Reference ID: 24733

Note: H 8.1.5 #24733e

Abstract: Effects of soaking wet parchment coffee processed by three different demucilization methods (Natural fermentation followed by manual wash, Enzyme treatment followed by machine wash and Machine wash alone) under different organic acids viz., Citric, Lactic, Malic, Phosphoric and Ascorbic acids was studied at two concentrations of 0.0001 M and 0.001 M. Coffee processed by natural fermentation + manual wash + acid soaking had good body, fair acidity and slight bitter/medicinal taste. The added cost involved in use of acids for soaking wet parchment equivalent to a tonne of clean coffee at the conc. of 0.0001 M was found to be Rs.10/-, 10/-, 15/-, 20/- and 98/- for malic, phosphoric, lactic, citric and ascorbic acid respectively.

[204] D.F. Barbin, A.L.S.M. Felicio, D.-W. Sun, S.L. Nixdorf, E.Y. Hirooka. (2014). Application of infrared spectral techniques on quality and compositional attributes of coffee: An overview. *Food Research International*. 61 pp 23 - 32.

Reference ID: 24734

Note: H 8.1.5 #24734e

Abstract: During the last two decades, near and mid-infrared spectral analyses have emerged as a reliable and promising analytical tool for objective assessment of coffee quality attributes. The literature presented in this review clearly reveals that near and mid-infrared approaches have a huge potential for gaining rapid information about the chemical composition and related properties of coffee. In addition to its ability for effectively quantifying and characterising quality attributes of some important features of coffee such as moisture, lipids and caffeine content, classification into quality grades and determination of sensory attributes, it is able to measure multiple chemical

constituents simultaneously avoiding extensive sample preparation. Developing a quality evaluation system based on infrared spectral information to assess the coffee quality parameters and to ensure its authentication would bring economical benefits to the coffee industry by increasing consumer confidence in the quality of products. This paper provides an overview of the recently developed approaches and latest research carried out in near and mid-infrared spectral technology for evaluating the quality and composition of coffee and the possibility of its widespread deployment.

[205] S.C. Jackels, C.F. Jackels. (2005). Characterization of the Coffee Mucilage Fermentation Process Using Chemical Indicators: A Field Study in Nicaragua. *Journal of Food Science*. 70(5) pp C321 - C325.

Reference ID: 24735

Note: H 8.1.5 #24735e

Abstract: ABSTRACT: The recent “crisis” brought about by the collapse of the worldwide commodity coffee market has caused severe economic conditions for coffee producers in developing countries, including those of Central America. As a result, many coffee producers desire to improve the quality and consistency of their product to enter the specialty market. With the ultimate aim of assisting coffee producers in their quality control efforts, this study was designed to determine the feasibility of simple chemical measurements of the fermentation process on remote farms and to assess the potential of these measurements for assisting the producers in control and optimization efforts. Temperature, pH, and the concentrations of glucose, ethanol, and lactic acid were measured throughout the course of 7 coffee mucilage fermentation batches on 4 farms. In each batch, a pattern was observed in which the pH was initially in the range 5.5 to 5.7 and decreased sharply to about 4.6 as fermentation neared completion. Glucose concentration was seen to drop throughout the course of most batches, whereas either ethanol or lactic acid increased sharply near completion. The pH profile may prove useful in predicting the time of fermentation completion and in preventing over-fermentation of coffee mucilage.

[206] B.A. Goodman, C. Yeretjian. (2015). Free Radical Processes in Coffee II - Liquids (Chapter 68). pp 567 - 574.

Reference ID: 24736

Note: H 8.1.5 #24736

[207] W. Kim, S.-Y. Kim, D.-O. Kim, B.-Y. Kim, M.-Y. Baik. (2018). Puffing, a novel coffee bean processing technique for the enhancement of extract yield and antioxidant capacity. *Food Chemistry*. 240 pp 594 - 600.

Reference ID: 24737

Note: H 8.1.5 #24737

Abstract: Puffing of coffee beans, which induces heat- and pressure-derived physicochemical changes, was applied as an alternative to roasting. Roasted or puffed coffee beans with equivalent lightness values were compared. The moisture content was higher while the crude fat and protein compositions were lower in puffed beans than in roasted beans. The pH was lower and the acid content was higher in puffed beans than in roasted beans. The roasted beans exhibited greater specific volumes, while the puffed beans displayed greater extraction yields. The trigonelline and total phenolic contents were greater in puffed beans than in roasted beans resulting in an enhanced antioxidant capacity. Sensory evaluation of roasted and puffed coffee bean brews revealed that puffing did not affect the flavor or overall acceptance. The current study provides evidence that puffing is an alternative to roasting coffee beans with

various benefits.

[208] S. Avallone, J.M. Brillouet, B. Guyot, E. Olguin, J.P. Guiraud. (2002). Involvement of pectolytic micro-organisms in coffee fermentation. *International Journal of Food Science & Technology*. 37(2) pp 191 - 198.

Reference ID: 24738

Note: H 8.1.5 #24738

Abstract: During the fermentation of *Coffea arabica* L., the most frequently found pectolytic bacteria were *Erwinia herbicola* and *Klebsiella pneumoniae*. These micro-organisms produce pectatelyase which is unable to depolymerize esterified pectins of mucilage without previous de-esterification. Furthermore, the optimal activities are observed at pH 8.5 whereas fermentation conditions are acidic (5.3–3.5). The major lactic acid bacteria, *Leuconostoc mesenteroides*, do not produce pectolytic enzymes. Only a *Lactobacillus brevis* strain, rarely isolated with a low frequency, shows a polygalacturonase activity compatible with fermentation conditions. Mucilage decomposition seems to be correlated to acidification and not to enzymatic pectolysis. Inoculation with pectolytic micro-organisms allows microbiological control of the fermentation but does not speed up the process. It would be preferable to use lactic acid bacteria so that the pH remained as close as possible to natural fermentation, where acidification is important. This practice would standardize the coffee fermentation microflora and therefore control the end product quality.

[209] D. Giacalone, T.K. Degn, N. Yang, C. Liu, I. Fisk, M. Münchow. (2018). Common roasting defects in coffee: Aroma composition, sensory characterization and consumer perception. *Food Quality and Preference*. In Press. pp 1 - 33.

Reference ID: 24739

Note: H 8.1.5 #24739e

Abstract: The demand for high quality and specialty coffee is increasing worldwide. In order to meet these demands, a more uniform and standardized quality assessment of coffee is essential. The aim of this study was to make a sensory scientific and chemical characterization of common roasting defects in coffee, and to investigate their potential relevance for consumers' acceptance of coffee. To this end, six time-temperature roasting profiles based on a single origin Arabica bean were developed: one 'normal', representing a reference coffee free of defects, and five common roast defects ('dark', 'light', 'scorched', 'baked' and 'underdeveloped'). The coffee samples obtained from these beans were evaluated by means of (1) aroma analysis by Gas Chromatography-Mass Spectrometry (GC-MS), (2) sensory descriptive analysis (DA) by trained assessors, and (3) hedonic and sensory evaluation by consumers using a Check-All-That-Apply (CATA) questionnaire. Multivariate analyses of aroma, DA, and CATA data produced similar sample spaces, showing a clear opposition of the light roast to the dark and scorched roasts), with the normal roast having average values of key aroma compounds. The DA data confirmed this indications and showed the normal roast to have a balanced sensory profile compared to the other defects. Importantly, the normal roast was also significantly preferred in the consumer test (N=83), and significantly associated to positive CATA attributes 'Harmonic', 'Pleasant', and 'Balanced'. Taken overall, the results provide a solid basis for understanding chemical and sensory markers associated with common roasting defects, which coffee professionals may use internally in both quality control and product development applications.

[210] S. Oestreich-Janzen. (2013). Chemistry of Coffee. Book. pp 1 - 28.

Reference ID: 24740

Note: H 8.1.5 #24730e

Abstract: Chemistry of coffee, under the heading of biodiversity, covers both general and new aspects of interest: the challenge of an expanding cultivation of coffee; the rise and threat of species; coffee components developing in the fruit, at postharvest treatment, via the roasting process, in the preparation of the beverage; and, finally, the beverage's effects on humans.

[211] J. Pabón-Usaquén, J. Rodrigo Sanz, C. Oliveros. (2009). Manejo del Café Desmucilaginado Mecánicamente: Handling Mechanically Demucilaged Coffee. Secondary Manejo del Café Desmucilaginado Mecánicamente: Handling Mechanically Demucilaged Coffee. Federacion Nacional de Cafeteros de Colombia. Colombia. pp 1 - 9.

Reference ID: 24741

Note: H 8.1.5 #24741e

Abstract: La tecnología para el Beneficio Ecológico del café por vía húmeda, con manejo de los subproductos, BECOLSUB, fue desarrollada en Cenicafé para utilizar el agua estrictamente necesaria con el fin de realizar el beneficio de café y controlar más del 90% de la contaminación de las aguas. El desmucilaginator mecánico, DESLIM, que hace parte fundamental de esta tecnología, se encarga de remover el mucílago del café por medios mecánicos, con lavado y limpieza adicional de los granos, utilizando menos de un litro de agua por kilogramo de café pergamino seco. Con el desmucilaginator mecánico, trabajando los flujos de café y agua adecuados para cada modelo, se obtiene café lavado con más de 98% de remoción de mucílago, el cual puede llevarse inmediatamente al secador y así obtener café de alta calidad física y en taza (4, 7, 10).

[212] J. Rosero. (2010). Fermentacion. pp 1 - 23.

Reference ID: 24742

Note: H general #24742

Abstract: La fermentacion es un proceso catabolico de oxidacion incompleta, totalmente anaerobico, siendo el producto final un compuesto organico. Estos productos finales son los que caracterizan los diversos tipos de fermentaciones.

[213] C. Lambot, J. Husson, L. Bedon, S. Michaux, E. Goulois, C. Lindinger, P. Broun. (2010). Ethyl Formate as a Marker for the Fermented Off-Note in Coffee. 23rd International Conference on Coffee Science. pp 193 - 197.

Reference ID: 24743

Note: H 8.1.5 #24743

Abstract: An analytical method is developed for the determination of ethyl formate in roasted coffee. Coffee samples selected for this study are grown and processed in identical defined and reproducible conditions. After roasting of samples, a trained panel was able to detect samples having the fermented off-note among all samples. Ethyl formate is identified as a marker for fermented off-note in coffee (*Coffea canephora* and *Coffea arabica*) by means of gas chromatography combined with headspace solid phase microextraction (SPME-GC). A positive relation is therefore found between the sensory data and the chemical marker even for slightly fermented off-note samples identified by the sensory panel.

[214] M. Gibson, P. Newsham. (2018). Tea and Coffee (Chapter 18). pp 353 - 372.

Reference ID: 24744

Note: H 8.1.5 #24744

Abstract: Strictly speaking, tea and coffee belong in the herbs and spices section, but they are of sufficient importance to denote a small exclusive chapter to these popular beverages. It should come as no surprise really that among all the colas, sodas, wines, whiskies, and other popular beverages, tea and coffee are collectively the most popular and widely consumed drinks around the world today. Again, not surprisingly, tea and coffee contain numerous chemicals and chemical defenses that are common to both groups. Both tea leaves and coffee beans share a bitter alkaloid called caffeine and quantities of similar phenolic compounds. That said, they are both very different beverages. On the one hand, tea is a plant whose leaves are rich in enzymes that are carefully captured and preserved through minimal heat and drying. On the other hand, coffee starts its cycle as a seed, rich in proteins, carbohydrates, and oil, but unlike its opposite number, coffee is the product of a more robust process of high heat and grinding.

[215] N. Bhumiratana, K. Adhikari, E. Chambers. (2011). Evolution of sensory aroma attributes from coffee beans to brewed coffee. LWT - Food Science and Technology. 44(10) pp 2185 - 2192.

Reference ID: 24745

Note: H 8.1.5 #24745

Abstract: This study investigated the impact of degree of roasting, grinding, and brewing on the evolution of coffee aroma in green coffee beans from Ethiopia, Hawaii, and El Salvador. Using a highly-trained descriptive panel, 15 aromatic sensory attributes were identified and quantified in green beans, roasted beans (light, medium, and dark), ground coffee, and brewed coffee. Analysis of variance (ANOVA) and principal components analysis (PCA) were done separately for each preparation stage/step. The ANOVA showed that green beans had low coffee-related characteristics and were high in beany, green, musty/earthy, and sour aromatics, all of which carried through to the final brews. In general, the light roast was perceived to be sweeter in all stages and the darker roasts attained higher intensity of the typical 'coffee' attributes with which coffee consumers might like (coffee, roasted, burnt/acrid, and ashy/sooty). The aroma profiles generated were more influenced by the preparation stages and degrees of roasting than the coffee varieties.

[216] J.R. Santos, O. Viegas, R.N.M.J. Páscoa, I.M.P.L.V.O. Ferreira, A.O.S.S. Rangel, J.A. Lopes. (2016). In-line monitoring of the coffee roasting process with near infrared spectroscopy: Measurement of sucrose and colour. Food Chemistry. 208 pp 103 - 110.

Reference ID: 24746

Note: H 8.1.5 #24746

Abstract: In this work, a real-time and in-situ analytical tool based on near infrared spectroscopy is proposed to predict two of the most relevant coffee parameters during the roasting process, sucrose and colour. The methodology was developed taking in consideration different coffee varieties (Arabica and Robusta), coffee origins (Brazil, East-Timor, India and Uganda) and roasting process procedures (slow and fast). All near infrared spectroscopy-based calibrations were developed resorting to partial least squares regression. The results proved the suitability of this methodology as demonstrated by range-error-ratio and coefficient of determination higher than 10 and 0.85 respectively, for all modelled parameters. The relationship between sucrose and

colour development during the roasting process is further discussed, in light of designing in real-time coffee products with similar visual appearance and distinct organoleptic profile.

[217] J.S. da Rosa, O. Freitas-Silva, J.R.C. Rouws, I.G. da Silva Moreira, F.J.M. Novaes, D. de Almeida Azevedo, N. Schwab, R.L. de Oliveira Godoy, M.N. Eberlin, C.M. de Rezende. (2016). Mass spectrometry screening of Arabica coffee roasting: A non-target and non-volatile approach by EASI-MS and ESI-MS. *Food Research International*. 89 pp 967 - 975.

Reference ID: 24747

Note: H 8.1.5 #24747

Abstract: Coffee roasting needs precise control and innovative techniques that are economically viable to monitor and improve its consistency. In this study, mass spectrometry was used as a tool to screen chemical markers that appear on the surface of coffee beans (whole bean) along the roasting process. A non-target and non-volatile approach was used with an ambient technique (EASI) coupled to a single quadrupole mass analyzer to monitor roasting chemical changes in the coffee bean. Green (raw), soft, medium, dark and very dark roasted coffee beans showed a decrease in ions in the range of m/z 500–600, whereas an increase in abundance in the m/z 800–900 range was clearly observed in the most roasted coffees. A multivariate approach through PCA separated the different roasts in 70% of the variance using PC1 and PC2. The major ions in the range of m/z 500–600 were characterized by ESI-MS and also HPLC-fluorescence as the N-alkanoyltryptamides, surface constituents of coffee wax layer which are almost fully degraded in darker roasts. The ions in the range of m/z 800–900 were characterized as di- and triacylglycerols and its increase during the roasting process was systematically observed. For these classes of chemical markers of the roasting process, ESI-MS showed also the sodium and potassium adducts with good relative abundances.

[218] J.D. Bustos-Vanegas, P.C. Corrêa, M.A. Martins, F.M. Baptestini, R.C. Campos, G.H.H. de Oliveira, E.H.M. Nunes. (2018). Developing predictive models for determining physical properties of coffee beans during the roasting process. *Industrial Crops and Products*. 112 pp 839 - 845.

Reference ID: 24748

Note: H 8.1.5 #24748

Abstract: This study aims to evaluate and model the variation in the physical properties of coffee beans in isothermal roasting conditions, providing mathematical expressions that can be used for heat and mass transfer models for coffee roasting. Arabica coffee beans were studied with an initial moisture content of $0.129 \text{ kgw kgdm}^{-1}$ and roasted in a direct gas burning roaster. Five temperatures were set inside the cylinder (200, 220, 240, 260 and 280°C). The beans were roasted uniformly by suspension in the center of the drum. A thermocouple recorded the temperature every 5 s. X-ray microtomography was used to analyze the evolution of the internal matrix during the roasting process. The moisture content and physical properties (volume, surface area, and density) of each coffee bean were evaluated every 20 s. Empirical models were fitted to represent the physical properties as a function of the moisture content. It was observed that the volumetric expansion is isotropic at roasting temperatures above 220°C . The final bean volume can reach up to 1.8 times the initial volume. The bean density varied linearly with the moisture content, presenting a larger drop at a higher roasting temperature.

[219] T.A. Catelani, J.R. Santos, R.N.M.J. Páscoa, L. Pezza, H.R. Pezza, J.A. Lopes. (2018). Real-time monitoring of a coffee roasting process with near infrared spectroscopy using multivariate statistical analysis: A feasibility study. *Talanta*. 179 pp 292 - 299.

Reference ID: 24749

Note: H 8.1.5 #24749

Abstract: This work proposes the use of near infrared (NIR) spectroscopy in diffuse reflectance mode and multivariate statistical process control (MSPC) based on principal component analysis (PCA) for real-time monitoring of the coffee roasting process. The main objective was the development of a MSPC methodology able to early detect disturbances to the roasting process resorting to real-time acquisition of NIR spectra. A total of fifteen roasting batches were defined according to an experimental design to develop the MSPC models. This methodology was tested on a set of five batches where disturbances of different nature were imposed to simulate real faulty situations. Some of these batches were used to optimize the model while the remaining was used to test the methodology. A modelling strategy based on a time sliding window provided the best results in terms of distinguishing batches with and without disturbances, resorting to typical MSPC charts: Hotelling's T² and squared predicted error statistics. A PCA model encompassing a time window of four minutes with three principal components was able to efficiently detect all disturbances assayed. NIR spectroscopy combined with the MSPC approach proved to be an adequate auxiliary tool for coffee roasters to detect faults in a conventional roasting process in real-time.

[220] T.R. Lingle, S.N. Menon. (2017). Cupping and Grading—Discovering Character and Quality (Chapter 8). pp 181 - 203.

Reference ID: 24750

Note: H 8.1.5 #24750

Abstract: In 1984, the Speciality Coffee Association of America (SCAA) published the first text on cupping—Coffee Cuppers Hand Book written by Ted R. Lingle. This hand book helped transform the craft of cupping based on experience and practice, into the “science” of cupping, based on coffee's physical chemistry. The protocol and the arabica cupping form devised by the SCAA are highlighted in the chapter. The “Q” system and certifying of cuppers as “Q” graders help to understand the criteria for evaluating and classifying arabica coffee as specialty or otherwise. The core of this chapter is the expansion of the “Q” system to include robusta coffees and the efforts of the Uganda Coffee Development Authority and Coffee Quality Development Institute of the SCAA to develop the robusta cupping protocol and the cupping form. The factors influencing robusta flavors such as plant strain, altitude, shade trees, processing provide an insight into the diversity in the cupping quality of robustas. Traditional coffee grading methodology for both arabica and robusta coffees helps the reader to understand the defects in these species of coffee and how they are identified and classified in each producing origin. Although speciality arabicas will continue their journey in an upward spiral, the market for “fine robustas” will also develop and grow in parallel, with cupping playing a major role in distinguishing and identifying unique and distinctive coffees.

[221] M. Jeguirim, L. Limousy, M. Labaki. (2017). Environmental applications of coffee processing by-products (Chapter 9). pp 245 - 297.

Reference ID: 24751

Note: H 8.1.5 #24751

Abstract: This chapter explores the possibilities of using coffee processing by-products (e.g., coffee husks, coffee grounds and coffee beans) for environmental applications (e.g., adsorption of heavy metals, dye removal etc.). The elaboration of char from coffee processing by-products is presented and some applications devoted to the removal of cations and dyes from wastewater. The preparation of activated carbon (AC) is detailed. Chemical and physical activation methods are described as well as the characteristics of the AC obtained (textural, structural properties and surface chemistry). The role of the activation process on the adsorption of cations, anions, and organic molecules (pharmaceutical products, pesticides, micropollutants) contained in water is discussed. The use of AC for gas treatment is detailed, especially for acid pollutants (H_2S , NO_2) and CO_2 coming from postcombustion. The last part of this chapter is devoted to the preparation of AC for catalytic application (decomposition of organic molecules). For this specific application, AC has to be functionalized (sulfonation of the surface, or impregnation of K and Fe) in order to obtain catalytic properties.

[222] Z. Berk. (2009). Extraction (Chapter 11). pp 259 - 277.

Reference ID: 24752

Note: H 8.1.1.9 #24752

Abstract: Publisher Summary This chapter describes extraction, a separation process based on differences in solubility. A solvent is used to solubilize and separate a solute from other materials with lower solubility in the solvent. Solid–liquid extraction is a separation process based on the preferential dissolution of one or more of the components of a solid mixture in a liquid solvent. In this context, the term “solid mixture” is used in its practical meaning. In the case of solvent extraction of oil from oilseeds, for example, the oil is already in the form of liquid droplets in the raw material. In the case of extraction of sugar from beet, the sugar is in solution in the cell juices before contacting the solvent water. Additionally, a supercritical fluid (SCF) is a substance at a temperature and pressure above those of the critical point. Supercritical fluid extraction (SCFE or SFE) is an extraction process carried out using a supercritical fluid as a solvent. Although a number of substances could serve as solvents in SFE, carbon dioxide is by far the most commonly used extraction medium. Carbon dioxide near its critical point is a fairly good solvent for low-molecular-weight nonpolar to slightly polar solutes. However, the solubility of oils in supercritical CO_2 is considerably lower than in conventional hydrocarbon solvents. The solvation capability of SCFs is of considerable economic importance as it determines the extraction yields and the mass ratio of solvent to feed, hence the physical size of the system and the operating cost.

[223] F. Wei, M. Tanokura. (2015). Chemical Changes in the Components of Coffee Beans during Roasting (Chapter 10). pp 83 - 91.

Reference ID: 24753

Note: H 8.1.5 #24753

Abstract: Roasting is probably the most important factor in the development of the complex flavors that make coffee enjoyable. During the roasting process, the beans undergo many complex and poorly defined chemical reactions, leading to important physical changes and formation of the substances responsible for the sensory

qualities of the beverage. This chapter describes the chemical changes of the main components of green coffee beans: carbohydrates (oligosaccharides and polysaccharides), chlorogenic acids, quinic acids, trigonelline, proteins, peptides, and free amino acids, as well as the formation of aliphatic acids, lactones, aroma components, and melanoidins during the coffee bean roasting process, based on the results of recent studies.

[224] B.A. Goodman, C. Yeretjian. (2015). Free Radical Processes in Coffee I - Solid Samples (Chapter 67). pp 559 - 566.

Reference ID: 24754

Note: #24754e

[225] M. Anese. (2015). Furan and Other Furanic Compounds in Coffee: Occurrence, Mitigation Strategies, and Importance of Processing (Chapter 65). pp 541 - 547.

Reference ID: 24755

Note: H 8.1.5 #24755

Abstract: Roasting is responsible for the development of the desired taste and aroma in brewed coffee, but also for producing undesired compounds. Among these are furan and 5-hydroxymethylfurfural (HMF), which have been reported to be toxic and probably carcinogenic to humans. In particular, brewed coffee is the major source of furan and HMF in the coffee drinker's diet. Despite the great number of papers dealing with the influence of composition and process variables on furan and HMF formation and occurrence in coffee, very little information is available about the possible routes to mitigate furan and HMF concentrations in coffee, and thus consumer intake. In this chapter, the factors affecting the presence of furan and HMF in coffee as well as the technological interventions suggested in the literature to reduce their levels are reported. In particular, the mitigation strategies have been classified either as preventive or removal interventions. The former allow furan and HMF concentrations to be kept as low as possible during the roasting process; the latter are aimed to move away the already formed undesired molecules.

[226] J.O. Lawal, A. Taiwo Olayinka, B. Famuyiwa. (2017). Evaluation of the Vulnerability of Cocoa Farmers to Climate Change and Their Coping Strategies in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). pp 1 - 14.

Reference ID: 24756

Note: #24756e > #24507e

Abstract: The renewed quest for sustainable economic development which is synonymous with sustainable agricultural development and hence agricultural sustainability impelled this study titled "evaluation of the vulnerability of cocoa farmers to climate change and their coping strategies in Nigeria" the study was carried out in Ondo State. Multi-stage sampling technique was used to select a sample of 140 cocoa farmers from whom data were collected using structured and validated questionnaire. Data bothering on the respondents' socio-economic characteristics, such as age, years of farming experiences, household size, level of education as well as data on the various methods of farmers coping strategies were collected and analyzed with the use of descriptive statistical tools. The Ordinary Least Square multiple regression analytical tools were also used in determining the factors that majorly affect the farmers' vulnerability to climate. Result showed that the average age of farmers is 48years and with an average farming experience of 25 years. Result further shows that the study area has an average household size of six and an average yearly income of one hundred and eleven thousand, seven hundred and thirty naira. Majority

(30 farmers representing 21.58%) of the farmers experience drought and heavy rain as major climatic problem affecting cocoa production while 10% of them indicated heavy rain as major climatic problem. Factors such as farm size and year of farming experience has positive effect on the adaptability of the cocoa farmers to climate change and this are significant at 1 percent level. It was concluded that, efforts should be made at both micro and macro levels of government to improve on the mitigation and adaptive strategies of climate change available to farmers by making such more affordable, available and user friendly through extension education on the appropriate uses of such technologies in a more sustainable manner.

[227] C. Velázquez, A.M. Pérez Carvajal, L.A. Prado Barragán. (2016). Fruit Processing in Central America and Mexico (Chapter 2). pp 21 - 48.

Reference ID: 24757

Note: H 8.6 #24757

Abstract: The fruit production and processing in Central America and Mexico are discussed in this chapter, considering the volume of production, the competitiveness that this crops have in the region and world, and some sociocultural differences between the countries that help to explain the different aspects of the agro–industry. Central American countries are world leaders in agricultural production in tropical fruits like banana and pineapple, and Mexico places importance on agriculture also and is the world leader in products like avocado, coffee, and citrus fruits. The compositions of these major tropical fruits are analyzed and compared, considering not only nutrients, but also biological activities related to major molecules of special interest.

[228] K.G. do Livramento, F.M. Borém, A.C. José, A.V. Santos, D.E. do Livramento, J.D. Alves, L.V. Paiva. (2017). Proteomic analysis of coffee grains exposed to different drying process. Food Chemistry. 221 pp 1874 - 1882.

Reference ID: 24758

Note: H 8.1.5 #24758

Abstract: Many biochemical events occur inside grains during post-harvest processes. Several methods have been developed to relate the chemical composition of the coffee grain to the beverage quality, including identification of possible molecular markers for flavor characterizing. This study was aimed at evaluating the changes in the proteomic profile of pulped and natural *C. arabica* grains dried in a yard or dryer at 60°C. It was observed that fruits dried in a dryer at 60°C showed an altered proteomic profile, with a reduction in the most abundant proteins compared to those yard-dried grains. Among the identified proteins, those involved in the metabolism of sugars and stress response were highlighted. Results have shown that post-harvest processes that impact coffee quality are related to changes in protein abundance, indicating that proteomic analysis may be effective in the identification of biochemical changes in coffee grains subjected to different post-harvest processes.

[229] C.R.G. Brighenti, M.A. Cirillo. (2018). Analysis of defects in coffee beans compared to biplots for simultaneous tables. Revista Ciencia Agronomica. 49(1) pp 62 - 69.

Reference ID: 24759

Note: H 8.1.5 #24759e

Abstract: The demand for high quality coffee has become a consolidated criterion to achieve the best prices. Currently, cooperatives evaluate the coffee beans mainly through the particle size and the number of defects in the sample. This evaluation type generates counting data that originates contingency tables from different periods or

groups involving the same variables in the row and column and there may be interest in knowing if two tables are related and how much are related. These are the so-called combined tables. Statistical analysis techniques normally employed do not include categorical data in the combined tables. The aim of this study was to evaluate the incidence of different types of defects in samples of large flat coffee beans in two different harvests through the construction of biplots. The decomposition theory in single simultaneous values of double entry contingency tables was used. The results of defect counting in beans of 24 coffee samples from southern Minas Gerais, Brazil, were evaluated in the 2014 and 2015 harvests. Moreover, the association among defect types, considered within different total defect proportions in the sample, was verified based on the percentage in 17/18 sieves. It was also evaluated the relative sums of squares from the similarity and dissimilarity among the harvests. It is concluded that the simultaneous analysis technique allows better visualizing the common behavior and alterations among different harvests, distinguishing the defect types associated with each harvest and among different proportions of large flat beans

[230] S.R. Evangelista, C.F. Silva, M.G.P. da Cruz Miguel, C. de Souza Cordeiro, A.C.M. Pinheiro, W.F. Duarte, R.F. Schwan. (2014). Improvement of coffee beverage quality by using selected yeasts strains during the fermentation in dry process. Food Research International. 61 pp 183 - 195.

Reference ID: 24760

Note: H 8.1.5 #24760

Abstract: Coffee is an important commercial product to Brazil with its consumption distributed globally. The aim of this work was to evaluate the potential of yeast strains as starter cultures for dry fermentation of washed and non-washed coffee beans. Four yeast strains (*Saccharomyces cerevisiae* UFLA YCN727, *S. cerevisiae* UFLA YCN724, *Candida parapsilosis* UFLA YCN448 and *Pichia guilliermondii* UFLA YCN731) were inoculated separately in washed and non washed coffee cherries and in the control was not added any of the starter cultures. The fruits inoculated were spread on trays and placed on a terrace until the coffee beans reached 11% of moisture. Samples were collected for evaluation of the persistence of the inoculum by PCR-DGGE, and for chemical composition by HPLC and GC-FID. Sensory analysis was performed using the Temporal Dominance of Sensations (TDS) methodology. In all tests the yeasts persisted until the end of fermentation. There was no propionic and butyric acid production in concentrations that could compromise the final quality of the beverage. Forty-eight volatile compounds were identified, some were similar for green and roasted coffee. The most abundant class of compounds was alcohols (11–27%) followed by furan in roasted grains (~27%), and aldehydes (~13%) in green grains. The coffee inoculated with yeast showed sensations of flavors higher than the control coffee indicating increased sensory quality. The treatment with *C. parapsilosis* UFLA YCN448 showed dominance rate higher (near 1) for the sensation of caramel. In non-washed coffee those sensations were not pleasant in relation to the washed coffee, except when *P. guilliermondii* UFLA YCN731 was inoculated, suggesting that washing the fruit before the fermentation process positively influenced the final product quality. A coffee with special aroma of caramel, herbs and fruits could be produced using the starter cultures *C. parapsilosis* UFLA YCN448 and *S. cerevisiae* UFLA YCN727 in coffee processed by the dry method.

[231] L.S. Ribeiro, D.E. Ribeiro, S.R. Evangelista, M.G.C.P. Miguel, A.C.M. Pinheiro, F.M. Borém, R.F. Schwan. (2017). Controlled fermentation of semi-dry coffee (*Coffea arabica*) using starter cultures: A sensory perspective. LWT - Food Science and Technology. 82 pp 32 - 38.

Reference ID: 24761

Note: H 8.1.5 #24761

Abstract: Sensory analysis is one of the most important techniques to assess coffee quality. This study aimed to evaluate the sensory effect of inoculating two varieties of coffee (Ouro Amarelo and Mundo Novo) processed by a semi-dry method, with three yeast strains (*Saccharomyces cerevisiae* CCMA 0200 and CCMA 0543 and *Torulaspota delbrueckii* CCMA 0684, respectively) obtained from the Culture Collection of Agriculture Microbiology (CCMA). Two sensory analysis techniques were used (cup taste and temporal dominance of sensations analysis). Pulped coffee beans were inoculated with the respective yeast strains and compared to a non-inoculated (control) sample. Ouro Amarelo showed the highest scores for the attributes evaluated compared to variety Mundo Novo. The use of strains CCMA 0543 and CCMA 0684 improved the beverage sensations of both coffee varieties. Variety Ouro Amarelo inoculated with CCMA 0543, highlighted acidity and nuts sensations and Mundo Novo inoculated with CCMA 0543 and CCMA 0684 treatments, respectively, reduced the astringency sensation. The addition of CCMA 0543 starter culture highlighted the acidity of the coffee, improving the sensory results among the yeast strains, for both coffee varieties. The use of two sensory analysis techniques provided better descriptive and comparative analysis of the sensory characteristics of the treatments.

[232] W.K. Garde, S.G. Buchberger, D. Wendell, M.J. Kupferle. (2017). Application of Moringa Oleifera seed extract to treat coffee fermentation wastewater. Journal of Hazardous Materials. 329 pp 102 - 109.

Reference ID: 24762

Note: H 8.1.5 #24762

Abstract: Wastewater generated from wet processing of coffee cherries degrades stream water quality downstream of processing mills and impacts human health. The widespread popularity of coffee as an export makes this a global problem, although the immediate impact is local. Approximately 40% of all coffee around the world is wet processed, producing wastewater rich in organic nutrients that can be hazardous to aquatic systems. Moringa Oleifera Seed Extract (MOSE) offers promise as a local and affordable "appropriate" coagulation technology for aiding in the treatment of coffee wastewater. Field research was conducted at the Kauai Coffee Company to investigate the application of MOSE to treat coffee fermentation wastewater (CFW). Coagulation tests were conducted at five pH CFW levels (3–7) and MOSE doses (0–4g/L). After settling, TSS, COD, nitrate, nitrite, total nitrogen, and pH of supernatant from each test were measured. MOSE reduced TSS, COD, nitrate, and nitrite in CFW to varying degrees dependent on pH and dose applied. TSS removal ranged from 8% to 54%. Insoluble COD removal ranged from 26% to 100% and total COD removal ranged from 1% to 25%. Nitrate and nitrite reduction ranged from 20% to 100%.

[233] D. Dadi, E. Mengistie, G. Terefe, T. Getahun, A. Haddis, W. Birke, A. Beyene, P. Luis, B. Van der Bruggen. (2018). Assessment of the effluent quality of wet coffee processing wastewater and its influence on downstream water quality. *Ecohydrology & Hydrobiology*. 18(2) pp 201 - 211.

Reference ID: 24763

Note: H 8.1.5 #24763

Abstract: The objective of this study was to evaluate the impact of effluents from traditional wet coffee processing plants on the downstream water quality in Ethiopia. Composite water samples were collected from 11 rivers/streams associated with wet coffee processing plants at the peak hours of coffee processing, and water quality parameters were measured for the wastewater discharged as well as for the river water upstream and downstream of the discharge point. Acidic pH values were recorded for all plant effluents. The organic content of the effluents varied from one plant to another but was considerably high overall, with maximum values of 7200mg/L and 871mg/L for COD and BOD₅, respectively. This high level of organic content in the effluents depleted the oxygen content to the level of 0.25mg/L. The organic load and the presence of nutrients invoke a large risk of eutrophication. We found that variations in coffee bean soaking time, pulp fermentation, and the absence of appropriate treatment facilities were the major factors affecting the water pollutant parameters. In general, the measured values of effluent parameters significantly deviated from both the Ethiopian-EPA and US-EPA guidelines. Thus, water bodies and ecosystems located downstream of the traditional wet coffee processing plants are at an alarming risk of ecological disruption, and there may also be severe health consequences for the nearby residents. These findings raise the need for further research into the design and implementation of coffee waste valorization and treatment in view of sustainable coffee production.

[234] C.E. Mills, M.J. Oruna-Concha, D.S. Mottram, G.R. Gibson, J.P.E. Spencer. (2013). The effect of processing on chlorogenic acid content of commercially available coffee. *Food Chemistry*. 141(4) pp 3335 - 3340.

Reference ID: 24764

Note: H 8.1.5 #24764

Abstract: Chlorogenic acids (CGA) are a class of polyphenols noted for their health benefits. These compounds were identified and quantified, using LC–MS and HPLC, in commercially available coffees which varied in processing conditions. Analysis of ground and instant coffees indicated the presence of caffeoylquinic acids (CQA), feruloylquinic acids (FQA) and dicaffeoylquinic acids (diCQA) in all 18 samples tested. 5-CQA was present at the highest levels, between 25 and 30% of total CGA; subsequent relative quantities were: 4-CQA>3-CQA>5-FQA>4-FQA>diCQA (sum of 3,4, 3,5 and 4,5-diCQA). CGA content varied greatly (27.33–121.25mg/200ml coffee brew), driven primarily by the degree of coffee bean roasting (a high amount of roasting had a detrimental effect on CGA content). These results highlight the broad range of CGA quantity in commercial coffee and demonstrate that coffee choice is important in delivering optimum CGA intake to consumers.

[235] Malaysian Palm Oil Board, MPOB. (2017). Malaysian Oil Palm Statistics 2017 -37th Edition. Secondary Malaysian Oil Palm Statistics 2017 -37th Edition. Malaysian Palm Oil Board (MPOB). Malaysia. pp 1 - 205.

Reference ID: 24765

Note: H 8.1.1 #24765

[236] S.K. Sanyal, S.K. Dutta, T. Satyanarayana, K. Surekha, S.P. Datta, D.R. Biswas, K. Majumdar. (2017). Extended Summaries and Abstracts of the International Conference on Advances in Potassium Research for Efficient Soil and Crop Management. The International Conference on Advances in Potassium Research for Efficient Soil & Crop Management. New Delhi, India. pp 1 - 138.

Reference ID: 24766

Note: H 1.8 #24766

[237] C & CI. (2018). C&CI: Coffee and Cocoa International July 2018 Vol 45 No 3. 45 pp 1 - 50.

Reference ID: 24767

Note: S serial #24767

[238] V.C. Baligar, A.-A.F. Almeida, D. Ahnert, J.L. Pires, E. Arévalo-Gardini, R. Goenaga, Z. He, M. Elson. (2017). Impact of drought on morphological, physiological and nutrient use efficiency of elite cacao genotypes from Bahia-Brazil, Tarapoto-Peru and Puerto Rico-USA. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24768

Note: #24768e > #24507e

Abstract: Worldwide, drought is considered one of the most limiting abiotic stress factors for cacao growth, development and production. A series of greenhouse and growth chamber experiments were undertaken to assess drought effects on early cacao morphological and physiological traits and nutrient use efficiency of elite cacao genotypes of Brazil, Peru and Puerto Rico. Cacao genotypes showed varying degrees of intra-specific variations for growth (shoot and root biomass, leaf area, specific leaf area, stem height and diameter, root length, relative growth rate), physiology (photosynthesis, chl a/b, net assimilation rate, water use efficiency) and macro nutrient use efficiency under drought. Understanding of growth, morphology, physiology and nutrient use efficiency plant traits influenced by drought will facilitate identification of cacao genotypes tolerant to drought. Such drought tolerant genotypes could be useful in crop improvement programs to breed superior cultivars for drought stressed ecosystem.

[239] F. Ruf. (2017). Climate Variability, Deforestation and Cocoa Production shifts in Ghana. A threat or a source of innovation? 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 13.

Reference ID: 24769

Note: #24769e > #24507e

Abstract: In the former Gold Coast, cocoa was introduced in the late 19th century in the eastern, sub-humid part of the country. Then cocoa area expanded with a massive influx of migrants, moving into the western regions. The two main motivations of migration are clearly the thirst of land as a patrimony and the thirst of forest to get a successful and rapid growing of cocoa.

Nevertheless, as the western region is wetter, to what extent the climatic east-west gradient was a driving factor of the shifting cocoa frontier? The objective is to clarify this interaction between climate change, markets, public policies regarding migration and cocoa production on the other.

The questions are answered through the analysis of severe droughts that occurred at the regional West-African level in the early 1970s, mostly felt in the Sahelian regions, and in 1982/83 which also severely hit the forest/cocoa regions of Ghana (and Côte

d'Ivoire). The methodological principle is to combine rainfall data, elements of public policies, national and regional production statistics and social-economic surveys at village levels, giving insights of farmers' strategies at different periods.

The Sahelian drought in the early 1970s did not trigger migrations from Sahel to Ghana due to the Aliens Compliance Order in 1969, highly unfavorable to foreign migrants. The 1982/83 drought hit Ghana itself and clearly accelerated migration around 1983-85. Besides migration, the 1982/83 also played a role in replanting, followed by various innovations in replanting. The place which was liberated by fire was eventually taken over by a younger generation to replant cocoa or diversify towards rubber and oil palm. In coherence with the Boserupian principles, ecological change can lead to technical innovations, but also lead to renewed institutional arrangements such as the abunu contract. Both technical and social innovations played a role in the revival of the Ghanaian cocoa production and at the same time in diversification.

[240] I.C. Urueta, E.I. Leiva, R. Ramirez. (2017). Crecimiento y desarrollo del cultivo del cacao en bosque húmedo premontano (BH-PM) y bosque húmedo tropical (BH-T) influenciado por el fenómeno del niño: Growth and development of cocoa cultivation in humid premontane forest (BH-PM) and tropical humid forest (BH-T) influenced by El Niño Phenomenon. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24770

Note: #24770e > #24507e (note: Journal is in spanish)

Abstract: La producción promedio de cacao en Colombia presenta rendimientos inferiores a los 500 kg por hectárea al año, dado los bajos niveles de tecnología en el manejo agronómico del cultivo, en donde, una de las principales limitantes se encuentra en el desconocimiento del comportamiento de la fenología del cacao, es de resaltar que el crecimiento y desarrollo dependen de las condiciones climáticas, edáficas y de los requerimientos nutricionales. Sin embargo, los estudios indican que la alternancia del crecimiento en el trópico es influenciada por las condiciones meteorológicas, en la actualidad los fenómenos de cambio en el patrón de lluvias y temperaturas, han demostrado que son los factores de mayor efecto en el ciclo productivo del cacao. La humedad relativa y la radiación pueden modificar el comportamiento fisiológico de los cultivos. Se estudió el crecimiento y desarrollo del cultivo de cacao en bh-PM y bh-T, se registraron variables meteorológicas contrastantes en precipitación, temperatura, humedad relativa entre otros, que fueron relacionadas con las variables fisiológicas, durante los años 2015 y 2016. La caracterización climática permitió identificar que en estos periodos se presentó fenómeno del niño, confirmado por el Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM). Las variables reproductivas, floración, frutos de 0 a 2 meses, 2 a 4 meses, > 4 meses, frutos secos y el estado de crecimiento vegetativo, registrados mensualmente evidenciaron que el fenómeno del niño, seguido por un periodo con incremento en la precipitación afectaron estas variables, generando la alteración en el periodo vegetativo y disminución en la producción.

[241] C. Bunn, M. Lundy, P. Läderach, F. Castro. (2017). Global climate change impacts on cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24771

Note: #24771e > #24507e

Abstract: Global climate models project a continued increase of temperatures and changes in the spatial and temporal distribution of precipitation. These developments

have been shown to potentially impact cocoa production at its most important origins. The prospect of reduced cocoa yields on existing plantations renewed concerns that prevailing cocoa demand could drive producers even deeper into forests in other regions. Thus, prioritization of adaptation strategies for cocoa production and ecosystem conservation efforts will benefit from a global intercomparison of climate change impacts.

We modeled the global distribution of suitable climates for cocoa production under historic and future conditions. A database of cocoa occurrence locations and historic climate data was used to train the Random Forest classification algorithm. Model evaluation on historic data showed a high ability to correctly identify current production regions. The classifier was extrapolated on climate data from multiple global climate models for low, intermediate and high radiative forcing scenarios for mid and end of century projections.

Across all cocoa origins decreases of climatic suitability were projected. We find that available area of high suitability will be diminished while area with low suitability scores may be increasingly available. Furthermore, we find that projected impacts will be unlikely to make major cocoa producing regions unsuitable altogether. These findings could be partially explained with the high uncertainty of precipitation projections of global climate models. Temperatures were found to rise beyond historically experienced levels with high certainty. Areas most likely to retain high suitability were found in proximity of forest reserves where precipitation is most likely to remain sufficiently high. Climate change is thus likely to cause additional challenges to the sector at global scale. Research should focus on the impacts of high temperatures on quality and vitality of the plant, and the management of increased drought risk. Furthermore, the implications of changed climate conditions for regional pest and disease patterns remain largely uncertain.

We conclude that cocoa production will continue to threaten biodiverse forests across tropical countries. Cocoa production is a primary beneficiary of ecosystem services provided by resilient landscapes. Deforestation will exacerbate the effects of climate change by resulting in locally reduced precipitation, addition to emissions from land use change, and diminished barriers to pest and disease spread. Efforts to make cocoa deforestation free are therefore in the self-interest of the cocoa sector.

[242] F. Lahive, L.R. Handley, P. Hadley, A.J. Daymond. (2017). The impacts of climate change variables on vegetative and reproductive development of six genotypes of cacao. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24772

Note: #24772e > #24507e

Abstract: Whilst climate change has the potential to effect cacao production, limited research has been performed examining the impact these changes are likely to have on cacao physiology and yield, and the potential to identify genetic variation in responses.

Data is presented from the culmination of a five-year, greenhouse-based research project on the effects of elevated CO₂ (ECO₂) and water deficit stress in mature pod-bearing clones (CL 19/10, ICS 1, IMC 67, POUND 7/B, SCA 6, SPEC 54/1). Trees were grown for two years under CO₂ enrichment (700 ppm) and limited soil moisture. Overall, water deficit caused a reduction in photosynthesis, stomatal conductance and a number of growth parameters, and an increase in water-use efficiency (WUE). Stem diameter increment, photosynthesis, quantum efficiency and WUE increased significantly in response to ECO₂. The decline in quantum efficiency due to water

stress was less severe under the elevated compared to the ambient CO₂ treatment. Similarly, the water deficit treatment resulted in a significant increase in WUE which was further enhanced under eCO₂ in particular genotypes.

In mature clones, the effects of eCO₂ on pod development were not apparent until the second year of exposure when pod size increased under eCO₂. Water deficit caused a decrease in pod development in the first year of exposure but not the second, suggesting a potential adaptive response to water stress.

Genetic differences in fatty acid responses to eCO₂ were evident in SCA 6 and POUND 7/B. Genotypic variation in quantum efficiency, WUE and biomass partitioning between leaves and stems was also identified.

Overall, eCO₂ had a positive effect on a number of growth and photosynthetic parameters in cacao and it appears that eCO₂ could play an important role in mitigating against some of the negative impacts of water deficit stress through enhancement of WUE.

A new project is under way at the University of Reading (2017-2021) which builds upon this research. It aims to identify the physiological basis for tolerance to water deficit and high temperature stress. The interactive effects of elevated CO₂ and high temperature stress will be explored and screening tools will be developed to speed up the identification of more resilient germplasm. Using data from past and ongoing research, models will be developed to predict physiological and yield responses to varying climate conditions.

[243] V. Medina, B. Laliberte, S. Weise, J. van Etten. (2017). Exploring cacao genetic diversity for resilience to climate change – validating or contradicting current predictive models of production suitability. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 10.

Reference ID: 24773

Note: #24773e > #24507e

Abstract: A number of modelling studies predict that climatic change will negatively affect cacao productivity. The anticipated increased evaporative and water demands cannot realistically be compensated with increased irrigation in many cocoa producing regions, and moving to new production areas will imply a stimulus for deforestation. Thus, maximizing current production areas by integrating climate-ready management practices and stress-tolerant planting materials is an important part of the solution. But even though modelling studies paint a bleak future for cacao production, many of the tolerance mechanisms and adaptation responses in the genetic diversity of cacao are still little understood and greater efficiency and inclusiveness is warranted in such analysis. Before these modelling results can be translated into action, we must work towards better modelling approaches. This paper suggests important avenues to enhance the applicability and use of cacao climate modelling exercises. These gaps could be filled with future collaborative investigations, new areas of modelling and research to be further explored to identify novel and tolerant genetic material, using big data analysis and crowdsourcing.

To contribute to a more careful assessment of the available options, this paper also presents a summary of the current status of physiological research on cacao and abiotic stresses, focusing on increased drought, temperature and CO₂ levels, and the role of genetic diversity for greater resilience. It then examines climate impact studies relevant to cacao production. While it finds that these studies represent cacao physiological responses to climate-induced stresses in a narrow way and generally are short on validation or sensitivity analysis, the bulk of the data suggests that the extent of how drought or heat affects cacao is determined by the individual genotype's

inherent traits that allow avoidance, tolerance or escape. Thus, if the genetic diversity is fully exploited, for development of improved planting materials, both by research institutes and farmers, there is great potential for increased cacao resilience through selective breeding, and identification of tolerant genotypes. The key lies in tapping the genetic potential of cacao as a way to fully understand production limits and constraints.

[244] W. Niether, L. Armengot, N. Adamtey, M. Schneider, G. Gerold. (2017). Reciprocal effects of soil moisture dynamics and land-use systems with cacao in Alto Beni, Bolivia. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24774

Note: #24774e > #24507e

Abstract: Soil moisture is a function of topography, soil texture, vegetation and meteorological conditions and therefore highly spatial and temporal variable. Vegetation reduces evaporation from the soil but takes up water for production and transpiration. Vice versa, vegetation is affected by water availability. In many agricultural systems, especially in the tropics with distinct dry seasons, water availability limits production. Cacao production relies on a stable humid and warm climate. Drought causes a reduction in yield and long-term drought affects the vitality of the trees. Land-use systems with cacao range from monocultures to highly diverse agroforestry systems. Agroforestry systems have higher water needs for the dense vegetation than monocultures, but little information is available on belowground complementarity or competition for water.

We measured pedohydrological characteristics and soil moisture dynamics in four depths over a 30-months period in six different land-use systems, comprising cacao monocultures, cacao agroforestry systems and a fallow without cacao in a long-term trial in Bolivia. By excluding the influence of topography and soil texture, we could relate the spatial variability to the land-use system. Soil moisture was reduced in the upper 30 cm, implying less plant available water in the main cacao rooting zone in monocultures compared to agroforestry systems. In turn, agroforestry systems exploited water deeper along the soil profile, indicating a complementarity in water use between the cacao and the shade trees. On the other hand, soil texture and water retention capacity influenced the plant available water. In our case, the cacao yield of the same type of production system was not affected by the soil heterogeneity.

Additionally, we assessed the soil moisture and plant available water in a natural regrowth (fallow) of the same age as the cacao plantations. The regrowth had a high naturally developed stem density and a high canopy with low canopy openness. Soil moisture was lower over the whole profile than in the cacao production system, indicating a high water use of the fast growing pioneer species which dominated the stand in comparison to the slow growing cacao and to the multipurpose tree species in the agroforestry systems.

[245] P. Bermeo, J.E. Ospina-Noreña. (2017). Evaluación de los requerimientos hídricos actuales y futuros, bajo escenarios de cambio climático en cultivos de cacao en el municipio de Nilo, Cundinamarca. Colombia: Evaluation of current and future water requirements, under climate change scenarios in cocoa crops in the municipality of Nilo, Cundinamarca. Colombia. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24775

Note: #24775e > #24507e (note: Journal is in spanish)

Abstract: El clima y el recurso hídrico son elementos importantes para los sistemas productivos agrícolas como el cacao (*Theobroma cacao*). En la actualidad, en Colombia no se tienen registros de los requerimientos hídricos de este cultivo y tampoco se sabe cómo podrán variar estos en escenarios climáticos futuros. Por lo tanto, este estudio busca evaluar los requerimientos hídricos actuales y futuros bajo escenarios de cambio climático del cultivo de Cacao en el municipio de Nilo (Cundinamarca). Se utilizó una línea base con datos de las principales variables climáticas, provenientes del IDEAM desde 1975- 2005 (actuales), 11 modelos de predicción climática y los nuevos escenarios de emisiones de gases de efecto de invernadero, definidos como caminos representativos de concentración ó RCP's (por sus siglas en inglés) 2.6, 4.5, 6.0 y 8.5, con sus respectivos cambios esperados en las temperaturas y precipitación; para los años 2050 y 2070. También fue calculada la evapotranspiración potencial y se realizó el balance hídrico para hallar los déficits, excedentes, almacenaje y cambio de agua en el suelo, evapotranspiración real, además del cálculo del índice de Lang (Precipitación/Temperatura media) y el de disponibilidad hídrica (IDH). Para evaluar los requerimientos hídricos se tuvo en cuenta las variables climáticas, características fisiológicas del cultivo y el tipo de suelos de la región estudiada. Los resultados muestran aumentos en la temperatura media anual de 1.9°C y 2.4 °C, para los años 2050 y 2070, respectivamente y una disminución de la precipitación anual de 22% y 21% para los dos años mencionados. Se espera un aumento en el déficit del 152.8% y cambios en el índice de Lang, pasando de una zona subhúmeda a una zona Árida, y un índice de disponibilidad hídrica de adecuada a seca, lo que conlleva a un aumento del requerimiento de agua del cultivo del 49% para el 2050. Este estudio se convierte en una herramienta para diseñar estrategias de adaptación adecuadas en el municipio de Nilo frente a escenarios de cambio climático futuros.

[246] A. Camacho, E. Olaya, V. Vargas. (2017). Fertiriego en el cultivo de cacao alternativa de mitigación ante el cambio climático para la región Ucayali: Fertiriego in the cultivation of alternative cocoa of mitigation in the face of climate change for the Ucayali region. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24776

Note: #24776e > #24507e (note: journal is in spanish)

Abstract: El cultivo de cacao tiene gran importancia dentro de la economía peruana, por tratarse de un rubro que genera divisas y es fuente sostenible de materia prima para las industrias locales fabricantes de chocolates y derivados, creando trabajo para numerosos estratos sociales que intervienen en la cadena productiva, permitiendo que todos los actores que engloba a la producción primaria, manejo pos cosecha, comercialización e incremento de sus utilidades económicas.

Por lo que se hace imprescindible implementar un tipo de tecnología que no se encuentra instalada en los cacaotales, como consecuencia directa de su presupuesto económico limitado que no contempla la implementación de este tipo de infraestructura.

Esta investigación se viene ejecutando en la Estación Experimental Agraria Pucallpa, Anexo Campo Verde km.44. Provincia de Coronel Portillo, Distrito de Campo Verde, el fin es evaluar el efecto del riego y el uso de cobertores plásticos para plantones de cacao instalados sin sombra vegetal. Esta tecnología es la adopción de un trabajo compartido con la empresa privada Agroindustrial Triunfal.

Los objetivos son evaluar parámetros agronómicos, la optimización del uso del agua y los fertilizantes a través del sistema de riego por goteo, determinar las necesidades

hídricas del cultivo en la fase de instalación y validar la tecnología.

[247] R.K. Kalloo, L.A. Motilal, G.S.H. Baccus-Taylor, P. Umaharan. (2017). A Preliminary Investigation into the Effect of Variety on the Chemical Composition of Cacao (*Theobroma Cacao* L.) Pulp. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 97.

Reference ID: 24777

Note: #24777e > #24507e

Abstract: The development of flavours during cocoa fermentation is attributed to several components and cacao pulp has been shown to contribute to such developments and expressions of flavours. Selected cultivars were used to investigate whether the type of variety could influence the chemical composition of cacao pulp. Cacao pods from 30 accessions held in the International Cocoa Genebank Trinidad were selected at a uniformly ripened stage. The cacao pulp juice was extracted and analysed for pH, total titratable acidity, vitamin C and reducing sugars content. ANOVA and Tukey post hoc tests showed that there was significant variation ($P < 5\%$) for all pulp parameters amongst the accessions. The accessions within the Refractario cluster were highly varied in their chemical compositions and did not form any noticeable subgrouping from the Principal Component Analysis (PCA). The remaining accessions were also moderately scattered from the PCA highlighting the variability of the chemical composition of cacao pulp across varieties. This emphasises the need to understand the composition of cacao pulp for the maximum expression of flavours during processing and production techniques.

[248] A.B. Eskes, C.A.C. Rodriguez, D. Ahnert, D.4 Condori, A. Parizel, F. C. De Paula Durão, Matsigenkas, Chuncho growers in Peru. (2017). Advances on Genetical and Naturally Induced Variations for Fine Flavors and Aromas in *Theobroma cacao*. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 14.

Reference ID: 24778

Note: #24778e > #24507e

Abstract: The fine-flavor cocoa industry explores mainly six varietal chocolate sensory traits found in four traditional cocoa (*Theobroma cacao* L.) varieties. The role of cocoa pulp flavors and aromas has been ignored until recently when we showed that pulp sensory traits are correlated to fine-chocolate sensory traits. This opened the way for two important applications: 1. Selection of fine flavor cocoa varieties by fresh fruit sensory evaluations, and 2. Transformation of bulk cocoas into fine cocoas by aromatic substances added to fermenting cocoa masses ("TropMix" method). Progress for both applications is presented.

Firstly, growers of the native Chuncho variety in Cusco, Peru, make pulp juices from preferred trees. Pulp and raw bean evaluations of 226 farmers' preferred trees disclosed 64 unique and mostly multi-trait sensory profiles. Twenty-nine of the 40 flavors and aromas identified mimic those of known fruit and flower or spice species, such as mandarin, soursop, custard apple, cranberry, peach, banana, inga, mango, mint, cinnamon, jasmine, rose, lily, etc. Such large genetic diversity and mimicry is still unknown to occur in other cocoa varieties and also not in other commercial fleshy fruit species. The 14 sensory traits found so far in other cocoa varieties are all included in the Chuncho sensory trait panoply, suggesting that Chuncho is part of the "Centre of Origin" for cocoa flavors and aromas. Commercialization of the Chuncho sensory profiles should potentially boost the fine flavor cocoa industry, this time based on the Matsigenka and not on the Maya cocoa traditions.

Secondly, 55 "TropMix" fermentations to induce flavor and aroma variations showed

that:

- a. "Bulk" cocoas can be transformed into fine cocoas, even by the TropMix control treatment (bean pre-conditioning);
- b. Bulk cocoas fermented with eight fruit pulps and/or ten spices generated innumerable "extra-fine" sensory profiles.

Finally, in view of our results we feel the necessity to propose that the expression of "extra-fine" is used for cocoas displaying two or more fine-flavor sensory traits. Our results warrant important cocoa quality paradigm changes with repercussions for the fine cocoa production chain that potentially may become a mainstream cocoa production chain.

[249] F. Davrieux, J.J. Rakotomalala, S. Assemat, N.L. Raheinandrasana, I. Staub, F. Descroix. (2017). Adaptation du processus de fermentation aux contraintes locales. Application au cacao du Sambirano de Madagascar: Adaptation of the process of fermentation to local constraints applied to cocoa of sambirano of Madagascar. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24779

Note: #24779e > #24507e (journal is in french)

Abstract: Le cacao de Madagascar est réputé pour donner un chocolat fruité et aromatique. La production (4000-6000 tonnes) est concentrée dans la vallée du Sambirano. Le développement des traits de qualité et de saveur est lié à la variété de cacao, au type de sol, au climat, à la gestion des cultures et aux traitements post-récolte. La fermentation, en particulier, est considérée comme une étape clé dans le développement des arômes. Mais une grande partie de la production du Sambirano provient de petits producteurs avec de faibles quantités de cacao frais et pas d'installation pour les traitements post-récolte. Cette situation conduit à une absence ou à une mauvaise fermentation du cacao, ce qui entraîne une perte de qualité. L'objectif principal de cette étude était d'adapter la fermentation aux contraintes locales: faible volume de cacao frais et pas d'installation adaptée. Cette étude a été réalisée en utilisant le cacao de la plantation biologique Akesson à Ambanja. Au total, 80 échantillons ont été fermentés dans des conditions contrôlées. Trois fermenteurs différents ont été testés: des sacs, des bidons d'huile comestible et les bidons d'huile comestible isolés avec des feuilles de bananier. Chaque fermenteur a été testé pour 3 volumes de cacao: 5, 10 et 20 litres. Des échantillons de contrôle supplémentaires ont été fermentés dans les fermenteurs industriels d'Akesson. La qualité des fermentations a été estimée au travers des profils de températures de fermentation, du test à la coupe, de la couleur et des profils biochimiques et sensoriels. Les paramètres physiques de la fermentation (températures et rendement) et les critères biochimiques (polyphénols et azote ammoniacal) indiquent qu'une fermentation a bien eu lieu dans tous les cas. Les profils sensoriels montrent que la note qualité globale est similaire pour tous les cacaos, sans différence significative avec les contrôles, à l'exception de l'essai "Bidon-isolé - 20 litres" qui a été noté de moindre qualité en raison d'un goût alcoolique plus élevé. Ces résultats permettent le transfert de bonnes pratiques de fermentation aux agriculteurs, avec du matériel disponible partout à un prix minimum. Cette approche se traduira par une mise à niveau de la qualité, similaire aux plantations industrielles, et nous l'espérons, une croissance des revenus des petits agriculteurs.

[250] S. Mujaffar, D. Sukha, A. Ramroop. (2017). Comparison of the drying behavior of fermented cocoa (*Theobroma cacao* L.) beans dried in a cocoa house, greenhouse and mechanical oven. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24780

Note: #24780e > #24507e

Abstract: The objective of this study was to compare the drying behavior of fermented cocoa (*Theobroma cacao* L.) beans dried in a traditional cocoa house replica and greenhouse-type dryer with that of beans dried in a mechanical cabinet oven at 40°C (drying for 8h with a rest period of 16h). Weight measurements were taken at the start of drying and at regular intervals during the drying process, and drying continued until there was no change in bean weight. Moisture content, water activity, pH and color attributes were measured at the start and at the end of drying. Sensory evaluation of the cocoa liquor was done on the dried samples. Initial moisture content of beans averaged 1.04 g H₂O/g DM (50.9% wb). Final (equilibrium) moisture values attained after 11.4 days of drying in the cocoa house and the greenhouse and after 9.3 days of drying in the oven averaged 0.60, 0.70 and 0.50 g H₂O/g DM (2.3-4.6 % wb), respectively. During the first 3 days of drying, the decline in moisture content was similar in oven-dried beans and beans dried in the cocoa house, while the decline in moisture in beans dried in the greenhouse was not as pronounced. The industry-accepted moisture of 6-8% (wb) was attained after 4.8, 6.3 and 4.3 days of drying for beans dried in the cocoa house, greenhouse and oven, respectively. Drying rate constants for the first day of drying in the cocoa house, greenhouse and oven averaged 0.1194, 0.0840 and 0.1124 1/h, respectively, and diffusivity values averaged 3.36, 2.37 and 3.17 x 10⁻¹⁰ m²/s. Moisture ratio curves were successfully modelled using the Hii et al. model. With respect to quality attributes, the pH of the cotyledon and testa of fresh (undried) beans averaged 4.98 and 4.86, respectively. Cotyledon pH did not change significantly with drying method, but was highest at 5.22 in oven dried beans. The pH of the testa of beans dried in the greenhouse was significantly higher than for the other drying methods. Hue angle (°) was higher in dried beans compared with fresh beans, with no effect of drying method seen.

The results of the sensory evaluation exercise revealed very little differences in bean acidity and astringency, with beans dried in the cocoa house obtaining a moderately higher score for cocoa flavor compared with beans dried in the greenhouse and in the oven.

[251] J. Tan, B. Balasubramanian, D. Sukha, S. Ramkisson, P. Umaharan. (2017). Sensing Cocoa (*Theobroma cacao* L.) Beans Fermentation by Electronic Nose System. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 18.

Reference ID: 24781

Note: #24781e > #24507e

Abstract: Fermentation is a very important postharvest process where many processing properties and 21 sensory attributes are developed. However, cocoa fermentation still remains empirical due to its 22 complex mechanisms that evolved many microbiological changes. Some equipment such as 23 HPLC, GC-MS, and near infrared spectroscopy may be useful to study cocoa fermentation, 24 however they are relatively expensive, timing consuming and inaccessible to cocoa farmers. In 25 this study, a machine learning based electronic nose system was developed to determine the 26 fermentation time of cocoa beans. The system achieved a misclassification rate as low as 14.2 % 27 with relatively show time and low cost.

[252] D.A. Sukha, P. Umaharan, D.R. Butler. (2017). The impact of pollen donor on flavor in cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24782

Note: #24782e > #24507e

Abstract: Past studies have shown evidence of pollen parent effects on yield, bean size and pod characteristics but its effect on flavor attributes is not clearly understood. An incomplete diallel mating design involving five cacao cultivars (West African Amelonado (WAA), Imperial College Selection (ICS) 1, Iquitos Mixed Calabacillo (IMC) 67 and two Trinidad Selected Hybrids (TSH) coded as CCL 200 and CCL 201) with widely differing flavor attributes were used to investigate the magnitude of female and male parent effects on key intrinsic flavor attributes. The seeds derived from pods arising from these pollinations were fermented, dried and made into cocoa liquor according to standardized methods. Flavor evaluations were carried out by a trained sensory panel for nine flavor attributes with five repetitions and hidden flavor reference controls. The study was conducted over two cocoa crop years. The results failed to detect dominant xenia effects for important ancillary flavor attributes i.e., cocoa flavor, acidity, fruitiness and floral flavors but showed significant female parent effects for cocoa and floral flavors. Small but inconsistent male parent effects were seen for astringency. Lack of xenia effect for the major flavor attributes implies that the flavor quality of cocoa beans is determined principally by the genotype of the female parent.

[253] D.A. Sukha, P. Umaharan, D.R. Butler. (2017). Evidence for applying the concept of “Terroir” in cocoa (*Theobroma cacao* L.) flavour and quality attributes. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24783

Note: #24783e > #24507e

Abstract: Overall growth of the fine/flavour chocolate industry over the last decade has been linked to origin linked products such as dark chocolate bars. “Terroir” is concerned with the relationship between the characteristics of an agricultural product (quality, taste, style) and its geographic origin, which might influence these characteristics. This concept has been well documented in viticulture as the sensory attributes of wine have been related to the environmental conditions in which the grapes are grown. These effects are challenging to study in other crops such as cocoa where “terroir” effects similar to wines are implied in many origin specific dark chocolates but have never been systematically tested. Two experiments were conducted over three growing seasons to investigate the impact of growing environments and practices at different processing locations on the flavour attributes of selected cocoa varieties in Trinidad. The first experiment examined the influence of box fermentation at three different processing locations, with sun drying, on the flavour of six different cocoa clones each harvested from the same field. The second experiment examined the influence of four different growing environments on seven cocoa clones growing in at least two of four different sites. The sensory attributes of liquors prepared from the various samples from the two experiments were assessed using a trained sensory panel. The results showed significant processing and growing environment effects on several flavour attributes with significant clonal effects and processing and growing environment x clone interactions in the two experiments. Near infrared reflectance spectroscopic analysis of bean samples provided independent quantitative support to the sensory results obtained. The findings suggest that conditions and practices at different processing locations and growing environments may have significant impact on the flavour attributes of cocoa while the contribution of

genotype to flavour could sometimes have a superseding influence with respect to certain flavour attributes. This work provides evidence and a scientific basis to support claims of “terroir” effects in cocoa for origin specific chocolates.

[254] W. Ipanaque, J. Castillo, H. Robles, I. Belupu. (2017). Desarrollo e implementación de un prototipo de acero inoxidable para evaluar el proceso de fermentación de granos de cacao: Development and implementation of a stainless steel prototype for evaluate the process of fermentation of cocoa beans. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 14.

Reference ID: 24784

Note: #24784e > #24507e (note: journal is in spanish)

Abstract: En la post-cosecha del cacao se ha encontrado un gran potencial para implementar tecnologías que mejoren estos procesos, en particular el de fermentación de cacao, es así que se desarrolló un prototipo de acero inoxidable para llevar a cabo la fermentación de este proceso, con el propósito de generar alternativas de uso práctico para productores de este cultivo y obtener un producto con características deseables de calidad.

El prototipo desarrollado se instaló en la Asociación de Productores de Banano y Cacao Orgánico (ASPROBO); consta de un sistema mecánico que realiza remociones de granos de cacao a velocidades bajas necesarias para el desarrollo del proceso fermentativo, además permite la recolección del mucilago que se segrega durante los primeros días de la fermentación, para ser utilizado en otras aplicaciones; también posee un sistema de aislamiento que evita pérdidas de calor y humedad en los granos, esto asegura la proliferación de los microorganismos responsables del proceso.

La recolección de datos de temperatura y de los sucesos que ocurren durante la fermentación, se lograron con sistemas embebidos, conectados a diversos sensores que forman parte del prototipo. El sistema adquiere los datos con un tiempo de muestreo igual a 10 segundos mostrándolos en tiempo real, mediante una interfaz con un entorno intuitivo y sencillo de utilizar. Este sistema permite tener acceso al proceso desde una página

Web, para monitorear, activar y desactivar las principales funciones. Para evaluar los resultados se fermentaron tres lotes de 100 Kg de granos de cacao en el prototipo construido y paralelamente 500 Kg de granos en cajas de madera, con la finalidad de comparar la temperatura, humedad y pH en ambos lotes. Al finalizar la fermentación se concluyó que las temperaturas en el prototipo de acero inoxidable fueron uniformes en los distintos niveles de la masa, hubo menor interferencia de la temperatura ambiente sobre la masa fermentada, y los valores de humedad y PH coincidieron con los rangos establecidos por diferentes autores internacionales. Por otro lado en los cajones de madera se notó un

gradiente significativo de temperatura en los diferentes niveles de la masa en el proceso de fermentación y, también mayor influencia de la temperatura ambiente, provocando que los granos se enfríen notablemente por las noches, disminuyendo el porcentaje de granos fermentados y con ello la calidad del mismo.

[255] W. Ipanaque, I. Belupu, J. Castillo, J. Salazar. (2017). Desarrollo e implementación de un software utilizando sistemas embebidos para el proceso de fermentación de cacao y su monitoreo remoto a través de web: Development and implementation of software using embedded systems for the Cacao fermentation process and its remote monitoring through the Web. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24785

Note: #24785e > #24507e (note: journal is in spanish)

Abstract: Se presenta el desarrollo de un software embebido aplicado al proceso de fermentación de Cacao. Se diseñó prototipos equipados con sensores que registran las variables de temperatura, oxígeno y dióxido de carbono durante el proceso y envían esta información a Internet. Finalmente se ha desarrollado un sistema Web que recibe la información y a través de gráficas monitorea y analizar el proceso en tiempo real.

[256] L.G. Salazar, R. Rojas, J. Hurtado. (2017). Aislamiento e identificación de microorganismos presentes durante el proceso de fermentación de *Theobroma cacao* L., variedad Chunchu del Cuzco: Isolation and identification of microorganisms present during the fermentation process of *Theobroma cacao* L., Chunchu del Cuzco variety. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24786

Note: #24786e > #24507e (note: Journal is in spanish)

Abstract: Los granos de cacao (*Theobroma cacao* L.) son la materia prima principal para la producción de chocolate. La fermentación de los granos de cacao es un proceso post cosecha esencial para el desarrollo de precursores del sabor del chocolate la cual viene dada por su genotipo. El proceso de fermentación del grano involucra microorganismos como levaduras, bacterias ácido lácticas y ácido acéticas, las cuales producen reacciones bioquímicas que impactan en el sabor y aroma del chocolate. El conocimiento y control de estos, ayudaría a la mejora del producto final. Perú posee una alta diversidad de genotipos del árbol de cacao. Entre ellas tenemos La variedad de cacao Chunchu la cual posee una superioridad en calidad organoléptica. En este trabajo se reporta el estudio microbiológico del proceso de la fermentación del cacao "Chunchu" del cultivar "Común Cáscara de Huevo". Se realizó una prueba de fermentación durante 4 días, en Quillambamba, Cusco. Se tomaron muestras de 20 gr de los granos en fermentación, cada 24 horas. Para el análisis microbiológico, se emplearon medios para conteo y aislamiento de levaduras (Sabouraud con cloranfenicol); bacterias ácido lácticas (agar MRS) y bacterias ácido acéticas (agar GYC). Posteriormente se realizaron pruebas bioquímicas para su identificación. Durante el análisis microbiológico se observó una sucesión de microorganismos. Las levaduras identificadas fueron: *Saccharomyces cerevisiae*, *Kloeckera apiculata*, *Candida* sp. Entre las bacteria ácido lácticas se aisló e identificó a *Leuconostoc mesenteroides* ssp, *Lactobacillus plantarum* y *Lactobacillus brevis*. En cuando a las bacterias ácido se determinó que pertenecían a los géneros *Acetobacter*, *Gluconobacter* y *Gluconacetobacter*.

[257] R.A. Mejia, C. Ruiz, R. Portales, R. Rojas. (2017). Quality profile of Peruvian dark chocolate: a preliminary approach 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24787

Note: #24787e > #24507e

Abstract: Peru is considered to be the centre of cocoa genetic diversity, since it harbours around 60% of the worldwide cocoa cultivars. Peruvian fine flavour cocoa stands out at international level due to its recognized diversity and richness of aroma and taste, which allow the production of high quality chocolate, especially with high cocoa content due to its potential health benefits. In the last years, Peruvian cocoa production has shown a remarkable growth. Likewise, an increasing number of local chocolate producers have promoted the exhibition of Peruvian chocolate in international markets and worldwide cocoa competitions with great success. Peru has a great opportunity to be recognized worldwide as a producer of high quality chocolates made from native fine flavour cocoa. To promote this process, studies are necessary to demonstrate the chemical-organoleptic quality of these chocolates. In this sense, the present study focused on the evaluation of the chemical (total phenolics, flavonoids, theobromine and caffeine), nutritional (proteins, carbohydrates, fat, fatty acids and fibre), antioxidant activities and sensory profiles of 5 Peruvian dark chocolates and a control sample. These single origin samples (Piura, San Martín, Amazonas and Cusco) contained between 60% and 70% cocoa. An international semi-trained panel of cocoa and by-products carried out the sensory evaluation. For the quantitative descriptive analysis (QDA), 5 descriptors for odour (fruity, floral, cocoa/chocolate, sweet/caramel/malt and off-odour), 8 for taste (fruity, floral, bitter, sweet/caramel/malt, astringent, cocoa/chocolate, nutty and off-taste) and 1 for mouthfeel (melting degree) were defined by the panellists. A 10 point-scale was used to score attribute intensity and global quality of the samples. Based on ANOVA ($p > 0.05$), only 8 descriptors (fruity, floral, cocoa/chocolate and sweet/caramel/malt odour; fruity, bitter and cocoa/chocolate taste; and melting degree) explained the chocolate differences. In addition, Principal Components Analysis of the sensory results showed that the first two principal components explained 89.1% of the data variance, in which two clusters of chocolate samples were identified. A first cluster of 2 products was characterized by its fruity flavour, while a second cluster of 3 products was associated to floral notes. According to the panellists, the overall quality of the five chocolates ranged from 5 to 6 points. The outcomes of this study provide a supporting base for further research towards the improvement of Peruvian chocolate quality.

[258] N. Fayeulle, A. Vallverdú-Queralt, E. Meudec, J.-C. Boulet, J.-M. Roger, C. Hue, R. Boulanger, V. Cheynier, N. Sommerer. (2017). Two molecules newly identified by mass spectrometry in fermented cocoa beans impact chocolate sensory quality. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24788

Note: #24788e > #24507e

Abstract: Polyphenols are a wide and diverse group of plant secondary metabolites found in large amount in cocoa beans. They can be further modified under specific conditions such as fermentation or oxidation. The aim of this study was to characterize this group of molecules and evaluate their impact on chocolate taste. Sixteen cocoa bean samples and the sixteen chocolate samples associated were analyzed. The chocolates were made by a standard process. They were divided into four sensory groups by sensory analysis.

The polyphenols have been extracted from the ground and defatted cocoa beans and analyzed by UHPLC-HRMS. Two new series of polyphenolic compounds have been detected in fermented cocoa beans. Two mass signals at m/z 605 and 893 (in the negative ionization mode) have been assigned to compounds known as ethyl bridged flavanols that had never been reported in cocoa. These molecules resulting from

condensation of flavanols with acetaldehyde can be formed in planta or more likely during fermentation as acetaldehyde is a microbial metabolite.

Chemometrics applied to cocoa polyphenol composition showed that ethyl-bridged flavanols are key molecules to discriminate cocoas according to the sensorial groups of the associated chocolate. Future studies will aim at determining the contribution of these molecules to cocoa and chocolate taste, especially bitterness and astringency.

[259] N.A. Ali, D.A. Sukha, G. Meerdink, P. Umaharan. (2017). Fermentation progression and quality attributes of Trinitario and Refractario cacao (*Theobroma cacao* L.) hybrid groups at the international cocoa genebank trinidad (ICGT) – opportunities for genetic branding. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24789

Note: #24789e > #24507e

Abstract: *Theobroma cacao* L. is an important tropical tree crop that is grown for its beans used in the food, beverage, cosmetic and pharmaceutical industries. There are ten genetic clusters and two hybrid groups (Trinitario and Refractario) originating from the admixing of several of the genetic clusters recognised within cacao. Although the two hybrid groups are highly regarded in the fine or flavour market segment of the cocoa industry, their fermentation behaviour and distinctive flavour/nutraceutical attributes are not fully understood. The aim of this study was to determine the fermentation behaviour, flavour, nutraceutical profiles and the market potential of these two hybrid groups grown in the same environment at the International Cocoa Genebank Trinidad (ICGT). The beans from the two groups were separately fermented with replications over three years using a small-scale box fermentation method. The samples collected at 0, 2, 4, 6 and 8 days of fermentation were sun-dried to 6.5-7.0% moisture content and analysed chemically and sensorially. The temperature and pH trends measured during fermentation were different but congruent with proper fermentation. Sensory assessment identified higher intensities of floral flavour in Trinitario samples fermented for 6 and 8 days. Overlaying chromatograms obtained via Gas Chromatography–Mass Spectrometry of samples belonging to both hybrids fermented for 6 days showed that Trinitario exhibited peaks not present in the chromatograms for Refractario, namely for 2-Heptanone (fruity, flowery), 2-Heptanol (sweet, citrus) and 2-Nonanone (fruity). Analysis via High-Performance Liquid Chromatography of samples fermented for 8 days show that Trinitario beans contained more theobromine, caffeine and (-)-epicatechin while Refractario beans had higher quantities of (+)-catechin and procyanidin B2. The study demonstrated the uniqueness of the two hybrids in relation to sensory characteristics and nutraceuticals; and underscored the importance of genetics and fermentation time on flavour diversity, which could be exploited through genetics-based branding.

[260] B. Laliberte, I. Drouault, F. Grazioli. (2017). Celebrating high quality cocoa production and diversity of flavours around the world – key lessons learnt from 6 editions since its creation in 2009. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24790

Note: #24790e > #24507e

Abstract: The Cocoa of Excellence (CoEx) Programme is the entry point for cocoa-producers to participate in the International Cocoa Awards (ICA), a global competition recognizing the work of cocoa farmers and celebrating quality and diversity of cocoa flavours. Launched in 2009 the CoEx Programme aims to recognize, value and

preserve cocoa by providing global recognition of high quality cocoa. Its objectives are to (1) increase awareness and promote education along the cocoa supply chain on the opportunity to produce high quality cocoa and preserve flavours resulting from genetic diversity, “terroir” and know-how of the farmers who prepare cocoa, (2) facilitate communication and linkages between cocoa farmers/producers and operators in the supply chains, and (3) stimulate and increase capacity of producing countries to recognize, seek out and preserve quality and diversity in cocoa.

Cocoa producing countries identify high quality cocoa samples with flavours representing the diversity of cocoa in their country. These samples are processed into liquor and untempered chocolate and blindly evaluated by the CoEx Technical Committee members. The best 50 samples are then processed into tempered chocolate moulded and assessed by a broader panel of professional chocolate makers, sensory and quality evaluation experts. The 3-5 best samples from each of the 4 cocoa-producing regions are selected and receive an International Cocoa Award celebrated at the Salon du Chocolat in Paris at the end of October. Contact information and flavour profiles of the best 50 samples is made available to bean buyers and chocolate makers through the CoEx Website. A detailed feedback report is produced for each cocoa bean sample received and sent confidentially to the producers.

The CoEx Programme and the ICA are organized every 2 years. The 2017 Edition is the sixth edition and since its creation in 2009, the CoEx Programme has received about 850 bean samples representing more than 50 countries and celebrated 114 International Cocoa Awards. The CoEx Programme carried out an in-depth evaluation to assess its impact at the cocoa-producers’ level particularly with regards to the improvement of quality and raising awareness of the genetic and flavour diversity around the world. This paper presents the preliminary results of the evaluation, how the role of the CoEx Programme is perceived by the stakeholders), what is working well and the key lessons learnt for improving the Programme.

[261] P. Lafargue Molina, A. Wetten, J.M. Allainguillaume, A.J. Daymond, J. Allainguillaume. (2017). The use of chloroplast markers for the traceability of certified sustainably produced cacao (*Theobroma cacao*) in the chocolate industry. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24791

Note: #24791e > #24507e

Abstract: Recently the chocolate industry has changed to a higher demand for sustainably certified cacao (Rainforest Alliance, UTZ, and FairTrade) and closer attention is being paid to how this sustainably produced cocoa can be traced. Companies like Mars, Hershey and Ferrero have stated that by 2020, all their cocoa will be certified sustainable. There is therefore a need for methodologies to be developed enabling the characterisation and geographical tracking of certified cocoa products. Research on chloroplast ultra-barcoding in cacao has revealed a level of DNA polymorphism sufficient to reliably identify lineages below the species level such as subspecies or varieties (Kane et al. 2012). This level of variation, in conjunction with the high copy number of the chloroplast genome, offers possibilities to develop reliable DNA assays which being, less susceptible to industrial DNA degradation than single locus nuclear markers, are suitable for the characterisation of sustainably produced chocolate products.

DNA was extracted from 159 representative trees of major cacao cultivars present in the International Cocoa Quarantine Centre in Reading (UK). All accessions were screened with four chloroplast simple sequence repeat (cpSSR) markers also known as microsatellites, to assess the chloroplast haplotype diversity of *Theobroma cacao*.

These loci were designed from polymorphic sites identified by Kane et al. (2012) to allow for multiplex PCR amplification. Fluorescently labelled products were screened using capillary analysis and all markers scored using GeneMarker. Eleven cpSSR alleles were identified across the four loci revealing six unique cacao chloroplast haplotypes. All markers were screened on DNA extracted from a range of commercially available chocolate products. The capillary profiles generated were normalised to determine the proportion of each specific cpSSR alleles per locus identified in each chocolate sample. Principal Component Analysis (PCA) of all samples for the proportion of all alleles gave contrasting results with distinct clustering observed for chocolate produced from beans harvested by small cooperatives in Peru, Ecuador, Venezuela, Trinidad and Madagascar but no differentiation was observed for chocolate derived from West African plantations reflecting the lack of allelic diversity found in cultivars in West Africa. These results indicate that this sensitive and relatively low cost barcoding approach has potential to support cocoa certification programmes for the Fine cocoa/premium cocoa market but is not likely to be appropriate for the identification of bulk cocoa production.

[262] J. Blancas, O. Acha, I. Collantes, N. Rodriguez, A. Castro, N. Ramos. (2017). Chemical study and antioxidant activity of Piura's white cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24792

Note: #24792e > #24507e

Abstract: Piura's white cocoa, called this way because it possesses whitish beans, is recognized as a high quality cocoa, for this reason it is highly appreciated by national and international chocolate producers. However, its chemical composition has not been studied thoroughly as well as other properties like antioxidant activity (AA) and total phenolic content (TPC). Therefore, this research project was aimed to: I) assess antioxidant activity and total phenolic content and II) characterize molecular structures of the diverse compounds by liquid chromatography - mass spectrometry.

Different beans of Piura's white cocoa were analyzed: I) violate beans, II) whitish beans, III) brown beans, IV) a mixture of different beans, and V) fermented beans (different beans). In order to assess the antioxidant activity and identify secondary metabolites being present, organic extraction was carried out by maceration with ethanol after cocoa defeating with petroleum ether. TPC was quantified by Folin-Ciocalteu method; results expressed in Gallic acid equivalents ranged from 7.15 to 44.37 mg GAE/g. Antioxidant activity determination was performed using two different colorimetric methods: di(phenyl)-(2,4,6-trinitrophenyl) iminoazanium (DPPH) free radical inhibition and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid (ABTS·+) free radical inhibition. Results expressed in Trolox equivalents ranged from 40.18 to 403.75 µmol TE/g for DPPH and from 64.02 to 501.87 µmol TE/g for ABTS. Brown and violet beans exhibited the highest values. A high correlation between TPC and antioxidant activity was found, $R^2 = 0.9984$ for TPC and DPPH assay; and $R^2 = 0.9968$ for TPC and ABTS assay.

Samples consisting of a mixture of different beans were analyzed by liquid chromatography coupled with electrospray mass spectrometry (HPLC-ESI-MS) in positive mode. Organic extract was fractioned before analysis, thus ethyl acetate and butanol fractions were analyzed. Several polyphenols were detected: Hydroxynnnamic acids, anthocyanins, flavan-3-ols, and procyanidin dimers.

[263] S. Nottelmann, B. Bisping, D. Kadow, C. Krabbe, A. Krähmer, S. Rohn, B. Rudolph, F. Tietz, K. Zug, F. Sobotta, C.V. Wallbrunn, K. Riehn. (2017). Sensory and GC-O analyses of cocoa and chocolate along the cocoa production chain. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24793

Note: #24793e > #24507e

Abstract: The identification of flavor and aroma relevant components in cocoa pulp and seeds, raw cacao, and cocoa based products is a key factor in cocoa research. There is strong evidence that (i) the genotype, (ii) the fermentation conditions, and (iii) the post-harvest processing have a significant impact on the flavor development in cocoa.

To further enlighten these correlations the CORNET project “Quality improved Cocoa and Cocoa-based Products with Flavor Profiles on Demand – From Farm to Chocolate Bar” (Federal Funding Advisory Service on Research and Innovation (IGF) Project No. 169EN/2 funded by the Federal Ministry for Economic Affairs and Energy (BMWi) through the German Federation of Industrial Research Associations (AiF) represented by the Research Association of the German Food Industry (FEI)) focuses on investigating the sensory profiles of both well-known and new cocoa genotypes from four selected Peruvian cocoa farms that are exposed to different fermentation conditions and post harvest treatments.

Methods: To ensure a high level of internal and external validity and reliability of the results, an international sensory panel with experts in the field of cocoa production and research was recruited and trained on the basis of a newly developed standardized protocol for molded liquors. Established protocols usually focus on the evaluation of liquid liquors. The training involves both, traditional sensory tests as well as gas-chromatography olfactometry methods for detecting and evaluating aroma and flavor-relevant components.

Expected Results and Discussion: Combined with the characterization of the chemical composition, the project aims to generate a new sensory evaluation procedure and a related evaluation scheme for both, cocoa and cocoa products. This protocol can be used to guarantee a quality based cocoa and chocolate production with flavor profiles on demand from bean to chocolate. It enables experts to perform sensory analyses all over the world with a higher comparability between the results. A key factor for that is, besides a standardized protocol, the tasting of molded cocoa liquors.

[264] W. Niether, I. Smit, L. Armengot, M. Schneider, G. Gerold, E. Pawelzik. (2017). Physiological response in beans of three cacao (*Theobroma cacao* L.) cultivars to micro-environmental growing conditions in cacao agroforestry systems and monocultures under conventional and organic management. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24794

Note: #24794e > #24507e

Abstract: Cocoa beans are produced all across the humid tropics under different environmental conditions provided by the region but also by the type of production system and the season. Among other ecosystem services, agroforestry systems and organic farming differ from conventional monocultures in their soil quality, i.e. water holding capacity and enhanced nutrient cycling that can affect crop nutrient uptake and their molecular characteristics. Additionally, agroforestry systems provide a buffered microclimate, implying that environmental stressful conditions and strong variation in the course of the year can be reduced.

We analyzed cocoa beans from three cacao cultivars, TSH-565, ICS-1xIMC-67 and

the local cultivar Ila-22, growing in different production systems comprising monoculture and agroforestry system, both under conventional and agroforestry systems, and a successional agroforestry system in Alto Beni (Bolivia). Beans were harvested at the beginning and at the end of the dry season to determine the physiological response to climate during fruit maturation. We measured the total phenolic content from milled cotyledons according to the Folin-Ciocalteu's assay and polyamines from defatted cocoa powder via HPLC as indicators for abiotic stresses. Conventional farming in monocultures was increasing tree growth and production compared to organic monocultures. The reduced water availability when pods were ripening during the dry season increased the total phenolic content and reduced the concentration of spermine, a polyamine. Effects of environmental growing conditions were not strong, but can explain variations in cocoa bean quality apart from post-harvest processing. Especially when analyzing cocoa beans from different origins the climatic conditions, soil water availability during harvesting season and the shade conditions of the production systems should be taken into consideration.

[265] J. Baumgartner, D. Contreras, C. Liberati, Z. Saavedra. (2017). Creando sistemas prácticos e inclusivos para el análisis sensorial del cacao: Creating practical and inclusive systems for sensory analysis of cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24795

Note: #24795e > #24507e (Note: Journal is in spanish)

Abstract: En el 2010, Equal Exchange inició el Programa de Desarrollo de Cooperativas con el objetivo de fortalecer a sus socios en la cadena de suministro y para relacionarse con ellos en formas nuevas e innovadoras. Consideramos que para que los pequeños productores tengan éxito en mercados internacionales, sus cooperativas deben no solo recolectar su cacao, sino que también se les debe proveer asistencia técnica que los ayude a aumentar niveles de productividad, agregar calidad y, por lo tanto, valor al producto.

Cuando este proyecto inició, no existía una metodología única para la evaluación del cacao en grano tanto física como organoléptica. En una alianza estratégica con TCHO Chocolate de California y con cooperativas de Perú, Ecuador y República Dominicana, se planteó trabajar tres temas puntuales e importantes para evaluar y garantizar la calidad del cacao: una ficha y manual de catación, un protocolo estándar de preparación de muestras, y un programa de formación de evaluadores.

Todo este trabajo se basa en la necesidad de los productores, de contar con herramientas que les permitan conocer el potencial, cualidades y perfil sensorial de una muestra de cacao con el fin de mejorar las negociaciones con clientes. De esta forma, representantes de organizaciones de pequeños productores, en coordinación con miembros de la Red de Catadores del Perú, han estado trabajando para desarrollar un lenguaje común y estándares de análisis sensorial para que sean parte de una conversación de la cual han estado excluidos históricamente. Esto también permitirá que los productores demanden precios más justos por la calidad de sus productos.

Un estudio realizado en coordinación con CATIE mostró que las iniciativas de calidad permitieron que las cooperativas del proyecto CDP mejoraron sus procesos, las relaciones con clientes y obtuvieron un mayor conocimiento sobre su producto. En el 2010, cinco paneles de catación de las cooperativas participativas habían analizado 25 muestras de licor de cacao y, hasta el 2016, evaluaron casi 3,000 muestras. Como resultado, se generó \$2,323,189 en premios de calidad para estas cooperativas. Nuestra experiencia nos demuestra que estas inversiones en la calidad si rinden

resultados rentables.

En este artículo, vamos a presentar nuestra Ficha de Catación para análisis sensorial de cacao. Explicaremos cómo se diferencia de otros sistemas de evaluación sensorial, cómo se desarrolló de forma colaborativa por varios actores de la cadena del valor, y como se puede utilizar para fortalecer los procesos de calidad y la comercialización del cacao.

[266] R.P. Saavedra-Arbildo, H. Cárdenas-Salazar, K.J. Márquez-Dávila, Y. Beraun-Cruz, M.S. Carranza-Cruz, O.P. Hurtado-Gonzales, J.A. Chia-Wong. (2017). Colecta y estudio de las características morfológicas y organolépticas en fruta fresca y licor de arboles de cacao (*Theobroma cacao* L.) con atributos de poseer características de fino y de aroma: Collection and study of morphological and organoleptic characteristics in fresh fruit and liquor of cocoa trees (*Theobroma cacao* L.) with attributes of having characteristics of fine and aroma. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 10.

Reference ID: 24796

Note: #24796e > #24507e (note: Journal is in spanish)

Abstract: El cacao es un importante componente económico de muchas familias en las regiones de San Martín, Huánuco, Ucayali, Cuzco, Amazonas y Piura en el Perú. En el marco del proyecto “Estudio molecular de la diversidad genética de los cacaos aromáticos en el Perú con fines del fortalecimiento de su competitividad y aumento de la producción nacional de cacao de calidad” financiado con fondos de INNÓVATEPERU, se está realizando un trabajo de investigación cuyo objetivo es caracterizar a nivel morfológico y organoléptico de una colección de cacao con potencial de fino y de aroma.

Se evaluaron 80 árboles de cacao, utilizando la metodología descrita por (García, 2008) descriptores morfológicos de fruto y de semilla. Por otro lado, se realizó la evaluación sensorial en fruta fresca utilizando los principales atributos de sabores básicos (dulce, acidez, amargor y salado) y de sabores específicos (frutal y floral). También, se realizó la evaluación organoléptica en licor de cacao, para ello, las semillas de cada accesión fueron fermentadas por 7 días, secados en 4 días hasta obtener una humedad del 7% y tostados a una temperatura de 135°C por 20 minutos, descascarados y sometidos a un molino concheador por 8 horas a una temperatura de 49°C, y finalmente enfriados. Cada muestra fue evaluada por catadores certificados Q-grader. Los atributos evaluados fueron fragancia, sabor, amargor, astringencia, acidez, frutal, nuez, limpieza, post gusto y balance. Ambas evaluaciones fueron realizadas utilizando una escala hedónica de 0 a 9 puntos. Los datos consignados fueron analizados mediante agrupamiento UPGMA y componentes principales, usando el coeficiente de Pearson.

Se encontró que hay una gran homogeneidad fenotípica entre los individuos de esta colección por región, lo que mostraría que hay poca diversidad de cacao a nivel regional. Estos estudios pueden proporcionar un punto de partida para valorizar los cacaos finos y de aroma del Perú, proporcionar información para gestionar Marcas Colectivas o Denominación de origen, y mediante herramientas moleculares, establecer un futuro programa de mejoramiento genético del cacao.

[267] G. Bobadilla, C. Ruiz, R. Rojas. (2017). Chemical-nutritional profile and antioxidant activity of the couverture chocolate of the Peruvian chocolate factory la Ibérica. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24797

Note: #24797e > #24507e

Abstract: Cocoa (*Theobroma cacao* L.) and its derived products such as chocolate, are foods with recognized beneficial health properties, mainly associated with their high content of polyphenols and other bioactive compounds. In Peru there are several companies engaged in the manufacture of products based on Peruvian cacao. There is for example La Ibérica, a Peruvian company located in Arequipa, with over 100 years of recognized experience. The aim of this study was to analyze the couverture chocolate (52%) of La Iberica, which is important for the manufacture of other chocolate derived products, in order to assess its nutritional potential and content of health beneficial compounds. Proximate analysis of couverture chocolate from La Ibérica showed high carbohydrate (53.9%), fat (32.7%) and protein (6.5%) contents. The fatty acid profile, determined by gas chromatography, showed mainly the presence of palmitic (26.5%), stearic (32.0%) and oleic 38.3%) acids. The concentration of theobromine (0.4 g/100g chocolate), assessed by HPLC chromatography, was 2.4 times greater than caffeine (0.17 g/100g chocolate). The content of total phenolic compounds, quantified by spectrophotometric method, was 1.5%. The epicatechin concentration, measured by HPLC chromatography, was 1.9 times greater than catechin (63.7 and 34.2 mg/100 g chocolate, respectively). The antioxidant activity in the DPPH test, expressed as median effective concentration, was 0.14 mg/mL. Antioxidant activity in the ORAC test was 489.1 µmol Trolox equivalents/g couverture chocolate

[268] E. Hegmann, W. Phillips, R. Lieberei, A. Ploeger. (2017). New resistant cocoa selections from Costa Rica have fine aroma potential. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 13.

Reference ID: 24798

Note: #24798e > #24507e

Abstract: In this research the aroma potential of six new cocoa genotypes (CATIE-R1, CATIE-R4, CATIE-R6, PMCT-58, ICS-95 (T1) and CC-137) selected at CATIE, Costa Rica, was studied. Since 2007, these high-yielding and disease resistant cocoa clones are cultivated by cocoa farmers and cooperatives throughout Central-America, however, detailed information on the individual aroma potential is lacking. The main factors which interact and define the aroma characteristics of the traded product "raw cocoa" are genotype, post-harvest management, cultivation site and climatic conditions. Cocoa liquors produced from "Fine or Flavour Cocoa" are characterized by chocolate aroma and additional fine aroma notes described as e.g. fruity, floral or nutty. These aroma compounds originate from plant secondary metabolites and their derivatives, such as terpenes, alcohols, esters, aldehydes, methyl ketones, with most of them being formed or stored in the fruit pulp. Apparently, these aromas migrate into the seed during fermentation and contribute to the organoleptic character of the cocoa bean. The aim of this study was to determine whether the new cocoa selections from CATIE have a "Fine or Flavour"- potential and which post-harvest treatment can be advised to exploit the full aroma potential of these clones. Monoclonal fermentations and fruit pulp analytics were carried out in Costa Rica and at the University of Hamburg, resp., in order to study and identify the main components involved in aroma formation of these new resistant varieties. The results demonstrate that fermentation

procedure and -duration have to be adjusted to the clonal material and environmental conditions, because both highly influence the fermentation processes. The analyzed clonal fruit pulps of the CATIE-Selections displayed a basic content of the two dominating esters 2-pentanol acetate and 2-heptanol acetate, combined with a distinctive mixture of various minor compounds which form the genotype-specific fine aroma. Thus, the individual aroma bouquet is defined by rather minor compounds of lower concentrations. Furthermore, the results show that fruit pulp's aroma composition and aroma intensity vary with the prevailing climate in the phase of cocoa pod ripening, as well as the ripening status of the pods.

[269] B. Bimont, D. Sukha, M. Escalante, P. Umaharan. (2017). Optimization of the cocoa beans (*Theobroma cacao* L.) fermentation – the impact of a pre-fermentation beans exposure on fermentation time and final flavor. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24799

Note: #24799e > #24507e

Abstract: Cocoa beans (*Theobroma Cacao* L.) are the main ingredient for chocolate making. The most important processing step of the bean is the fermentation. Indeed, the aroma precursors necessary for the flavor development are formed at that time. Its quality is then fundamental for a good quality chocolate. The purpose of this study was to improve fermentation quality of cocoa beans via an adjustment of the pulp quantity and the inoculation by fruit flies (*Drosophila melanogaster*) prior to fermentation. The impact on the physical-chemical quality of the fermentation (duration of the process and homogenization) and/or the sensory quality of the beans was then assessed. Two distinct Trinitario varieties of beans were tested, older Imperial College Selections (ICS) and newer Trinidad Selected Hybrids (TSH). The beans were exposed in both the sun and shade (50% light) for different times (5h and 24h), to be subject to a slight drying in order to decrease the pulp quantity by on one hand, and an inoculation by *D. Melanogaster* on the other hand and then each exposure level was fermented for 6 days. For each of the three sets of experiments, fermentation temperature (°C) and acidity (pH) of testa and cotyledon monitoring was measured during every day of the fermentation, as well, as a cut-test and cocoa liquor tasting after drying, from days 3, 5 and 6 of the fermentation.

All the results show that beans exposed to the sun did not ferment properly. However, beans exposed to the shade were better fermented than the others. No significant difference was observed between the two varieties used and the natural inoculation of the beans by *D. Melanogaster* in the shade improves the quality of the fermentation. Therefore for these varieties, increasing the quantity of pulp had a positive effect on the bean quality, which fermented better and had a more interesting sensory profile.

[270] V. Vargas, M. Vásquez. (2017). Cacao fino y de aroma: una alternativa para la agroexportación: Fine cocoa and Aroma: An alternative for agroexportation. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru.

Reference ID: 24800

Note: #24800e > #24507e (Note: journal is in spanish)

Abstract: El proyecto se viene ejecutando en la Estación Experimental Agraria Pucallpa, del Instituto Nacional de Innovación Agraria (INIA), en los Anexos Campo Verde Km. 44; Alexander von Humboldt, Km 86 y Pucallpa Km 4, de la carretera Federico Basadre de la Región Ucayali. El clima es cálido y húmedo, con temperaturas entre 20 y 35°C y temperatura promedio de 26°C, precipitación anual de 1750 a 3000 mm. Altitud entre 154 y 350 msnm, latitud sur 08°22'00" y longitud

oeste 74°34'00". El área de estudio se ubica en las zonas ecológicas de bosque húmedo tropical (BH-t) a bosque húmedo premontano tropical (bh-pt). El suelo es de tipo Ultisols e Inceptisols, la textura varía de franco-arcilloso-arenoso a franco-arcilloso y el pH de 4.5 a 5 (extremadamente ácido).

El objetivo principal del estudio es mejorar en productividad y calidad de grano seco de cacao, producido y comercializado por las familias rurales amazónicas, mediante la facilitación al acceso de germoplasma local seleccionado por sus características superiores de fino y aroma y mayores rendimientos, lo cual contribuirá a incrementar la rentabilidad y sostenibilidad de los sistemas de producción de cacao.

Se identificó las principales zonas cacaoteras de la Amazonia Peruana, con apoyo de las principales instituciones del estado y privados, organizaciones de productores involucrados en el cultivo, lográndose identificar 14 zonas cacaoteras a nivel nacional que sirvió como referencia para realizar la colecta del material genético de cacao.

La selección y colecta del material genético de cacao, se realizó de 11 Regiones donde existen zonas cacaoteras: Tumbes, Piura, Ayacucho, Cuzco, Huánuco, Junín, Pasco, Iquitos, Ucayali, Amazonas y San Martín; y la colecta se realizó de 67 productores, logrando clonar 128 plantas promisorias.

Por la condición de sombreado que requiere el cultivo de cacao, inicialmente se sembró el plátano como sombra variedad bellaco (*Musa sp*) a un distanciamiento de 3 x 3m (1111 plantas /ha) y como sombra permanente se instalaron especies forestales: guaba (*Inga edulis*), tornillo (*Cedrelinga catenaeformis*) y shihuahuaco (*Dipteryx alata* Vogel) a un distanciamiento de 18 m x 18m.

Se logró establecer un banco de germoplasma de cacao fino y de aroma bajo el sistema agroforestal (SAF) que cuenta con 128 clones de cacao y por cada clon se instaló 5 plantas, repetidas en tres localidades diferentes. A cinco meses de trasplantado los clones de cacao, presentan un crecimiento en altura de planta promedio entre 42.8 y 47.3 cm, y diámetro de tallo entre 0.9 a 1.2 cm, no existiendo diferencias significativas por procedencia en ambas características.

[271] P.E. Aikpokpodion, F.E. Asowata. (2017). Health risk assessment of selected heavy metals in some imported chocolates sold in southwestern, Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24801

Note: #24801e > #24507e

Abstract: Consumption of chocolate is common among Nigerian children who live in the cities. In spite of the palatability and nutritional significance of chocolate, it hardly exists without traces of heavy metal contamination. The study was carried out to evaluate the level of selected heavy metals in chocolate and their potential health impacts on children who consume the product on regular basis. Thirty (30) brands of chocolates including 26 milk and 4 dark chocolates were purchased and analyzed. The total hazard quotient ranged between 0.06 – 0.25 for Ni while it ranged between 0.03-0.13, 0.03-0.09, 0.06-0.47, 0.0015-0.0042 and 0.029-0.10 for Pb, Zn, Cu, Cr and Fe respectively. The low values of calculated target hazard quotient suggests the safety of the investigated chocolates with respect to heavy metal contamination.

[272] S.P. Soplin. (2017). Niveles de cadmio en el chocolate: NM y ECA, sí; OTC, no: Levels of cadmium in chocolate: NM and ECA, yes; OTC, no. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24802

Note: #24802e > #24507e (note: Journal is in spanish)

Abstract: The needs of consumer protection and safety of the environment, lead to

the establishment of maximum levels (ML) in food and environmental quality standards (ECA), with respect to the soils according to their use -agricultural, urban and industrial. This is the case of cadmium (Cd), whose content in food generates concern and, therefore, specific MLs.

Cd, when found in food, comes from other compartments of the environment (soil, water and air), which generates the corresponding ECAs. In both cases, it is done through norms of different rank and scope. When the ML and ECA, have values with excess and without sufficient scientific basis, they can become obstacles to the productive process and technical barriers to trade (OTC).

Regulation EU 488/2014, whose entry into force is expected from 2019, establishes ML for Cd in four types of chocolate (final consumption), but uses arguments from ECA, and is inconsistent when setting similar values to very different foods in origin and representativeness in the total dietary exposure of cadmium of consumers.

The Joint FAO / WHO Expert Committee on Food Additives (JECFA), (Report of its 77th Session) estimated that the intake of Cd through chocolate equals 0.02 to 1.6% of the probable tolerable monthly intake (IMTP). This total food exposure to Cd in the large consumers of cocoa and its products had probably been overestimated and did not consider it a cause of concern (JECFA, 2013) for public health.

The scientific arguments of the rules on cadmium in the environment and food, specifically chocolate, are analyzed. Measures are proposed to achieve a better normative balance between food security (consumer protection), care for the environment and the non-obstruction of trade in cocoa and its derivatives.

The priority will always be the protection and health of consumers, saved which cannot fall into excesses that harm the trade of a product as strategic as cocoa and unnecessarily stigmatize the wonderful chocolate.

In Peru and other countries of the Region, tens of thousands of families of small farmers depend on it.

[273] A.G. Revoredo, J. Hurtado. (2017). Efecto del tratamiento con 3 cepas de streptomicetos en la acumulación de cadmio en plantas de *Theobroma cacao* L : Effect of treatment of 3 strains of streptomycetes on the accumulation of cadmium in *Theobroma cacao* L. plants. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24803

Note: #24803e > #24507e (note: journal is in spanish)

Abstract: El Perú es un país productor de cacao por excelencia y actualmente afronta el problema de la presencia de cadmio en los suelos de algunas zonas cacaoteras que puede llevar a la acumulación de éste en las semillas de cacao. Este trabajo tiene como objetivo determinar la actividad biorremediadora de 3 cepas de Streptomyces: Streptomyces variabilis (AB5 y X) y Streptomyces sp. (C2) en plantas de cacao (*Theobroma cacao* L.) utilizando dos concentraciones diferentes de cadmio: 100 y 200 ppm. Las variables que se analizaron fueron el tamaño de la planta y cantidad de hojas a los 26 días, 1 mes y 2 semanas, 2 y 3 meses. Adicionalmente a los 3 meses se midió el tamaño de la raíz, grosor del tallo, tamaño de la hoja y estado nutricional de la planta a través del color de las hojas. Por último se cuantificó el cadmio absorbido por la planta de cacao y se determinó la efectividad de las cepas en impedir la absorción de cadmio.

La cepa C2 fue la única con actividad biorremediadora comprobada ya que reduce la absorción de cadmio en un promedio de 39.67% en el tratamiento con Cd 100 ppm con respecto a su control (p=0.58). Las cepas X y AB5 no mostraron actividad biorremediadora.. Se determinó que la cepa X fue la que prevaleció en el suelo al final

del experimento.

[274] J. Crozier, S.S. Sastroutomo, J.C.K. Ngim, A.W. Susilo, S. Abdoellah, A.S.C. Ling, R. Haya, K. Ramle, P. Gende, E. Tade, M. Gómez, L. Pipitone, J. Flood. (2017). "Cocoasafe": capacity building and knowledge sharing in SPS in cocoa in South East Asia and the Pacific. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24804

Note: #24804e > #24507e

Abstract: Concerns about food safety have led many consuming markets such as the European Union (EU), USA and Japan, to enact legislation concerning accepted levels of pesticides and other harmful substances in imported commodities such as cocoa. Such legislation reduces cocoa producing countries ability to export their cocoa unless legislative and regulatory measures on sanitary and phytosanitary (SPS) standards are met. Any rejection of cocoa imports will impact both the GDP of the exporting countries and the livelihoods of the smallholder producers who grow cocoa. The "Cocoasafe" project was a multi partner project funded by the Standards Trade and Development Facility (STDF) and participating countries which aimed to strengthen SPS capacity through the cocoa supply chain in Indonesia, Malaysia and Papua New Guinea. The project aimed to improve the safety and quality of cocoa through developing capacity along in-country supply chains, both to understand the need for compliance to SPS measures and to conduct best practice to reduce harmful residues and contaminants. Knowledge sharing between stakeholder groups in the region was also facilitated. The training syllabus was adapted from CABI's 'Discovery Learning Manual' to fit local farm management practices. Training topics included cocoa planting materials, shade management, soil health, pest/disease management, in addition to cocoa safety and quality standards. Best practice recommendations relevant to each country were included as well as raising awareness of contamination by heavy metals, pesticide residues, polycyclic aromatic hydrocarbons (PAHs) and mycotoxins. A Training of Trainers approach was used to train Master Facilitators who in turn trained local extension staff, lead farmers, post-harvest processors and input suppliers as Facilitators to pass this knowledge to farmers and other stakeholder along the supply chain. Pre and post-training surveys were conducted to evaluate the level of understanding of the training. Analysis of the survey data indicated that farmer leaders' knowledge on GAP, pest/disease management and safe use of pesticides improved significantly, input suppliers understanding of pesticide regulations was improved while post-harvest processors had an improved understanding of compliance of cocoa storage SPS standards. Project outputs such as training manuals, videos and posters were translated into local languages as well as being available in English. In addition to the main training activities in the individual countries, CABI hosts and maintains project website where all training material and resources can be accessed (www.cocoasafe.org). This also links to individual country partner websites.

[275] C.O. Arévalo-Hernández, E. Arévalo-Gardini, A. Farfán-Pinedo, Baligar V., Z. He. (2017). Metales pesados en suelos, hojas y granos de zonas cacaoteras del Peru: Heavy metals in soils, leaves and grains of cacao zones in Peru. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24805

Note: #24805e > #24507e

Abstract: El cacao es uno de los principales productos de exportación orgánica no

tradicional del Perú; sin embargo, la acumulación de metales pesados en diversos productos agrícolas limita la exportación y comercialización de estos productos. Así, este trabajo tuvo como objetivo determinar el contenido de metales pesados en las principales zonas (Norte- Tumbes, Piura, Cajamarca y Amazonas; Centro- San Martín, Huánuco y Junín; Sur-Cuzco) productoras de cacao del Perú. Se consideraron plantaciones entre 10 y 15 años de edad, en zonas que representen la realidad del cultivo de cada región. Los suelos fueron muestreados en seis profundidades (0-5, 5-10, 10-20, 20-40, 40-60, 60-80 cm), a partir de una mezcla de 8 calicatas de 80 cm de profundidad. Hojas y granos de cacao fueron colectadas de 70 plantaciones de cacao de 10 a 15 años de edad y la naturaleza genotípica del clon fue registrado. Se determinaron los contenidos de Cd, Ni, Pb, Fe, Cu, Zn, Mn de los suelos, hojas y granos para cada profundidad muestreada. El análisis estadístico fue determinado por un análisis de variancia y posterior comparación de medias por Scott-Knott ($P < 0.05$). De forma general, los valores de metales pesados no presentaron diferencias significativas entre las profundidades muestreadas y se encontraron por debajo de los niveles críticos de contaminación. Las concentraciones de metales pesados en hojas y granos, estuvieron debajo de los límites críticos reportados para la mayoría de plantas. Sin embargo, altas concentraciones de Cd fueron reportadas en algunas regiones (Amazonas, Piura y Tumbes). Existió diferencias significativas entre los genotipos de cacao encontrados en campo, indicando que el uso de clones con baja acumulación de metales pesados podría ser una alternativa para evitar problemas de comercialización y contribuir con la seguridad alimentaria de cada región. A pesar de los bajos niveles de metales pesados en los suelos existió alta absorción de cadmio, indicando que las características del manejo del suelo, realizado en las parcelas muestreadas, favorece su absorción.

[276] J. Chupillon-Cubas, C.O. Arévalo-Hernández, E. Arévalo-Gardini, A. Farfán-Pinedo, Baligar V. (2017). Acumulación de cadmio en seis genotipos de cacao utilizados como patrón: Accumulation of cadmium in six cocoa genotypes used as a standard. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 3.

Reference ID: 24806

Note: #24806e > #24507e (note; Journal is in spanish)

Abstract: El cacao es uno de los principales cultivos de la amazonia del Perú y la mayor área sembrada está en Región San Martín. Este cultivo es propagado por semillas que se usan como patrón y luego son injertados con clones promisorios. El objetivo de este estudio fue determinar la absorción de cadmio para seis genotipos de cacao, utilizados como patrón. El experimento fue realizado en la Estación Experimental "Juan Bernito" del Instituto de Cultivos Tropicales-ICT en la ciudad de Tarapoto. Las semillas se colectaron de diferentes mazorcas de clones: CCN-51, IMC-67, SCA-6, EET-400 y POUND-12 y un cacao común (Híbrido) como control, provenientes del banco de germoplasma del ICT, luego fueron sembrados en sustrato preparado a base de tierra negra y arena de río en relación 3:1, contaminado con cloruro de cadmio a 25 mg kg⁻¹, contenido en macetas de 4kg, 10 repeticiones por tratamiento y cuidadas por 4 meses. La materia seca de la parte aérea y radicular fueron medidas al final del experimento. La concentración de cadmio fue determinada tanto en la parte aérea como la parte radicular para cada genotipo. Se realizó el análisis de variancia y comparación de medias por Scott-Knott ($P < 0,05$). El cacao común presentó mayor acumulación de materia seca, sin diferencias ($P < 0.05$) con POUND 12 y EET 400 en la parte aérea y IMC67 y POUND 12 en las raíces. El clon EET-400, acumuló más cadmio tanto en la parte aérea como en la raíz, en

comparación a los otros clones con diferencias significativas al cacao común (control). El clon IMC67, presentó el menor contenido de cadmio tanto en la parte aérea como en la raíz, con diferencias significativas al control, siendo el clon más propicio para su uso por los agricultores.

[277] J. Cáceres, E. Torres. (2017). Microorganismos cultivables asociados a cadmio (Cd) presentes en suelos cacaoteros de los municipios de Yacopí y Nilo, como estrategia de biorremediación: Cultivable microorganisms associated with cadmium (Cd) present in cocoa soils in the municipalities of Yacopí and Nilo, as a bioremediation strategy. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp -.

Reference ID: 24807

Note: #24807e > #24507e (note: Journal is in spanish)

Abstract: En Colombia, el cultivo de Cacao (*Theobroma cacao* L.) está bien posicionado en el mercado internacional por su sabor y aroma y se ha reportado un incremento del 45% en exportaciones a países de la Unión Europea. No obstante, esta planta puede absorber y traslocar cadmio (Cd) al fruto, lo que podría restringir su exportación. El Cd es un metal pesado, tóxico y móvil en el suelo, cuyas fuentes pueden ser geogénicas, producto de erupciones volcánicas, meteorización de la roca madre y quema de vegetación, o antropogénicas, por fertilización, desechos industriales y minería. En busca de alternativas para disminuir los niveles de Cd en grano, se caracterizó la comunidad microbiana cultivable asociada a suelos cacaoteros con diferentes niveles de Cd (bajo<1.2; medio:1.2-4.0; alto>4.0 mg/kg), en los municipios de Nilo y Yacopí (Cundinamarca), en cinco localidades. Para ello, se determinó la abundancia y diversidad de los morfotipos aislados en medio sólido con 6 mg/kg de Cd, aumentando la dosis a 12-18-24 mg/kg para conocer el nivel de tolerancia a Cd, en condiciones de laboratorio. Adicionalmente, se caracterizaron macro y microscópicamente los morfotipos puros obtenidos y también se identificaron a nivel molecular usando marcadores 16S e ITS1-4 del rADN para bacterias y hongos, respectivamente. Los resultados obtenidos se analizaron con base en las condiciones de suelo y manejo agronómico. Se encontró mayor abundancia de bacterias (logUFC > 5.6) que de hongos (logUFC > 5.2) en todos los suelos estudiados, sin embargo el suelo con el nivel más alto de Cd presentó menor abundancia y mayor riqueza de hongos y bacterias, con respecto a las demás localidades. El 82% (n=28) de las bacterias aisladas corresponden al filo Proteobacterias con géneros representativos y con potencial agrobiotecnológico como *Pseudomonas* spp. *Halomonas* sp. y *Herbaspirillum* sp. y el 93% (n=55) de los morfotipos fúngicos pertenece a la división Ascomycota con *Aspergillus* sp., *Penicillium* sp., *Fusarium* sp., *Trichoderma* sp, entre otros. La mayor tolerancia a Cd de los morfotipos bacterianos fue de 18 mg/kg de Cd, tolerada por 54.2% (n=19) de los morfotipos aislados, mientras que el 93% (n=55) de los hongos toleró 24 mg/kg de Cd. Los resultados obtenidos en este estudio brindan conocimiento de la diversidad microbiana asociada al cultivo de cacao con potencial para ser utilizada en programas de biorremediación, con tecnologías regionales que permitan el uso de los microorganismos in situ o utilizando los microorganismos para elaborar productos biotecnológicos.

[278] J.O. Lawal, B.S. Famuyiwa, O. Taiwo. (2017). Shocks and factors influencing welfare among cocoa farming households in cross-rivers state, Nigeria 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24808

Note: #24808e > #24507e

Abstract: Shocks are adverse events which generate reduction in income and influence the welfare of farming households of which cocoa farmers are not exempted; this study found the shocks peculiar to them and the factors influencing welfare among Cocoa Farming Households (CFHs) in cross rivers state. Primary data were collected with questionnaire using multi-stage technique; two local government areas (LGAs) were purposively chosen based on their volume of cocoa production and heavy presence of CFHs. From each of the LGAs, four villages were randomly chosen and in the third stage, 120 CFHs from Etung and Ikom LGAs were randomly selected proportionate to the number of CFHs in the villages. Data collected were subjected to descriptive analysis; and standard welfare function specified and estimated using the Logit Regression model. Results showed male headed households are 64.17% mean ages of household head cocoa farm and farm sizes as 45.93 \pm 13.91 23.30 \pm 16.46 years and 4.60 \pm 3.50 ha respectively. Shocks experienced are downward price fluctuations pest and diseases incidences, poor access to credit illness of household members poor harvest and labour shortage on cocoa farms. Factors influencing welfare negatively are illnesses of household members

[279] J.O. Lawal, B.S. Famuyiwa, O. Taiwo. (2017). Factors influencing the use of labour saving technologies on cocoa farms in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 11.

Reference ID: 24809

Note: #24809e > #24507e

Abstract: The drudgery of farm operations on cocoa production is the bane of poor productivity and major cause of the non-involvement of youths in the cocoa business in the country. Labour Saving Technologies (LSTs) are the devices that reduce labour input thereby reducing the energy expended and overall cost of production on cocoa among farmers along the value chain at the same time improving production. Data were collected from the three high cocoa producing states in Nigeria using well structured questionnaire; two cocoa producing Local Government Areas (LGAs) were selected per state, 120 farmers were interviewed thus making a total of 360 respondents. The major objectives of the study were to identify the existing labour saving devices among farmers and to find the determinants of use of LSTs among cocoa farmers. The data collected were analyzed using descriptive and inferential statistics. Results of analysis revealed that 77.5 percent of the cocoa farm household heads were male, mean age of the household head was 44.97 \pm 14.84 years, household size was 8 \pm 3 persons, Farm size is 5.33 \pm 3.94 hectares, mean age of cocoa trees was 18.71 \pm 11.56 years, year of experience at 28.15 \pm 14.41years. Mainly 78.4 percent of the farming households use hired labour on their farms, 14.7 percent use family labour and only 56.9 percent of the farming households claim to use labour saving technologies on their farms. Majority of the farmers' use pump sprayers (86.5 %), motorcycles are owned by only a few 38%, Wheelbarrows is owned by 42.3%. The regression result shows that the use of labour saving technologies is determined by access to credit, years of cocoa farming experience ($p < 0.01$), access to extension services and age size of cocoa farms ($p < 0.05$) among cocoa farming households. In conclusion, most of the cocoa farmers see land clearing and weeding as the most laborious and costly of all labour activities on the cocoa plantation. Labour usage on cocoa farms showed that hired labour of between ages 18-30 years are mostly used for land clearing, weeding, parasite removal, harvesting, pod breaking, bagging and transportation of cocoa beans. For land clearing, motorized hand grass cutters/land slather was suggested; also for drying operations which has been a problem to farmers they have suggested the fabrication of an auto bus-like dryer to reduce the drudgery

of cocoa production.

[280] D. Kos, R.B.W. Lensink. (2017). Commitments vs flexibility regarding take-up of pension savings accounts: a randomised control trial on cocoa farmers in Ghana. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 18.

Reference ID: 24810

Note: #24810e > #24507e

Abstract: The aim of this paper is to examine the uptake of a newly developed long-term savings (pension) product of cocoa farmers in Ghana. Given that cocoa farmers are poor, have fluctuating income, and are exposed to a number of costs between two cocoa seasons, an ideal pensions' product has to combine tailoring for farmers' current financial needs and the financial needs of the future to sustain themselves financially in the old age. We therefore test the difference in uptake of two pensions products where a part of the pension is saved until retirement age, and the other part is flexible and can be used as a regular bank account with no penalties for early withdrawal. Both pension products yield an attractive interest rate (twice the treasury bills rate), but with the first pension product, 50% of savings can be withdrawn at any point in time, and the other 50% is locked until retirement age. With the second product, only 30% can be withdrawn at any point in time, whereas the rest is locked until retirement age.

Our main contribution is that we test the relevance of flexibility vs commitments in terms of uptake of a long-term savings product. We conducted a Randomised Control Trial (RCT) where we randomized the pension products across 21 cocoa communities and 1169 farmers in the Eastern region of Ghana.

We find an overall higher uptake of pensions for individuals with higher income fluctuation, and education level above primary school. The main result of our analysis is that offering a more flexible long-term savings product significantly increase uptake of pensions, but only for, women and those receiving remittances from migrated household members.

[281] F.A.T. Mendes. (2017). State of Pará, Brazil: an option for the global supply of cocoa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24811

Note: #24811e > #24507e

Abstract: From the 1970s onwards, cacao farming in the state of Pará returned to a prominent position among Amazonian agricultural alternatives. Backed by technified production systems, improved seeds, technical assistance and credit, the cacaucultura paraense has gone from its secular annual production average of 1,700 tons to 118,000 tons in 2016.

Currently, Brazilian cacao is distributed in the northeast (Bahia), southeast (Espírito Santo), Midwest (Mato Grosso) and North (Pará, Rondônia and Amazonas) regions. Provisional estimates for 2017 point to a national production of 260,000 tons of cocoa, of which the state of Pará may contribute a significant 125,000 tons, equivalent to 48.1% of national production. This dynamism is being carried out in a planted area of 170 thousand hectares, of which 130 thousand are already in production, cultivated by about 22 thousand families, accounting for the generation of more than 250 thousand direct and indirect jobs formal and informal).

Based on agroforestry systems (SAF), established in medium to high fertility soils, exploited predominantly by small producers, regional cocoa activity is one of the most competitive in the world. Even with a low intake of inputs, the average yield of the crop

in the state is around 900 kg / ha, reaching about 1,000 kg / ha in the region known as Transamazônica, where productivity is frequently recorded above 2 thousand kg /ha. These numbers are more relevant when compared to the yields practiced in the cacao region of Bahia (300 kg / ha), or with countries such as Côte d'Ivoire (660 kg / ha) and Ghana (550 kg / ha), respectively 1st and 2nd world cacao producer. Such performance, coupled with the frankly preservationist characteristics of cocoa production in agroforestry systems, selects cacao farming as one of the most interesting agricultural alternatives for sustainable rural development in the State.

The increasing demand for planting new areas of cocoa, combined with a progressive production, will allow Pará cacao farms to take better advantage of the recognized intrinsic qualities of the cocoa beans produced (higher fat content and melting point), thus guaranteeing greater participation in new blends, accessing in a more competitive way the traditional and conservative international market of cacao.

The objective of this work is to make public the possibilities that the state of Pará presents as a large supplier of cocoa beans.

[282] V. Ingram, Y. Waarts, F. van Rijn, T. Koster, B. de Vas. (2017). The impacts of cocoa sustainability initiatives in West Africa. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 17.

Reference ID: 24812

Note: #24812e > #24507e

Abstract: As solutions to the multiple, long-running challenges facing cocoa growers and cocoa production, sustainability initiatives, including associations platforms and networks, voluntary sustainability standards, corporate and non-governmental and civil society initiatives have been developed. Largely implemented by cocoa farmers and groups, these initiatives are often supported by traders, government agencies, certification organisations and other not-for-profit organisations. This chapter looks at the such different sustainability initiatives and their social, economic and environmental impacts on cocoa farmers, cocoa farms and cocoa ecosystems. Examples of impacts in Ghana and Ivory Coast are provided. Trends in research on sustainability initiatives include increasingly multi-disciplinary collaborations, such as on climate smart cocoa, improved soil fertility and productivity and living incomes. Trends in practice include the harmonisation between standards and a move to "standards plus", going beyond certification towards integrated, farmer specific targeted interventions combining standards with farm and livelihood support, and policies and regulations that go beyond certification such as pricing, child and slave labour.

[283] M. Asamoah, F. Owusu-Ansah, P.F. Brannor, S. Ofori, C.O. Darkwa. (2017). Farmers' knowledge and utilization of CRIG recommended technologies and perceptions of government policies to enhance cocoa productivity. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24813

Note: #24813e > #24507e

Abstract: This study aimed at assessing farmers' knowledge, utilization and challenges associated with CRIG recommended cocoa technologies as well as farmers' perceptions of government policies on yield enhancing policies in Ghana. A total of 322 cocoa farmers were randomly selected from 25 communities in five cocoa growing regions for interviewing using a formal questionnaire in 2017. Results indicated that there were marked variances between farmers' knowledge in terms of recommended practices and what they actually practised. While some over-indulged

in the practices, others underutilized the recommendations; and both attitudes may lead to inefficiencies or abuse of chemicals. Apart from age of the cocoa farms, there was no significant relationship between productivity on one hand, and training (P-value=0.498), group membership (P-value=0.841) and educational level of farmers (P-value=0.338) which calls for a further research and analysis. In terms of government policies for cocoa such as free supply of hybrid seedlings and agro-inputs including fertilizer to farmers, the majority of respondents supported the continuation but, acknowledged some basic challenges. Thus, they gave some suggestions to making them more beneficial. Others, however, advocated for a replacement with a more sustaining effort such as open market policy with subsidy to cushion farmers to purchase inputs on their own. It is recommended that these farmers' perceptions and comments be given due considerations by the Ghana Cocoa Board (COCOBOD) to enhance the intended benefits of the policies put in place to increase cocoa production and productivity in Ghana.

[284] F. Amon-Armah, A.I. Amoah, N.A. Anyidoho, S. Muilerman, F. Owusu-Ansah, M. Asamoah, A. Badu-Yeboah, S.S. Oduro. (2017). A typology of young cocoa farmers in Ghana - attitudes, motivation and aspirations. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24814

Note: #24814e > #24507e

Abstract: The average age of cocoa farmers over the decades suggest that most people tend to venture cocoa farming career at a latter age of their lives. While older farmers are less likely to well adopt good agricultural practices and are more risk averse in farm investments, young cocoa farmers are more likely to well adopt good agricultural practices to enhance yields. This rationale is partly behind the drive to bring more young people into cocoa farming with the government, donor agencies and civil society organizations making great investments into the young people with the aim to increase national production as well as secure the future of the Ghanaian cocoa industry. However, the young people tend to be considered as a relatively homogenous group when the reality is great heterogeneity in young people's characteristics, past experiences, and future aspirations. We argue in this paper that it is important to know the typology of youth within the farming communities in order to make judicious investments. This paper introduces the concept of young cocoa farmer typology as a means for targeting prudent investment and extension delivery. The paper is based on a survey that was conducted in Offinso, Wassa Akropong and Asumura in the Ashanti, Western and Brong-Ahafo regions of Ghana respectively with a total of 120 young cocoa farmers. Using the two-step clustering approach, three types of young cocoa farmers were derived: positive young cocoa farmers (34.2%), pessimistic young farmers (36.7%) and stuck young farmers (29.1%). Results suggest that these young farmers' exposure and previous experiences, in particular their familiarity with successful cocoa farmers in their immediate environment significantly motivated their attitudes towards cocoa farming. Further, the future aspirations of young farmers could significantly affect their attitudes. It is thus recommended that government policies and programmes or interventions to increase youth in cocoa farming for cocoa sustainability be more targeted, with customized approaches that addresses heterogeneity among cocoa farmers in order that interventions may achieve the desired impact.

[285] N. Schaad, I. Fromm. (2017). Analysis of cocoa beans processing and quality in post-harvest in South East Sulawesi in Indonesia 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24815

Note: #24815e > #24507e

Abstract: The production of cocoa, introduced in Indonesia during the 1980s, is now decreasing due to many different factors, among them decreased yields due to aging trees, the appearance of pests and diseases, and the farmers not being able to solve these problems due to their lack of knowledge. In 2012, Swisscontact implemented the Sustainable Cocoa Program (SCPP) to improve the competitiveness of the farmers in the cocoa value chain and to increase the productivity of cocoa beans on farm-level. The present study, conducted with the support of Swisscontact, is divided in two main different parts. The first part is a farmer analysis conducted in the district of Kolaka Timur to observe the effect of the SCPP and the UTZ certification on the agricultural practices and the post-harvest method on farm-level. Three different farmers' groups were interviewed: 16 farmers involved in the SCPP and UTZ certified, 22 farmers involved in SCPP without any certification and 20 none-SCPP farmers. 32 women were interviewed as well to evaluate the gender equity in cocoa production. The second part of the study is an analysis of the quality of the cocoa beans by the different stakeholders of the value chain regarding the tools and the use of specific quality criteria. Eight local traders, six processing and trading companies and three associations involved in the cocoa sector were interviewed.

The results in the first part show that the SCPP has an impact on the productivity of cocoa beans in the long term: the annual yield is significantly higher in the first group (UTZ-SCPP) and the agricultural practices are improved as well. The SCPP, with the creation of farmers' cooperative, also increased the market access to the farmers. The second part shows that the tools and criteria used for analysing the quality of the cocoa beans are not the same in the value chain.

Regarding the application of post-harvest practices, the study shows that the processing companies don't have a real interest in buying fermented beans and they rather buy almost raw beans at a low price. The conclusion is that farmers involved in the SCPP have the possibility to produce a higher volume of cocoa beans but a market for fermented beans has to be created in order to add more value to the cocoa beans from Indonesia.

[286] D. Lujan, M. Solis. (2017). Análisis de factibilidad técnica-económica para la obtención de pulpa congelada de cacao empleando un sistema de colecta semiautomático: caso de estudio "cooperativa agroindustrial y de servicios": Analysis of technical-economic feasibility for obtaining frozen pulp of cocoa using a semi-automatic collection system: Case study "AGROINDUSTRIAL AND SERVICES COOPERATIVE". 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 9.

Reference ID: 24816

Note: #24816e > #24507e (note: Journal is in Spanish)

Abstract: El cultivo del cacao actualmente involucra, a nivel mundial, un total de 7 millones ha y alrededor del 90% de la producción proviene de pequeñas unidades con un área no mayor de 5 ha por productor (1). En el Perú, 90 mil familias se dedican al cultivo del cacao y la superficie cosechada abarca aproximadamente 120 mil ha con proyecciones de crecimiento de hasta 140 mil ha en los próximos 5 años. El ingreso de las familias productoras se ve afectado por las fluctuaciones del precio del cacao en los mercados internacionales, el cual repercute directamente en el precio a

nivel de chacra. En el 2015, el kilogramo (Kg) de cacao se cotizaba en la Bolsa de Nueva York a S/10.35 (2) y el precio a nivel de productor era de S/ 5.90 (3). Una alternativa para reducir la exposición del productor a las fluctuaciones en el precio internacional del cacao, consiste en generar ingresos adicionales mediante el aprovechamiento de los subproductos del cacao (mazorca, cascarilla y/o pulpa). La pulpa de cacao representa un 4% del peso del fruto, pero gran parte de esta pulpa, generalmente se pierde durante la poscosecha. Debido a sus características organolépticas y a su composición, la pulpa del fruto del cacao tiene un alto potencial de convertirse en un producto de valor agregado, sin embargo, la mayor limitante es que este producto intermedio tiene un tiempo de vida útil muy corto. El presente estudio trata sobre la viabilidad técnico-económica del aprovechamiento de la pulpa de cacao, como producto intermedio congelado puesto en una planta en Lima, con la finalidad de generar ingresos directos para el productor y/o cooperativa. Para dicho análisis se tomó como modelo a la “Cooperativa Agroindustrial de Servicios (CAI BELLA)”, ubicada en Tingo María y conformada por 60 asociados. Esta cooperativa cuenta con una extensión de 122.5 hectáreas con un rendimiento promedio de 800 kg/ha. A través de un sistema semiautomático de colecta, han logrado obtener rendimientos de pulpa de aproximadamente 15 L por 100 kg de cacao fresco. Para el análisis se consideraron los datos históricos de superficie cosechada, producción, rendimiento y precio en chacra, reportados por el Ministerio de Agricultura y Riego (MINAGRI); se utilizó la Tasa Anual Compuesta de Crecimiento (CAGR) para realizar las proyecciones y finalmente se calcularon indicadores financieros de Valor Presente Neto (VPN o VAN), Tasa Interna de Retorno (TIR) y Período de Recupero (PR).

[287] E. Arévalo-Gardini. (2017). Instituto de Cultivos Tropicales-ICT, technological advances and effective solutions to increase cocoa productivity and minimize the impact of climate change in Peru. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24817

Note: #24817e > #24507e (note: journal is in spanish)

Abstract: El Perú, es en la actualidad, el segundo mayor productor de cacao orgánico en el mundo, con 120 mil ha y producción de más de 92 mil toneladas de grano. En la Región San Martín, cuando el Instituto de Cultivos Tropicales-ICT fue creado (1993), existían alrededor de 2,143 ha de cacao y en la actualidad existen cerca de 41,984 ha de cacao, con una productividad de 950 kg/ha, esto gracias a los esfuerzos de muchas instituciones, principalmente el ICT, con el soporte de instituciones de Estados Unidos de América, que fue el encargado de generar y validar tecnología de cacao en San Martín y el Perú. Producto de esto es la capacitación de más de 25,000 agricultores de diferentes partes del país en el manejo técnico del cultivo de cacao y diversificación de cultivos, bajo diferentes metodologías de capacitación. Entrenamiento de más de 1300 profesionales peruanos y extranjeros de varias organizaciones (PDA, DEVIDA, ACOPAGRO, UNSM, ROMERO TRADING, INIA, GRSM, GIZ, CAC, GOLD GREEN, PEAM, PEHCBM, ADRA, CACVRAE, APROCAV, INDACO, APPCACAO, Alianza Cacao-Perú, etc.) en metodologías participativas de escuelas de campo (ECA) en el cultivo de cacao y otros como café, palma aceitera, sacha inchi, etc. También se financió y apoyó la realización de 53 tesis (pregrado, maestría y doctorado), prácticas pre-profesionales e internados de más de 320 estudiantes de diversas universidades e institutos tanto nacionales como extranjeros; Además de la implementación de 5400 ha de cacao, en áreas de influencia con el cultivo de coca. El ICT cuenta con tres estaciones experimentales: El Choclino, Juan Bernito y Bello horizonte, donde se encuentran modernos laboratorios de suelos,

tejidos vegetales, biología molecular y fitopatología que ayudan al desarrollo de las investigaciones y la extensión para mejorar la productividad del cacao. Cuenta con el banco de germoplasma mas grande del Perú, con más de 900 genotipos, entre internacionales, silvestres y nacionales, con el fin de seleccionar variedades tolerantes a los principales problemas que afectan la cacaucultura en el Perú y el mundo. El ICT continua desarrollando proyectos en busca de aumentar la productividad del cultivo de cacao sosteniblemente, con el soporte de entidades nacionales (INNOVATE, CONCYTEC, INCAGRO) e internacionales (USDA-ARS; University of Florida, USA; Universidad Estadual de Santa Cruz, Brasil; CEPLAC, Brasil). Actualmente, desarrolla investigaciones relacionadas al mejoramiento genético, plagas y enfermedades, estrés abiótico, metales pesados, biología molecular, fertilidad y conservación de suelos, calidad de grano, manejo integrado de plagas y enfermedades, Sistemas de producción agroforestal, transformación y calidad del grano. La cacaucultura en el Perú y el mundo tiene un aliado estratégico en el ICT para la mejora de su productividad sostenible, contribuyendo con la seguridad alimentaria y medio ambiente.

[288] C. Bunn, M. Lundy, R. Asare, S. Daniels, L. Jassogne, P. Laderach, A. Martinez, S. Muilerman, M. Noponen, T. Talsma, E. Teague. (2017). Scaling pathways for a climate smart cocoa sector 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24818

Note: #24818e > #24507e

Abstract: Climate change has been projected to change the geography of cocoa production unless production practices are adapted to novel conditions. Climate exposure mapping contributes to a better understanding of where, when and to what degree climate shifts will impact production and allows us to identify more resilient practices. However this information on its own does not lead to wide spread adoption. Scaling climate smart practices is therefore a priority to secure long term sustainability of the sector. Because cocoa production is a multi-decadal investment and many efficient measures to mitigate risk require a long lead time adaptive action should be taken now to avoid production losses from an incrementally changing climate. We argue that a multi-stakeholder approach will be required as no single technology or scaling pathway may account for the diversity of decision environments of the actors involved.

Prioritization of climate change adaptation is challenged by the heterogeneity of projected hazards across space, high uncertainty of data to guide ex-ante decision making and a lack of tried and tested off the shelf approaches to deliver relevant information to cocoa practitioners. Making the cocoa sector climate smart will therefore need to link climate science as it develops with stakeholders along the supply chain, develop novel approaches to incentivize innovative climate risk management strategies, and build capacity within the sector to confront climate change at scale.

We discuss the advantages and limits of four possible scaling pathways for climate smart cocoa. Voluntary certification, impact investing, private sector training, and policy guidance were considered. We classified these pathways by actors' incentives to prioritize long term viability over short term gains, flexibility to react to novel information, the number of farmers reached and the efficacy of action. Information was collected through a series of individual stakeholder interviews and workshops across the important cocoa origins of West Africa and Latin America and along the value chain. We find that no single pathway checks all preconditions for efficient scaling in isolation. Certifiers and incentive investors with their smaller constituencies were

found to be more likely to base decisions on novel information and may act as catalysts to develop no-regret approaches that may be more acceptable for private and public actors. We therefore suggest a platform approach to scaling in which each actor embraces climate smart practices depending on their preferences and collaborates with other actors while incorporating novel information in an iterative fashion.

[289] M.J. End, C.J. Turnbull. (2017). The INCOCOA website and virtual library improving information sharing within the cocoa research community. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 4.

Reference ID: 24819

Note: #24819e > #24507e

Abstract: Good communication and awareness of current and previous research activities are important in reducing unintentional duplication or repetition of previous research and in promoting collaborative activities to the ultimate benefit of the cocoa sector. There are numerous abstracts information services available, which help researchers access recently published literature. However, there is also a wealth of “grey literature”, such as institutional reports and bulletins, newsletters, conference and meeting reports, which is either unpublished or has been published in a non-commercial form and is often more difficult to find. The INCOCOA Virtual Library initiative sets out to improve access to this literature through links to existing bibliographic resources and by encouraging the cocoa community to contribute new resources.

The INCOCOA groups are informal networks created to promote the exchange of ideas and information amongst cocoa scientists. The current groups under the INCOCOA umbrella are INAFORSTA (the international scientific group dedicated to the analysis and improvement of the relationships between people, cocoa, trees, forests and the environment), INCOPED (International Permanent Working Group for Cocoa Pests and Diseases), INCOSOM (International Group on Cocoa and Soil Management) and INGENIC (International Group for Genetic Improvement of Cocoa). The INCOCOA website (www.incocoa.org) provides a portal to each of the groups and includes a news section (Twitter Feed) and a resources section, which incorporates the Virtual Library.

The library provides direct access to material published by the INCOCOA groups and allows users to query various bibliographic databases (using a web services approach) via a single search page. The user can opt to search in one or more of these databases and will be presented with a list of matching references. Depending on the source database and copyright restrictions, access may be provided to a digital version of the paper or a link to the website hosting the database. The databases currently linked include the Penn State database (June 2016, compiled from sources including PubMed and other abstract information service providers), the Cocoa Research UK library (mainly outputs from activities and projects supported by the UK industry), the Gerritsma database (compiled mid-1990’s including many historic and grey literature sources), the ICGD library (literature on cocoa genetic resources) and the Lockwood and Campbell databases (mainly literature on entomology and insect-vectored diseases).

Progress in expanding the range of linked databases and other developments for the INCOCOA group websites are discussed.

[290] N. Cryer, E. Haughey, E. Omane, E. Kumah, N. Guy-Abel Silue, S. Boyd. (2017). Development of a decision support framework for the rehabilitation and sustainable intensification of cocoa production on small holder farms. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 8.

Reference ID: 24820

Note: #24820e > #24507e

Abstract: Sustainable high productivity cocoa farming requires the holistic combination of the best planting material with appropriate fertilizer supply, comprehensive farm management practises, and sufficient knowledge. Many farmers currently do not achieve high productivity due to limitations in their farming situation. To aid the transition of farmers from a low input – low output situation to a highly profitable, high productivity situation there is a need to provide farmers with a detailed plan with which they can effectively develop their farm. We have developed a decision support framework that integrates the key activities that farmers should take, and the impact of each activity on farm performance. This framework includes a calendar indicating the optimum time to conduct work; the amounts of resources required in terms of funding and labour, and an understanding of the impact of each activity in terms of increases to farm performance. Importantly, the level of risk, based on measurements of on-farm year-to-year variation in performance, are included. Comparing the financial implications of inputs vs. the benefits in yield and profit to the farmer allows a detailed and fully budgeted pathway to be provided for each individual farm. Here we present an overview of current tracks of research focusing on the promotion of Good Agricultural Practice. The research tracks are united in a conceptual decision support framework including a detailed economic understanding, which maps out the renovation of small holder cocoa farms.

[291] F. Hütz-Adams, A. Laven, R. Bymolt, M. Tyszler. (2017). Towards a living income calculation for cocoa households in Ghana and Côte d'Ivoire. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 10.

Reference ID: 24821

Note: #24821e > #24507e

Abstract: The cocoa sector faces many challenges. According to available data, most of the farmers in West Africa live below the World Bank poverty line, and are under pressure from high inflation rates and declining inflation-adjusted cocoa prices. Meanwhile, according to the United Nations Guiding Principles on Business and Human Rights, all companies are responsible for ensuring human rights violations do not occur within their value chains. The introduction of a 'living income' is important for avoiding human rights abuses: Without a living income many of the problems within the sector cannot be solved. One of the major difficulties in defining a living income is a lack of accessible and reliable data on the present income sources of cocoa farmers. In this paper, the authors present robust quantitative and qualitative data on current income diversification strategies among 3045 cocoa growing households in Ghana and Côte d'Ivoire. This extensive data set is collected in November 2016 – January 2017 (Ghana) and February-March 2017 (Cdi) by KIT, in collaboration with local research partners ALC and ALP. The data will be used to contribute to the ongoing efforts to develop an approach on how to calculate a living income for cocoa growing households in these two countries. The surveys gives important insights on how to proceed in the living income debate. The data collected on household size, farm size, income diversification and sources are sufficient baseline for the further debate on living income using a household approach.

Additionally, it shows that cocoa farming households have a diversified income. Even

though, cocoa is still the most important crop for cocoa households, it accounts for only roughly 63% of total income. Furthermore, the research also collected qualitative data, which will help to understand intra household dynamics and economic decision-making.

Additional data on cocoa producing household's income and poverty levels will be published in the near future.

[292] A.A. Sankar, P. Umaharan. (2017). CocoaNexT - the nexus of stakeholders for cocoa research dissemination and sharing. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24822

Note: #24822e > #24507e

Abstract: There is tremendous unrealised potential in the cocoa industry of the Caribbean, and while the neighbouring regions may have a greater measure of success, there is still significant room for improvement. Slow adoption of innovations, best practices and new technologies in the cocoa industry is in part due to lack of proper channels for information gathering and sharing among stakeholders. Stakeholders are more likely to adopt an innovation when they know that it has been successfully tried and tested by other stakeholders in the industry. CocoaNexT is a Pan Caribbean website developed by Cocoa Research Centre of The University of the West Indies (CRC-UWI) for country-specific data, and information sharing. It is designed to disseminate information from research on propagation, cultivar development and deployment, post-harvest, value addition and IP registration to cocoa farmers, breeders and other stakeholders of the Americas. CocoaNexT will serve as a platform for delivery and promotion of services such as: DNA fingerprinting, flavour consultation, propagation, cultivation, variety improvement, disease management, certification and, importantly, a portal to share information among stakeholders. Regional collaboration has been and continues to be vital for the continued development of this interactive medium to build momentum and pave the way for continuous improvement. Through this platform, stakeholders in each country will have access to a directory of expertise, a practical knowledge base for all aspects of industry and a forum for collaboration to drive innovations forward to the benefit of the industry. The website design has been completed, a domain reserved and content is being input into the framework/structure.

[293] A. Laven, R. Bymolt, M. Tyszler, C. Steijn, F. Hütz-Adams, F. Ruf. (2017). The importance of cocoa in a diversified farm. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 13.

Reference ID: 24823

Note: #24823e > #24507e

Abstract: This paper presents initial results based on a large-scale research project led by the Royal Tropical Institute (Bymolt et al. forthcoming) 1. The aim of the research is to question many of the myths and assumptions about the cocoa sector in Côte d'Ivoire and Ghana. Three research areas and their interlinkages were investigated: 1) dominant and subsidiary crop and livelihoods options; 2) differentiation of farming households in cocoa regions; and 3) intra-household dynamics, gender and nutrition. The following mixed methods were used for data collection: a systematic desk-study of 100 research papers; a household survey conducted with 1,560 households in cocoa growing areas in Ghana and 1,485 households in Côte d'Ivoire (34% female respondents); 76 focus group discussions; and an ethnographic study in three cocoa growing communities. This paper aims to share initial findings of this

ongoing research trajectory, which shows that cocoa is not the only source of revenue for farmers in cocoa growing areas, although it remains at the core of the vast majority of cocoa farmers' concerns and priorities. The final research report, including the data set, will be published in early 2018.

[294] T. Blare, J. Donovan. (2017). Intensification of cocoa in the Peruvian Amazon: Gender relations and options for deeper engagement by women. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 12.

Reference ID: 24824

Note: #24824e > #24507e

Abstract: Despite the important role women play in on-farm cocoa production activities, little is known about the influence of efforts to intensify production on gender roles and women's empowerment. We examined gender roles in asset ownership, productive and domestic activities and household decision-making as well as women's interest and time constraints in cocoa production following an intervention to intensify cocoa production in the region of the Valleys of the Rivers Apurimac, Ene and Montaro (VRAEM), Peru—an area which has suffered from years of social conflict, resulting in households having abandoned their farms. We collected sex-disaggregated data from 61 structured, household interviews and conducted informant interviews with NGOs, cocoa buyers, and governmental officials to verify and clarify the findings. The results revealed that cocoa intensification programs have contributed to enhanced cocoa productivity and household income. Nonetheless, many households had failed to replicate this economic success outside of cocoa; nearly a third of them were dependent on cocoa as their only source of income.

Women have played an important role in intensification of cocoa production. They often engage in the same tasks as men, and tended to be involved in making decisions on how the earnings from cocoa production were spent. However, women were largely excluded from making decisions on the marketing of cocoa and the purchase and sale of land and major farm equipment. Because of differentiated gender roles, women were expected to complete all domestic activities, leaving them with little time to be involved in on-farm activities and participate in trainings and cooperative meetings, even though many women displayed a strong interest in cocoa production. Many women also felt uninformed about meetings, the provision of technical assistance and market conditions. Recommendations for building more gender inclusive value chains include using mobile phones to share production information, market prices and meeting times; forming women and youth groups and training and hiring women technicians. Results also suggest an opportunity to move beyond the promotion of only cocoa to a diversity of economic activities that are important for women and the finances of smallholder households in the VRAEM.

[295] N. Porchet, C. Nordmann, M. Castillo. (2017). Turning the chocolate business upside down! Case story of a Swiss chocolate company co-owned by Peruvian farmers. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24825

Note: #24825e > #24507e

Abstract: The great majority of smallholder cocoa farmers today are marginalized, trapped in poverty and without possibility to take their own decisions. They strongly depend on the stock market and chocolate industry, which is dominated by some few transnational corporations maximizing their profits. The common market logic with very low cocoa prices as its consequence keeps the farmers in poverty and

encourages them to follow agricultural practices with detrimental impacts on the environment and the very sustainability of cocoa production.

To address these challenges, Choba Choba – a Swiss-Peruvian venture – is prototyping a new social business model with cocoa smallholders and consumers at the very core of the value chain. Farmers are shareholders and decision makers of their own company, profit from its success, define the selling price of their cocoa and develop advanced capacities to produce high quality original cocoa in an ecological set-up including nature conservation and promotion of cocoa biodiversity. Through communication activities chocolate consumers around the world are more aware of the current tremendous challenges of the farmers and therefore choose sustainable products. They personally meet and exchange with the producers of their beloved and unique chocolate.

The aim of this paper is to highlight the persistent challenges of smallholder cocoa producers and introduce the innovative social business model of Choba Choba, as a viable and life-changing model that can be replicated in the chocolate sector and beyond. The backbone of the model will be clearly explained through its theory of change jointly defined by the cocoa producers and the company staff. This will be followed by a description of the impact assessment system being set up to monitor the effects of the venture on the farmer's livelihoods and competencies, their natural environment, the sustainability of chocolate consumption and the scaling of impact within the global chocolate world. Finally, first tangible impacts after two years of activity will be shared such as the significant revenue increase and access to the "chocola revolution fund" (5% of chocolate sales distributed to farmers), the first achievements in the preservation of biodiversity as well as other important less unquantifiable dimensions like improved competencies and self-esteem.

Choba Choba's vision is a chocolate world in which smallholder cocoa producers are self-confident professional entrepreneurs with a direct connection to their consumers, live a prosperous and happy life in harmony with their environment and are an example for all the smallholder farmers in the world.

[296] J.C.F. Barrientos, W.A.G. Gómez. (2017). Análisis de la adopción de tecnología de producción de cacao en Nilo y Yacopí (Cundinamarca – Colombia): Analysis of the adoption of cocoa production technology in Nilo and Yacopí (Cundinamarca - Colombia). 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24826

Note: #24826e > #24507e (note: journal is in spanish)

Abstract: A pesar del incremento continuo de superficie y volumen de producción de cacao, y del potencial productivo y exportador que tiene, Colombia no ha incrementado significativamente su productividad desde hace décadas, manteniéndose ésta en alrededor de 0,5 t/ha. Y a pesar de que existe una propuesta tecnológica en oferta para elevar la producción y productividad, su adopción por parte de los productores no llena las expectativas. Con el propósito de indagar sobre este proceso se ha realizado una investigación descriptiva y explicativa en dos municipios del departamento Cundinamarca, Nilo y Yacopi. La información para el análisis se obtuvo de fuentes documentales, entrevistas con productores, líderes de organizaciones y técnicos de campo, así como de grupos focales con productores y sus líderes. Como resultado se obtuvo lo siguiente: En la zona de estudio hay y ha habido oferta de servicios de asistencia técnica con temas similares sobre el cultivo, y con frecuencia, especificidad, y calidad variables. Los métodos más utilizados son las capacitaciones, y días y escuelas de campo, orientados principalmente a grupos

de productores. La adopción se sitúa en un nivel medio-bajo en ambos municipios, aunque con un leve repunte en Yacopí por la importancia económica del cacao y presencia permanente de Fedecacao en la zona. Las principales limitantes de adopción tienen que ver con los relativos altos costos de implementación y su dificultad, los bajos y fluctuantes precios, el relativo largo tiempo de respuesta de la recomendación técnica, los desaciertos en las recomendaciones, y la escasez de mano de obra. Las estrategias de mejora se desprenden de las mismas limitaciones y de las experiencias de los productores y técnicos de campo. Estas tienen que ver con el acceso a mercados más favorables y con un mayor desarrollo de la oferta de servicios de asistencia técnica, así como con una mayor coordinación y cooperación entre prestadores de servicio de asistencia técnica.

[297] D.F.S. Hartatri, H. Firmanto. (2017). Direct partnership on cocoa processing in Papua Island, Indonesia for improving farmers' access to Japan market. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 5.

Reference ID: 24827

Note: #24827e > #24507e

Abstract: Direct partnership has involved three actors; they are small scale business unit, called CV Kakao Kita, international trading company (Company A) and Indonesian Coffee and Cocoa Research Institute (ICCRI). The cocoa processing and marketing activities of this partnership appears to offer exciting benefits for cocoa smallholders' livelihoods improvements. This paper reports on a direct partnership action in the Indonesian island of Papua, where such a direct partnership has been developed over five-year period. This particular experience found that smallholder cocoa farmers in Papua received slightly higher price. This leads by the farmer groups produce a higher quality of fermented dried cocoa beans. Furthermore, limited knowledge, skills and financial facilities in Papua has encouraged the international wholesaler to adopt farmers' empowerment approach. Therefore, the direct partnership between farmers and the buyer has also improved farmers' access to knowledge and skills particularly on cocoa processing method, and financial facilities, particularly saving facility. In addition, direct partnership approach has facilitated smallholder farmers in Papua to obtain buyer certainty and to obtain more access on marketing because the cocoa beans are bought by international wholesaler and sold to retailer in Japan market.

In order to improve the price of cocoa products, CV Kakao Kita has initiated collaborative work with ICCRI on processing intermediate and end products. Further, the intermediate and end products bought by Company A and then sell to distributors and consumers in Japan. This has paralleled with the Government of Indonesia's (GOI's) program namely downstream program which encourages cocoa export into intermediate and end products. However, the minimum knowledge and skills on good agricultural practices (GAP) and downstream processing have limited farmers to obtain higher income. Therefore, improving knowledge and skills of smallholder farmers on GAP and cocoa processing is required to support smallholder farmers' access to Japan market.

[298] J. Alvarado, J. Iturrios. (2017). Determinantes de la productividad en pequeños productores de cacao de las regiones de San Martín, Huánuco y Ucayali (SM/H/U): una aproximación exploratoria al modelo tecnológico de productividad en estas regiones: Determinants of productivity in small cocoa producers in the regions of San Martín, Huánuco and Ucayali (SM/H/U): an exploratory approach to the technological model of productivity in these regions. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 13.

Reference ID: 24828

Note: #24828e > #24507e (note: journal is in spanish)

Abstract: El Perú ostenta una de las productividades promedio de cacao más altas del mundo, 769 kilos por hectárea, en comparación con otros países productores. Las regiones de San Martín, Huánuco y Ucayali, representan el 54% del cacao que se produce en el Perú y un 43% de los productores dedicados a este cultivo. Este estudio presenta un análisis de los determinantes de la productividad del cacao en estas tres regiones de la amazonia del Perú.

Utilizando una muestra representativa de 415 productores con cultivos de tres o más años de producción y un modelo de Mínimos Cuadrados Ordinarios, encontramos que la edad del cultivo del cacao, los años de experiencia del productor en el cultivo del cacao, y la presencia de cacao nativo son las variables más significativas en explicar las diferencias en los rendimientos del cultivo de cacao. Las dos primeras tienen signos positivos, mientras que el cacao nativo, que muchos productores llaman equivocadamente criollo, tiene una relación negativa. Otras variables que aparecen en el modelo dentro del umbral de significancia estadística (90%) son el uso de crédito formal, la edad del productor, y los precios pagados en chacra. Cercanas a este umbral aparecen otras variables como la presencia del clon CCN51, la edad del jefe de hogar y el trabajo fuera de la parcela (al 88%). Poda y abonamiento recién aparecen significativos a un 85%, mientras que la educación del productor y la fertilización no aparecen con influencia estadísticamente significativa sobre los rendimientos. Los clones finos de aroma con más de tres años en producción comercial si bien aparecen con signo positivo, constituyeron una muestra muy pequeña aun (19 casos) por lo que tampoco aparecen como significativos.

Una de nuestras principales conclusiones es que el modelo tecnológico que viene explicando el éxito del crecimiento del cacao y su productividad en estas tres regiones del Perú, se sustenta en la juventud de las plantas y en la introducción masiva de la injertación como técnica para expandir el cultivo de nuevos clones de cacao, como el CCN51, introducidos gracias a la asistencia técnica de los programas de desarrollo alternativo promovidos por el Gobierno Peruano con el decisivo apoyo de la Agencia de los Estados Unidos para el Desarrollo Internacional, USAID, durante estos últimos 15 años, lo que a su vez ha permitido formar una generación de productores de cacao capacitados y con experiencia, que es el otro pilar encontrado en el modelo tecnológico de productividad. Sin embargo, a juzgar por los resultados estadísticos, se hace necesario aumentar la eficacia de la poda y el abonamiento, e incluso más aun de la fertilización, pues estas tres variables no aparecen con mucha fuerza dentro del modelo tecnológico seguido hasta el momento, y esto a largo plazo va a significar que con el envejecimiento de las plantas y el deterioro de la riqueza nutricional del suelo decaiga la productividad y la rentabilidad del cultivo.

[299] S. Louafi, A. Meter, B. Laliberte, V. Medina. (2017). Design and implementation of a global collaborative framework on Cacao Genetic Resources: incentives, constraints and institutional structures. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 22.

Reference ID: 24829

Note: #24829e > #24507e

Abstract: Research in cacao genetics plays a crucial role for the sustainability of the cacao sector. Effective management and improvement of cacao genetic resources relies on the exchange of resources such as genetic material, data or knowledge between different countries and across continents. It often involves global collaboration among a range of diverse actors interested in cacao genetic resources but with different capacities, aspirations and motivations. The cacao genetic community has already engaged in large-scale research collaboration in the past especially through the international CFC/ICCO/Bioversity projects from 1998 to 2010 and a new collaborative initiative is currently being discussed, the Collaborative Framework for Cacao Evaluation (CFCE). This paper aims at understanding the opportunities and constraints for the formation process of collaborative inter-organisational initiative in cacao genetic research. It identifies the range of challenges to be addressed by the cacao community to make more informed choices about definition of common objectives, process and governance structure in establishing a collaborative initiative. This paper draws from an analysis of a survey conducted in April 2016 on a sample of 391 people involved in cacao genetic resources related activities, a bibliographic analysis as well as an indepth evaluation and interviews carried out on the CFC/ICCO/Bioversity projects, drawing out the key lessons learnt and recommendations. Preliminary results show that existing barriers can potentially play against global collaboration and undermine a perceived sense of convergent interests. However, these constraints are more than counterbalanced by the existence of institutions that have the ability to support global collaboration and by pre-existing social relationships, including the CFC / ICCO / Bioversity project, that reflect a sense of strategic interdependency among potential participants. Therefore, the community's capacity to build on the awareness of the benefits of global collaboration and to agree on global objectives will depend on its ability to overcome tensions created by geographical distances, disciplinary divides or differences in capacity and to design a collaborative framework that will take advantage of existing converging forces while minimizing the effects of diverging forces.

[300] T.J. Casanova, F.M. Amores, GarzónA.I., R.G. Loor, I.A. Sotomayor, J.C. Jiménez, O.M. Tarqui, G.A. Rodríguez, G.C. Quijano, L.F. Plaza, H.E. Guerrero, F.G. Zambrano. (2017). Costos y distribución temporal de la inversión para el mejoramiento genético y desarrollo de una variedad clonal de cacao (*Theobroma cacao* L.) de alta productividad: Costs and temporary distribution of investment for the genetic improvement and development of a variety clonal cocoa (*Theobroma cacao* L.) high productivity. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 7.

Reference ID: 24830

Note: #24830e > #24507e (note: journal is in spanish)

Abstract: El presente trabajo se desarrolló con el objetivo de dotar al sector cacaotero de montos de inversión referencial para la obtención de una variedad clonal de cacao de alta productividad. El tipo de investigación utilizado es el de estudio de caso de naturaleza exploratoria-descriptiva, aplicando el método analítico para examinar las distintas etapas del proceso. Las fuentes principales de información fueron reportes

técnicos y publicaciones del Programa Nacional de Cacao. Diálogos con investigadores y ex investigadores de dicho Programa, con experiencia y conocimiento del proceso de mejoramiento genético del cacao, representaron también valiosas fuentes de información. Con la información obtenida, se construyó una matriz de datos para su análisis y procesamiento estadístico y contable. El proceso para conseguir una variedad de cacao genéticamente mejorada se dividió en cinco etapas: 1. Selección y cruzamiento de parentales con valor genético y siembra de plantas híbridas en campo, 2. Establecimiento, evaluación de progenies segregantes y selección de plantas híbridas, 3. Clonación de plantas seleccionadas para el establecimiento y evaluación de pruebas interclonales, 4. Selección de los clones con mayor productividad y establecimiento de parcelas semi-comerciales a nivel multilocal, y 5. Establecimiento de jardines clonales para la multiplicación de material de siembra, reporte final, registro en el Instituto Ecuatoriano de Propiedad Intelectual (IEPI) y publicaciones técnicas relacionadas. El monto total de inversión para completar este proceso, en un periodo de 19 años, es de USD\$ 3.551.096. Las etapas antes señaladas demandaron los siguientes montos: USD 1.836.744; USD\$ 1.005.952, USD\$ 262.883; USD\$ 318.973 y USD\$ 126.544. Los montos estimados para cada etapa se sostienen en la siguiente estructura de costos: Personal, Servicios e Insumos de campo, Equipos, Difusión, Terreno e Infraestructura. La primera etapa demandó la mayor inversión, mientras que el rubro de costo que soportó el mayor peso de la inversión fue Personal, con el 54,13% de los costos.

[301] O.O. Oduwole, B.S. Famuyiwa, S. Adebisi. (2017). Constraints to Youth Involvement in Cocoa Production in Nigeria. 2017 International Symposium of Cocoa Research (ISCR). Lima, Peru. pp 1 - 6.

Reference ID: 24831

Note: #24831e > #24507e

Abstract: Youth involvement in Cocoa farming in Nigeria can be a panacea to increasing the low level of production based on their dynamism, energy, and optimism. These qualities are much evident in West Africa sub-region where their activities have resulted in increase in production. However, about 65% of the country's population is in the youth age bracket of 16-40 years old, out of which only 35% are in agriculture while 65% between the ages of 15-60 years are unemployed. This study examines the constraints to youth involvement in cocoa production in Nigeria. A total of one hundred and fifty respondents were selected using a multistage cluster random sampling technique in five cocoa producing states in Nigeria. The major constraints affecting youth participation in cocoa production include: inadequate credit, low profitability of investment, lack of access to necessary inputs, and difficulty in land acquisition. There is a relationship between the constraints and farming knowledge. It is concluded that the youth should be mainstreamed into cocoa production through the establishment of business incubation platform across the producing states with provision made for credit and necessary inputs. This intervention will motivate youth in accepting Cocoa farming as a business like any other works of life.

[302] IPNI. 2010. Research with Impact - Diagnosing and Mapping the Need for Soil Improvement in Brazil. BRA-61. pp 1 - 1.

Reference ID: 24832

Note: #24832e

Abstract: Strategic planning for future fertilizer demands requires knowledge about where nutrients and soil amendments are currently lacking. Farmers are encouraged to sample soil from their fields on a regular basis to assess if any nutritional factors

are limiting crop yields. But compiling all these separate pieces of data into a comprehensive survey is needed to get a full understanding of the state of soil fertility. Brazil has lacked the data for creating a soil fertility survey that could be used for planning.

[303] T.M. Maaz. 2018. Plant Nutrition Today - Fall 2018 Issue 3 No 1: Plant Proteins, Glutens and Nitrogen. (3). pp 1 - 2.

Reference ID: 24833

Note: #24833e

Abstract: Soil fertility plays an important role in building plant protein because the nutritional value of plant seeds depends on having an adequate supply of N.

[304] S. Li. 2018. Plant Nutrition Today - Fall 2018 Issue 3 No 2: Potassium Fertilization is Critical to Sunflower. (3). pp 1 - 2.

Reference ID: 24834

Note: #24834e

Abstract: Field trials conducted on-farm in northwest China typically find that K fertilization significantly affects seed yield and quality ...more than 75% of (oil sunflower) trials have had good yield responses to K application ... 100 % of (edible sunflower) trials have had significant yield responses to K.

[305] T.S. Murrell. 2018. Plant Nutrition Today - Fall 2018 Issue 3 No 3: The Concept of "Minimal" Exchangeable Potassium. (3). pp 1 - 2.

Reference ID: 24835

Note: #24835e

Abstract: ... soil (K) fertility and exchangeable K are not the same. Soil fertility includes all of the exchangeable K, but it also includes an additional portion of non-exchangeable K that plants use.

[306] IFA. (2018). Executive Summary - IFA 2030 Scenarios: Digging deeper, thinking harder, planning further. IFA Executive Summary. pp 1 - 7.

Reference ID: 24836

Note: #24836e (pls note: this report is nearly the same as #24553)

Abstract: As the world grows towards 10 billion people, creating greater natural resource constraints, and as new technologies change our lives and our possibilities more than ever before, the global fertilizer industry wishes to define its place in this future. To help do this, the International Fertilizer Association (IFA) embarked on a long-range strategic planning process using scenario planning methodologies. They focused on the most pressing issues facing the fertilizer industry as a way to extend thinking and test preparedness; a 'wind tunnel' for designing industry-wide and company-specific approaches that are informed, robust and anticipatory.

[307] P. Glasbergen. (2018). Smallholders do not Eat Certificates. Ecological Economics. 147 pp 243 - 252.

Reference ID: 24837

Note: 24837e

Abstract: Voluntary standards and certification schemes aim to play an important role in the creation of a more sustainable production of agricultural commodities in the South. In this paper, we contend that most studies on the sustainability of these certifications take the objectives of voluntary standard-setting and certifying arrangements as the reference point, thereby implicitly accepting a problem definition

that is not necessarily aligned with the needs, interests and preferences of the smallholder producers in a developing context. Based on the results of a four years research project on coffee and palm oil smallholders and certifications in Indonesia, this paper questions the transformative capacity of the standards and certifications regarding a more sustainable agricultural production. This capacity is located at the interface of the global demands, which are channeled down from the top of the value chain, and the local context where local producers take their decisions. Based on the empirical research it is argued that voluntary standards and certifications pave the way for a more sustainable agricultural production, but are not necessarily the right way forward to a more systemic change.

[308] T.M. Maaz, S. Waldo, T. Bruulsema, R. Mikkelsen. (2018). Inconsistencies undermine the conclusion that agriculture is a dominant source of NO_x in California. *Science Advances*. 4(9) pp 1 - 3.

Reference ID: 24838

Note: #24838e

Abstract: Almaraz et al. reported that agricultural soils are a dominant source of NO_x pollution in California (20 to 32% of total statewide NO_x emissions). However, this conclusion may be undermined by the lack of agreement between their modeled estimates and previously reported empirical measurements, the extrapolation of NO_x fluxes during hot moments to derive annual estimates, and the overestimation of nitrogen fertilizer consumption in California.

[309] J. Lyons-White, A.T. Knight. (2018). Palm oil supply chain complexity impedes implementation of corporate no-deforestation commitments. *Global Environmental Change*. 50 pp 303 - 313.

Reference ID: 24839

Note: #24839e

Abstract: In recent years, many palm oil companies have committed to eliminating deforestation activities from their operations. NGO reports and companies' self-identified challenges indicate that barriers exist that impede the implementation of these commitments. Here we show that complexity across the extent of the palm oil supply chain poses a major barrier that hinders companies from being able to secure guaranteed no-deforestation commitments. Other barriers include the lack of consensus on definitions of deforestation, inadequate government support and persisting markets for unsustainably-produced palm oil in China and India, which undermine companies' efforts to achieve supplier engagement and compliance. Current certification standards, meanwhile, require amendment to help overcome barriers posed by supply chain complexity. In conclusion, the existing model used to address palm oil-driven deforestation, based on NGO shaming campaigns and unilateral adoption of commitments by individual companies, is unlikely to achieve no deforestation in the current context of palm oil production and trade. Instead, a broader set of complementary mechanisms is required to overcome supply chain complexity and ensure that no-deforestation commitments can be implemented successfully.

[310] D. W. Goodall. (1949). A Quantitative Study of the Early Development of the Seedling of Cacao (*Theobroma cacao*). *Annals of Botany*. 13(1) pp 1 - 21.

Reference ID: 24840

Note: #24840e

Abstract: IN the course of investigations of the growth rate of the cacao seedling it became of interest to know to what extent the plant depended upon the cotyledons for

the supply of material, at what stage it became independent of the reserves stored in the seed, how much of the seed reserves were lost in respiration before this occurred, and in what manner the material translocated from the cotyledons and formed by assimilation was distributed among the various other organs of the seedling as development proceeded.

[311] R. Asare, V. Afari-Sefa, S. Muilerman. (2018). Access to Improved Hybrid Seeds in Ghana: Implications for Establishment and Rehabilitation of Cocoa Farms. *Experimental Agriculture*. 54(2) pp 273 - 285.

Reference ID: 24841

Note: #24841e

Abstract: Poor access to improved seeds in West and Central Africa has compromised crop yields and productivity as most farmers source the bulk of their seeds from informal channels. The use of farmer produced seeds has mostly resulted in high seedling mortality thereby presenting challenges to cocoa rehabilitation programmes across the sub region. With the aid of a mobile data collection system (MDCS), the first of its kind to enhance accuracy of survey results in an improved seed supply system through brokerage and linkages among diverse actors, this study assesses Ghanaian farmers' access to improved hybrid cocoa seeds and provides evidence on the socio-cultural factors that affect field performance of such planting materials. Results show that farmers value a seed brokerage system (SBS), which is facilitated through group bulk purchase, timely acquisition and delivery of seeds. The study also revealed that farm size, land use type and gender have significant effect on survival rate of transplanted hybrid cocoa seedlings over two dry seasons. Regardless of the rehabilitation process, mean survival rate was high (79%) although an 11% ($p < 0.000$) difference occurred between gender with men recording a higher rate. The majority of farmers prefer cultivating cocoa on forest and fallow lands, implying continued degradation of forest areas. There is therefore an urgent need for a change of mind set, to advocate for land recycling to spare forest areas to thrive.