

New Entries to IPNI Library as References

Valkama E., R. Uusitalo, K. Ylivainio, P. Virkajarvi, and E. Turtola. 2009. Phosphorus fertilization: A meta-analysis of 80 years of research in Finland. *Agriculture, Ecosystems & Environment*, 130:75-85.

Reference ID: 20312

Notes: #20312e

Abstract: In order to integrate Finnish phosphorus (P) fertilization trials, we performed a meta-analysis on the relationship between P rates (6-100 kg ha⁻¹) and the yield increase of agricultural crops, and studied the source of variation in yield responses (soil group, soil test P, soil pH, plant group, cereal species, productivity without P fertilization, and cultivation zone). Our database consisted of over 400 short- and long-term experiments conducted in Finland over 80 years, between 1927 and 2007. The crops studied were spring-sown barley, oats, spring and autumn-sown wheat and rye, potato, turnip, pea, and perennial grass mixtures. The experiments had been carried out all over the country, on clay, coarse-textured mineral and organic soils. The meta-analysis demonstrated that P fertilization significantly increased crop yields (by 11%) compared to the control (fertilized with nitrogen and potassium). However, the yield response to P fertilization was highly dependent on the soil group: on clay soils it was only 5%, while on coarse-textured mineral and organic soils it was 10% and 15%, respectively. On clay and organic soils, the lowest P rates (6-15 kg ha⁻¹, mean 13 kg ha⁻¹) were enough to gain the maximum yield increases of cereals, while coarse-textured mineral soils needed higher P rates (16-30 kg ha⁻¹, mean 25 kg ha⁻¹). In the case of perennial grass mixtures, maximum yield increases were obtained in all soil groups with the lowest P rates (6-15 kg ha⁻¹, mean 13 kg ha⁻¹). Yield responses to P fertilization were apparent on coarse-textured mineral and organic soils with low soil test P, measured by the acid ammonium acetate method (<10 mg PAc l⁻¹, coarse-textured mineral; <8mg PAc l⁻¹, organic), or on soils with low productivity without P fertilization (<2000 kg ha⁻¹). The responses were negligible or low on soils with medium or high soil test P (>10 mg PAc l⁻¹, coarse-textured mineral soils; 8mg PAc l⁻¹, organic soils), or with medium (2000-3500 kg ha⁻¹) or high (3500-5000 kg ha⁻¹) productivity. On clay soils, P fertilization increased yields to the same extent regardless of soil test P level or productivity. Finally, neither soil pH (3.2-6.6) nor cultivation zone (with growth periods varying between 100 and 175 days) had any effect on yield responses in any soil group. For cereals and perennial grass mixtures, the P rates justified by the meta-analysis were only about half of the maximum values allowed by the third Finnish Agri-Environmental Program, or those applied in practice on Finnish livestock farms. Thus excessive P application can be further markedly reduced without measurable yield decrease.

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Reference ID: 20318

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Notes: #20346e

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Reference ID: 20347

Notes: S 8.1.1 #20347e

Ayodelle T. 2014. Challenges and opportunities oil palm industry in Africa. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20348

Notes: S 8.1.1 #20348e < #20347e

Abstract: A productive agricultural sector in Africa is vital to the continent's future. It is an essential tool for poverty reduction, food security and broader economic growth. Agriculture in Africa does, however, suffer from chronic underinvestment. This can in part be attributed to neglect by central governments, who exhibit what development experts refer to as 'urban bias'. This occurs across a range of institutions, including poor political leadership, ineffective agricultural administrations and poor government budgetary management. Rather than waiting for wholesale institutional reform, it is vital that the private sector fill in these gaps where government is failing. Oil palm is a plantation crop that is well-suited to succeed in these circumstances. Potential FFB yields in Nigeria are comparable with those in South East Asia. It is therefore likely that African smallholders will be able to take advantage of the relatively small economies of scale required for profitable oil palm operations. Indeed, this is the case already in some economies; 80 per cent of production in Nigeria and Ghana is undertaken by smallholders. Headwinds, however, remain in the form of increasing requirements for sustainability measures, generally from Western companies. These include the 'no deforestation' campaign currently being undertaken by the so-called 'Palm Oil Innovations Group'. The problems with this approach are that: i) it significantly increases the barriers to entry for new players; ii) it significantly increases compliance costs for smallholders who are generally unable to afford to implement the standards required, which leads to; iii) smallholders are often removed from supply chains to implement these standards. Unilever, for example, estimated that 80 per cent of its smallholder suppliers would be removed from its supply chain to meet its new sustainability policies. The RSPO standard is similar with financial and economic impracticalities of the standard for smallholders have similarly been observed by analysts and the RSPO organisation itself. In this regard, the current model being pursued in both Indonesia and Malaysia - for the development and implementation of national standards (ISPO and MSPO respectively) - is an ideal policy solution. Because the standards are based on existing regulatory requirements, national development goals and priorities effectively form part of each standard and are not dictated by external actors, such as international NGOs or other market intermediaries. Further, the development of these standards has followed national standard development procedures, and therefore include the governance requirements missing from voluntary standards.

This paper subsequently argues that African palm oil producers should look to the Malaysian and Indonesian standards as the model for the future. This will provide further opportunities within global supply chains via international mutual recognition of these standards under an umbrella certifying body. Multilateral organisations such as IFAD, AfDB and FAO are well-positioned to assist in developing these standards.

Mesa-Dishington J. and B. Hernandez-Salame. 2014. Current trends and outlook for the oil palm agribusiness in Latin America. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20349

Notes: S 8.1.1 #20349e < #20347e

Abstract: Continental America is a key player in the oils and fats market both as a producer and a consumer. Oil palm is grown in the continent's tropical region which covers Central America, the northern section of South America, and the Caribbean.

Due to the increasing demand for oils and fats around the world, for both edible and non-edible uses, investment in oil palm in Latin America is an interesting opportunity due to land availability without compromising high conservation areas and oil palm's high oil yield per hectare compared to other oilseeds. Continental America consumes more palm oil than it produces. This can be explained, on the one hand, by the increasing demand for palm oil in North America for its health and nutritional advantages; and on the other, by the demand for palm oil for non-edible uses such as the production of biodiesel in tropical Central and South America. One of the main challenges for the production of oil palm in Latin America is to overcome the sanitary problems caused by pests and diseases, consequence of the ample biodiversity of the region. This requires greater investments in research. Another important challenge is the higher costs of production observed in Latin America, partially explained by labor costs, compared to those in Asian countries. To close this competitiveness gaps, it is necessary to improve the technologies that are commonly used. The development of the oil palm agribusinesses in the region is an opportunity for inclusive businesses, a source of better incomes in rural areas, through formal and well remunerated jobs. These social benefits added to responsible environmental practices, are differentiating factors in the international markets, which are increasingly requiring sustainable products. Latin America offers the conditions to develop successful projects that are economically, socially, and environmentally sustainable, and for this reason it has the possibility to differentiate itself from other producing regions through certifications such as the RSPO.

Xu X. 2014. Palm oil feeds the world. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20350

Notes: S 8.1.1 #20350e < #20347e

Abstract: Palm oil takes more than one third of the world oil and fat production. From agriculture point of view, palm has the highest oil and fat yield per acre per year comparing to other oil crops. Consequently palm oil is the cheapest among other oils and fats in general. Palm oil is an important and versatile vegetable oil which is used as a raw material for both food and non-food industries. The acceptance of palm oil worldwide is due to its unique properties that encourage its use in a wide range of end products. These properties are made more versatile by the various fractions and refined forms that are available in the world market. The four main traditional uses of palm oil in food products are for cooking/frying oil, shortenings, and margarine and confectionary fats. Palm oil is popularly used in both solid fat products as well as in the liquid cooking oil sector especially in industrial frying applications. It offers several technical characteristics desirable in food applications, such as resistance to oxidation, which contributes towards longer shelf life of end products. Palm oil is ideally suited for use as an ingredient in shortenings and margarines as it has 20 - 22% solid fat content (SFC) at 20°C, which helps in the formulation of fat products with a plastic range. It tends to crystallize in small beta-prime crystals, a property desirable for some applications, in particular table and industrial margarines. Palm oil also has other functional attributes that make it a valuable ingredient in food formulations. In many applications, palm oil can be combined with harder fractions such as palm stearin to produce products of the required consistency without hydrogenation. Palm oil products also find wide applications in the non-food sector, especially in the production of soaps and detergents, pharmaceutical products, cosmetics, and oleochemical products. Soap production is one of the most important applications. Fatty acids derived from the splitting process can be used directly in products like candle, cosmetics and in

rubber processing. Derivatives of fatty acid include fatty esters (the most important of which is fatty acid methyl ester), fatty alcohols, fatty amines and fatty amides. Fatty esters are used in various industries such as biodiesel, textile, cosmetic, pharmaceutical, plastic and other applications.

Darmosarkoro W. 2014. Indonesian palm oil industry in supporting food and energy securities. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20351

Notes: S 8.1.1 #20351e < #20347e

Abstract: Indonesia is blessed with rich in natural resources to provide food and energy for the world and Indonesian people. However, nowadays Indonesia face problems in importation of meat and cattle fossil fuel that challenging national food security and energy security. In other side, Indonesia exporting palm oil products including palm oil mill and palm kernel meal that mostly used to supply demand of world's oil/fat based food products, feedstock for supporting animal husbandry and also feedstock for energy production e.g. biodiesel and biogas. Palm oil industry also produce by products and residues both in plantation as well as in palm oil mill that may supply feedstocks for animal husbandry and renewable energy in form of biodiesel, biofuel, biogas and electricity. The huge quantities of biomass available from palm oil industry may contribute to support food security and energy security in Indonesian context.

Ardiansyah F. 2014. Toward green agriculture: the case of oil palm development. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20352

Notes: S 8.1.1 #20352e < #20347e

Abstract: Over the last two decades, palm oil has emerged as one of the most significant contributors to Indonesia's economy, topped only by oil, gas, and mineral products. In 2009, Indonesia surpassed Malaysia to become the biggest producer of palm oil in the world, with production accelerating dramatically in recent years. Indonesia also possesses the largest area of land in oil palm plantations in the world. The market clearly drove this oil palm boom, prompted largely by the increase in food demand in Indonesia, India and China as well as the plan to expand biofuel markets in Europe and other countries. Rapid expansion of oil palm plantations, however, has been accused to have led to the conversion of important and fragile terrestrial ecosystems, including a significant area of tropical forests and peat lands. NGOs and the public, for instance, often accuse oil palm plantations as one of the responsible sectors whenever forest and land fires occurring in Southeast Asia. Some key palm oil actors, ranging from buyers, retailers, producers, financiers and NGOs, have been active in seeking possible solutions, among others, by developing standards and best practices which aim at transforming the palm oil sector. The creation of the Roundtable on Sustainable Palm Oil and other similar national platforms indicate the willingness of palm oil stakeholders to change for the better. Challenges to realise sustainable palm oil and to some extent, "green" agriculture, are huge, especially in applying such standards and best practices at local level where different vested interests may hinder the application of responsible and sustainable practices. This paper attempts to discuss progress achieved and challenges faced by palm oil actors and relevant stakeholders on the journey of sustainable palm oil. The scope of the paper includes discussion about land use, reducing deforestation and peat land conversion and degradation, and stakeholder collaboration. The intent of this paper is not to provide an exhaustive coverage of all

issues of sustainable palm oil and green agriculture; instead, the paper aims to capture strategic lessons-learned so that palm oil actors and relevant stakeholders can continue their efforts to improve policies and practices in this respective sector.

Abdullah M. E. M. 2014. Establishment of a wealthy oil palm community through sustainable development with reference to Felda and FGV. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20353

Notes: S 8.1.1 #20353e < #20347e

Abstract: Felda was set up in 1956 with the objectives of poverty eradication and providing land for the landless. The Felda model involved grouping of farmers into organized 317 Schemes and managed like commercial estates. There are currently 112,635 farmers in the Felda Group scattered over 521,938 hectares of land in 11 states of Malaysia. Felda initially started as a land developer but then the model evolved to include the commercial development. Many of Felda's departments that were servicing the land projects e.g. milling, transport, security, bulking, engineering, R&D etc. were eventually privatized. Felda Holdings Bhd which is the umbrella for the 74 companies has an equity structure, where 51% is owned by the Farmer's Cooperative, "Koperasi Permodalan Felda (KPF)". KPF gives an average of 15% dividend per annum from the time of its inception in 1980. In 2007, the Felda Global Ventures (FGV) was incorporated and in 2012, FGV was listed, thereby unlocking the wealth in Felda. Today the Felda farmers have a 20% stake in FGV through a trust and also hold shares individually, giving them another source of dividend income. Through the growth of FGV organically and inorganically, within the country and abroad, the potentials of greater wealth creation is envisaged. As Felda developed over the years, it was based on sustainable principles encompassing economic development, social upliftment of its farmers and a growing responsibility to the environment. These are captured in Felda's sustainability effort by way of its involvement in Roundtable for Sustainable Palm Oil (RSPO) and International Sustainability and Carbon Certification (ISCC) of its mills and estates/schemes complexes. With 72 mill complexes covering 723,394 hectares of oil palm, Felda and Felda Global Ventures are committed to ensure that all its 72 mill complexes will be certified by 2017.

Turnbull N., H. de Franqueville, B. Frederic, S. Jeyen, I. Syahputra, B. Cochard, and T. Durand-Gasselin. 2014. Screening methodology to select oil palm planting material partially resistant to *Ganoderma boninense*. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20354

Notes: S 8.1.1 #20354e < #20347e

Abstract: Many oil palm plantations experience considerable losses mainly due to basal stem rot disease, caused by *Ganoderma boninense*, a telluric fungus which provokes lethal damages to the crop. Cultural practices, agronomic and phytosanitary management can reduce the impact of the disease. It should come along with the use of planting materials which are resistant, even partially, to *G. boninense*. Total resistance of plants to such fungus has not yet been reported, but many examples of partial resistances have been observed including for oil palm. Inoculation of oil palm seedling in nursery or pre-nursery is generally possible using *Ganoderma* colonized rubber wood blocks as inoculum source. A methodology has been developed to systematically screen oil palm planting material for its resistance to *G. boninense* in pre-nursery. This methodology, which is highly reproducible and

consistent, allows breeders to develop as a routine a relatively high-throughput phenotyping. More than 5 000 cross have been evaluated to date. Our research group has first confirmed the absence of interaction between *G. boninense* isolates and tested oil palm progenies. The prevailing of additive variance has been highlighted. From this founding it has been decided to standardize the methodology by using testers. Since a long time, pure Deli material is well known for its relatively high susceptibility to basal stem rot disease. Therefore emphasis was given to test Deli origins. Sixteen of them were evaluated for their resistance, this represent 115 Deli progenies and 1847 crosses tested. At the same time existing breeding field, seed garden, parental garden and progeny tests, were carefully observed. Four Deli origins which show partial resistance both in field and in early screening test were selected. Advantage was taken of wide within origin variability to select the best SIB crosses amongst them. Twelve B group origins (pisifera) were evaluated mainly from la Mé and Yangambi origins. This represents 26 B group progenies.

Rahmadi H. Y., Y. Yenni, N. Supena, S. Ernayunita, R. Faizah, S. Wening, and A. R. Purba. 2014. Progress of *Elaeis oleifera* breeding in IOPRI. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20355

Notes: S 8.1.1 #20355e < #20347e

Abstract: The first *Elaeis oleifera* IOPRI's germplasm were planted in 1941 originated from Brazil, than in 1952 *E. oleifera* from Suriname were planted in 1952. Afterwards, in 1975 interspecific hybrids (F1) were planted from Colombian *E. oleifera*. While the interspecific hybrids program of *E. oleifera* from Brazil and Suriname were planted between 1977 until 1980 and the first Backcross cycle (BC1) were planted between 1990 until 1995 and continued in 2006 and 2013 alongside with the BC2 and BC1 clones programs. *E. oleifera* breeding programs were relatively slow due to the fact that the yields were low and the oil quality characteristics (high unsaturated fatty acid and high beta-carotene content) were additive. Hence beta-carotene contents in *E. oleifera* germplasm could reach up to 4000 ppm, but the best BC1 could only reach 2100 ppm. However there are hopes, since some BC1 FFB planted in 2006 could reach up to 250 kg/palm/year with 28% of OER. In 2011 the *E. oleifera* breeding program was revised due to inconsistency of the *E. guineensis* donor from the previous program therefore the best *E. guineensis* from IOPRI's RRS second cycle were used as donor for the new F1 and BC programs. More works were conducted in improving *E. oleifera*, F1 and BC germinating rate, clonal propagation and used in Ganoderma nursery test.

Choo C. N., C. K. Wong, M. R. Nur Akilla, C. C. Ee, A. A. Ilham, and C. C. Tan. 2014. Genotype effect on oil palm tissue culture callogenesis and embryogenesis. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20356

Notes: S 8.1.1 #20356e < #20347e

Abstract: 12 clones were recloned, replicated by cloning the ramets, ranging from 4 to 15 ramets per clone, in order to evaluate the genotype effect on callogenesis (CI) and embryogenesis (CD). The CI percentages (clone mean basis) ranged from 18.1% - 38.5% with a mean of 29.2%, while the CD percentages (clone mean basis) ranged from 1.9% - 9.9% with a mean of 5.2%. Differences in CI and CD observed among clones were statistically significantly at 5% significance level by analysis of variance. Each clonal ortet was subjected to two proprietary protocols, different only in the quantity of a plant growth regulator. The difference in CI percentages and

difference in CD percentages between two protocols, mean 30.0% versus mean 28.4% and mean 5.4% versus mean 5.1% respectively, were statistically not significant at 5% significance level by analysis of variance.

Rhebergen T., M. Hoffmann, S. Zingore, T. Oberthür, K. Acheampong, G. Dwumfour, V. Zutah, C. Adu-Frimpong, F. Ohipeni, and T. Fairhurst. 2014. The effects of climate, soil and oil palm management practices on yield in Ghana. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20357

Notes: S 8.1.1 #20357e < #20347e

Abstract: The demand for palm oil and derived products in Ghana is presently outstripping supply, and fruit bunch yields are decreasing. Yield gaps in oil palm smallholdings and plantations in Ghana are explained by sub-optimal climate conditions, soil fertility constraints, and field management. In 2012, the International Plant Nutrition Institute and Solidaridad West Africa initiated a seven year project, to implement 'Best Management Practices (BMP)' to improve productivity in three oil palm plantations and 20 smallholder farms. In order to assess entry points for increasing productivity in existing oil palm plantings, a simple model is used to partition yield gaps between different causes. Differences in yield between fields under BMP and standard plantation and smallholder practices provide an indication of the scope for yield improvement. Estimates of yield potential (Y_p) and water-limited yield (Y_w) were obtained using PalmSim, an oil palm growth and yield model and also used to estimate yield gaps. With the PalmSim model, simulated Y_p and Y_w in BMP sites ranged from 38-45 and 21-32 t FFB ha⁻¹ respectively. The average difference between the simulated Y_p and Y_w across all sites was 15.0 t ha⁻¹, indicating a large yield gap explained solely by water stress. The average yield in plantations after 12 months of BMP implementation was 12.8 t ha⁻¹ compared with 11.6 t ha⁻¹ for control plots (REF) (+1.2 t ha⁻¹, +10%), and for smallholder farmers, average BMP yields were 10.9 t ha⁻¹, compared with 8.4 t ha⁻¹ in REF fields (+2.5 t ha⁻¹, +30%). The short-term yield response with BMP can be explained by shorter harvest intervals and complete crop recovery after the installation of proper access in BMP fields. Yield gaps were larger in smallholder farms at 12.6 t ha⁻¹, compared with 6.4 t ha⁻¹ in plantations. There is a large potential to increase yields in smallholder farms simply by improving crop recovery with the installation of proper infield access and tight control of harvest intervals. Field trials will continue until 2018, by which time we expect all fields under BMP will have reached maximum attainable yield. To meet the projected oil demand in Ghana and to avoid palm oil imports, yield intensification is required in existing plantings because there is limited land available for further expansion that meets the requirements for sustainable palm oil production.

Ajambang W., C. Mondjeli, M. Galdima, G. Nstomboh, G. Ngando, S. W. Ardie, H. Volkaert, and Sudarsono. 2014. Response of oil palm to mechanical and abiotic stress. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20358

Notes: S 8.1.1 #20358e < #20347e

Abstract: Plants exhibit morphological and physiological variations with respect to changes in their immediate environment. These responses are intended to acclimatise the plant to the external shocks. Today's major challenge would be to understand the molecular mechanisms underlying the response to these unstable climatic conditions in order to be able to regulate productivity at the level of the

laboratory. For molecular studies, where tissue extraction and RNA isolation are needed, it would be very important to know the exact time to extract tissue samples because regulatory genes are time specific and mRNA degrades very fast. The objective of this research was to determine the amount of time needed for the oil palm to initiate response mechanisms against complete defoliation treatment and estimate the quantity of soil water deficit that would optimize this treatment. Defoliation was done on 03 trees every month between 2007 and 2011 giving a total of 162 trees. Some 18 climate-related research variables were used to evaluate their role in male inflorescence emission. A Pearson's regression analysis, a paired and two -sample t-test were used. There was an increase in male inflorescence emission after treatment. Complete defoliation accompanied by Soil water deficit of 16.8 mm during the second month after treatment significantly increased male inflorescence emission. Plants responded to treatment between the 30th and 60th day after treatment (DAP). This might be due to the fact that the oil palm has a heavy trunk containing 65% of its total carbohydrates and thus serve as buffer in times of stress. Molecular scientists would easily identify stress regulating genes if they isolate their nucleic acids between the 30th and 60th DAP for transcriptome analysis.

Hidayat T. C., I. R. Harahap, Y. Pangaribuan, Sumaryanto, and W. R. Fauzi. 2014. Micro climate changes of oil palm plantation: case study in Padang Bolak, North Sumatra. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20359

Notes: S 8.1.1 #20359e < #20347e

Abstract: The expansion of oil palm plantations in the present has led to use marginal or degraded land. Marginal land is a land which has limitation in physics, chemistry, biology, topography, and climate favorable for plant. Generally, non-permanent physical limiting factors such as slope, soil eroded or compaction, biology can be overcome by added organic matter in soil. Others while chemistry properties which have related to soil fertility can be overcome by fertilization. In other hand, climatic factors practically almost insurmountable. However, climate in one region will change as conditions change around the area. Specialty for micro-climate is strongly influenced by various factors; one of them is the condition of plant vegetation. Indeed, there are some observations proven that micro climate changes in semi-arid area by alternating planted oil palm. This study is conducted to learn how big the influence of oil palm plantations to changes the microclimate of semi-arid area. This research is a field study to determine the effect of oil palm plantations to changes in the microclimate of semi-arid area in district Aek Nabara-Barumun, Padang Lawas, North Sumatra Province. The study lasted for 3 years starting from the year 2012 to 2014 and objects of this study are Grass lands, Immature Oil Palms, and Mature Oil Palms. Parameters measured were as follows: The microclimate includes precipitation, air temperature, soil temperature, air humidity, and length of irradiation using an automatic weather station (AWS). Whereas oil palm vegetative observation consists of plant height, number of leaves, rachis length, leaf area and leaf area index (LAI). Photosynthesis rate, transpiration rate and stomata conductance are measured by Li-Cor 6400. All of observations were made on the 9th leaves for immature and 17th leaves for mature oil palms. AWS observations show that solar radiation is present more high on immature oil palm area; rainfall is present better in mature oil palm area; the lowest dew point and humidity belong to grassland area. Meanwhile air temperature is same for all observation areas. In other hand wind speed of grassland is the highest. There are significantly different for all vegetative parameters among 2,5 and 14 years oil palms

in semi-arid compare to control except for LAI parameter in 5 years old. There is not significantly difference among oil palms age for photosynthesis rate, but there are significantly difference for transpiration rate and conductance H₂O. The highest transpiration rate is belong to 5 years old oil palm 4.76 mmol H₂O/m²/s, follow by 14 years old 3.76 mmol H₂O/m²/s and for 2 years old just 2.52 mmol H₂O/m²/s. Meanwhile stomata conductances are 1.83 kpa, 2.30 kpa, 2.32 kpa for 2, 5 and 14 years old. Even oil palm performed in semi-arid area are not as good as in favorable area, we conclude that oil palm can be planted in semi-arid area and had contribution on the changing of its microclimates.

Totok S. and S. Arif. 2014. Application of remote sensing and GIS based technology for oil palm thinning. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20360

Notes: S 8.1.1 #20360e < #20347e

Abstract: One of the agronomic problems faced in planting oil palm in rolling to hilly terrain is the etiolation that can reduce yield. Conventional method on selecting palms to be thinned is solely based on visual observation that could be inaccurate, particularly when coverage is large and dominant topography is hillocky. A study was therefore conducted to help identifying potentially etiolated palms or areas using high resolution remote sensing imagery with geographic information system (GIS) analysis. Individual palms were first digitized from imagery using series of GIS processing and the result was then finalized manually. Using individual palm data, two methods were combined to achieve objective of the study. The first method was designed to simulate canopy area and quantify overlapping area of each individual palms. The second method was carried out by dividing available space to surrounding palms evenly. Overlapping area from the first method and distributed area from the second method were then classified based on their deviation from mean value. Potential etiolated palms were detected when overlapping area is larger than 1 standard deviation in the first method or distributed area is lower than 1 standard deviation in the second method. Ground validation showed that the approach was 49% correct in pin-pointing the etiolated palms. Poor result might be due to errors in generating palm point data, difficulties in pin-pointing the selected palms in the ground and unique palm growth status. This method was however 88% accurate in showing potential etiolation areas. Refinement in the model and also further validation is required to improve the technology.

Lim K. H. 2014. Enhancing oil palm productivity on sandy soils through best management practices. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20361

Notes: S 8.1.1 #20361e < #20347e

Abstract: Large tracts of sandy soils (> 70 % sand and < 15% clay) are found in Kalimantan, Indonesia and some parts of Malaysia (West coast of Peninsular Malaysia, Sabah and Sarawak). The topography of the sandy areas is flat to gently undulating. Natural vegetation on these sandy soils are usually scattered gelam forests and shrubs. Sandy soils on sloping terrain are easily eroded when cleared. When degraded, sandy soils are normally covered with lalang, ferns, low shrubs and can be relatively bare. Midday surface temperature on bare sand surface can be as high as 35°C. During dry seasons, the vegetation on sandy soils are prone to fire. Sandy soils are classified as problem soils for oil palm cultivation due to presence of several yield limiting factors that require Best Management Practices (BMPs) to produce economically sustainable productivity. The sandy soils in

Kalimantan can be divided broadly into 2 groups namely the deep sandy soils (Entisols) and the sandy spodic soils with a cemented spodic horizon or hard-pan within 100 cm of the soil profile (Spodosols). Deep sandy soils have very low clay content. The sand particles are generally coarser and with very low organic matter content to depth of 100 cm or more. The deep sandy soils are excessively drained, have very low fertility and water holding capacity. The sandy soils with a cemented spodic horizon have sandy texture overlying a cemented hard-pan. Below the hard-pan, a more clayey layer is often present. Shallow spodic soils with an impermeable cemented hard-pan at 30-50 cm from soil surface are most problematic as they are easily flooded after rains and very dry during prolonged dry seasons. The cemented hard-pan with variable thickness, forms a root restricting layer for oil palm cultivation. Planning sandy soils for oil palm cultivation should begin prior to land clearing. Before initiating development of any sandy area, a proper soil survey and mapping the depths of the spodic layer are important. The main BMPs to enhance productivity of sandy spodic soils are good land preparation and construction of a system of dis-continuous field drains (series of soil pits connected by shallow drains) for controlled drainage during rainy seasons and water conservation during dry periods. Other important BMPs are good ground cover establishment and balanced/adequate fertilization. Maintaining high organic matter on the sand surface by planting *Mucuna bracteata* and yearly EFB application at 200 kg/palm/year are also important to enhance productivity on the sandy soils. Since low carbon stock sandy soils are often found in close proximity with high carbon stock peat soils, the carbon credit from planting oil palms on sandy soils should be considered to offset the high carbon stock associated with oil palm cultivation on peat. The success factors and research focus required to further enhance oil palm productivity on sandy soils are discussed in this paper.

Cheah S. C. 2014. DNA sequencing technology: progress and application in oil palm. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20362

Notes: S 8.1.1 #20362e < #20347e

Abstract: The turn of the 20th century saw the advent of the principles of inheritance arising from the studies of Gregor Mendel on the garden pea. It took more than forty years for the chemical nature of the factors that govern inheritance, named genes in 1920 by Hans Winkler, to be elucidated as deoxyribonucleic acid (DNA). The publication of the structure of DNA in 1953 by James Watson and Francis Crick marked the beginning of a new era in biology. According to the Watson-Crick structure, a DNA molecule can be characterised by the order of its four bases on the ribose backbone of the molecule, namely, adenine (A), cytosine (C), guanine (G) and thymine (T). With the discovery of the triplet genetic code, determining the order of the bases on the DNA molecule (that is, DNA sequencing) became essential for the discovery of its function. Thus began the development of methods to sequence DNA, starting in the mid-1960s. The earliest methods depended on the separation of nucleotides using polyacrylamide gel electrophoresis, which was to be followed by the use of capillary electrophoresis. Leroy Hood at CalTech, collaborating with Applied Biosystems (ABI), developed an automated DNA sequencer in 1986, based on the Sanger protocol. The Sanger protocol using dideoxy chain termination has been the method of choice for DNA sequencing until 2005. In that year, Roche introduced a high throughput sequencer, the 454, into the market. This next generation sequencer (NGS) was based on the technique of pyrosequencing. Following this, massively parallel sequencers capable of generating large amounts of

data were produced by Illumina and ABI. The advent of these NGS machines brought down the cost of sequencing, leading to a barrage of genome sequencing projects for microbes, animals and plants. NGS, however, produced short reads, and combined with the large volume of data generated, this method requires huge computing power for processing. In recent years, single molecule sequencing machines using nanotechnology that have the capability of generating long reads have been introduced. These so-called third generation sequencers have the advantage of being able to sequence through regions of repeats in the DNA molecule as well as differentiate methylated from non-methylated bases. Our company, ACGT Sdn Bhd, based in Kuala Lumpur, Malaysia, applies DNA sequencing as a foundation for product development. ACGT has achieved three world firsts in genome sequencing. In May 2008, ACGT together with its collaborator, the US-based Synthetic Genomics, Inc. (SGI), announced the completion of the first draft of the oil palm genome. Subsequently, ACGT and SGI completed draft genomes of *Jatropha* (in May 2009) and *Ganoderma boninense* (in November 2010). Since then, ACGT has continued to improve on the quality of these three reference genomes and developed new sequencing protocols for generating resources for crop improvement and disease control. In-house sequencing and bioinformatics capabilities were established at ACGT to enable

Cros D., M. Denis, L. Sanchez, B. Cochard, A. Flori, T. Durand-Gasselin, B. Nouy, A. Omoré, V. Pomies, V. Riou, E. Suryana, and J.-M. Bouvet. 2014. Genomic selection in oil palm (*Elaeis guineensis* Jacq.). Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20363

Notes: S 8.1.1 #20363e < #20347e

Abstract: Genomic selection (GS) can increase the genetic gain in plants. In perennial crops, this can be achieved via shortened breeding cycles and increased selection intensity. For many species, the main challenge is to obtain sufficient accuracy to train GS models, despite small populations. Our objective was to obtain the first empirical estimate of GS accuracy in oil palm (*Elaeis guineensis*), the major world oil crop. We used three populations (Deli, Group B and La Mé) with 93 to 131 individuals, genotyped with 265 SSR. We estimated the within population GS accuracy when predicting masked estimated breeding values for eight yield traits. We used three methods to sample training sets and five statistical methods to estimate genomic breeding values. The results showed that, in Group B and La Mé, GS could achieve higher accuracy than the pedigree-based model, indicating that GS could account for family effects and Mendelian sampling terms. The GS accuracy ranged from -0.57 to 0.94 and was correlated with the relationship between training and test sets (amax). Training sets optimized with CDmean gave the highest amax and accuracies, ranging from 0.49 (pulp to fruit ratio in Group B) to 0.94 (fruit weight in Group B). The statistical methods did not affect the GS accuracy. Finally, Group B and La Mé individuals could be preselected for progeny tests by applying GS to key yield traits, therefore increasing the selection intensity. Our results should be valuable for breeding programs with small populations, long breeding cycles or reduced effective size.

Wening S., N. Supena, H. Y. Rahmadi, R. Faizah, Y. Yenni, and A. R. Purba. 2014. Oil palm molecular breeding: progress in IOPRI. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20364

Notes: S 8.1.1 #20364e < #20347e

Abstract: The long life cycle of oil palm limits the achievement of efforts in oil palm breeding. Its genome information is a mandatory if molecular breeding will be involved as a tool to achieve the breeding goal. This paper reviews the latest progress of oil palm genomics and molecular breeding in Indonesian Oil Palm Research Institute (IOPRI). In IOPRI, molecular marker is involved in oil palm germplasm management, to help development of core collection and its maintenance. The DNA fingerprinting of oil palm germplasm is managed along with development of genotyping database, which would be useful for some genotyping purposes. Identification of markers linked with certain characters is in progress, for application of marker-assisted selection. Some results of studies showed that breeding guided by genomic information has a good prospect in accelerating progresses. The development of molecular breeding system is needed, including activities in the field, laboratory, as well as recording and documentation system.

Lamade E., J. Ollivier, Th. Rozier-Abouab, and E. Gerardeaux. 2014. Occurrence of potassium location in oil palm tissues with reserve sugars: consequences for oil palm K status determination. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20365

Notes: S 8.1.1 #20365e < #20347e

Abstract: In some fertilizer trials for oil palm, it is observed that potassium leaf content was not in concordance with potassium application. In some cases no « leaf » response is observed (leaflet potassium content from leaf rank 17 according to specific LD IRHO method) whatever the K level. Agronomists have suggested to look for potassium content in others organs like rachis, showing best adjustment between K content, yield and K application; This K content difference between rachis and leaflets may be related to their different metabolic role for the plant; When leaflets are devoted to photosynthetic acquisition of carbon for the whole plant, rachis play obviously a role in photosynthetic product transportation; Potassium is often mentioned as involved in sugars translocation. In order to explain K content variations within organs, an experimental observations design has been elaborated on a factorial fertilizer trial (ALCP10, factorial K4 x Ca2 in North Sumatra) involving precise samplings on vegetative organs as leaflets petioles, rachis, trunk and roots as well as fruits, spikelets and bunch stalk. Both mineral content analyses and sugars content (soluble sugars and starch) were performed on a total of 36 oil palm trees belonging to two different contrasting genetic materials. For strengthening our hypotheses, two other set of data were overviewed for K and sugars locations; The first one is a complete dissection of a crown from very young bud leaf stage until old leaves, the second is an exploration of sugars reserves in the crown in North Sumatra conditions. Maximal K mineral content was observed in trunk bottom (for all planting material and treatment) when soluble sugars are high and starch low. Generally it has been observed that potassium is high in petiole of very young leaves (1 to 3) and increasing in bunch rachis until fruit maturation. Leaflets of young leaves (rank -2) contain more potassium than leaflets at rank 17 due to their high proportion in reserve sugars before starting strong photosynthetic activity. Hypothesis is merging from a high co-occurrence of K with soluble sugars in oil palm (most probably glucose) which are involved in the reserve mobilization to elaborate not only bunches but also new young leaves. An inverse relation is found between K concentration and starch.. It seems that equilibrium between starch and soluble sugars content at organs scale and the K level are a key to elaborate a clear K nutrient status for oil palm.

Ginting E. N. 2014. Using DRIS (Diagnosis Recommendation Integrated System) for determination nutrients balance in oil palm leaf tissue to improve efficiency. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20366

Notes: S 8.1.1 #20366e < #20347e

Abstract: High fertilizer input means high cost, and this is not a guarantee that the high productivity will be achieved. Since cost of fertiliser is the most expensive cost in oil pal cultivation, it is important to have an accurate fertilizer recommendation system that can improve oil palm productivity as well as to safe the cost of fertilizer. The main purpose of fertilization in oil palm plantations was to fulfil nutrients for plant in sufficient quantities and in balance condition. Nutrient balance is the aspect that we must pay attention because fertilization without considering nutrient balance will lead an inefficiency and increasing the risk of negative environmental impact. DRIS (Diagnosis Recommendation Integrated System) is a method for evaluating plant nutrient status by considering nutrients balance in plant tissue to obtain the most balance nutrients composition. The major advantage of this approach lies in its ability to sort nutrients based on the most nutrient needed by the plant. This paper reviews the application of DRIS approach for oil palm fertilizer recommendation as an alternative to diagnose imbalance nutrients in oil palm leaf in order to increase fertilization effectively and efficiency in oil palm plantation.

Tohiruddin L. 2014. The important role of trace elements to obtain and maintain the optimum yield of oil palm in North and South Sumatra. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20367

Notes: S 8.1.1 #20367e < #20347e

Abstract: Previous research by BLRS revealed that long-term application of Urea, Super Phosphate and Muriate of Potash significantly reduced leaf copper and zinc levels which may limit yield response to those major fertilizers. To further investigate the possible deficiency of trace elements on mineral soils in Sumatra trials testing application of B, Cu and Zn fertilizers to oil palm have been carried out in different locations on mineral soils in both North and South Sumatra. Their effect on yield and the content of both major and minor elements in the leaves has been monitored and is reported in this paper. Over 2012-2013 Cu fertilizer application significantly increased oil palm FFB yields in one out of four trials in North Sumatra and in both the two trials in South Sumatra. Furthermore, Zn fertilizer application had no significant effects on yield components in all North Sumatra trials, but significantly depressed FFB yield in one trial in South Sumatra. Meanwhile, B fertilizer application in the two trials in North Sumatra significantly increased FFB yields. The FFB yield response to Cu fertilizer in the three trials is closely related to the increase of both leaf N and Cu levels. The yield response to Cu fertilizer is likely if leaf Cu levels are below 5 ppm. FFB yield response to B fertilizer in Sumatra seems unlikely if leaf B is greater than 12 ppm, In North Sumatra, yield responses to B were observed in the two trials having leaf B levels less than 12 ppm, but in South Sumatra yield responses to B were not observed in the two trials which both had leaf levels below 12 ppm. Thus leaf B analysis alone is not a fully reliable indicator of response to B fertilizer.

Fonguimgo T. F., M. M. Hanafi, A. B. Idris, and S. R. Syed Omar. 2014. Nutritional characteristics of *Ganoderma* susceptible and *Ganoderma* tolerant oil palm seedlings. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20368

Notes: S 8.1.1 #20368e < #20347e

Abstract: The world's demand of oils and fats has drastically increased over the last decades and will still increase following the fast growing of the world's population. Oil palm, as the world's highest yielding oil crop, has an important role to play in meeting various demands of these commodities. Tremendous human efforts made to improve the oil palm productivity have been dashed by the basal stem rot (BSR) disease caused by *Ganoderma boninense*, especially in Malaysia and Indonesia, the leading oil palm producers. To date, no effective solution exists against BSR despite numerous attempt strategies developed and tested. Some oil palm progenies exhibit different behavior towards the disease but the underlying basis is unknown. Nutritional factors are known to affect plant susceptibility/tolerance but have not yet been investigated in oil palm. Our study was designed to find out whether differences in nutrient contents could explain differences in *Ganoderma* status of oil palm progenies. Nutrient analysis was carried out in root, bulb, petiole, rachis and leaf tissues of *Ganoderma* susceptible and *Ganoderma* tolerant oil palm progenies. The results indicate highly significant differences and variations of nutrient partitioning in progenies tested. However, discriminating in one side susceptible progenies and in another side the tolerant ones was not possible, suggesting that further investigations are still needed.

Susanto A., A. E. Prasetyo, H. Priwiratama, and S. Wening. 2014. Management screening of *Ganoderma* tolerant oil palm: phytopathology perspective. Pusat Penelitian Kelapa Sawit, Indonesia. Ref Type: Conference Proceeding

Reference ID: 20369

Notes: S 8.1.1 #20369e < #20347

Abstract: Basal stem rot disease which is caused by *Ganoderma boninense* is the most destructive disease of oil palm plantation in Indonesia. High disease incidences of *Ganoderma* have caused significant losses. Several cultural practices, biological and chemical techniques have been developed, but no optimal control achieved. Planting of *Ganoderma* tolerant oil palm is now determined as ideal control measure. Screening method for *Ganoderma* tolerant oil palm has been being developed by many institutions. This research aims to suggest better screening method through phytopathology view. Two experiments were set up for this research. They were clustering of *Ganoderma* isolate from Indonesia using ligninolytic enzymes activity and planting media screening in nursery stage. The results showed that *Ganoderma* has variety of ligninolytic enzymes activity and the best planting media for screening *Ganoderma* tolerant oil palm was mixture of mineral soil and sand (25:75). Based on this research, planting media using mineral and sand in ratio 25:75 including more than one isolate of *Ganoderma* for pathogenicity test was better method suggested for screening.

Pardey A. E. B., C. E. B. Trilleras, M. S. C. Triana, and K. L. O. Rodas. 2014. Biology of lacewing bug *Leptopharsa gibbicularina* and selection of fungal entomopathogens to control its populations in oil palm plantations in Colombia. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20370

Notes: S 8.1.1 #20370e < #20347

Abstract: Oil palm plantations in Colombia are affected by several insect pests, but those who are associated to plant diseases are of capital importance. This is the case of the lacewing *Leptopharsa gibbicularina* which when feed on the foliage of palms, open the entrance for several fungi of the genera: *Pestalotiopsis*, *Colletotrichum*, *Gloeosporium* and *Helminthosporium*, which cause a wilting on the foliage called "Pestalotiopsis". Studies on the life cycle (28 °C, RH 85%) of *L. gibbicularina* have shown that egg hatching takes 16 ± 2 days, nymphs lasted 18.9 ± 3.3 days and adult stage lasted 37.2 ± 5.9 days. Females oviposited eggs individually on underside of leaf and attached to the parenchyma. These studies were basic to establish a colony of this insect to test entomopathogenic fungi. Initially a pathogenicity test was carried out to select several fungi isolates: *Isaria fumosorosea* (CPIf1001), *Purpureocillium lilacinus* (CPPI0601) and *Beauveria bassiana* (CPBb0404). These tests showed that all of them were able to produce disease in the *L. gibbicularina* population tested. Then a virulence test was performed using young oil palms, ($27.8 \pm 3.2^{\circ}\text{C}$, RH $84,7 \pm 13,2\%$, and 9.7 mm of rain), which were previously infested with adults of *L. gibbicularina* and sprayed with these fungi using a dosage of 1×10^{13} conidia/ha. There were significant differences among treatments; greatest mortality (100%) was caused by *P. lilacinus*, followed by *B. bassiana* (92.9%), which were different from *I. fumosorosea* (74.4%). A further experiment to test three dosages (5×10^{12} , 1×10^{13} , 1.5×10^{13} , conidia/ha), was conducted and results showed that there were no statistical differences among dosages and fungi isolates. Mortality for isolates *P. lilacinus* and *B. bassiana* were higher than 88%, and are considered for further research to test them under commercial plantations using a dosage of 1×10^{13} conidia/ha.

Mohd Noor H. 2014. Sustainable biological control of rats using barn owls *Tyto Alba* in agricultural habitat in Malaysia: Fifty years of research. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20371

Notes: S 8.1.1 #20371e < #20347

Abstract: The Barn owl *Tyto alba javanica* has been naturally propagated and encouraged by providing artificial nest boxes in Malaysia since the 1970's. A vagrant species believed to have migrated from the island of Java at the turn of the century is now a common presence in the oil palm and ricefield throughout the peninsular Malaysia. This paper described the understanding of the ecology of the barn owl under facilitated breeding and augmentation programme for the past 50 years. In economic terms it has lead to considerable reduction in rodenticide application by at least 40 to 80% in oil palm plantation and ricefield. In terms of level of damage, propagation of barn owls in combination with reduced rodenticide baiting has lead to a reduction to the acceptable 5% damage in both ecosystems. Studies over the years have established the optimum nest box density for a sustainable control, types of nest box for suitable breeding condition as well as establishing the foraging pattern of the owls in plantation habitats under optimum prey densities. Current concern of the development of rodenticide application in the face of alleged and claimed resistance in rodent population has paved the way for studies on the impact of secondary poisoning on barn owls. Detection of rodenticide residues from both first and second generation anticoagulant rodenticides in the vital organs, feeding pellets and egg contents have prompted research work on designing new approaches of bait application and the quest for biorodenticide for a sustainable barn owl propagation programme. Since oil palm plantations have thrived in Borneo, translocation programme have been initiated to introduce the owls to Sabah and

Sarawak. This open up new frontiers of research since the rodent species assemblage in Borneo, as well as meteorological and microclimatic parameters are different compared to the peninsular.

Prasetyo A. E., A. Susanto, and E. S. Sutarta. 2014. Status of *Elaeidobius kamerunicus* towards 30 years in Indonesia. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20372

Notes: S 8.1.1 #20372e < #20347

Abstract: Since introduced in early 1983, *Elaeidobius kamerunicus* Faust (Coleoptera: Curculionidae) has become the main pollinating agent of oil palm in Indonesia. This weevil has been substituted the assisted pollination to natural pollination with a good fruit set. Towards 30 years of its existence in Indonesia, the populations of *E. kamerunicus* and its aggressiveness have been on a decline in some area. This situation has affected the lower oil palm fruit set. Some factors causing these declines were the lack of breeding sites, global climate change, inbreeding depression, and the presence of natural enemies. Optimizations of *E. kamerunicus* by applying a breeding box, hatch and carry technique or mobile hatch and carry technique which consider more effective and efficient were some effort to solve the problem. Perhaps, introductions of new oil palm pollinating insect like *E. subvittatus* possible to keep a good oil palm fruit set.

Lubis F. I., I. Agustin, Riana, L. Kurniawan, and S. Latif. 2014. The occurrence of poor fruit set at Central Kalimantan. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20373

Notes: S 8.1.1 #20373e < #20347

Abstract: Poor oil palm fruit set quality occurred at Natai Baru Estate, PT. Sawit Sumbermas Sarana Tbk., Central Kalimantan in young palm (4 - 6 years old) in a wide area of 957 ha. Observation on June 2013 showed that the fruit set was 3.0% to 11.6%. The poor fruit set quality effect to declining bunch weight up to 33%. The overall mean of *E. kamerunicus* population density was 19,924 *E. kamerunicus*/ha, with range of 10,669 to 31,556. The variation indicated the instability of the population in this area. The factors responsible for this instability could be the number of available male inflorescences and high rainfall which reached up to 480.5 mm/month with rainy days up to 21 days/month. Some efforts that have been carried out in order to improve the quality of fruit set such as assisted pollination, hatchery system and reintroduction of *E. kamerunicus* from North Sumatra.

Lopez J., P. R. Tolentino, D. Sunindyo, A. E. Prasetyo, and A. Susanto. 2014. Effect of *Bacillus thuringiensis* subsp. *Kurstaki* on the African Pollinating Weevil, *Elaeidobius kamerunicus*. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20374

Notes: S 8.1.1 #20374e < #20347

Abstract: Applications of various chemical based insecticides to control pests in oil palm plantations allegedly provide negative impact on the population decline of oil palm pollinating insects, *Elaeidobius kamerunicus*. Bioinsecticide active ingredient *Bacillus thuringiensis* is often used to control a number of important lepidopteran pests of oil palm although has not been tested for their effects on *E. kamerunicus* in Indonesia. In vivo testing was carried out with the concentrations of *B. thuringiensis* var. *kurstaki* (strain ABTS-351) of 20 mL/15 L water, 30 mL/15 L water and 40 mL/15 L water. The active ingredient for the chemical based insecticides utilized were

deltamethrin 250 g/L and fipronil 50 g/L at concentrations of 30 mL/15 L water and 37.5 mL/15 L water, respectively. Fresh water was used as the positive control. The test result shows the application of *B. thuringiensis* against weevils *E. kamerunicus* spray solution at a concentration of 20 mL/15 L of water and 30 mL/15 L of water did not reduced the population of *E. kamerunicus*. Concentration of 40 mL/15 L of water lowered the weevil population up to 27% on the 8th day after application. The suspension concentration of *B. thuringiensis* of 40 mL/15 L water did not significant affect the mortality to the larvae of *E. kamerunicus*, which develop into adult weevils in the next cycle, unlike the chemical insecticides. In contrast, application of insecticides deltamethrin and fipronil resulted in 100% total mortality of *E. kamerunicus* one day after the application. *Bacillus thuringiensis* var. *kurstaki* (strain ABTS-351) is a safe bioinsecticide for *E. kamerunicus* in a control program of various lepidopterous pests in oil palm plantations.

Prasetyo J. H. H., J. Djujhana, B. Sitepu, S. P. C. Nelson, and P. D. S. Caligari. 2014. Variation between and within deli dura progenies. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20375

Notes: S 8.1.1 #20375e < #20347

Abstract: Deli dura material is widely used by oil palm seed producers to produce dura x pisifera commercial planting material for oil palm growers (plantations and smallholders). A range of breeding strategies have been deployed to develop Deli dura material including various levels of inbreeding (selfing and sib crosses), inter-progeny crosses within Deli dura material and out-crossing by introgression. Outcrosses have usually been with other dura materials but occasionally with tenera/pisifera breeding materials. Since, if we accept that the pedigree details are legitimate, the Deli dura material is descended from just four original palms the genetic variation of this material is limited. Therefore, the potential for long term genetic progress within Deli dura should be restricted, but this has never been quantified other than by a pedigree assessment or calculation of inbreeding coefficients. The objective of this study was to determine the genetic variation both between and within 12 dura progenies (F2 and F3 generations) by progeny testing a random sample of twenty dura palms from within each progeny. Six D x P progeny trials were planted and the trials were 'connected' by standard crosses to allow a combined analysis. The genetic variation within each dura progeny was estimated by assessing the variance between general combining ability values of a random sample of twenty progeny tested dura palms. The results of this study show that there was variation between progeny means for certain important traits. The genetic variation within dura progenies was highly variable for different traits. Some dura progenies had very low genetic variation (assessed by general combining ability (GCA) variances of 20 palms per dura progeny) while other progenies had high variances for a range of traits. This assessment shows there is potential for breeding progress by selection and potentially a further round of selfing of selected progeny tested palms.

Supena N., Y. Yenni, Sujadi, H. Y. Rahmadi, M. Arif, and A. R. Purba. 2014. Characterization of oil palm germplasm introduced from Cameroon. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20376

Notes: S 8.1.1 #20376e < #20347

Abstract: Cameroon is well known as one of the centers of origin of the oil palm in

equatorial Africa. Indonesia had introduced Cameroon's oil palm seed in May 2008 by a consortium. Ninety two accessions were planted at IOPRI field trials on three locations i.e. Adolina, Marihat and Bah Jambi Estate (PTPN IV, North Sumatera). This paper was aimed to show the characterization of the ex-Cameroon materials from several observation parameters. The parameters were plant height, rachis length, bunch number, bunch weight, color of skin fruit, segregation and crown disease accident. Observation was conducted at the first year of the crop yield. Some results showed CMR079D has the lowest height with 81.5 ± 26 cm while CMR055D has the highest with 166.3 ± 42.5 cm. CMR025D and CMR055D accessions have the highest bunch weight each 3.28 and 3.19 kg. CMR025D that was recorded as virescens accession produced nigrescens and virescens fruits segregated each 65% and 35%, so do respectively CMR054D, CMR067D, and CMR077D.

Handayani L. and Y. Juhyana. 2014. Various performance and future potential of AVROS, Binga, Ekona, Yangambi, Angola and their introgression in tenera breeding materials. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20377

Notes: S 8.1.1 #20377e < #20347

Abstract: Genetic diversity is a basis for plant breeding activities. One way to increase genetic diversity is through crossing/ introgressing. Crosses have been made between AVROS, Binga, Ekona, AVROS x Binga, AVROS x Ekona, AVROS x Yangambi, (Dabou Deli x Angola) x La Mé, Angola x La Mé, and Pure Angola. All material are advanced materials from second or third generations except (Dabou Deli x Angola) x La Mé, Angola x La Mé, and Pure Angola are first generation materials. Field trials were conducted to evaluate yield, vegetative growth, and bunch and oil characters. AVROS x Binga, AVROS x Ekona, and AVROS x Yangambi achieved high oil and kernel yield and fresh fruit bunch. Those high fresh fruit bunch is supported by higher number of bunches for AVROS x Binga and big bunch for AVROS x Ekona and AVROS x Yangambi. AVROS x Ekona also achieved the highest oil to bunch about 35%. AVROS and AVROS introgressed materials have good bunch and oil character, which are thick mesocarp, high oil to mesocarp, and thin shell. Almost all materials have vigorous frond except Ekona has the shortest frond and (Dabou Deli x Angola) x La Mé has the lightest frond and small leaf area. Selected palms and progenies will be used for other breeding purposes, and introgressing with other source will be useful to achieved desired characters.

Buntaran H., Nasrullah, and Y. Yenni. 2014. Determination of parental value of oil palm (*Elaeis guineensis* Jacq.) progeny tests using regression approach. Pusat Penelitian Kelapa Sawit.

Reference ID: 20378

Notes: S 8.1.1 #20378e < #20347

Abstract: D×P/T crosses in oil palm breeding are used to test parents in order to produce superior varieties that favourable for breeding purposes. Parents that produce a lot of superior progenies are highly valuable. The objective of this study was to evaluate the parental value through progenies of their crosses. The trials conducted by Indonesian Oil Palm Research Institute (IOPRI) at six field trials, and to single out parents that have the best contribution in terms of bunch number (BN) and fresh fruit bunches (FFB). Records of data varied from 5 to 14 years. Eighty two crosses were selected as they have common ancestors. The mean of BN and FFB were regressed on genetic contribution of their parents so obtained regression

coefficient. The regression coefficient reflected the parental value. Two parents, which had similar regression coefficient, means both might be mutually interchangeable in a cross. The parents with highest regression coefficient for BN and FFB are valuable parents in plant breeding programme. There were five groups created based on the genetic contribution of parents for BN and FFB.

Setiawati U., M. Rahmaningsih, H. Ritonga, P. Nelson, and P. D. S. Caligari. 2014. Advances in breeding for *Ganoderma* partial resistance in field and nursery trials. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20380

Notes: S 8.1.1 #20380e < #20347

Abstract: *Ganoderma* infection is causing increasingly serious economic losses to oil palm growers in South-East Asia when, as often is the case, there is a continuous cycle of plantings. Under these conditions serious losses are often experienced even by the second round of planting. It is currently attempted to reduce and control *Ganoderma* infection by a range of cultural practices, antagonistic biopesticides and chemical techniques. However, the results of these practices are generally not sufficient to mitigate the risk or reduce the reality of serious yield and palm losses from this disease; indeed no technique is providing the solution the oil palm industry requires. The ideal approach to prevent *Ganoderma* infection is to plant material which has reasonable levels of genetic resistance to *Ganoderma* because this approach has the potential to deliver to oil palm growers a low cost, simple to implement and durable approach. With the above in mind, Sumatra Bioscience started field screening its progenies to assess variation for *Ganoderma* susceptibility/resistance in 2000. The field screening was conducted in both single and multilocation trials. Five years later the development of a nursery screening protocol was undertaken through collaboration between CIRAD, Socfindo and Sumatra Bioscience. The *Ganoderma* inoculum sources for these nursery tests were rubber wood blocks artificially inoculated with a single *Ganoderma* isolate. The objective of both field and nursery screening was to identify crosses, define breeding material with proven partial resistance to *Ganoderma* sp and ultimately to release partially resistant *Ganoderma* commercial planting material. It was clear that there was continuous variation for *Ganoderma* infection both between and within Sumatra Bioscience's progenies, in nursery and field. This implies that several, and possibly many genes are involved (horizontal resistance). This paper describes the approaches and recent results from Sumatra Bioscience's *Ganoderma* resistance breeding programme.

Mohamed Saad S. H., T.-Y. Seng, L.-J. Leao, E. Ritter, S. A. Mohd Noor, and S. S. R. S. Alwee. 2014. Construction of a microsatellite genetic linkage map for an oil palm inter-specific backcross two. Pusat Penelitian Kelapa Sawit, Indobesia.

Reference ID: 20381

Notes: S 8.1.1 #20381e < #20347

Abstract: Oil palm is a tropical perennial crop in the genus *Elaeis* in the family Arecacea. There are only two species, namely *Elaeis guineensis*, from Africa, and *Elaeis oleifera* from South America. The two species are inter-fertile and inter-specific hybridization followed by backcrossing is a feasible approach to combine desirable agronomic traits such as disease resistance, increased proportion of unsaturated fatty acids and shorter palms from *E. oleifera* and high productivity from *E. guineensis*. Such introgression can be aided by marker assisted selection (MAS), a combination of conventional and molecular genetics, to select individuals

possessing trait(s) of interest. MAS uses linkages between markers and traits and hence the objective of this study was to construct a genetic linkage map for an inter-specific backcross two (BC2). A pseudo backcross was used as in the oil palm, because of long generation times, strict recurrent backcrossing is not possible and interspecific differences are larger than within species. Two Felda BC2 crosses, coded AG1 and BD26, of the same parents but created at different times and planted in different locations and in different years, with a combined population of 114 individuals was used as the mapping population. The map was constructed based on 229 microsatellite (SSR) markers, obtained from other published oil palm maps as well unpublished markers from Felda's work, using MapRF7 software. The BC2 linkage map comprised 538 marker loci in 16 linkage groups (tallying with oil palm's 16 chromosomes) with a total length of 2049.4 cM. The development of the genetic map is a starting point towards identifying QTLs associated with traits of interest. In tandem phenotypic data, particularly vegetative measurements and fatty acid compositions are being collected from each palm for QTL analysis. As additional SSR markers become available they will be integrated onto this map together with results of QTLs analysis.

Prasetyo J. H. H. and J. Djujhana. 2014. Yield performance of Deli x AVROS and CBP10 materials. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20382

Notes: S 8.1.1 #20382e < #20347

Abstract: The aim of oil palm breeding programme is to select best planting materials to improve oil palm yield with slow vegetative growth. One of the approach to achieve this goal is by introducing new oil palm materials through joint breeding programme. In 1980's, Harrisons and Crosfield and Unilever Plantations conducted a joint breeding programme which was known as Combined Breeding Programme (CBP), it was to combining oil palm resources at Binga, Congo (formerly Zaire) and Dami, Papua New Guinea. The series of CBP programmes were established with different purposes and this paper focus on CBP10 with aim to improve harvest index combined with high photosynthetic conversion efficiency. Selection for yield and growth has been done on CBP10 materials planted at Bah Lias Research Station - Indonesia, but harvest index and photosynthetic conversion efficiency were not calculated. A progeny testing trial was planted in 2005 to test cross combination between CBP10, Deli dura and AVROS pisifera, and compare with Deli x AVROS material (including standard crosses). Over five years recording, Dura x Pisifera (DxP) progenies of Deli x AVROS show higher yield, but followed with a disadvantage in trunk increment. Crosses between CBP10 dura x CBP10 pisifera are resulting short trunk material, which also have lower oil and kernel yield (OKY) and fresh fruit bunch (FFB) yield. One DxP progeny of CBP10 achieved an oil-to-bunch (OB) ratio 35.0%. Although the progeny testing trial does not meet the objective of CBP10 programme, other character can still be explored. Coefficients of variation values shows CBP10 material has wide range variation in FFB, number of bunch (NOB), OB ratio, kernel-to-bunch (KB), leaf area ratio (LAR), and frond length (FRL). It is considerably to be potential for used in further breeding programme such as look for high OB material and vegetative compactness performance by selecting best dura and pisifera palms either by self-crossing and/or sib-crossing.

Sujadi, H. Y. Rahmadi, Y. Yenni, and A. R. Purba. 2014. Oil palm (*Elaeis guineensis*) characterization to develop oil palm individual test guidelines (TG). Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20383

Notes: S 8.1.1 #20383e < #20347

Abstract: Characterization of IOPRI's oil palm germplasm and varieties had been performed to develop individual Test Guidelines (TG). Oil palm TG was developed to test the distinctness, uniformity and stability (DUS) of candidate varieties to be awarded Plant Variety Protection (PVP) submitted in the Ministry of Agriculture, Republic of Indonesia. The observations were conducted in different palm ages. Characters observed were vegetative traits in immature palms, generative traits in mature palm and bunch analysis. The result shows that oil palm could be differentiated. Seven characters were found different in oil palm germplasm. These characters were: frond number, frond length, bunch size, spike number, spike length, weight of 10 fruits, and fruit length. These characters were proposed as distinguishing traits in the DUS test.

Supena N. and Y. Yenni. 2014. Tolerance of oil palm seedlings to Aluminium stress. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20384

Notes: S 8.1.1 #20384e < #20347

Abstract: Aluminium (Al) can disturb plant in the form of trivalent cations (Al^{3+}) lead to inhibition of cell division and elongation in the root tip. This disruption could result in decrease crop production. This research was aimed to study the response of IOPRI's oil palm varieties to Al stress. The hypothesis proposed in this study was that the oil palm varieties gave different responses on morphological and physiological variables while treated some levels of Al. The research was conducted at screen house by using a factorial design with two factors. The first factor was Al stress level that was treated on the growing media with five (5) levels, which were 0, 75, 150, 225, and 300 ppm. The second factor was 5 different oil palm varieties which were DxP PPKS239, DxP PPKS540, DxP PPKS718, DxP Simalungun, and DxP Dumpy. Each variety had the same opportunity to receive the level of Al stress that there were 25 units of the treatment combinations. Each unit consisted of 15 seeds and repeated 3 times. Observations were conducted when the plants were 2-3 months in the pre nursery stage at some characters. The characters were plant height, stem diameter, primary root length, total root length, nutrient content (N, P, and K), shoot and sugar reducing content. The results showed that the oil palm varieties had different responses at primary root length (at $\alpha = 0.05$ level), K nutrient ($\alpha = 0.01$), shoot sugar reducing ($\alpha = 0.01$) and root sugar reducing content ($\alpha = 0.01$). Each oil palm variety had different on tolerance level to Al stress. Simalungun was the best tolerance variety to Al stress, and Dumpy, PPKS540, PPKS239, and PPKS718 were respectively tolerance to Al stress.

Kaewtaphan P., W. Chanprasert, S. Sayasoonthorn, O. Wongsri, T. Petchrun, and S. Srikul. 2014. De-ocperulation and dry heat treatment on breaking seed dormancy of oil palm. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20385

Notes: S 8.1.1 #20385e < #20347

Abstract: Dormancy mechanism is very important in seed germination of oil palm. Dry heat treatment at 40°C for 60-80 days is the method commercially used nowadays. However, dry heat method can be inconvenient in terms of high cost of

maintaining the temperature and amount of time to break dormancy. Thus, in this experiment, method of breaking dormancy by machine de-operculation was studied comparing to the dry heat method. Before breaking dormancy, seed of hybrid oil palm was divided into 3 groups according to seed weight, i.e. 1.6-3.1, 3.2-4.6 and 4.7-6.1 g/seed. Data recorded were seed germination and abnormal seedling percentages after transplanting for 3 and 6 months. The results showed that the method of breaking dormancy by machine de-operculation gave better results over the dry heat method and machine de-operculation gave rise to a faster germination. Seed germination percentage and percent normal germinated seed (germinated seed producing shoot and root) of high seed weight group were higher than those of low seed weight group. For the percentage of abnormal seedlings after transplanting, it was found that there were no significant differences between the 2 dormancy breaking methods and the 3 different seed weights. It can be concluded that machine de-operculation is a promising method for commercial production of germinated oil palm seed.

Arif M. 2014. Tolerance and development of germinated oil palm seeds coated by *Trichoderma* TO *Ganoderma boninense* . Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20386

Notes: S 8.1.1 #20386e < #20347

Abstract: Until now, *Ganoderma boninense* still works as main disease on oil palm plantation. The most well-known method to control the disease is by spreading bio-fungicide which contains *Trichoderma* sp., natural enemy of *Ganoderma*. However, efficiency of the application is questioned due to spreading *Trichoderma* on planting media may not directly affect and control the disease. The research utilized *Trichoderma* as filming variable on germinated oil palm seeds with 4 levels of application, namely control with no filming application (F1), soaked by *Trichoderma* emulsion (F2) which was generated by Plant Protection Unit of IOPRI, sprayed by bio-fertilizer X (F3) which contains *Trichoderma* and endophyte bacteria, and soaked by bio-fertilizer X (F4). The trial also utilized 3 different levels of planting media, viz. 100% top soil (M1), top soil:sand=3:1 (M2), and top soil:sand=1:3 (M3). Observation was done for 3 vegetative characters during nursery, namely plant height, stem diameter, and leaf amount. Data analysis shown that both level of filming application by utilizing bio-fertilizer X provided higher average on plant height and leaf number characters, which was believed due to benefits provided by endophyte bacteria contained in the bio-fertilizer. The similar phenomena was also shown by planting media, where 100% top soil generated higher plants and higher number of leaves. Based on colony forming unit (CFU) analysis on *Trichoderma* existence in planting media, the research indicated that albeit no significant result was shown between the four levels of filming application, higher CFU average was formed on F2 (29.33) compared to F1, F3 and F4 which were 18.67, 19.58, and 17.96, respectively. In conclusion, filming may be one of the methods to control *Ganoderma*. However, further researches are needed to gain more effective technique and filming formula which is suitable for oil palm seeds.

Wening S., A. E. Prasetyo, A. Susanto, Y. Yenni, and A. R. Purba. 2014. BSA-AFLP to identify tolerant oil palm to *Ganoderma* . Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20387

Notes: S 8.1.1 #20387e < #20347

Abstract: Basal stem rot disease caused by *Ganoderma boninense* is an important oil palm disease in Indonesia. It is needed DNA markers which could be used in identification oil palm which is tolerant to *Ganoderma*. Observation was conducted in the nursery, to identify tolerant and susceptible oil palm to *Ganoderma* by artificial inoculation of seedling progenies by *G. boninense*. The material was used to find polymorphism between susceptible and tolerant DNA by Bulk Segregant Analysis-Amplified Fragment Length Polymerase (BSA-AFLP), to construct PCR-based DNA marker. It was needed an optimization to obtain clear DNA profiles of high number of bulked samples. There were polymorphisms obtained by comparison of DNA bulking of tolerance and susceptible seedlings. The polymorphisms will be verified using larger number of individual samples.

Seng T.-Y., S. H. Mohamed Saad, N. H. Ramli, S. H. Roowi, K.-T. Aw, L.-J. Leao, V. Rao, and S. S. R. S. Alwee. 2014. Development of a microsatellite (SSR) markers panel for clonal fidelity and breeding legitimacy in oil palm. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20388

Notes: S 8.1.1 #20388e < #20347

Abstract: Oil palm is the most productive oil crop in the world and grown in the tropics especially Indonesia and Malaysia. In both countries breeding programmes are being actively pursued to further improve oil yields. Exploitation of improved types is through tissue culture or as seeds from controlled crosses. As the volumes for commercial production, or even for research purposes, are large lapses can happen and the resulting mix-ups or illegitimacy can affect the success or otherwise of the breeding and tissue culture programme. DNA fingerprints, generated using molecular markers, can help determine the legitimacy of palms in breeding crosses and fidelity between clones and their ortets. Molecular markers developed from oil palm genome sequences, such as microsatellite or simple sequence repeat (SSR) markers are suitable for producing such fingerprints. The sensitivity, reproducibility, co-dominance and strong discriminatory power of SSR markers make them particularly suitable for detecting somaclonal variation, fidelity and cross illegitimacy. The objective of this study was to develop a SSR markers panel which would be suitable for the range of FELDA's oil palm breeding and clonal materials. In all 80 SSR markers were tested; of which 20 were found most robust and now constitute the Felda markers panel for clonal fidelity and legitimacy analysis. FELDA's SSR markers panel is now routinely used for clonal fidelity assessment of all dura and pisifera clones, used in semi- and bi-clonal production, as well as all breeding crosses.

Rismayanti, Sudarsono, N. Khumaida, W. Purbowasito, N. Haska, and A. Rohandi. 2014. Can snap marker be used as indicator of unsaturated fatty acid composition in oil palm? Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20389

Notes: S 8.1.1 #20389e < #20347

Abstract: Stearoyl Acyl-carrier-protein Desaturase (SAD) is a key enzyme for oleic acid biosynthesis. This enzyme play an important role in determining composition of unsaturated fatty acids in oil palm (*Elaeis* sp.). In this experiment, the genomic fragment of SAD was isolated and identified from various sources of oil palm and used to generate SNAP marker. There were 13 loci of single nucleotide polymorphisms (SNPs) identified from SAD genomic fragments and they were used to design 26 pairs of oligonucleotide primers to generate 13 SNAP markers loci. The

13 SNAP markers were used to evaluate 50 oil palm accessions consisted of *E. Guineensis* and *E. Oleifera*. Out of the 13 SNAP marker loci analyzed, six (6) loci (2 in the intron and 4 in the exon part of SAD genomic fragment) were polymorphic for *E. guineensis* and *E. oleifera* accessions. Since *E. oleifera* is known to have different unsaturated fatty acids composition in its fruit than those of *E. guineensis*, these SNAP marker loci might be used to predict genetic variations and oleic acid biosynthetic activities among segregated progenies derived from hybridization of *E. oleifera* and *E. guineensis*.

Reflini. 2014. In vitro propagation of oil palm using inflorescence as the explants. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20390

Notes: S 8.1.1 #20390e < #20347

Abstract: Most of the commercial laboratories worldwide are using somatic embryogenesis of oil palm from shoot tip explants. But it is constrained by the limitations of the source of explants mainly from elite palm cultivars. Therefore, the immature inflorescences were used as an alternative source of explants. Advantages of using inflorescences are not causing severe damage to the mother palm. The objective of this study was to compare sex of inflorescence explants for embryogenic callus induction and to develop a propagation protocol with soaking treatment before being transferred to the culture medium. One and three weeks soaking period were tested for male and female inflorescences. Inflorescences were taken from fourteen palms at different growth stages (fronds 7 to 19) and cultured on a basal MS medium supplemented with sucrose, vitamins and plant growth regulators 2,4-D and NAA. The cultures were incubated at $28 \pm 2^\circ\text{C}$ in the dark and transferred onto fresh culture medium every 3 months. Results revealed that three weeks soaking period increase callus and somatic embryos induction for both sexes of inflorescences. Male inflorescences gave a lower callus induction; nevertheless, percentage of somatic embryos induction was higher than the female inflorescences. The embryos had successfully germinated into plantlets intact.

Faizah R., S. Wening, H. Y. Rahmadi, Y. Yenni, and A. R. Purba. 2014. Correlation between homozygosity and inbreeding symptoms of SP 450 T fourth generation and dura deli fifth generation of selfing population. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20391

Notes: S 8.1.1 #20391e < #20347

Abstract: Reproducing selected parental lines as candidate mother palms for commercial seeds in Reciprocal Recurrent Selection (RRS) oil palm breeding program usually conducted by selfing. However, this practice increased homozygosity level in selected mother palms. This study concerned on level of homozygosity of SP 540 T fourth generations and Dura Deli Dolok Sinumbah fifth generations (3 populations respectively) and its correlation to inbreeding symptoms. Polymerase Chain Reaction-Simple Sequence Repeat (PCR-SSR) with 16 markers developed for oil palm was used to analyze 328 samples. The result showed that level of homozygosity of SP 540 T fourth selfing generations ranged between 0.44-0.84, and 0.61 in average. While the levels of homozygosity of Dura Deli fifth selfing generations ranged between 0.60-0.93, and 0.78 in average. The homozygosity level in Dura Deli was 1.27% higher than SP 540 T populations. It was known that the higher the level of homozygosity, the often inbreeding symptoms observed. In oil palm, this phenomenon was confirmed with the high correlation ($R^2=0.95$) between

level of homozygosity with inbreeding symptoms percentage observed.

Fillianti H., S. Wening, Y. Alfiko, W. U. Ananda, and J. Djuhana. 2014. Genetic diversity of Cameroon wild oil palm introduced in Bah Lias research station. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20392

Notes: S 8.1.1 #20392e < #20347

Abstract: Cameroon wild oil palm material in Sumatra Bioscience were introduced in year 2009 as a result of a prospection founded by a consortium of 13 Indonesian companies, and were planted in two breeding trials in year 2010. The genetic of the Cameroon wild material were previously unknown, thus graphical genotyping information is needed. The result of the analysis provides valuable information for breeders to be used for germplasm collection management and for future breeding crossing programmes. Genetic diversity of 960 wild oil palm accessions of seven regions of Cameroon were analysed using 32 Simple Sequence Repeats (SSRs). The result showed that the genetic diversity of Cameroon wild was higher than current Sumatra Bioscience oil palm breeding material. It was genetically more similar to commercial pisifera compared to other SumBio commercial materials. The Cameroon wild accessions were genetically clustered into four groups which were not congruent with the geographical position of the samples and no specific phenotype or ecology character was found for a certain group.

Cros D., M. Denis, J.-M. Bouvet, and L. Sanchez. 2014. Comparing strategies of genomic selection to increase oil palm fresh fruit bunch yield. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20393

Notes: S 8.1.1 #20393e < #20347

Abstract: Heterosis in a complex trait can result from multiplicative interactions between its components. To study the potential of genomic selection (GS) in such a context, we focused on oil palm where bunch production is the product of average bunch weight (ABW) and bunch number (BN). We simulated two realistic oil palm breeding populations and compared over four generations the current reciprocal recurrent selection (RRS) method with reciprocal recurrent genomic selection (RRGS). The goal of all breeding strategies was to select the best individuals in the two parental populations for hybrid performance on bunch production. For RRGS, we used the phenotypes of hybrids as data records in the GBLUP method to obtain the parental genomic estimated breeding and 2500 SNP. We studied the effects of four parameters on the selection response in hybrids: (1) the molecular data used to calibrate the GS model: in RRGS_PAR, we only used parental genotypes and in RRGS_HYB we also used genotypes of hybrid individuals, taking into account the parental origin of marker alleles; (2) the frequency of calibration of GS model [every generation, every two generations, every four generations]; (3) for RRGS_HYB, the number of genotyped hybrids [300, 1000, 1700 individuals] and (4) the number of selection candidates [120, 300 individuals]. We concluded that both RRGS_PAR and RRGS_HYB could lead to a much higher selection response than RRS, because they allowed reducing the generation interval and increasing selection intensity. RRGS_HYB required the genotyping of at least 1000 hybrid individuals to calibrate efficiently the GS model.

Siregar H. A. and S. Wening. 2014. Genetic relationship analysis by different allele scoring methods. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20394

Notes: S 8.1.1 #20394e < #20347

Abstract: Population A and B of Reciprocal Recurrent Selection (RRS) of Indonesian Oil Palm Research Institute (IOPRI) was analyzed their genetic relationship by using Simple Sequence Repeat (SSR). Two different allele scoring methods which produced binary and codominant data were used. There are differences in the genetic relationship analysis results produced by the two approaches. This result confirms that the best method is needed to be determined to gain valid data used in genetic relationship analysis, using SSR.

Donough C. R., A. Cahyo, T. Oberthür, R. Wandri, J. Gerendas, and G. Abdul Rahim. 2014. Improving nutrient management of oil palms on sandy soils in Kalimantan using the 4R concept of IPNI. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20395

Notes: S 8.1.1 #20395e < #20347

Abstract: As oil palm cultivation expands into increasingly marginal areas in Kalimantan, with very sandy soils, some coupled with unevenly distributed rainfall, proper nutrient management becomes even more important for oil palm productivity and economic viability of the plantations. On such sandy soils, leaching loss of nutrients is expected to be higher especially during high rainfall periods. Based on the 4R concept of nutrient management (IPNI, 2012), efficiency of applied fertilizers on such soils can be improved by higher application frequency. To test this hypothesis, a project was started in October 2011 at PT Sungai Rangit by IPNI SEAP, PT Sampoerna Agro and K+S Kali GmbH. In the project, blending of individual fertilizers prior to field application allows four rounds each of N, P, K, and Mg per year in the improved practice treatment (referred to as nutrition best management practice, NBMP), compared to the control treatment where the fertilizers are applied individually according to standard estate practice (SEP). Two rates of application viz. full and reduced (approx. 20% lower) are tested as well, giving a total of four treatment combinations. In each treatment block, two plots are embedded, one receiving the same fertilizers as the rest of the block, the other left unfertilized. Gerendas et. al. (2013), reporting on the application frequency effect after the first year, showed that the fertilizer recovery efficiency (FRE) with the NBMP was 10% and 18% higher for N and K, respectively. However in the second year of the project, overall yield was reduced in all treatments in line with a general regional yield decline and only N showed a better FRE with NBMP. With respect to the application rate effect to date, there has not been an apparent yield 'penalty' with the reduced rate either with NBMP or SEP, and FRE has generally been higher, as expected, with the reduced rate. Given the yield decline in the second year that was unrelated to the current treatments, and with two more years to run in the project, it would be premature to make conclusions now on either application frequency or application rate. Initial results for nutrient content in FFB from oil palms grown in this environment showed much lower values compared to earlier reports from North Sumatra, suggesting that nutrient removal values may be influenced by local conditions. This information is important for the profitability of plantations and for sustainable intensification of oil palm production in similar conditions elsewhere.

Simamora A. N., E. N. Ernayunita, Fakhruallah, R. Faizah, and H. Y. Rahmadi. 2014. Pre-acclimatization treatment to enhance oil palm (*Elaeis guineensis* Jacq.) plantlet viability. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20396

Notes: S 8.1.1 #20396e < #20347

Abstract: Oil palm plantlet viability in acclimatization stage was rather low. Acclimatization stage is a critical phase since the plantlets were transformed from heterotroph to autotroph. These changes influence the ability of the plantlets to control water deficit, hence plantlets were sensitive to stresses when transplanted in acclimatization. The aim of this study was to understand the effect of water immersion in pre acclimatization stage towards plantlet viability. This study used Completely Randomized Design and the treatments were water immersion duration before acclimatization for 0, 1, 2, 3 and 4 days. Each treatment consists of 3 replicates and each replicates consist of 100 plantlets. Variables observed in this study were percentage of plantlets viability (%) in acclimatization, ramet and prenursery stage. The result shows water immersion for two days increase plantlet viability in acclimatization stage until more than 97%. Two days of water immersion also improve ramet viability in pre-nursery up to 7% compared to the untreated plantlet from 86% (without immersion) to 93%. Two days of water immersion was the best treatment through pre-acclimatization to enhance plantlet viability.

Ritter E., R. D. Setiowati, M. Hernandez, A. Herran, S. Wening, and R. Purba. 2014. Linkage mapping and QTL analysis in an oil palm population from IOPRI using RAD markers. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20397

Notes: S 8.1.1 #20397e < #20347

Abstract: A linkage map has been constructed in a D x T oil palm population from IOPRI breeding material using RAD (Restriction site associated DNA) markers and a few SSR markers. The map was aligned with the chromosome sequence scaffolds of oil palm using in silico mapping techniques and contains around 350 loci. On the other hand, phenotypic data for height, circumference and ten other traits from bunch analyses considering different component ratios between bunch, fruit, kernel, mesocarp and oil contents were used for QTL (Quantitative Trait Loci) detection applying interval mapping techniques or regression analyses. We detected a total of 50 QTLs for the 12 traits varying between 2 QTLs for circumference and 8 QTLs for fruit to bunch ratio. Individual QTLs explained between 10.3 and 33.7% of the total variance and their cumulative effects explained between 24.1 and 62 %. Clusters of QTLs for different traits were observed at several map locations, reflecting the observed trait correlations. In many cases very similar genomic locations were detected for QTLs which had been published previously for individual traits, but we found also new QTLs or QTLs for new traits which have not been published yet. This study represents a first promising approach for combining classical and in silico methods for map construction and QTL analyses.

Mardianto K., Ernayunita, E. Nazri, and H. Y. Rahmadi. 2014. Embryo diversity in IOPRI tissue culture laboratory. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20398

Notes: S 8.1.1 #20398e < #20347

Abstract: Oil palm somatic embryos were formed from induced callus. Embryo produced in development phases is quite diverse. This study aimed to identify the diversity of oil palm somatic embryos. The research was conducted at Tissue Culture

Laboratory of Indonesian Oil Palm Research Institute in Marihat. Sampling method was used to observe embryos from six different ortets planted in embryo induction and multiplication medium. Based on the observation, there were embryoid and polyembryoid forms allegedly had different abilities in leaf development.

Mohd Din A., A. Kushairi, A. Noh, and N. Rajanaidu. 2014. Genetic performance of vegetative traits of MPOB oil palm interspecific hybrids in inland and coastal soils. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20399

Notes: S 8.1.1 #20399e < #20347

Abstract: Oil palm interspecific hybrids were derived from the North Carolina mating design 1 (NCM 1) involving 236 *Elaeis oleifera* palms (from collection by Martineau of Socfin) as maternal parents and 76 *Elaeis guineensis* (pisifera) palms (from Sabah Breeding Programme) as paternal parents. The progenies were planted in Malaysia on inland soils of Kluang, Johor and Ulu Paka, Trengganu, and on coastal soil of Teluk Intan, Perak. There were significant differences between pisiferas in Kluang, Ulu Paka and Teluk Intan for all the seven vegetative traits viz. petiole cross-section (PCS) rachis length (RL), leaflet length (LL), leaflet width (LW), leaflet number (LN), height (HT) and leaf area (LA). Small PCS, short RL and low HT are favoured by oil palm planters for ease of frond pruning, higher density planting and longer economic lifespan, respectively. The highest heritability due to pisifera parents, h^2_p were recorded in Teluk Intan with heritabilities of 74.7% (PCS), 43.1% (RL), 66.2% (LL), 54.9% (LW), 100.0% (LN), 80.6% (HT) and 63.0% (LA). The lowest PCS (8.65 cm²), RL (3.91 m) and HT (0.28 m) were obtained in Kluang by progenies MS2063 [0.142/7833 x W(T)9], MS2083 [0.142/7391 x W(T)9] and MS2081[0.142/7436 x (HE ZE B2 x AVROS 4/12)], respectively. Based on general combining ability (GCA), the lowest PCS (14.36 cm²) and RL (4.40 m) were obtained in Kluang by pisifera 181OP7 [W(T)9], whereas the lowest HT (0.46 m) was given by pisifera 181OP15 [LN(T)5]. The outcome of this study revealed the importance of utilising suitable pisiferas with good GCA as paternal parent in the creation of oil palm intersepecific hybrids with the desired vegetative traits.

Sim C. H., S. H. Lee, L. L. Lim, S. K. Ng, and S. Mohan. 2014. IOI's pisifera genetic diversity study using SSR markers. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20400

Notes: S 8.1.1 #20400e < #20347

Abstract: As pisifera palms are predominantly female sterile, they cannot be exploited for commercial planting. They are mainly used as male sources by breeders in the crossing with dura palms to produce the tenera (DxP) hybrid. Hence, it is important to assess the genetic diversity of pisifera so that suitable male parent is selected in the breeding programme. 178 pisifera palms used in this study are of Cameroon, Ekona, Nifor, AVROS, URT, Binga, MPOB AVROS and Dami AVROS origin. Genotyping of these pisifera palms was performed by using 20 pairs of Simple Sequence Repeats (SSR) markers. Dendrogram constructed based on Nei's genetic distances using the un-weighted pairgroup mean algorithm (UPGMA) showed that the pisiferas under study were divided into two main clusters. Breeders could also refer to the information obtained from this study to assist them in the selection of suitable materials for breeding. Besides, if breeders find the pisiferas of certain origins can potentially be used in future breeding programs, these pisiferas could be cloned through tissue culture for future use. The results will be discussed in detail in the full paper.

Ernayunita, Fakhruallah, E. Nazri, A. N. Simamora, and H. Y. Rahmadi. 2014. Oil palm (*Elaeis guineensis* Jacq.) plantlet packaging and shipment simple method. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20401

Notes: S 8.1.1 #20401e < #20347

Abstract: Special treatments are needed to ship oil palm plantlet to prevent any damage of the plantlet during shipment and to ensure plantlet normal growth after shipment. This study aim was to choose the best air shipping method for oil palm plantlet. This study used Completely Randomized Design and the treatments consists of 3 replicates, and each replicate consist of 25 test tubes (50 plantlets). Treatments tested was different types of packaging (styrofoam box + culture rack, styrofoam box + styrofoam pellet, and card board + cotton). Variables observed were package weight, package strength, plantlet and test tubes condition after shipment. Plantlets were placed in the package accordingly and air shipped from Medan, North Sumatera to Pekanbaru, Riau for 4 days. The result shows that styrofoam box + styrofoam pellet packaging was the lightest with 5,83 kg and significantly different with other packaging hence cheaper than others. The entire package were in good condition, except for the cardboard + cotton. 99% of the test tubes were in good condition, except for the styrofoam + culture rack packaging and the plantlets were fresh (nearly 100%) in all packages. Plantlet air shipment was better in styrofoam + culture rack packaging.

Donough C. R., S. N. Mohanaraj, Rahmadsyah, and T. Oberthür. 2014. Growth of oil palm seedlings influenced by nursery practices in Malaysia and Indonesia. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20402

Notes: S 8.1.1 #20402e < #20347

Abstract: In 2011, the International Plant Nutrition Institute's Southeast Asia Program (IPNI SEAP) initiated a project called 'BMP All Stages' with plantation partners in Sabah, Malaysia, and South Sumatra, Indonesia, to assess the impact on future oil palm yield of best management practices (BMPs) during the nursery, immature, and mature stages of the oil palm production cycle. At each stage, BMPs are compared to the current standard estate practices (SEPs) of IPNI SEAP's project partners. At each location, planting materials are produced in oil palm nurseries to plant five sets of commercial-scale blocks (20ha per block minimum area) of oil palm. Each block will be monitored, initially for growth and subsequently for yield, until the completion of at least four years of crop production. At both locations, several rounds of the nursery stage have now been completed. Initial results from the nursery stage are presented here, as part of the ongoing evaluation. In Sabah, the following SEPs differed from the BMPs prescribed by IPNI SEAP: . Plastic pot trays, instead of conventional polybags, were used in the pre-nursery; . Organic material and mycorrhizal fungi inoculum were added to the pre- and main nursery potting medium; . Organic-based fertilizers were included in the pre- and main nursery fertilization programs; and . Drip irrigation was used in the main nursery. In South Sumatra, the SEPs were very similar to IPNI SEAP's prescribed BMPs except for fertilization, where: . The SEP provided ca. 60% more nutrients from a higher number of applications in the pre-nursery; while . In the main nursery, the difference was not as large, and varied for individual nutrients, with a key difference being the P fertilizer source, with ca. 60% water-soluble form supplied to the BMP seedlings. Results todate show that at the end of the nursery stage, i.e. when seedlings were ready for field planting, growth was better with BMP in South

Sumatra but the opposite was true in Sabah. If this is confirmed when all the remaining nursery rounds are completed, revisions may be justifiable to current industry standard nursery practices.

Fauzi W. R., T. C. Hidayat, I. R. Harahap, Y. Pangaribuan, Sumaryanto, I. Pradiko, and M. Syarovy. 2014. Assessment of decreased fresh fruit bunch production based on rainfall and dry spell analysis in Bukit Sentang estate. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20403

Notes: S 8.1.1 #20403e < #20347

Abstract: The research was conducted to determine the correlation among rainfall and dry spell with Fresh fruit Bunch by observation method on related parameters. Data analyzed using time lag correlation showed that rainfall, rain days and dry spell on 7 month before harvest correlated to production and FFB numbers with coefficient correlation of -0.43, -0.45 and 0.43 to FFB production and - 0.48, 0.50 and 0.47 respectively that correlated with anthesis phase of female flower. Rainfall on 22, 23 and 24 month before harvest was correlated to produktivity and FFB numbers with coefficient correlation of 0.53, 0.49 and 0.43 to FFB production and 0.48, 0.49, and 0.47. Rain days and dry spell 24 month before harvest correlated to production and FFB numbers with coefficient correlation of 0.43 and -0.44 to FFB production and 0.48 and 0.57 respectively that correlated with sex differential phase of flower.

Latif S., F. I. Lubis, L. Kurniawan, and V. Andriawan. 2014. Oil palm productivity performance at the estates of PT. Citra Borneo Indah, Central Kalimantan. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20404

Notes: S 8.1.1 #20404e < #20347

Abstract: There are three estates within Citra Borneo Indah Group namely Kondang, Rangda and Pulau performed a high oil palm productivity in the last six years. At Kondang estate the highest productivity (34.47 ton FFB/ha/year) was recorded in the year 2009 that obtained from the first palm planted in 2001. For the next three years (2010-2012) from the same plant, the productivity was 33.04; 31.01 and 30.85 ton FFB/ha/year, respectively. The Rangda estate obtained the highest productivity (32.29 ton FFB/ha/year) in 2011 from 9 years old of palm planted in 2002. The second grade (29.92 ton FFB/ha/year) was obtained from 8 years old palm planted in 2004. The highest productivity (30.86 ton FFB/ha/year) of Pulau estate was recorded in 2012 from 9 years old of palm planted in 2003. In the previous year, the same plant produced 29.38 ton FFB/ha/year. Based on average bunch weight, each estate showed the increasing of bunch weight in line with the increasing of palm age. For Kondang estate, average bunch weight increased from 8.32 kg (5 yr) to 14.75 kg (10 yr) The similar trend could be seen from Rangda and Pulau estates. It increased from 7.28 kg (5 yr) to 13.18 kg (10 yr) of Rangda while at Pulau estate it increased from 6.64 kg (5 yr) to 14.37 kg (10 yr). In general, the productivity of the estates tended to decrease into below 30 ton FFB/ha/year. Several factors such as high abortion rate of bunch followed high production in the previous year and climate were probably the main causes of this phenomenon. From the data of 3 estates, it could be noted that the most productive estate was Kondang.

Santoso H. 2014. Tracing caterpillar attach on oil palm plantation with quickbird imagery. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20405

Notes: S 8.1.1 #20405e < #20347

Abstract: Caterpillar attach on oil palm plantation will affected to oil palm productivity if not controlling immediately. Caterpillar attach monitoring will influenced with census worker. Remote sensing technology had produced high quality of imagery with high spatial accuracy (2,5 - 0,5 meter) and several band as Quickbird imagery. It had 4 multispectral band (blue, green, red, and infrared) and 1 panchromatic band. This research aims to tracing caterpillar attach that had happen in one afdeling of one estate in Asahan district of North Sumatera Province. Until August 2008, according monitoring results of caterpillar attach in this afdeling showed more than 350 ha of area attached with caterpillar (almost 50 % of planted area). Results tracing of caterpillar attach with Quickbird imagery that 4 August 2008 archived imagery using NDVI showed spotty pattern of caterpillar attach. Caterpillar attach sign on NDVI approach is pixel composition in 3 x 3 pattern not fully with one color. ItÖs can be understand, because the caterpillar eat the oil palm leaf fully or several part of leaf that given several part damage of oil palm canopy. The damage part of leaf given difference reflection with healthy/green leaf. This research should be more detailed doing to known the relationship of several level of caterpillar attach with spectral reflection on oil palm with no leg time both imagery capture with caterpillar attach happen. It can be used for known how the interpretation accuracy of tracing or identification of caterpillar attach with remote sensing imagery.

Nasution K. Y. 2014. Effect of El Nino La Nina and rainfall on FFB yield of oil palm (*Elaeis guineensis* Jacq.) in Central Kalimantan. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20406

Notes: S 8.1.1 #20406e < #20347

Abstract: Deviation climate often effect negative influence. One of the main factor is ENSO (El Nino Southern Oscillation) phenomena. El Nino usually associated as long dry season and La Nina as wet season or flooding. The aim of this paper is to know the effect of El Nino, La Nina and rainfall on Fresh Fruit Bunch (FFB) yield using sampling in Central Kalimantan. Based on analysis result, there ware effect among El Nino, La Nina and rainfall on FFB yield in Central Kalimantan. FFB yield of oil palm fluctuated as influenced by rainfall. In 2004, 2006 and 2009/2010 where rainfall decreased has impact on FFB yield the next two to three years. In 2004/2005, 2007/2008 and 2010/2011 rainfall increase for the next two years FFB yield of oil palm increased significantly compared with the previous year. if compared with FFB actual yield with FFB potential yield fluctuated. In 2005, 2006, 2008, average FFB actual yield was under FFB potential yield, while in 2011 the actual yield was same with the FFB potential yield of oil palm which should be higher than the FFB potential yield. In 2007, 2009, 2010 and 2012, average FFB yield actual was higher than the FFB yield potential in oil palm plantations in central Kalimantan. It was affected by El Nino, La Nina that occurred two previous years, so the impact on the FFB yield of oil palm plantations. From the data Oceanic Nino Index (ONI), El Nino and La Nina had occurred seven times from 1990 to 2013, so that it could be concluded El Nino and La Nina occurs 3.14 years in Indonesia. In 2014, El Nino was predicted from some institution will be neutral to weak at the end of the year. Based on Oceanic Nino Index (ONI), oil palm plantations can anticipate decrease oil palm yield on the influence of ENSO especially rainfall, so that stakeholders, oil palm plantation

companies and planter in field can create anticipation with way conservation of mechanical and the biological.

Fauzi W. R. and Sumaryanto. 2014. Fertilization of NPK and its effect to vegetative growth of oil palm in first stage seedling. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20407

Notes: S 8.1.1 #20407e < #20347

Abstract: The research was conducted to determine the effect of NPK fertilization in pre nursery stage. The method that used was randomized complete block design with four treatments and eight replication, each replication consist of five seed. The treatments were control (without fertilizer), Urea (2 g/L/100 seed), NPK I (NPK 15-09-20 + NCa fertilizer) and NPK II (NPK 15-15-6-4 + Urea). The parameters was plant height, number of leaf, leaf length, leaf width, leaf area, wet weight, dry weight and chlorophyll content. The result showed NPK II treatment were increase height of plant and leaf length significantly than others, NPK I treatment significantly increased leaf width than other, Urea, NPK I and NPK II treatments increased significantly leaf area, chlorophyll content and dry weight.

Syakir M. A., F. Santiabudi, Miswandi, A. Ardiyanto, M. Chu, and K. H. Lim. 2014. Development of organic fertilizers from pressed EFB compost. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20408

Notes: S 8.1.1 #20408e < #20347

Abstract: A sustainable approach to further enhance the green image of palm oil is the development of renewable organic fertilizers from the large quantities of 'organic wastes' generated by the palm oil milling process. This study reports the development of cost-effective organic fertilizers from pressed EFB compost for use in nurseries and first year oil palm field plantings. Another objective of this study is to reduce labour requirement by reducing the number of fertilizer application rounds. The manufacturing process begins by mechanically pressing Empty Fruit Bunches (EFB) for residual oil. The pressed EFB are then composted with daily addition of Palm Oil Mill Effluent (POME). Composting with daily turning using a mechanical turner is carried out for 6 weeks to produce a compost with average nutrient content of N (1.6 %), P₂O₅ (0.8%), K₂O (2.5 %) and MgO (0.9 %). The compost is then dried to about 10 % moisture and pulverised with a mechanical grinder. It is then fortified with inorganic fertilizers to upgrade the nutrient content into two formulations (PKN and PKT1). A polybag trial on main nursery seedlings compared the use of the Formulation PKN with a commercial Organic Fertilizer B and an Inorganic Compound Fertilizer. There were significant differences in vegetative measurements (seedling height and bole diameter) between the 3 treatments at 5 and 9 month old. An additional advantage of the using the organic fertilizer is the reduction in the number of fertilizer applications from 9 to 5 rounds. The Formulation PKT1 was tested on first year oil palm field planting on an Ultisol. The main objective is to partially replace the very expensive Controlled Release Fertilizer (CRF) which is incorporated in the planting holes. Seven months after field planting, the Treatment with 500 gm PKT1 plus 200 gm CRF was comparable in vegetative measurements to the Control Treatment with 300 gm CRF. The use of organic fertilizers can help to improve the physical, chemical and biological properties of soils under oil palm cultivation. It will also reduce methane (CH₄) emission, which is an important Green House Gas (GHG) via the co-composting of EFB with POME.

Darlan N. H., I. Pradiko, and H. H. Siregar. 2014. The first performance of oil palm in high altitude. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20409

Notes: S 8.1.1 #20409e < #20347

Abstract: The increasing of global temperature began since the industrial era, that is 0.2 to 0.3 OC in the last 40 years (1954 - 1994). The increasing temperature causes oil palm development in high altitude (elevation > 600 m asl) could be implemented. Nowadays, total of oil palm plantation in high altitude in North Sumatra was about 4.725 ha, and some of them was planted in > 1000 m asl of altitude. Generally, the palm tends to have faster height growth rather in the lower land, related to solar radiation competing. The palm has a longer immature period and only produce 3.12 ton FFB/ha with FFB number of 4 bunches per palm, and average weight bunches of 7.22 kg/bunch in 5 years after planting. The main constrain of oil palm plantation in >1000 m asl is climate condition, such as the low temperature and solar radiation, and also the high humidity. The occurrences of minimum temperature below 15 °C were almost happen every month that will interfere oil palm growth. The low temperature also reduces *Elaeidobius* sp numbers and activity which will cause partenocarpy bunches due to imperfect pollination. The limited solar radiation will made palm lack of energy to photosynthesize which cause longer time to produce or ripen bunches. Meanwhile the high humidity will induce a great occurrences of rot bunches diseases cause by *Marasmius* sp which will result in greater loss on palm productivity. These conditions shall be considered and overcome before planting oil palm in higher altitude (>1000 m asl) in order to have an optimum productivity.

Liu Z., D. Gusyana, and M. Manning. 2014. Prevention and cure of Boron deficiency in oil palm. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20410

Notes: S 8.1.1 #20410e < #20347

Abstract: As one of the essential micronutrients, boron plays an important role in a number of vital processes in oil palm growth such as cell division, root development, cell wall formation, and sugar transport and calcium uptake. The symptoms of boron deficiency in oil palm include "fishbone leaf" or "hooked leaf", white stripe occurrence in leaves, seedless fruitlet, and inadequate fresh fruit bunch. Studies show that the addition of boron in oil palm can correct the above symptoms, increase yields upwards of 5% and deliver Cost to Benefit ratios of 1 to 10x. Rio Tinto Minerals/U.S. Borax is a global leader in borate supply and science with three high quality borate fertilizers, i.e Granubor® 2 (borax pentahydrate with 14.3% of boron), Fertibor® (borax pentahydrate with 15.2% of boron) and Solubor® (disodium octaborate tetrahydrate with 20.9% of boron). Specifically, Granubor® 2 is an ideal material for dry blends for soil application. Fertibor® works in isolated soil applications and supplemental auxiliary application. Solubor® allows the most flexibility for applying boron in solution. It can be dissolved alone in water or in liquid fertilizer and/or pesticide and then applied to the soil or directly onto the palms. In this paper, we demonstrate the prevention and cure of boron deficiencies in oil palm by Granubor® 2, Fertibor® and Solubor®.

Lestari D., R. Wandri, and D. Sarim. 2014. Effect of bio-fertilizer on vegetative growth of oil palm nursery. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20411

Notes: S 8.1.1 #20411e < #20347

Abstract: The objective of this research was to determine the combination effect of

inorganic fertilizers and Agrinos' Bio-product HYT® on vegetative growth of oil palm nursery. This research was carried out from November 2012 until November 2013 at Surya Adi Estate - PT. Binasawit Makmur, South Sumatera. The trial was arranged in Randomized Complete Block Design (RCBD), with 9 combinations of trial and 3 replications. Those were : P1B1 (50% in-organic fertilizer); P1B2 (50% in-organic fertilizer + medium HYT®); P1B3 (50% inorganic fertilizer + high HYT®); P2B1 (75% in-organic fertilizer); P2B2 (75% in-organic fertilizer + medium HYT®); P2B3 (75% in-organic fertilizer + high HYT®); P3B1 (100% inorganic fertilizer); P3B2 (100% in-organic fertilizer + medium HYT®) and P3B3 (100% inorganic fertilizer + high HYT®). The best treatment combination were P2B3. This treatment significantly increased the vegetative growth of plant height and bole diameter. The treatment of P2B3 increased the frond base diameter up to 12.60% (76.47 mm) to the control (67.92 mm). Moreover, it increased the plant height up to 14.30% (120.94 cm) to the control (105.82 cm). This study proved that the application of biofertilizer HYT® was able to reduce in-organic fertilizer by 25% (P2B3).

Fauzi W. R., Sumaryanto, T. C. Hidayat, I. R. Harahap, and Y. Pangaribuan. 2014. The characteristic differences of two genus *Mucuna* (*Mucuna bracteata* and *Mucuna pruriens*) as cover crop in oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20412

Notes: S 8.1.1 #20412e < #20347

Abstract: Legume cover crop is very important in oil palm plantation especially in immature palm oil. Commonly LCC that used on oil palm is *Mucuna bracteata* were introduced from India. But there is other species similar to *Mucuna bracteta*, namely *Mucuna pruriens*. The fundamental differences of two species ini *Mucuna bracteta* can only produce the seed in highland but *mucuna pruriens* able to produce the seed in lowland. The aim of this research is to determina the charracteristic of the two species. Parameters observed were the growth of tendrill, leaf shape, inflorecense, and seed characteristic. The result show that the tendrill growth of *mucuna pruriens* was lower than *Mucuna bracteata*, The inforecences of the two species were differrent based on inflorecenses picture, and the seed relatively similar.

Hidayat T. C., S. H. Ahmad, R. Abu Bakar, S. Z. Sakimin, and I. R. Harahap. 2014. Effect of Paclobutrazol on oil palm seedling performance and leaf greenness. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20413

Notes: S 8.1.1 #20413e < #20347

Abstract: The development of oil palm plantation to marginal and dry land is inevitable, such as in south of Sumatera, Borneo and Sulawesi, Indonesia, and Perlis in Malaysia. Due to this development, the needs of oil palm seedling are increasing too. Nevertheless, these planting materials are not simply need in a big amount but must compact in performance. With compact performance, it is easy to maintains, easy to transplant to the field, decreasing transportation cost and given a strong green to the leaves. However, plant hormones play a key role as mediators between environmental signals and adaptive plant response. One of plant hormones that could retard growth and produce a compact plant performance Paclobutrazol (PBZ). PBZ is a triazole that has reported to protect plants against several environmental stresses. It also have been reported that PBZ stimulate th accumulation of chlorophyll in the leaves. Even though, the response will vary depending on the type of application, doses, concentration and plant species. The

aim of this research is to determine the effect of PBZ on oil palm performance and leaf greenness. This is a randomized completely block design with involve eight concentrations of PBZ. They are 0, 33, 50, 66, 100, 150, 200 and 300 mg/polybag, with 5 replications. PBZ is applied by soil drenching on 6 month old oil palm seedling. Growth parameter measured at 9 month old, such as Plant height, Trunk diameter, Rachis length, number of fronds, Specific Leaf Area and Florescence meter (chl/leaf greenness).

Ginting P. A., O. Efendi, N. Masculen, Rozalia, Khairunnisa, A. Martina, Titrawani, Herman, A. J. Silalahi, and A. C. Sitorus. 2014. Biological control of termites (*Coptotermes curvignathus* L.) using formulated *Beauveria bassiana* and *Metarhizium anisopliae* and compost as trapping agents in peat soil plantations. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20414

Notes: S 8.1.1 #20414e < #20347

Abstract: Termite is one of major pests in oil palm plantations, especially those planted in peat soil. Integrated pest management (IPM) practices have been suggested to investigate and control the infestations, as more peat soil area are converted to oil palm plantations. The most common method of using chemical agent and have been used over the last decade is no longer effective to control this pest below the threshold level. Practices such as cultural practices and biological control using entomopathogen are recommended as the new approaches. Monitoring the pest and its behavior, however, is a challenging task because trapping termites can be very difficult. This paper present the most effective method of trapping termites using compost was produced by aerated tunnel composting (ATC) system from oil palm empty fruit bunch (EFB) and then controlling them using Formulated *B. bassiana* and *M. anisopliae* an entomopathogen. The investigation in the field showed that in the heavily infested area, termites are found in 90 % of all the compost piles and each of 5 % and 4 % in the infested young and old palm of < 15 years. Termite species of *Coptotermes curvignathus* is the only spesies detected in the compost and it is also the only species that is known to infest oil palms. The non-sterilize and termite-infested compost and palm was then used as the growth media for *B. bassiana* and *M. anisopliae*. The result showed that 99 % of termites (*C. curvignathus*) were infected within 8 days of treatment. The dead termites were then isolated and planted in vitro. The result showed that infection of both *B. bassiana* *M. anisopliae* was indeed the cause of death. These results showed that both *B. bassiana* and *M. anisopliae* has the potential to be a biological control agent of termites in peat soil plantations. A field trial was also conducted using compost piles as trapping the termites that have been sprayed with formulated *B. Bassiana* and *M. anisopliae*. This study showed that more than 90% colony of termites was not found in all application plots on EFB compost piles around circles and trunks after application although the results show that 29 % termite colonies no longer found in the control plots due to human disturbance. The infected termites are not found on compost piles and also trunks that have been sprayed, so that the determination of the effectiveness both formulated *Beauveria* and *Metarhizium* applications just by looking at the presence of termite colonies after application. These studies showed that compost produced from EFB using the ATC method has multi function. It can be used as organic fertilisers to the plantations. It can also be used as a termites trapping agent combined with *B. bassiana* and *M. anisopliae* as a sustainable solution to termites' problem in oil palm plantations.

Dian R., P. Niken, G. Andre, and A. R. Gatot. 2014. Correlation between rainfall pattern and *Elaeidobius kamerunicus* beetle population affecting the formation of fruit set. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20415

Notes: S 8.1.1 #20415e < #20347

Abstract: *Elaeodobius kamerunicus* is one of palm pollinator beetles. Beetle population are allegedly affected by climatic conditions, especially rainfall pattern. This study aims to determine the relationship between rainfall pattern and *Elaeodobius kamerunicus* beetle population affecting the formation of fruit set, indicated by the availability of beetles in each area corresponding with different rainfall conditions. The study was conducted in Inti Permata Bunda Dua (IPBD) Estate, Sumber Sawit Estate and Hikmah Empat Estate between the period of June till December 2013. Observations on beetle population and bunches per ha were made monthly for all estates. The results indicated that an average of 700 beetles are found per bunch and Hikmah Empat Estate is below the population mean. The mean population per bunch in Hikmah Empat Estate is 407 beetles, while Sumber Sawit Estate has 1525 beetles and IPBD Estate has 1024 beetles. We observed that higher amount of rainfall usually lead to lower population of *Elaeodobius kamerunicus*. Value of fruit set formation in Hikmah Empat Estate is 51%, Sumber Sawit Estate is 64% and IPBD Estate is 66%. Higher population of *Elaeodobius kamerunicus* beetle correlates to greater percentage of fruit set formation.

Rozziansha T. A. P., K. Karo-karo, and A. Susanto. 2014. Application of light trap in high population of *Oryctes rhinoceros*. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20416

Notes: S 8.1.1 #20416e < #20347

Abstract: *Oryctes rhinoceros* is one of the major pest in oil palm plantation in Indonesia. Commonly this pest attack young palm in replanting area. In some cases, severe attack could make the death of palm. Replanting technique with chipping and without delaying planting caused high population of *O. rhinoceros*. The objectives of this research was to decreased the *O. rhinoceros* population with application of light trap technique. This research was carried out in Rambutan Estate, PT. Perkebunan Nusantara III, North Sumatera. Another techniques also used in this research, i.e. net trap, pherotrap and handpicking of larvae and pupae. The results showed that the light trap could decreased population of *O. rhinoceros* in high population. This technique can trap 23,142 beetles in 5 months. Other techniques were used such as pherotrap, net trap and hand picking could trap 3,051 beetles, 698 beetles, and 51,972 beetles respectively.

Hamid N. H., C. M. R. Zainal Abidin, H. Salim, and A. H. Ahmad. 2014. Comparative efficacy of *Metarhizium anisopliae* (solid substrate) and chemical insecticide against *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae) in oil palm replanting area. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20417

Notes: S 8.1.1 #20417e < #20347

Abstract: The need of using different *M. anisopliae* formulation as an alternative method to control *O. rhinoceros* was simulated in this study due to its practicality for large scale replanting programme. *M. anisopliae* in the form of maize-solid substrate (MSS) was applied to the breeding sites of *Oryctes rhinoceros* in oil palm and oil palm replanting areas using the manual spreader technique. The result showed that the mean for the total larval infection throughout the study in SS treated plots and SP

treated plots were 22.99% and 3.21% respectively. The t-test showed there was a high significant difference in the mean score between the two treatments ($T= 2.731$, $P<0.05$). These results indicated that *M. anisopliae* applied in the form of solid substrate treatment produced good bio-control efficacy against *O. rhinoceros* larval population and probably would prevent the outbreaks of *O. rhinoceros* in newly planted oil palms. This proves the high potential of *M. anisopliae* as a very effective bio-control agent even in solid substrate form. This type of treatment provides another possibility that should be explored in combating *O. rhinoceros* larval population outbreaks. MSS form is going to be the simplest and most practical approach for planters in controlling *O. rhinoceros* in their replanting programmes. This discovery has opened up a new avenue for commercial application.

Maxime M., L. Anthony, C.-L. Cathy, J. S. Tan, K. Christophe, T. Durant-Gasselin, S. S. R. S. Alwee, B. Frederic, and L. Camus-Kulandaivelu. 2014. Identification and developement of new polymorphic Microsatellite markers for *Ganoderma boninense* main causal agent of oil palm basal stem rot disease. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20418

Notes: S 8.1.1 #20418e < #20347

Abstract: *Ganoderma boninense* is a telluric lignicolous basidiomycete and the main causal agent of the basal stem rot, one of the most devastating diseases of oil palm (*Eleais guinensis*). While the fight against *G. boninense* should be a priority in South-East Asia, only scarce information is available about the diversity level of this fungus, and almost nothing is known about its genetic structure and history. In this context, the development of an informative molecular marker set for characterizing *G. boninense* diversity is a key step to understand the biology of this pathogen. A *G. boninense* draft genome sequence assembly of 61.5 Mb (from 454 and Illumina sequencing) has been used to identify and develop a set of microsatellites markers (SSR). A total of 652 SSR were identified and primers for 145 SSR were developed. These SSR are characterized by motif from 2 to 6 bases long and 5 to 34 repetitions. A total of 97 SSR were successfully amplified on a first small set of *G. boninense* isolates from Indonesia. Then a population of 48 isolates from several locations in South-East Asia was screened to characterize each locus for allele number, heterozygoty and null allele absence. These results allow us to propose an efficient SSR set to study *G. boninense* in infected oil palm plantations in order to better understand the history of this pathogen.

Simanjuntak D. and A. Susanto. 2014. Activity of *Elaeidobius kamerunicus* in highland and of oil palm plantation in North Sumatera. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20419

Notes: S 8.1.1 #20419e < #20347

Abstract: *Elaeidobius kamerunicus* is an pollinating weevil that successful adapt and proliferate replace artificial pollination were done by humans. Over the years, pollinating weevils are more dominant in the lowland areas. But, its presence on the highland has not been studied until now. Therefore, the aim of this research was to observe the activity of *E. kamerunicus* as an pollinating weevil on oil palm plantation in the highlands. This research was conducted in two areas of oil palm plantations in North Sumatra at an altitude of 683 m asl to 1.061 m asl. The results showed between altitude of place to the number of anthesis male flowers, fruit set, the population of *E. kamerunicus* on anthesis male flowers, and the number of *E.*

kamerunicus visit the receptive female flowers, has a correlation value respectively 0,006; 0,086; 0,018, and 0,029. Overall, at an altitude 600-700 m asl; 700-900 m asl, and 900-1100 m asl value of fruit set respectively 62,92%, 64,94%, and 53,95%. Likewise the population of *E. kamerunicus* on the anthesis male flowers respectively 32.436 imagoes/ha; 87.734 imagoes/ha, and 65.993 imagoes/ha and the number of *E. kamerunicus* visit the receptive female flowers respectively 13 imagoes/ha; 36 imagoes/ha, and 319 imagoes/ha. While the average of fruit set in the lowlands of North Sumatra was 67,56%, with the number of *E. kamerunicus* on the anthesis male flowers were 2.571 imagoes/ha.

Zainal Abidin C. M. R., N. H. Hamid, and S. Hamzah. 2014. A powder formulation of *Metarhizium anisopliae* to control of *Oryctes rhinoceros* under the different application techniques. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20420

Notes: S 8.1.1 #20420e < #20347

Abstract: A powder formulation of *Metarhizium anisopliae* spores was studied for its efficacy against *Oryctes rhinoceros* beetles in a commercial field. Two application delivery techniques were evaluated, namely the blanket application of the product suspension solution to all biomass heaps in the field and secondly, the integrated application of the spore solution to selected artificial breeding sites establishments at the peripherals of the selected fields, where pheromone traps were also installed. Both techniques were able to infect and kill more than 30% of the *O. rhinoceros* especially its 3rd and 2nd instars larval stage during the period of study. The plots treated with *M. anisopliae* showed statistically significantly higher percentage of infected grubs when compared to the control (non treated) plots. The infection rate was positively correlated with beetles density collected. However, there were no significant difference observed on new palm damages between the treated and the control plots. The results indicated that the powder formulation of *M. anisopliae* spores used in the study was effective to be used as bio pesticide to control *O. rhinoceros*. The integrated approach of applying *M. anisopliae* to artificial breeding sites where pheromone traps were installed was similarly as effective as the blanket application of the *M. anisopliae* spores to the entire area. This innovative delivery technique provided a strong potential to solve many issues of high incidence of *O. rhinoceros* population in oil palm replants and towards establishing biologically based management practices to control rhinoceros beetle over a large scale replanting program.

Rozziansha T. A. P., H. Priwiratama, and A. Susanto. 2014. Insect biodiversity in oil palm - forest boundaries. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20421

Notes: S 8.1.1 #20421e < #20347

Abstract: The biodiversity of insect in forest and oil plantation was different. The changes in this ecosystem caused decreasing of insects biodiversity. This condition could promote a succession some insects became pests and outbreak. Therefore, information about insect biodiversity is necessary. This research aim to gain information of insect biodiversity in oil palm and forest boundaries. Sampling was conducted with used Malaise trap, yellow pan trap, pit fall trap and sweep net. The results showed, Order Hymenoptera and Lepidoptera was dominance in both location. The diversity index in forest boundaries were higher than oil palm.

Faizal I., Y. P. Ruswanjaya, L. Devi, D. Marettta, A. Nur Saryanah, Sulastrri, B. Sahari, and S. Hardjotedjo. 2014. Design a Specific primer for *Ganoderma boninense* detection in oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20422

Notes: S 8.1.1 #20422e < #20347

Abstract: In period 2011-2012, we detected the gene marker of ITS (Internal Transcribed Spacer) to determine the existence of *G.boninense* at plantation owned PT Astra Agro Lestari at Aceh Singkil, Kumai and Mamuju. Subsequently, sequencing of the gene has been conducted to comparing the sequences amongst them. ITS gene marker can be amplified using specific primer initially designed from gene bank database. From initial specific primer, we have designed a new specific primer from comparing and aligning various sequences of three location *G. boninense* that existed. Fortunately, the new specific primer for ITS gene can be used for amplification any organs in palm oil plant including in leaves and soil in severe and moderate level attack of *G. boninense*. BLASTn (homology percentage ITS sequences comparing with gene bank database) results revealed that ITS sequences of three location has 98% homolog to *G. boninense* in gene bank database. If we comparing the ITS sequences of *G. boninense* from Aceh Singkil, Kumai and Mamuju to each other, almost 80% ITS sequences is homolog. The heterolog sequences are shown that the sequence is a specific location for *G. boninense*.

Simanjuntak D. and A. Susanto. 2014. Frond desiccation disease in oil palm plantations in Indonesia. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20423

Notes: S 8.1.1 #20423e < #20347

Abstract: Recently, many planters reported the existence of new disease in their plantation. Although less lethal, but the spread of this new disease already existed in the oil palm plantations in East Kalimantan and Kota Pinang (Riau). Not many studies have reported about the development of this disease. Based on observations in the field, oil palm diseased in Kota Pinang (Riau) has similar symptoms to oil palm diseased in East Kalimantan. This new disease was named frond desiccation. The symptoms are decay starting from the tip into the middle of frond, became a dry rot, and infected tissue eventually dies. Through the process of isolation from infected tissue have obtained two types of fungal origin East Kalimantan and four types of fungal origin Kota Pinang. These fungus are still being tested by Koch's postulates, to see if there is a correlation with the disease.

Dian R. and G. Abdul Rahim. 2014. Study of climate variations with distribution of nettle caterpillar (*Elaeis guineensis*) in Sampoerna Agro oil palm region of South Sumatra. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20424

Notes: S 8.1.1 #20424e < #20347

Abstract: Nettle caterpillars are one of the major pests found in oil palm plantations. Generally, nettle caterpillars appeared from the beginning to the end of rainy season. The purpose of these observations was to determine the relationship between rainfall pattern and the level of nettle caterpillar attack; measured by the increase of nettle caterpillars' population. The data used for the purpose of this observation were the rainfall and nettle caterpillars monitoring data of for the last 4 years in Surya Adi. These data were analyzed by using regression analysis. The rainfall factor consisted

of relevant rainfall in immediate month (RF 0), the previous month (RF1), rainfall lag 2 (RF 2), and rainfall lag 3 (RF 3). There was a significant difference between RF 0 and nettle caterpillar population that was amounted to 0.53. There was a significant difference between RF lag 1 and nettle caterpillar population that was amounted to 0.419. There was a regression equation % nettle caterpillar = - 2.23 + 0.0345 RF0 + 0.0172 RF1, with the value of R2 is 0.317. Rainfall data in the last four years indicated that the period of rainy season occurred between October to May, which was followed by the rising nettle caterpillar population. Nettle caterpillar population reached its peak in March. There were some analysis that indicated that high rainfall was not followed by the increasing caterpillar population; due to some limited factors, such as biological control measures, the presence of beneficial weed, and an abundance of predator. The results of this study showed that there was a correlation between the increase of nettle caterpillar population and the increasing rainfall in RF 0 and RF lag 1.

Camus-Kulandaivelu L., M. Maxime, J. S. Tan, K. Christophe, T. Durant-Gasselin, S. S. R. S. Alwee, and B. Frederic. 2014. Identification of laccase genes in *Ganoderma boninense* draft genome assembly. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20425

Notes: S 8.1.1 #20425e < #20347

Abstract: *Ganoderma boninense*, a soil born fungus, is the main agent of basal stem rot, one of the most devastating diseases of oil palm (*Eleais guinensis*). Observation of oil palm infection by *G. boninense* in natural conditions has shown the fungus capacity to quickly degrade the stem base, leading to important cracks and finally to tree fall. This important degradation of host tissue likely implies lignolytic enzymes, in particular laccase activity. Those enzymes have been well described in several rot disease involving fungus and their role in the pathogenicity of some fungus like the honey mushroom (*Armillaria mellea*) is well established. In this context, the study of *G. boninense* wood degradation genes, and in particular of laccase genes, seems to be of key interest to a better understanding of basal stem rot disease. We produced and assembled a draft sequence genome of an Indonesian *G. boninense* isolate using 454 and Illumina technology. This draft genome assembly was annotated ab initio with Augustus software that predicts genes models from genomic sequence. We obtained 22228 gene models, among which 34 showed similarity with laccase. Among these 34 gene models, 25 exhibited the 4 laccase signature sequence domains. The analysis of their subcellular addressing, their peptide signal and their comparison to other fungal laccases brings new insight into their potential role in *G. boninense* aggressiveness against oil palm.

Prasetyo A. E. and A. Susanto. 2014. Life period of palm infected by *Ganoderma* . Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20426

Notes: S 8.1.1 #20426e < #20347

Abstract: Nowadays, the disease symptoms caused by *Ganoderma boninense* was non-diagnostic especially in the second planting generation or more. Sometime the palm had collapsed despite didn't show any symptoms of *Ganoderma* disease. *Ganoderma* disease symptoms characterized by yellowing of the leaves then chlorosis, weak and broke of the old midrib, unopened of spear leaf more than two, and the appearance of the fruiting bodies of *Ganoderma* as a disease sign. Observations were carried out in Gunung Bayu estate 10 years old of palm and belonged to third generation of oil palm. The observation area has a disease

incidence of 41.19 %. Criteria Ganoderma disease symptoms observed included: not visually symptomatic, mild symptoms and severe symptoms. Observations during one year showed that the palms with severe symptoms have been collapsed until 52.17% followed by mild symptoms and not symptomatic were 10.87% and 2.17%, respectively. Palms with severe symptoms would not be able to survive for 2 years. The mean number of fresh fruit bunches in palms which have severe symptoms was only 2.25 bunches/palm while palm that have mild symptomatic and not symptomatic have higher productivity, were 3.37 bunches/palm and 3.89 bunches/palm, respectively. The productivity of fresh fruit bunches of palms which have symptomatic severe disease would be decrease almost half of the normal for one year.

Susanto A. and A. E. Prasetyo. 2014. High production of young oil palm through optimizing oil palm pollinating weevil (*Elaeidobius kamerunicus*). Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20427

Notes: S 8.1.1 #20427e < #20347

Abstract: Young oil palm plants have a rudimentary physiological process, which often results in imperfect fruit in terms of the size and weight as the factories determine. To achieve high productivity of the oil palm at the age between 4-6 years, some agronomic measures shall be taken such as consolidating and inserting oil palm seedlings, planting legume cover crop (*Mucuna bracteata*), management of weed, fertilizing, sanitazion & castration, and controlling pests and diseases. Meanwhile non-agronomic measures for achieving target of high productivity are preparing tools for harvest and making road and drainage ditches to prevent inundated oil palms. Another possible measure for high productivity is optimizing the role of pollinating weevil during the castration process by retaining the male flowers and applying hatch and carry technique of *Elaeidobius kamerunicus*.

Simanjuntak D. and A. Susanto. 2014. The effectiveness comparison between fogging method and laboratory scale method as a way to multiply the Nucleo Polyhedral Virus-Setothosea Asigna. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20428

Notes: S 8.1.1 #20428e < #20347

Abstract: Setothosea asigna is one of the major pests in oil palm plantations. One of the potential natural enemies to control S. asigna is nucleopolyhedral viruses (NPV). Over the years, the propagation of NPV were done by spraying on field, such as fogging. Therefore, this research aims to determine the effectiveness of NPV propagation by using fogging method compared to laboratory method such as dropping NPV into the mouth of S. asigna larvae. The results showed that at 14 days after application (DAA), mortality of S. asigna on the dropping method has reached 100%, despite the fact that at 5 DAA S. asigna larvae on the dropping method had shown typical symptoms like milky disease with mortality value 66%. Meanwhile on the fogging method, mortality of S. asigna occurred since 6 DAA i.e. 63.06% . 88.73%, it continues until 14 DAA with mortality value 89.19% . 100%. These results indicate that the dropping NPV into the mouth of S. asigna larvae can be used as an NPV propagation alternative, more better than fogging method.

Mohd Nasir A. R., I. Ariffin, and R. Ishak. 2014. The effectiveness of metsulfuron methyl in controlling *Mucuna bracteata* encroachment in young palm circle. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20429

Notes: S 8.1.1 #20429e < #20347

Abstract: The present study was carried out to identify several herbicides / mixtures in controlling the spread of *Mucuna bracteata* to the weeded circle in young oil palm plantation area. Two experiments have been conducted in the place where the leguminous cover crop was established successfully. Result in Experiment 1 showed that the glufosinate ammonium (T1) and sodium chlorate (T5) gave faster control (93% and 80% respectively) at 7 days after spray as compared to metsulfuron methyl + glyphosate (T3), metsulfuron methyl + surfactant (T2) and metsulfuron methyl (T4) (55%, 25% and 10% respectively). But, at 21 days after spray, T1, T2 and T3 already gave 100% weed control whereas T4 and T5 (80%). It was maintained at significantly higher for T3 which still gave 90% control of the weeds in palm circle at 49 days after spray. This was followed by metsulfuron methyl (60%), glufosinate ammonium (55%) and sodium chlorate (50%). For the Experiment 2, it was indicated that, relatively, the metsulfuron methyl + glufosinate ammonium (T2) and metsulfuron methyl + glyphosate (T4) gave 100% weed control as compared to glufosinate ammonium (T1) and glyphosate (T3) at 21 days after spray. Both of them also showed the same trend which gave higher weed control at 49 days after spray (58% and 63% respectively). It is different as compared to the use of glufosinate ammonium or glyphosate solely which showed weed regeneration and *M. bracteata* encroachment almost 100% in palm circle at 49 days after spray. Therefore, by using metsulfuron methyl as a mixture is able to extend the control of *M. bracteata* as well as controlling other type of weeds in palm circle.

Susanto A., A. E. Prasetyo, and S. Wening. 2014. Physical and chemical properties of soil with the *Ganoderma*-infected oil palms in Indonesia. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20430

Notes: S 8.1.1 #20430e < #20347

Abstract: *Ganoderma boninense* fungus is the soilborne pathogens, the most destructive pathogens in oil palm plantations. The disease has been widely spread and is found in almost all oil palm plantations in Indonesia. This study aimed to determine the physical and chemical properties of soil where oil palm or other plants with *Ganoderma* infection grow for the possible control techniques of this disease. The soil sampling was taken to best represent the whole islands in the Indonesia with oil palm plantations. The soil collection resulted in 26 soil samples. From the samples, the physical and chemical properties of the soil including soil texture, pH, C/N ratio, the availability of P and K element were then analyzed. The analysis shows that *Ganoderma* can survive in a silty clay loam, clay loam, sandy loam, clay, loam, sandy clay loam, and sandy clay soil texture with a pH range of 3.7 to 7.7. In terms of the C/N ratio parameter, *Ganoderma* is most found in moderate value (8-12) and on the ground with slightly high availability of P element. *Ganoderma* also manages to grow on the plants growing in soil with low, rather low, moderate and slightly high value and the one with high availability of the K element.

Suzanti F., R. Widhyastuti, S. Rahayu, W. O. Purba, and A. Susanto. 2014. Structure and composition of vascular epiphyte in North Sumatra oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20431

Notes: S 8.1.1 #20431e < #20347

Abstract: As an important component of the ecosystem of oil palm plantation, vascular epiphyte shows only small participation on research. Until this time, no specific recommendation given by any institution regarding the function or even action needed to manage the epiphyte. This research concerns about the structure and the composition of vascular epiphyte in one of oil palm plantation in North Sumatera which will be the approach for vascular epiphyte management. Research was conducted during October to December 2012 in Bukit Sentang plantation of IOPRI (Indonesian Oil Palm Research Institute) by first dividing oil palm population into three group, based on year of planting; 1-5 years old, 6-15 years, and more than 15 years. Purposive sampling with 20x10m sized plot assistant was method chosen; and five plot were set up for each group. The result shows 21 species and 16 family of vascular epiphyte observed in Bukit Sentang Plantation. The highest Important Value (IV) index from three groups shown by *Nephrolepis biserrata*; 80.95 (1-5 years old), 78.66 (6-15 years) and 84.73 (>15 years old). Similarity index for those three groups is 62% to 69% or classified as similar criteria.

Priwiratama H., Hartanta, H. Syafii, and A. Susanto. 2014. Inter-island introduction of barn owl *Tyto alba* in Indonesia: Method, adaptability and initial impact to rat damage in oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20432

Notes: S 8.1.1 #20432e < #20347

Abstract: High infestation of rats has usually been found in the new expansion area of oil palm plantation particularly in Kalimantan. Thus, demand for introducing barn owl *Tyto alba* from Sumatera to control rats was increased in the past few years. To increase the rate of success in introducing the barn owl to the plantation, research on the importation processes and adaptation ability with further observation on rats attack is needed. Introduction of the barn owl was conducted from North Sumatra to East Kalimantan continuously since January 2012. The barn owl, 1-3 years old, was delivered in a delivery box with the dimension of 75x40x40 cm³ and 75x75x50 cm³. Barn owl *T. alba* has successfully been introduced to the plantation in East Kalimantan with the mortality of 7.14 - 33.33%. Higher mortality during delivery processes was observed in smaller delivery box. Barn owl was established in the new habitat with the occupancy rate of 14.29 - 16.68%. Initial declining of rats attack was observed 1 year after introduction process.

Permana B., B. Sahari, V. B. Tambunan, S. Harjotedjo, and R. E. Purba. 2014. Pollen grains estimation of *Elaeis guineensis* carried by *Elaeisobius kamerunicus* (Coleoptera: Curculionidae) using image analysis. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20433

Notes: S 8.1.1 #20433e < #20347

Abstract: *Elaeidobius kamerunicus* is the most important oil palm pollinator in Indonesia and Malaysia. How to measure pollen transfer from male to female inflorescences by this weevil is not clearly understood. Pollen delivery and pollen loss ratio also not well studied yet. The aim of this study is to provide basic information on the role of *E. kamerunicus* in transferring pollen from male to female

inflorescences. This study is also expected to enrich previous findings related to image processing and analysis software for pollen counting method. Male and female *E.kamerunicus* were captured from male and female flowers of the palm (N=60). Pollens attached on the weevil's body were separated using a "pump and suck" method with 100-300 KOH 10%. Pollen solution was dropped and distributed in a flat glass slide. Each chamber was captured as a JPEG format for pollen counting with ImageJ. Multiple macro was constructed to produce consistent, efficient, faster and similar count with manual counting. Image analysis was compared with manual counting and analyzed with Paired T-test, Pearson's correlation and linear regression. Result showed that ImageJ was found to be powerfull tool for the analysis of 925 images (Pearson's $r = 0.97 < 0.001$) and insignificant different in paired t-test for each group was identified. Based on the analysis of 3900 pollen images, male weevil was found to carry 4972 (± 211) from male inflorescences and 672 (± 48) from female inflorescences. In contrast, female only carried 2527 (± 123) and 320 (± 28) from male and female inflorescences, respectively. Pollen lost by *E.kamerunicus* was greater than pollen delivery (male and female weevil 86,5%>13,5% and 87, 4%>12,6%, respectively).

Purba W. O., H. Priwiratama, and A. Susanto. 2014. Application of peat water in herbicide formulation to control weed in oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20434

Notes: S 8.1.1 #20434e < #20347

Abstract: Water is a universal solvent and used commonly as primary carrier which constituting more than 95% of the herbicide spray volume. Water of peat land have different character with pure water thus estimated as one factor that affect the activity of herbicide in controlling weed in peat land. This research using two herbicide combination; glyphosate combined with metsulfuron methyl and glyphosat combined with ammonium glyphosinate to control weed in mature palm of oil palm plantation in Manduamas, Tapanuli Tengah. Each mixing herbicide were applied using pure water and peat water as solvent based on recommendation doses. Vegetation analysis using square method showed three dominant species in the field; *Echinochloa colona*, *Ageratum conizoides*, and *Cyperus compressus*. Relative frequency in sequence are 17.67%, 12.45%, 20.10% with each relative density about 23.02%, 22.71%, and 18.74%. Weed suppression level two weeks after the application, on both mixing herbicide with different water, showed no significance different. Suppression on broadleaved showed high level (around 80-90%) on both types of water while only around 40-50% supression on grasses weed.

Susanto A. and A. E. Prasetyo. 2014. Response of *Curvularia lunata* disease on different fungicides. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20435

Notes: S 8.1.1 #20435e < #20347

Abstract: Leaf spot of oil palm caused by *Curvularia* sp. is the major disease in nursery. Generally, preventive control measured of leaf spot disease was by implementation of correctly nursery. Normally by using application of fungicide if appear epidemic of leaf spot disease in the field. The objectives of this research were to determine causal agent of leaf spot disease of oil palm including the weeds on nursery and sourounding of nursery, screening of some fungicides, application methods of fungicide on nursery. The results showed that causal agent of leaf spot disease of oil palm was *Curvularia lunata*. The disease also found on grasses

(*Cyperus rotundus*) and *Imperata cylindrica*. Application of fungicide by rotation between difeconazol and copper oxide with frequency every 10 days could suppress the development of leaf spot disease of oil palm in the nursery.

Sahari B., D. Buchori, S. Manuwoto, A. Nurmansyah, R. A. Prabowo, S. Harjotedjo, and B. Palgoenadi. 2014. Response of hymenopteran parasitoid community toward the planting of flowering plant, *Turnera subulata* in oil palm plantations. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20436

Notes: S 8.1.1 #20436e < #20347

Abstract: Flowering plants provide foods for adult parasitoids. Response of Hymenopteran parasitoid community in oil palm plantation toward widely planted *Turnera subulata* J.E.Smith (Parietales: Turneraceae) is still in question. The objectives of the research are to (1) study spatial dynamic pattern of flower-visiting Hymenopteran parasitoids of *Turnera subulata* (2) identify dominance and taxon benefited from *T. subulata*. Ecological sampling was conducted by surveying hymenopteran parasitoid visiting flowers of *T. Subulata* strips from six blocks (25-30 Ha) representing three different ages of oil palm plantations (< 3 years old, 6 years old and 18 years old). Insects were collected using sweep net for about 25 minutes in 1 m² square plots. In addition, yellow pan traps were also set up. Both sampling methods were applied everyday along 30 days. Approximately 5,235 individual and 146 morphospecies belonging to 9 superfamilies and 14 families were recorded. Assemblage of Hymenopteran parasitoids are still very incompletely surveyed. Results indicated that flowers of *T. subulata* did not support all species of Hymenopteran parasitoid. From all recorded species, less than 10 species were identified to consistently visit *T. subulata*. *Brachymeria lasus* Walker (Hymenoptera: Chalcididae) was the most abundant and consistent species visiting flowers of *T. subulata* by occupying 47.36% of total specimens. Flower-visiting Hymenopteran parasitoid community was strongly affected by age gradient of oil palm plantations. Species composition of flower-visiting Hymenopteran parasitoids changed between ages of oil palm plantations. Implication of these findings toward biological control program are discussed.

Rozziansha T. A. P., Hartanta, and A. Susanto. 2014. Possibility of peat water for insecticides application. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20437

Notes: S 8.1.1 #20437e < #20347

Abstract: Sometimes nettle caterpillar and bagworm have outbreak in oil palm plantation in peat land area. Generally, control measure of these pests was used by insecticide application. Meanwhile in some plantation in peat soil, availability of pure water is limited. The aim of this research is to try possibility of peat water for application insecticides. This research was conducted in Labuhan Bilik Estate, North Sumatera. Some formulation that used in this research was Emulsifiable concentrate (EC), Suspension concentrate (SC), Soluble (liquid) concentrate (SL), Soluble powder (SP), Water dispersible granules (WDG). The results showed that peat water possible to use for fogging and spraying application.

Kurniawan A., L. A. Prabowo, A. Ardiyanto, and K. H. Lim. 2014. A method to control wild bamboo in oil palm plantations. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20438

Notes: S 8.1.1 #20438e < #20347

Abstract: The practice of zero-burning for converting logged-over forests to oil palm plantings has given rise to several wild bamboo species (*Bambusa* sp.) becoming persistent weed problem in oil palm plantations. This is especially serious in first generation oil palm plantations developed from logged-over forests. Depending on the bamboo species, the height varies from 0.3 m to 30 m and the stem diameter from 0.25 - 25 cm. They can grow quickly over-shading the young oil palms. The bamboo roots are very aggressive, competing for palm nutrients. The roots of some bamboo species are said to secrete inhibiting substances that could suppress the growth of other plant species. Control is usually done by mechanical uprooting and burning, or manual slashing followed by spraying with Triclopyr-Paraquat mixtures. However the kill is inconsistent and regrowth is common. In compliance with RSPO requirement, since Paraquat is now not used in many oil palm plantations, an alternative control method has been investigated. A plot trial with 5 replicates testing 4 levels of glyphosate (480g/l Isopropylamine glyphosate) ie. 100 ml, 120 ml, 240 ml and 360 ml product/15 litres water) was carried out in a BGA oil palm plantation in West Kalimantan. The control procedure consists of 2 parts. Firstly the bamboo clumps were first manually slashed by parang to about 30-40 cm from ground level. New bamboo leaves were then allowed to develop for 2-3 weeks before spraying using conventional knapsack sprayer. The most effective glyphosate treatment in this trial for controlling wild bamboo is 360 ml product/15 litres water. Generally at this rate, one spraying is adequate. 7 days after spraying, discoloration of the younger leaves was seen. After 14 days most of the leaves and stems turned brownish and fully dried up 21 days after spraying.

Prasetyo A. E. and A. Susanto. 2014. First introduction of *Elaeidobius kamerunicus* faust in Seram Island. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20439

Notes: S 8.1.1 #20439e < #20347

Abstract: *Elaeidobius kamerunicus* Faust is the main oil palm pollinating weevil in Indonesia until now. The oil palm plantations in Indonesia were located in different islands therefore the spreads of *E. kamerunicus* couldn't reached all of the island, which Seram island was one of them. Mass introduction of *E. kamerunicus* had been done from North Sumatra to Seram island at september 2013. The introductions was performed on larval and pupal stadia in 4-5 days post anthesis of male inflorescences. The introduction using plywood boxes have an average risk of death by 7.89% at 6 days delivery period. Observation before releasing of the weevils showed that there was no this insect in both of oil palm male and female flowers and the oil palm value fruit set was very low. After release within 1 month, *E. kamerunicus* able to grow well up to a distance of 500 m from the release point.

Hidayat F., S. Rahutomo, W. E. Widayati, and E. S. Sutarta. 2014. Endophyte bacteria utilization in oil palm plantation. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20440

Notes: S 8.1.1 #20440e < #20347

Abstract: Since 19th century, the microbe had been used as bio-fertilizer, but there were inconsistent result compare with the use of inorganic fertilizer in enhancing plant production even though bio-fertilizer more friendly to the environment than the other. Few researchers have found endophyte microorganism. The term endophyte refers to internal colonization of plant by microorganisms without any pathogenic effects on their hosts and Diazotrophs are bacteria that fix atmospheric nitrogen gas into a more usable form such as ammonia. Residing in the plant tissue is one of the

properties of endophyte diazotrophic bacteria and once established in the plant tissue, the endophyte spread through the stem and leaf. Endophytic diazotroph association firstly found on sugarcane. Indonesian Oil Palm Research Institute (IOPRI) and Indonesian Sugar Research Institute (ISRI) are collaborate to develop endophyte bacteria as a bio-fertilizer in oil palm plantation through several research such as examination of endophytic capability on oil palm by using green fluorescence protein (gfp) marker gene and its effect on oil palm seedlings growth. Twenty endophytic diazotroph bacteria isolates ISRI collection were used to study interaction its capability with oil palm in laboratory. Detection the occurrence of endophytic diazotroph bacteria in oil palm tissue was visualized by fluorescence microscope. The results showed that only nine isolates of endophytic diazotroph bacteria are compatible with oil palm. Then, only several bacteria was selected for bio-fertilizer. The bio-fertilizer then evaluated in green house and main nursery of oil palm seedling. The results showed that the biofertilizer which is contains multispecies endophyte diazotroph bacteria was increase the oil palm seedlings growth and also decrease the use of nitrogen inorganic fertilizer up to 25%.

Ningrum D. A., S. Wening, and S. Hanum. 2014. Screening of AFLP primers for molecular variability test in wild type oil palm (*Elaeis guineensis* Jacq.) from Cameroon. Pusat Penelitian Kelapa Sawit, Indonesia.

Referece ID: 20441

Notes: #20441e

Abstract: AFLP is a selective amplification of a subset of restriction fragments from a complex mixture of DNA fragments obtained after digestion of genomis DNA with restriction endonuclease. The success of AFLP is influenced by some factors. One of the factors is primers used in the reaction. A major of this research was to screen primers which had clear and many polymorphic products for molecular variability test in wild type oil palm (*Elaeis guineensis* Jacq.) from Cameroon. Sixteen primers combination were used in the screening. Six primers combination (EcoRI-AGG/MseI-CAC, EcoRI-AGG/MseI-CAG, EcoRI-AGA/MseI CAC, EcoRI-ACA/MseI-CTT, EcoRI-ACA/MseI-CAG, EcoRI-AGA/MseI-CTT) which show clear and many polymorphic products were selected for subsequent analysis.

Prasetyo A. E., D. Sunindyo, P. R. Tolentino, and A. Susanto. 2014. Effect of *Bacillus thuringiensis* application on *Elaeidobius kamerunicus* faust. Pusat Penelitian Kelapa Sawit, Indonesia.

Reference ID: 20442

Notes: #20442e

Abstract: Application of various insecticides to control pests in oil palm plantations probably has negative impact on declining of oil palm pollinating insects, *Elaeidobius kamerunicus*. *Bacillus thuringiensis* as bionsecticide was often used some important pests of oil palm but have never tested their effects on *E. kamerunicus* in Indonesia. In vivo testing has been carried out with the concentration of *B. thuringiensis* (soluble concetrade product) suspension in fresh water SC were 20 ml/15 l, 30 ml/15 l, and 40 ml/15 l. The other treatments were deltamethrin 250 g/l and fipronil 50 g/l as chemical insecticides with a concentration is 30 ml/15 l and 37.5 ml/15 l respectively. Fresh water was also used as positive control. The results showed that the application *B. thuringiensis* at a concentration of 20 ml/15 l and 30 ml/15 l against *E. kamerunicus* weevils does not reduce *E. kamerunicus* population significantly. The concentration of *B. thuringiensis* up to 40 ml/15 l was also not kill the larvae of *E. kamerunicus* which will develop into weevils in the next cycle. In contrast, application

of deltamethrin and fipronil resulted in mortality of *E. kamerunicus* weevils reaches 100% in one day after application. *Bacillus thuringiensis* as bioinsecticide to control oil palm pests are safe for *E. kamerunicus*.

Margono, B. A., Potapov, P. V., Turubanova, S., Stolle, F., and Hansen, Matthew C. Primary forest cover loss in Indonesia over 2000-2012. *Nature Clim.Change* , 1-6. 6-29-2014. Macmillan Publishers Limited.

Reference ID: 20443

Notes: #20443e

Abstract: Extensive clearing of Indonesian primary forests results in increased greenhouse gas emissions and biodiversity loss. However, there is no consensus on the areal extent and temporal trends of primary forest clearing in Indonesia. Here we report a spatially and temporally explicit quantification of Indonesian primary forest loss, which totalled over 6.02 Mha from 2000 to 2012 and increased on average by 47,600 ha per year. By 2012, annual primary forest loss in Indonesiawas estimated to be higher than in Brazil (0.84 Mha and 0.46 Mha, respectively). Proportional loss of primary forests in wetland landforms increased and almost all clearing of primary forests occurred within degraded types, meaning logging preceded conversion processes. Loss within ocial forest land uses that restrict or prohibit clearing totalled 40% of all loss within national forest land. The increasing loss of Indonesian primary forests has significant implications for climate change mitigation and biodiversity conservation eorts.

Schumpeter. Digital disruption on the farm. *The Economist* , 1-3. 5-24-2014.

Reference ID: 20444

Notes: #20444e

Abstract: Managers in the most traditional of industries distrust a promising new technology.

Schroth G., A. Jeusset, A. da Silva Gomes, C. T. Florence, N. A. P. Coelho, D. Faria, and P. Laderach. 2014. Climate friendliness of cocoa agroforests is compatible with productivity increase. *Mitig Adapt Strateg Glob Change*.

Reference ID: 20445

Notes: #20445e

Abstract: There is increasing demand for agricultural commodities that are produced in a climate-friendly manner. At the same time, in many or most tropical countries there is need for intensification of agricultural production to increase yields and incomes, and this usually requires higher external inputs that may cause additional greenhouse gas emissions. Here we investigate if production methods that have a beneficial effect on the climate (are climatefriendly) are compatible with increased inputs and yields for traditional, shaded cocoa (*Theobroma cacao*) production systems (locally known as cabrukas) in southern Bahia, Brazil. We use two easily measurable and manageable dimensions of climate friendliness, namely the carbon (C) stocks in the large trees and the C footprint as related to on-farm agrochemical and fuel use. Through interviews and field inventories in 26 cabruca farms representing a range of production practices and intensities, we identify the combinations of management practices, yields, C stocks and C footprints typically found in the region. We find that yield levels up to the highest encountered yield of 585 kg haociated with yields below the regional average. Input-related C emissions increased non-linearly with increasing yield, but eveninput-related emission levels. Cocoa yields responded positively to increased fertilizer applications, provided that

other factors related to large fertilizer applications that did not proportionately increase yields. We conclude that doubling the cocoa output from southern Bahia, where cabruças are the predominant form of growing cocoa, is compatible with climate-friendly production practices, measured by local standards. We suggest that the presented methodology can be used to identify opportunities for climate-friendly intensification of tree crops more generally, thereby increasing the contribution of commodity production to global climate change mitigation.

Sarpong K. O., O. F. Alexander, and E. K. Anin. 2013. An Assessment of Supply Chain Risks in the Cocoa Industry in the Ashanti Region, Ghana. *International Journal of Humanities and Social Science*, 3:191-201.

Reference ID: 20446

Notes: #20446e

Abstract: The cocoa industry represents a major source of income for most economies including Ghana. Despite huge investments made by Ghana government, the sector still faces various forms of risks. This study examines the various categories of risks within the cocoa supply chain in the Ashanti Region of Ghana. Quantitative method was adopted using Primary data. The study revealed that cocoa related diseases were the major production related risks. Again, high inflation rate and instability of the local currency were found as the key causal factors of commercial related risks whilst ineffective information sharing among the parties and partners accounted for the environmental related risks, negatively affecting productivity. It is recommended that farmers be given training on cocoa related disease to be able to deal with these risks whilst information sharing and trust building among the supply chain players should also be improved to enhance coordination and integration of the supply chain.

Meersman E., J. Steensels, M. Mathawan, P.-J. Wittocx, V. Saels, N. Struyf, H. Bernaert, G. Vrancken, and K. J. Verstrepen. 2013. Detailed Analysis of the Microbial Population in Malaysian Spontaneous Cocoa Pulp Fermentations Reveals a Core and Variable Microbiota. *Plos One*, 8:1-10.

Reference ID: 20447

Notes: #20447e

Abstract: The fermentation of cocoa pulp is one of the few remaining large-scale spontaneous microbial processes in today's food industry. The microbiota involved in cocoa pulp fermentations is complex and variable, which leads to inconsistent production efficiency and cocoa quality. Despite intensive research in the field, a detailed and comprehensive analysis of the microbiota is still lacking, especially for the expanding Asian production region. Here, we report a large-scale, comprehensive analysis of four spontaneous Malaysian cocoa pulp fermentations across two time points in the harvest season and two fermentation methods. Our results show that the cocoa microbiota consists of a "core" and a "variable" part. The bacterial populations show a remarkable consistency, with only two dominant species, *Lactobacillus fermentum* and *Acetobacter pasteurianus*. The fungal diversity is much larger, with four dominant species occurring in all fermentations ("core" yeasts), and a large number of yeasts that only occur in lower numbers and specific fermentations ("variable" yeasts). Despite this diversity, a clear pattern emerges, with early dominance of apiculate yeasts and late dominance of *Saccharomyces cerevisiae*. Our results provide new insights into the microbial diversity in Malaysian cocoa pulp fermentations and pave the way for the selection of starter cultures to increase efficiency and consistency.

Anonymous. Fertilizers boost fruit crop quality and yields. Fertilizer International 460, 34-37. 2014.

Reference ID: 20448

Notes: H 21 #20448e

Anonymous. Potash trade outlook: after the battle. Fertilizer International 460, 52-53. 2014.

Reference ID: 20449

Notes: H 20 #20449e

Anonymous. Advances in potash mining techniques. Fertilizer International 460, 54-57. 2014.

Reference ID: 20450

Notes: H 22 #20450e

Van Rikxoort H., G. Schroth, P. Laderach, and B. Rodriguez-Sanchez. 2014. Carbon footprints and carbon stocks reveal climate-friendly coffee production. AGRON SUSTAIN.DEV.

Reference ID: 20451

Notes: #20451e

Abstract: Coffee production is impacting the climate by emitting greenhouse gasses. Coffee production is also vulnerable to climate change. As a consequence, the coffee sector is interested in climate-friendly forms of coffee production, but there is no consensus of what exactly this implies. Therefore, we studied two aspects of the climate impact of coffee production: the standing carbon stocks in the production systems and the product carbon footprint, which measures the greenhouse gas emissions per unit weight of coffee produced. We collected data from 116 coffee farms in five Latin American countries, Mexico, Guatemala, Nicaragua, El Salvador, and Colombia, for four coffee production systems: (1) traditional polycultures, (2) commercial polycultures, (3) shaded monocultures, and (4) unshaded monocultures. We found that polycultures have a lower mean carbon footprint, of 6.2-7.3 kg CO₂-equivalent kg⁻¹ of parchment coffee, than monocultures, of 9.0-10.8 kg. We also found that traditional polycultures have much higher carbon stocks in the vegetation, of 42.5 Mg per ha, than unshaded monocultures, of 10.5 Mg. We designed a graphic system to classify production systems according to their climate friendliness. We identified several strategies to increase positive and reduce negative climate impacts of coffee production. Strategies include diversification of coffee farms with trees, the use of their wood to substitute for fossil fuel and energy-intensive building materials, the targeted use of fertilizer, and the use of dry or ecological processing methods for coffee instead of the traditional fully washed process.

Schroth G., L. C. Bede, A. O. Paiva, C. R. Cassano, A. M. Amorim, D. Faria, E. Marianto-Neto, A. M. Z. Martini, R. H. R. Sambuichi, and R. N. Lobo. 2013. Contribution of agroforests to landscape carbon storage. Mitig Adapt Strateg Glob Change.

Reference ID: 20452

Notes: #20452e

Abstract: While many studies have measured the carbon (C) stocks of traditional agroforests at the plot level, their contribution to overall landscape C storage has rarely been quantified. Here we demonstrate the significant contribution that traditional agroforests with shaded tree crops can make to landscape C storage, and

thus climate change mitigation, focusing on the cocoa (*Theobroma cacao*) agroforests (locally known as cabruças) of southern Bahia, Brazil. Using published allometric relationships and tree inventories of 55 shaded cocoa farms, 6 mature forests, 8 disturbed forests and 7 fallows, we calculate average aboveground C stocks of 87 and 46 Mg ha⁻¹ in traditional and intensified cocoa agroforests, respectively, 183 Mg ha⁻¹ in old-growth forests, 102 Mg ha⁻¹ in disturbed forests and 33 Mg ha⁻¹ in fallows. Based on the most recent land cover data available, we estimate that cocoa agroforests hold 59 % of the total aboveground C stocks of the tree dominated vegetation in this landscape, while forests hold 32 % and fallows hold 9 %. Carbon stocks of intensified cocoa agroforestry systems were only little over one-half of those of traditional agroforests, indicating a threat to landscape C stocks from current land use trends. We show that in agroforests as in natural forests, C stocks are highly concentrated in the largest trees. This suggests that the intensification of traditional agroforests, which generally involves increasing the density of cocoa and other tree crops and reducing the density of shade trees, is possible without greatly affecting their C storage if large trees are conserved. In order to conserve the climate stabilizing effect of traditional agroforests and steer necessary intensification measures towards climatefriendly solutions, we suggest that biodiversity and C-rich traditional agroforests should be included in current discussions about Reducing Emissions from Deforestation and Forest Degradation (REDD+) and/or their owners be rewarded for their environmental services through other incentive mechanisms.

Cassano C. R., G. Schroth, D. Faria, J. H. C. Delabie, and L. Bede. 2009. Landscape and farm scale management to enhance biodiversity conservation in the cocoa producing region of southern Bahia, Brazil. *Biodivers Conserv*, 18:577-603.

Reference ID: 20453

Notes: #20453e

Abstract: In southern Bahia, Brazil, large land areas are used for the production of cocoa (*Theobroma cacao*), which is predominantly grown under the shade of native trees in an agroforestry system locally known as cabruca. As a dominant forest-like landscape element of the cocoa region, the cabruças play an important role in the conservation of the region's biodiversity. The purpose of this review is to provide the scientific basis for an action plan to reconcile cocoa production and biodiversity conservation in southern Bahia. The available research collectively highlights the diversity of responses of different species and biological groups to both the habitat quality of the cabruças themselves and to the general characteristics of the landscape, such as the relative extent and spatial configuration of different vegetation types within the landscape mosaic. We identify factors that influence directly or indirectly the occurrence of native species in the cabruças and the wider landscape of the cocoa region and develop recommendations for their conservation management. We show that the current scientific knowledge already provides a good basis for a biodiversity friendly management of the cocoa region of southern Bahia, although more work is needed to refine some management recommendations, especially on shade canopy composition and density, and verify their economic viability. The implementation of our recommendations should be accompanied by appropriate biological and socioeconomic monitoring and the findings should inform a broad program of adaptive management of the cabruças and the wider cocoa landscape.

Hillier J., C. Walter, D. Malin, T. Garcia-Suarez, L. Mila-i-Canals, and P. Smith. 2011. A farm-focused calculator for emissions from crop and livestock production. *Environmental Modelling & Software*, 26:1070-1078.

Reference ID: 20454

Notes: #20454e

Abstract: Agriculture and deforestation contribute approximately one third of global greenhouse gas emissions. Major sources of emissions in this sector are from loss of soil carbon due to repeated soil disturbance under typical crop cultivation, fossil fuel use in the production of synthetic fertilisers, direct and indirect soil nitrous oxide emissions from fertiliser application, pesticide manufacture and use, and fossil fuel combustion in machinery use (e.g. tractors, irrigation, etc). Although knowledge of emissions sources aids in the determination of potential mitigation strategies (reduced or no-till methods, use of N-fixing leguminous crops in rotations, use of lower emissions fertilisers), there currently exist limited decision support and knowledge transfer tools to enable the farmer or grower to make choices appropriate to existing management practices. In this article we present a model, and open source software tool called the "Cool Farm Tool" integrating several globally determined empirical models in a greenhouse gas calculator. The software, in requiring inputs of which a farmer typically has good knowledge (and no more), has a specific farm-scale, decision-support focus. Due to its use of only readily available farm data, there is considerable scope for its use in global surveys to inform on current practices and potential for mitigation.

International Coffee Organization. World coffee trade (1963-2013): A review of the markets, challenges and opportunities facing the sector. 1-25. 2-24-2014.

Reference ID: 20455

Notes: #20455e

Chepote, R. E., Sodre, G. A., Reis, E. L., Pacheco, R. G., Marrocos, P. C. L., Serodio, M. H. de. C. F., and Valle, R. R. RECOMENDAÇÕES DE CORRETIVOS E FERTILIZANTES NA CULTURA DO CACAUEIRO NO SUL DA BAHIA - 2ª APROXIMAÇÃO. 1-36. 2005. MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO.

Reference ID: 20456

Notes: #20456e

Somarriba E., R. Cerda, L. Orozco, M. Cifuentes, H. Davila, T. Espin, H. Mavisoy, A. Guadalupe, E. Alvarado, V. Poveda, C. Astorga, E. Say, and O. Deheuvels. 2013. Carbon stocks and cocoa yields in agroforestry systems of Central America. *Agriculture, Ecosystems & Environment*, 173:46-57.

Reference ID: 20457

Notes: #20457e

Abstract: The cocoa tree (*Theobroma cacao* L.) is cultivated typically in agroforestry systems in close association with a rich list of tree species and other useful plants on the same plot. Cocoa based agroforestry systems are credited for stocking significant amounts of carbon and hence have the potential to mitigate climate change. Since cocoa yields decrease non-linearly with increasing shade, a need is to design optimal cocoa agroforestry systems with high yields and high carbon stocks. We estimated the carbon stocked in a network of 229 permanent sample plots in cacao-based agroforestry systems and natural forests in five Central American countries. Carbon stocks were fractioned by both system compartments

(aboveground, roots, soil, litter, dead wood - fine and coarse, and total) and tree use/form (cocoa, timber, fruit, bananas, shade and ornamentals, and palms). Cocoa plantations were assigned to a five-class typology and tested for independence with growing region using contingency analysis. Most Central American cocoa plantations had mixed or productive shade canopies. Only 4% of cocoa plantations were full sun or rustic (cocoa under thinned natural forest). Cocoa tree density was low (548 ± 192 trees ha⁻¹). Total carbon (soil + biomass + dead biomass) was 117 ± 47 Mg ha⁻¹, with 51 Mg ha⁻¹ in the soil and 49 Mg ha⁻¹ (42% of total carbon) in aboveground biomass (cocoa and canopy trees). Cocoa trees accumulated 9 Mg C ha⁻¹ (18% of carbon in aboveground biomass). Timber and fruit trees stored 65% of aboveground carbon. The annual rate of accumulation of carbon in aboveground biomass ranged between 1.3 and 2.6 Mg C ha⁻¹ y⁻¹. Trade-offs between carbon levels and yields were explored qualitatively using functional relationships documented in the scientific and technical literature, and expert knowledge. We argue that it is possible to design cocoa-based AFS with good yields (cocoa and shade canopy) and high carbon stock levels. The botanical composition of the shade canopy provides a large set of morphological and functional traits that can be used to optimize shade canopy design. Our results offer Central American cocoa producers a rigorous estimate of carbon stocks in their cocoa plantations. This knowledge may help them to certify and sell their cocoa, timber, fruits and other goods to niche markets with good prices. Our results will also assist governments and the private sector in (i) designing better legal, institutional and policy frameworks, local and national, promoting an agriculture with trees and (ii) contributing to the development of the national monitoring, reporting and verification systems required by the international community to access funding and payment for ecosystem services.

Waldron A., R. Justicia, L. Smith, and M. Sanchez. 2012. Conservation through Chocolate: a win-win for biodiversity and farmers in Ecuador's lowland tropics. *Conservation Letters*, 5:213-221.

Reference ID: 20458

Notes: #20458e

Abstract: Global biodiversity conservation significantly depends on bringing conservation measures to the agricultural production systems that dominate the earth's surface. One of the leading candidates for wildlife-friendly farming in the megadiverse lowland tropics is shade-grown cocoa. However, tropical farmers increasingly believe that shade reduces yield and consequently, are removing most shade trees from their farms. Conservation goals therefore conflict with production imperatives. Nevertheless, we tested the trade-off between production and biodiversity conservation in the critical conservation area of the Ecuadorean Chocó and found that both farmers and biodiversity would benefit from an increase in shade. This rare partial win-win situation in wildlife-friendly farming permits the creation of a sustainable, economically sensitive certification and geographic indication for biodiversity-friendly chocolate. We suggest that similar trade-off studies be carried out in other agroforestry regions of conservation importance, not least to establish the probable sustainability of conservation initiatives in production-centered landscapes.

JSSSPN. *Soil Science & Plant Nutrition* Vol.60, No.2 April 2014. Japanese Society of Soil Science and Plant Nutrition 60[2], 123-301. 2014.

Reference ID: 20459

Notes: S 1.3 #20459

Abstract: Content **Soil physics** Evaluation of models for description of wet aggregate size distribution from soils of different land uses Mohammad Taghi Tirkarsoltani, Manoochehr Gorji, Mohammad Hossein Mohammadi & Humberto Millan pages 123-133 **Soil chemistry and soil mineralogy** Rhizosphere soil enzymatic and microbial activities in bamboo forests in southeastern China Zhihua Tu, Lihua Chen, Xinxiao Yu & Yushan Zheng pages 134-144 **Plant nutrition** How does grafting affect the ionome of cherry tomato plants under water stress? E. Sánchez-Rodríguez, R. Leyva, C. Constan-Aguilar, L. Romero & J.M. Ruiz pages 145-155 Source-sink manipulation of *Camelina sativa* L. related to grain yield under stressful environment of Hokkaido, Japan Kounosuke Fujita, Shohei Fujita, Takayuki Fujita, Satoshi Konishi, Johann Vollmann, Pravat Kumar Mohapatra, Masashi Hosokawa, Masato Kuwahara, Hirofumi Saneoka & Toshiaki Tadano pages 156-161 **Soil fertility** Nitrogen budget in a soil-plant system after brachiaria grass desiccation Gustavo Castoldi, Laércio Augusto Pivetta & Ciro Antonio Rosolem pages 162-172 Short-term effects of fire intensity on soil organic matter and nutrient release after slash-and-burn in Eastern Province, Zambia Kaori Ando, Hitoshi Shinjo, Yoko Noro, Shotaro Takenaka, Reiichi Miura, Sesele B. Sokotela & Shinya Funakawa pages 173-182 White clover living mulch controlled only by mowing supplies nitrogen to corn Shin Deguchi, Sunao Uozumi, Eiko Touno, Makoto Kaneko & Keitaro Tawaraya pages 183-187 Evaluation of nitrogen status of agricultural soils in Java, Indonesia Junta Yanai, Taichi Omoto, Atsushi Nakao, Kana Koyama, Arief Hartono & Syaiful Anwar pages 188-195 **Fertilizers and soil amendments** Measurement of the maximum amount of water-extractable phosphorus in animal manure compost by continuous and sequential water extraction Teppei Komiyama, Toyooki Ito & Masahiko Saigusa pages 196-207 **Environment** Canada bluejoint foliar $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ indicate changed soil N availability by litter removal and N fertilization in a 13-year-old boreal plantation Miwa Y. Matsushima, Woo-Jung Choi & Scott X. Chang pages 208-215 Effect of plant-mediated oxygen supply and drainage on greenhouse gas emission from a tropical peatland in Central Kalimantan, Indonesia F. F. Adji, Y. Hamada, U. Darang, S.H. Limin & R. Hatano pages 216-230 Comparison of soil respiration among three different subalpine ecosystems on eastern Tibetan Plateau, China Youchao Chen, Ji Luo, Wei Li, Dong Yu & Jia She pages 231-241 Flood effect on CH_4 emission from the alas in Central Yakutia, East Siberia Alexey Romanovich Desyatkin, Fumiaki Takakai & Ryusuke Hatano pages 242-253 Combined effects of nitrogen deposition and biochar application on emissions of N_2O , CO_2 and NH_3 from agricultural and forest soils Liying Sun, Lu Li, Zhaozhi Chen, Jinyang Wang & Zhengqin Xiong pages 254-265 Phytoextraction by high-Cd-accumulating rice to reduce Cd in wheat grains grown in Cd-polluted fields Toshiyuki Ibaraki, Shin-ichi Fujitomi, Akiko Ishitsuka & Mikiko Yanaka pages 266-275 Effects of application of lime nitrogen and dicyandiamide on nitrous oxide emissions from green tea fields Yuhei Hirono & Kunihiko Nonaka pages 276-285 Optimizing water, nitrogen and crop density in canola cultivation using response surface methodology and central composite design Alireza Koocheki, Mehdi Nassiri Mahallati, Rooholla Moradi & Hamed Mansoori pages 286-298 **Abstracts** Abstracts of Nippon Dojo-Hiryogaku Zasshi pages 299-301

Morais, F. I. O. and Rosand, F. P. C. Effect of the calcium, magnesium and potassium balance on cacao growth. *Revista Theobroma* 1[3], 21-32. 1971.

Reference ID: 20460

Notes: #20460e

Abstract: Cacao seedlings grown under greenhouse conditions on a low fertility soil (oxysol) were submitted to several levels of Mg (0.43, 0.89, 1.38, 1.87 and 3.98 mEq/100 g of soil) and Ca (1.99, 2.49, 2.99, 3.98, 4.58 and 5.48 mEq/100 g of soil) in order to determine the effect of Mg/K and Ca+Mg/K ratios on plant growth. One control, without fertilizers, in each assay was also included. All the plants received an uniform dosage of nitrogen, phosphorus, potassium and micronutrients. Increasing values of Mg/K and Ca+Mg/K ratios due to changes in basis content of the soil were obtained 15 days after fertilizers application. However, decreasing values in the levels of phosphorus, basis content and potassium were shown at the end of the experiment. The results obtained showed significant responses to high dose of magnesium. However, the Mg/K ratio did not influence cacao growth. Data from dry mater measurements indicated a Ca+Mg/K ratio 16.5 to 24.5 to be the most suitable one for the growth of cacao under the conditions at this experiment. Since the relationships between production and Ca+Mg/K ratio could be represented by a straight line, it is suggested that the values obtained might theoretically be increased.

Morais, F. I. O., Prado, E. P., Cabala, P. R. F., and Santana, M. B. M. Effect of the ratio Ca/Mg of limestone on the growth of cocoa seedlings. *Revista Theobroma* 5[1], 21-30. 1975.

Reference ID: 20461

Notes: #20461e

Abstract: To determine the best Ca/Mg ratio of "limestone" for the growth of cacao, several young plants were grown under greenhouse conditions, on low fertility soil which had been previously mixed with different kinds of "lime ". A randomized design with six replications and 12 treatments was used. These treatments were: a) Control (without lime); b) 100% CO₃Ca; c) 90% CO₃Ca + 10% CO₃Mg; d) 80% CO₃Ca + 20% CO₃Mg; e) 70% CO₃Ca + 30% CO₃Mg; f) 60% CO₃Ca + 40% CO₃Mg; g) 50% CO₃Ca + 50% CO₃Mg; h) 40% CO₃Ca + 60% CO₃Mg; i) 30% CO₃Ca + 70% CO₃Mg; j) 20% CO₃Ca + 80% CO₃Mg; k) 90% CO₃Ca + 10% CO₃Mg and l) 100% CO₃Mg. The experimental unit consisted of one Catongo seedling cultivated in a black polyethylene bag which contained 10 kg of soil. Liming efficiently neutralized the aluminum and increased the amounts of exchangeable Ca + Mg in the soil, independent of the proportions of these nutrients in the added mixture. Regarding the growth of cacao, however, there was a tendency for an increase of this growth when the Ca/Mg ratio varied from 0.1 to 2.0. In the soil, the best growth occurred when the ratio fluctuated between 0.3 to 1.0. The authors recommend that this study be repeated with other soils of the cacao area of Brazil and that correlations between production and Ca/Mg ratio continue to be made in order to be able to gather sufficient information, which might permit more general conclusions about the value of such ratio.

Ezeta, F. N. and Santana, M. B. M. Effect of aluminium on nutrient uptake and concentration in cacao. *Revista Theobroma* 9[4], 173-184. 1979.

Reference ID: 20462

Notes: #20462e

Abstract: The effect of aluminum on growth and nutrient uptake of cacao seedlings (var. Catongo) was studied in nutrition solutions. Aluminum at concentrations of 0,

2.5, 5.0 and 10 ppm was added to modified (1/5) Steinberg nutrient solution, low in phosphorus and pH 4.2. No significant effects on the growth of the seedlings were observed, however, nutrient uptake was markedly affected. The presence of aluminum in the root medium, even at the lowest concentration, decreased uptake of N, P, Ca and Mg but increased potassium absorption. An inhibitory effect of aluminum on nitrate reduction results in the accumulation of nitrate in the tissue was also observed. The low content of divalent cations was compensated by potassium; therefore, the total content of bases in equivalents per unit weight of tissue remained nearly constant in all treatments.

Santana, M. B. M. and Igue, K. The mineral composition of cacao leaves as a variation of season and leaf age. *Revista Theobroma* 9[2], 63-76. 1979.

Reference ID: 20463

Notes: #20463e

Abstract: This study was conducted in order to determine the variations in mineral composition (N, P, K, Ca and Mg) of cacao leaves. The first part consisted in the determination of the most suitable leaf sample for chemical analysis as related to age, selfshading among leaves within the same tree and leaf flushings (buddings). The samples for this preliminary study were obtained from 4-year old Catongo cacao trees in an experimental field where fertilization timing was being studied. Subsequently another work was conducted to study the monthly variation of the major nutrients on leaves of cacao trees in shade by fertilizer. The results showed a trend of N and K to increase with fertilization and to decrease with leaf age; P showed little variation: a slight decrease in older leaves and an inverse response to fertilization. Calcium appeared at higher concentrations in the older leaves due to its low mobility and remained high in spite of leaf flushings. Magnesium was the least influenced by the factors under study. Little seasonal variation was observed for all the macro nutrients except potassium which decreased at the flushing period. Calcium showed an opposite pattern as compared to potassium. Shading and fertilization increased the levels of N and K while those of P and Mg decreased. The average values of N and K content of the leaves are, in general, lower than those obtained for other cocoa regions of the world.

Lucey, J., Hill, J., van der Meer, P., Reynolds, G., and Agus, F. Change in carbon stocks arising from land-use conversion to oil palm plantations. 1-22. 2014.

Reference ID: 20464

Notes: #20464e

Revista Theobroma. *Revista Theobroma* Vol.1, No.3 July-September 1971. *Revista Theobroma* 1[3], 1-48. 1971. Brasil.

Reference ID: 20465

Notes: #20465e

Abstract: Content 1. Influence of the origin of the pollen grain on some phenotypical characteristics of the cacao fruit (*Theobroma cacao* L.) 2. Chromosome morphology of the cacao cultivar "Catongo" 3. Pre-emergent weed control in maize 4. Effect of the calcium, magnesium and potassium balance on cocoa growth 5. Effect of aluminium saturation on the growth of cacao seedlings Notes Nematodes associated with cacao and rubber in Bahia A new drying system for cocoa beans.

Revista Theobroma. Revista Theobroma Vol.5, No.1 Jan-March 1975. Revista Theobroma 5[1], 1-30. 1975. Brasil.

Reference ID: 20466

Notes: #20466e

Abstract: Content 1. Soil sampling in cacao trees plantation of Bahia 2. The role of stingless bees (Meliponinae) in the pollination of Theobroma cacao L. in Tropical America 3. Effect of the ratio Ca/Mg of limestone on the growth of cocoa seedlings

Revista Theobroma. Revista Theobroma Vol.9, No.4 October-December 1979. Revista Theobroma 9[4], 137-200. 1979. Brasil.

Reference ID: 20467

Notes: #20467e

Abstract: Content 1. Studies on the genus Forcipomyia VI. The neotropical species of the subgenus Warmkea (Diptera: Ceratopogonidae) 2. Effect of substrates and foliar spray with fertilizers on the growth of cacao seedlings (in Portuguese) 3. Effect of aluminium on nutrient uptake and concentration in cacao (in Portuguese) 4. Water relation of young potted rubber plants subjected to various degrees of water stress Note Hyperparasitism by the fungus Dactylium sp. of Crinipellis pernicioso (Stahel) Singer, on witches' broom disease of cacao .

Revista Theobroma. Revista Theobroma Vol.9, No.2 April-June 1979. Revista Theobroma 9[2], 45-84. 1979. Brasil.

Reference ID: 20468

Notes: #20468e

Abstract: Content 1. Interaction and pathogenicity of Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949 and Rotylenchulus reniformis Linford & Oliveira, 1940 on black pepper (In Portuguese) 2. Contribution to the knowledge of the sugars component of cacao beans and "sweatings" (in Portuguese) 3. The mineral composition of cacao leaves as a variation of season and leaf age (in Portuguese) Note Ceratopogonid midges (Diptera: Nematocera) collected from cacao flowers in Palmira, Colombia: an account of their pollinating abilities.

De Moraes, M. V. P., Duarte, H. K., Teixeira, A. C. C., Barbosa, R. C. M., De Oliveira, C. E. S., Da Silva Neto, P. J., Da Silva Filho, J. V., De Almeida, C. M. V. C., and De Matos, P. G. G. Sistema de produção de cacau para a Amazônia brasileira. 1-82. 2001. Belém, Ceplac.

Reference ID: 20469

Notes: #20469e

De Santana Dantas P. A. 2011. RELAÇÃO ENTRE FERTILIDADE DO SOLO E NUTRIÇÃO DO CACAUEIRO NO SUL DA BAHIA. UNIVERSIDADE ESTADUAL DE SANTA CRUZ.

Reference ID: 20470

Notes: #20470e

Abstract: Nos sistemas agrossilviculturais cria-se um ambiente de acúmulo de nutrientes na superfície do solo diferente do encontrado no sistema convencional, resultante da deposição natural dos resíduos orgânicos, da reduzida movimentação do solo e do acúmulo superficial de insumos, especialmente aqueles de baixa mobilidade no solo. O conhecimento da disponibilidade dos nutrientes no solo é fundamental para uma recomendação de adubação adequada, evitando assim problemas de deficiência ou de toxidez. Quanto ao nitrogênio (N), em particular, a

substituição do método tradicional de avaliação do seu teor na planta pelo uso do medidor portátil de clorofilas do tipo SPAD (Soil and Plant Analysis Development) é promissor por se tratar de um aparelho portátil que estabelece um índice de modo não destrutivo, instantâneo e com menor custo. Os objetivos deste trabalho foram definir os extratores para fósforo (P), ferro (Fe), zinco (Zn), cobre (Cu) e manganês (Mn) que melhor se correlacionem com o estado nutricional das plantas; a profundidade de amostragem de solo para avaliação da disponibilidade de P, potássio (K), cálcio (Ca), magnésio (Mg), Fe, Zn, Cu e Mn; e determinar a capacidade do SPAD em estimar o teor foliar de N do cacaueiro (*Theobroma cacao*). A área de abrangência deste estudo envolve as zonas climáticas úmida e úmida a subúmida da região cacaueira da Bahia. Foram selecionadas dez propriedades rurais, em cada zona, com lavoura em sistema agrossilvicultural sem irrigação, que não utilizam fosfato natural e que tiveram a área renovada por enxertia de broto basal com clones tolerantes à vassoura de bruxa (*Moniliophthora perniciosa*). Em cada propriedade, quatro plantas (clone PH16) com idade superior a quatro anos foram selecionadas em condições edáficas e topográficas distintas. Foram coletadas oito folhas sadias por planta e em cada uma delas foram feitas seis leituras do índice SPAD. Além disso, determinaram-se o teor de N, P, K, Ca, Mg, Fe, Zn, Cu e Mn na folha, área foliar (AF) e a massa foliar específica (MFE). Foram coletadas amostras de solo às profundidades 0-05, 0-10, 0-20 e 20-40 cm. Para determinação de P disponível foram utilizados os extratores Resina (RTA), Mehlich-1 (M1) e Mehlich-3 (M3); para K foi utilizado o M1 e para Ca e Mg, o cloreto de potássio. Também foram determinados o pH em água e os teores de argila e de fósforo remanescente (P-Rem). Para determinação de Fe, Zn, Cu e Mn disponíveis foram utilizados os extratores M1, M3 e DTPA. O índice SPAD se correlacionou significativa e positivamente com o teor foliar de N, com a AF e negativamente com a MFE. Não houve correlação entre o conteúdo de N e o índice SPAD. O modelo de regressão linear simples para a predição do teor de N a partir do índice SPAD, sem a distinção dos ambientes foi o mais apropriado. A capacidade de extração de P no solo foi: resina de troca aniônica (RTA) > M1 > M3. Os extratores apresentaram correlações entre si variáveis em função da profundidade do solo e da zona climática. Para os nutrientes não trocáveis, seus teores extraídos pelas soluções apresentaram correlações entre si variáveis em função da profundidade e da região. O extrator de P que gerou melhores modelos entre os teores no solo e na planta foi o M1, seguido da RTA e do M3. Estimadores da capacidade tampão de P (teor de argila e P-Rem) não foram significativos quando incluídos nos modelos de teor foliar de P em função de seu teor no solo. Os valores médios de P, K, Ca, Mg, Cu, Mn, Zn e P-Rem decresceram em profundidade. Os teores de Fe extraídos por M1 e M3 aumentaram em profundidade. Para os nutrientes avaliados, a relação entre sua disponibilidade no solo e seu teor foliar no cacaueiro variou em função da zona climática do sul da Bahia, independente do extrator e da profundidade do solo. De modo geral, a profundidade de amostragem mais apropriada para avaliar a fertilidade do solo foi 0-10 cm, independente do nutriente, do extrator e da região. De modo geral, os maiores teores médios de Fe, Zn, Cu e Mn foram obtidos pelo extrator M3, seguido do DTPA e do M1. As correlações entre teor de argila e P-Rem x teores de Fe, Zn, Cu e Mn, de modo geral, não foram significativas. De modo geral, o extrator M1 foi o que gerou melhores correlações entre os teores de micronutrientes catiônicos no solo e na folha de cacaueiros.

Chepote, R. E., Sodre, G. A., Reis, E. L., Pacheco, R. G., and Marrocos, P. C. L. Recommendations of lime and fertilizers in the culture of cacao in South of Bahia, Brazil. Boletim Técnico nº 203, 1-43. 2013. Brasil, Ceplac.

Reference ID: 20471

Notes: #20471e

Abstract: In order to meet the agronomic demands that arise with the implementation of the new phase of cacao cultivation in southern Bahia, Brazil, characterized by planting of clonal varieties tolerant to witches' broom (*Moniliophthora perniciosa*), the Cacao Research Center (Cepec), main research unit of the Executive Commission of the Cacao Farming Plan (CEPLAC), updated the technical recommendations for the use of lime and fertilizers in the cultivation of cacao in the region. Recommendations vary according to ranges of P and K availability in soils, being the N rate set at 60 kg ha⁻¹ ano⁻¹. Thus, in soils with low available P content (< 9 mg dm⁻³) and K (<0.10 cmolc dm⁻³) it is recommended the application of 60-90-60 kg ha⁻¹ of N, P₂O₅ and K₂O, respectively. When these elements are in the middle range (P between 9 to 16 mg dm⁻³ and K between 0.10 to 0.25 cmolc dm⁻³) the annual applications are reduced to 60-60- 30 kg ha⁻¹ of N, P₂O₅ and K₂O. For the high range of P (17 to 30 mg dm⁻³) and K (> 0.25 cmolc dm⁻³) applications per year are reduced to 60-30-00 kg ha⁻¹ of N, P₂O₅ and K₂O. Above the upper limits is not recommended application of P or K, adding only 60 kg ha⁻¹ yr⁻¹ of N. New criterion in the use of organic fertilizers was introduced for soils with organic matter content below 30 g kg⁻¹. In these soils is recommended the use of compost of cacao husk and/or cattle manure at a dosage of 8 kg plant⁻¹. After two years of continuous fertilization in producing plantation and four years in new plantations of cacao clones, a new sampling and soil analysis is done to evaluate the residual effect of fertilizers. The recommendations include higher doses of fertilizer for average yields above 1200 kg ha⁻¹ yr⁻¹ of dry cacao seeds to provide sustainability to the increased production. In correcting soil acidity, new criteria were introduced for the use of gypsum based on the content of exchangeable Al and soil texture. The objective of the use of lime is to raise base saturation (Ca, Mg and K) to 60% of the total cation exchange capacity.

Souza Jr.J.O., J. W. V. Mello, V. V. H. Alvarez, and J. C. L. Neves. 1999. Cacao tree productivity as a function of soil characteristics. I: Chemical characteristics. R.Bras.Ci.Solo, 23:863-872.

Reference ID: 20474

Notes: #20474e

Abstract: The yield of 36 cacao trees (*Theobroma cacao* L.) on a farm in Itagibá, Bahia, Brazil were evaluated during the period of 1989-1995. The averages of the three highest yields (rainier years) and of the three lowest yields (drier years) of each area were considered the main variables. The variables were the chemical characteristics (pH in H₂O and in KCl, organic carbon, total N, Al, Ca, Mg, P, K, Na, Cu, Zn, Mn, Fe, H + Al and the remaining P) in relative to two depths (0-20 and 30-50 cm) of soils with different textures. Data obtained from routine analysis (pH, Ca, Mg, P and K), in 1995, were correlated with the values of these variables obtained in 1988 and 1991, to verify whether the present fertility would be correlated to a past condition. Soil P and K supplied by fertilization, underwent changes through this seven year period, while the pH, Ca and Mg remained more proportional. Copper was the nutrient which most restricted cacao tree; Ca, P and N also limited yield, mainly during the rainy years. K, Mg and pH were high in some areas, showing significant and negative effects on yield. In drier years, the less productive areas

presented more fertile soil (probably the younger ones), with less buffering capacity and less organic matter content. Regardless of rain availability, among the areas with loamy soils, the most productive had higher buffering P capacity.

de Oliveira F. A., Q. A. de Camargo Carmello, and H. A. A. Mascarenhas. 2001. Potassium availability and its relation to calcium and magnesium in greenhouse cultivated soybean. *Scientia Agricola*, 58:329-335.

Reference ID: 20475

Notes: #20475e

Abstract: Soybean does not respond well to high levels of K, because its availability has been related to interactions with Ca and Mg in the soil and, therefore, to liming. In order to study soybean K nutrition related to soil levels of Ca and Mg, a greenhouse experiment was carried out in pots with a sandy loam Typic Hapludox. A 5 x 7 factorial randomized block experimental design was adopted with four replications. Forty days before sowing, five levels of burned dolomite lime (0, 500, 1000, 1500, 2000 mg dm⁻³) were applied, mixed with seven K levels (0, 15, 30, 45, 60, 75, 90 mg dm⁻³) in the form of KCl, before sowing. Four plants were grown in each pot. Plants of the early blooming soybean cultivar, IAC-17 with 112-day cycle, were inoculated with *Bradyrhizobium japonicum*. Two plants were evaluated at the R2 stage (full bloom) and the other two at the R8 stage (full maturity). When the soil ratio of exchangeable (Ca+Mg)/K was greater than 36 or leaf (Ca+Mg)/K concentration greater than 3.6, the plants presented lower dry matter yield, K deficiency symptoms and lower leaf K concentration. Otherwise, greater dry matter yield, related to the optimum equilibrium of leaf K, Ca and Mg concentrations, were verified when the soil ratio of exchangeable (Ca+Mg)/K was between 20 to 30. The soil ratio of exchangeable (Ca+Mg)/K presented an important index to evaluate soil K availability for the soybean crop. Recommendations regarding K fertilization to the soybean crop must also consider the applied liming rates.

Souza Jr.J.O., J. C. Ker, J. W. V. Mello, and C. D. Cruz. 1999. Cacao tree productivity as a function of soil characteristics. II. Morphological - physical characteristics and some elements extracted by using concentrated sulfuric acid. *R.Bras.Ci.Solo*, 23:873-880.

Reference ID: 20476

Notes: #20476e

Abstract: Based on the seven year-productivities (1989 to 1995) of 36 cacao-producing areas, on a farm in southern of Bahia, Brazil, the average of the three most and least productive years was obtained corresponding, respectively, to the highest and lowest rain availability. By path analysis, these productivities were related to both the soil morphological-physical characteristics (A-horizon depth; color, soil and particle densities of A and B horizons; texture of soil layers at 0-20 and 30-50 cm depth and the presence of gravel or stones down to a 50 cm depth) and the element contents (Ti, K, Fe, Mn, Zn) extracted from a 30-50 cm depth layer by using concentrated sulfuric acid. The micronutrients extracted by the concentrated sulfuric acid were correlated with those extracted by Mehlich-1. Generally, the physical characteristics showed a better correlation with the drier years' productivity whereas the element contents extracted by concentrated sulfuric acid showed a better correlation with that of rainier years. The most productive areas were those having a deeper A horizon, a soil with greater porosity, higher contents of Ti and cationic micronutrients, and a lower content of K, all extracted by concentrated sulfuric acid. During the drier years, the most productive areas were

those with higher contents of clay and lower contents of silt and sand. Gravel occurrence down to 50 cm depth and the color of the soil horizons did not correlate significantly with plant productivity. Cu, Mn and, or Zn contents, extracted by concentrated sulfuric acid, indicated soils of greater fertility in cationic micronutrients for the cacao tree.

Da Silva J. V. O. 2009. Production and partition of biomass and nutrients and parameterization of a system for recommendation of N, P, and K for cocoa. UNIVERSIDADE ESTADUAL DE SANTA CRUZ, ILHÉUS, BAHIA.

Reference ID: 20477

Notes: #20477e

Abstract: The objective of this work was to set the parameters of the FERTICALC. System to serve as a recommendation tool for N, P and K fertilization in cacao cultivation. FERTICALC. is a software applicable to different types of agricultural crops, considers its particularities in terms of structural components for the calculation of the nutritional demands adjusted to a target productivity. The System is based on the basic principles of the nutritional balance method that estimate the levels of nutrients to be applied via fertilizer, which results from the differences between the quantities required by plants and those that can be provided naturally by the soil. This proposal fits the System of Calculation and Recommendation of Correctives and Fertilizers FERTICALC.. In the plant, the system estimates the nutrient demands for the culture based on the desired productivity. From this productivity an estimate of the biomass volume is made and from it the biomass of the other components. From these, the determination of the amount of nutrients in the yield is made and in the other components, finding the nutrient demands for the crop. In the soil, FERTICALC. estimates the potential capacity of nutrients supply through the soil analysis as sufficiency indices (SI). Thus, the difference between the demand of nutrients by the plant and the soil supply capacity is the nutritional balance; therefore, the recommended doses vary continuously with the desired productivity, the nutrient content and the nutrients buffer capacity of the soil. The quantification of total biomass production of cocoa plant parts was used to calculate the partition of its components distributed in 77% for shoots and 23% for root. Dry biomass in seeds was 1500 kg ha⁻¹. This quantification also enabled the determination of photoassimilate partitioning in pods, which was 55% for shells and 45% for seeds. The nutrient of greatest demand for cocoa cultivation was nitrogen. The simulations carried out showed that the FERTICALC. system recommends higher N doses than the currently indicated for cacao. On the other hand, it is desirable the incorporation of procedures to evaluate the economic viability of doses, as well as, better calibrate the rates of recovery of soil N, P and K by plants.

Revista Theobroma. Revista Theobroma Vol.18, No.4 October-December 1988. Revista Theobroma 18[4], 229-240. 1988. Bahia, Brazil.

Reference ID: 20478

Notes: #20478e

Abstract: Content 1. Response of young cacao plants to liming (in Portuguese) 2. Influence of the forms of lime and gypsum application on cacao growing (in Portuguese) 3. Change in the fermentation profile of cacao due to partial removal of bean pulp (in Portuguese) 4. Edaphic changes caused by planting forest species in tabuleiro (Haplorthox) soils in the South of Bahia (in Portuguese) Note New pests of cacao tree in the Reconcavo of Bahia, Brazil (in Portuguese).

Neto R. D. O. C. 2012. Liming, phosphorus, manganese and zinc for cocoa seedlings grown. UNIVERSIDADE ESTADUAL DE SANTA CRUZ, ILHÉUS-BAHIA.

Reference ID: 20479

Notes: #20479e

Abstract: The cacao is still important agricultural activity in southern Bahia, the state that maintains the first position in its production in Brazil. The development phase of a culture is essential for maximum economic use of its cultivation. Among the factors of production to soil fertility and plant nutrition are essential because only few can be handled by human action, resulting in an increment of production. In the cultivation of cocoa there is a research around the micronutrients and factors affecting their availability to plant. Zinc (Zn) is appointed as the element with greatest incidence of disability in cocoa cultivation. Manganese (Mn) is often found at levels near the macronutrients in the leaves of cacao. Phosphorus (P), and is a nutrient essential for the satisfactory development of seedlings, also affects the absorption of other nutrients by plants. The availability and absorption of these nutrients are affected by texture and by soil acidity. In order to evaluate the response to application of lime, P, Mn and Zn for cocoa seedlings were prepared two experiments. The first experiment consisted in a factorial 3 x 9 comprises three Oxisols with different amounts of clay and the application of nine doses of Zn in the form $ZnSO_4$ of 0, 1, 2, 4, 8, 16, 32, 48 and 64 mg dm⁻³ Zn. The variables analyzed were: dry matter (MSPA), leaf dry mass (LDM), stem dry mass (MSC), root dry mass (RDM), total dry matter (TDM), leaf area (LA) and specific leaf mass (SLM) evaluated at 240 days of cultivation. The diagnostic analysis leaf nutrient levels and soil were also performed. The MST was used as a variable basis for developing a nutritional classification of Zn in plants and soil. As a final result of the experiment were the different responses of soil Zn application both for biomass production and for the contents of P, K, Ca, Mg, Mn, Fe, Zn and Cu. For the second experiment, was conducted a tri-incomplete factorial experimental matrix using the Box-Berard increased (+3), the factors studied: base saturation (V), P and Mn. The amplitude V was 33.5 to 96.5%, the Mn doses ranging from 4 to 76 mg dm⁻³ and P 15 to 285 mg dm⁻³ (25% P applied to the soil volume). Plants were grown for 240 days, with the same dependent variables analyzed in the first experiment. In addition to the nutrient content in the sheet diagnosis, it is also evaluation of the amount total nutrients accumulated in the leaves. Regression models were obtained for all variables in sampling experiments. The application of Mn had no effect on the MSR, MST and MSC, but influenced the MSPA, MSF and AF of cocoa seedlings due to micronutrient interaction with the P and V%. The doses of Mn affected foliar K, P, Mg, Fe, Mn and Cu. The contents of leaf K, Ca, P, Mg, Fe, Mn, Zn and Cu were affected by increases in base saturation, P doses and doses of Mn.

Rosand, P. C., Santana, M. B. M., and de Miranda, E. R. Fertilidade dos solos ocupados com cacauzeiros no sul da Bahia. Boletim Técnico No.27, 1-31. 1975. Bahia, Brazil, Ceplac.

Reference ID: 20480

Notes: #20480e

Boucher, D., Elias, P., Faires, J., and Smith, S. Deforestation success stories - Tropical nations where forest protection and reforestation policies have worked. 1-51. 2014. Union of Concerned Scientists.

Reference ID: 20481

Notes: #20481e

van Asten P. J. A., L. W. I. Wairegi, D. Mukasa, and N. O. Uringi. 2011. Agronomic and economic benefits of coffee-banana intercropping in Uganda's smallholder farming systems. *Agricultural Systems*, 104:326-334.

Reference ID: 20482

Notes: #20482e

Abstract: Coffee and banana are major cash and food crops, respectively, for many smallholders in the East African highlands. Uganda is the largest banana producer and 2nd largest coffee producer in Africa. Both crops are predominantly grown as monocultures. However, coffee-banana intercropping is common in densely populated areas. This study assessed the profitability of intercropped coffee-banana systems compared to mono-cropped systems in regions growing Arabica (Mt. Elgon) and Robusta (south and west) coffee in Uganda. The study was carried out in 152 plots in 2006/2007. Data were collected through structured farmer interviews, field measurements and observations. Coffee yields did not differ significantly ($P < 0.05$) between mono-crops and intercrops. Arabica coffee yields were 1.23 and 1.18 t ha⁻¹ year⁻¹ of green beans in mono-cropped and intercropped plots, respectively. Robusta yields averaged 1.25 and 1.09 t ha⁻¹ year⁻¹ of green beans in mono-crops and intercrops, respectively. Banana yields were significantly higher ($P < 0.05$) in intercrops (20.19 t ha⁻¹ year⁻¹) compared with mono-crops (14.82 t ha⁻¹ year⁻¹) in Arabica growing region. In Robusta growing region, banana yields were significantly lower ($P < 0.05$) in intercrops (8.89 t ha⁻¹ year⁻¹) compared with mono-crops (15.04 t ha⁻¹ year⁻¹). Marginal rate of returns of adding banana to mono-cropped coffee was 911% and 200% in Arabica and Robusta growing regions, respectively. Fluctuations in coffee prices are not likely to affect the acceptability of intercrops when compared with coffee mono-crops in both regions, but an increase in wage rates by 100% can make intercropping unacceptable in Robusta growing region. This study showed that coffee-banana intercropping is much more beneficial than banana or coffee mono-cropping and that agricultural intensification of food and cash crops in African smallholder systems should not solely depend on the mono-crop pathway.

van Oijen M., J. Dauzat, J.-M. Harmand, G. Lawson, and P. Vaast. 2010. Coffee agroforestry systems in Central America: I. A review of quantitative information on physiological and ecological processes. *Agroforestry Systems*, 80:341-359.

Reference ID: 20483

Notes: #20483e

Abstract: Coffee is widely grown across Central America at altitudes between 600 and 2500 m, mostly in association with trees that provide shade and other services. Research on coffee agroforestry systems has identified many environmental factors, management strategies and plant characteristics that affect growth, yield and environmental impact of the system. Much of this literature only presents qualitative estimates of the importance of the different growth determining factors, or highly site-specific estimates. Quantitative information is required to allow statistical analysis or the construction of process-based models of the system. Here, we review the available quantitative information for the latter purpose, with emphasis on the data needs for modelling agroforestry systems common in Central America. Process-based models require environmental data-weather, soil-and data on the physiological characteristics of the coffee plants and trees. Our review showed that the current literature is insufficient to allow full parameterisation of a process-based model for any coffee-tree combination. Information on weather, coffee and trees is highly limited, but soil information seems more adequate. A regional network of

replicated multi-factorial experiments, focusing on the interactive effects of different environmental factors, may help address the main knowledge gaps.

Haefele S. M. and Y. Konboon. 2009. Nutrient management for rainfed lowland rice in northeast Thailand. *Field Crops Research*, 114:374-385.

Reference ID: 20484

Notes: #20484e

Abstract: Average grain yields of rainfed lowland rice in northeast Thailand are the lowest in the region, and they barely changed in the past decade. Improved fertilizer management is one of the few options to enhance cropping system productivity but related results from previous studies were often disappointing and sometimes contradictory, possibly due to the large variability of soil and water resources. Therefore, the objectives of this study were to develop a site-specific nutrient management approach, and to propose a related decision tool for farmers. For this purpose, we conducted on-farm experiments in Kumpa-Oong Village, Roi Et Province, during the 2003-2005 cropping seasons. Tested fertilizer treatments were designed based on topographic field position. A comparison of soil characteristics between lower and upper fields revealed significantly higher soil fertility for lower fields (higher pH, TOC, TSN, CEC, clay, and silt content; lower sand content). Across seasons and treatments, grain yields were higher in the valley bottom (VB; 2.82 t ha⁻¹) than on upper and middle terraces (UMT; 1.68 t ha⁻¹). In all seasons, significant fertilizer treatment effects were detected only in UMT fields. But the comparison of treatment effects in individual fields and in both toposequence positions showed that the limited average fertilizer response was mainly caused by low or even negative responses in fields with a higher control yield, i.e., with higher indigenous nutrient supply. A missing or even negative fertilizer response occurred at lower control yields in UMT fields, most probably because attainable yields in these fields were lower as a result of limited water resources. Thus, site-specific fertilizer recommendations need to take toposequence and the field-specific indigenous nutrient supply into account. Based on these results, we proposed a decision tool that helps farmers to choose the most adequate fertilizer treatment for their fields, based on their knowledge of specific field characteristics. On-farm testing of the proposed decision tool is the next step to show whether this approach is acceptable to farmers and can contribute to higher resource-use efficiency and system productivity.

Rival, A. and Levang, P. Palms of controversies - oil palm and development challenges. 1-58. 2014. Center for International Forestry Research (CIFOR).

Reference ID: 20485

Notes: 20485e

Snyder C. S., E. A. Davidson, P. Smith, and R. T. Venterea. 2014. Agriculture: sustainable crop and animal production to help mitigate nitrous oxide emissions. *Environmental Sustainability*, 9-10:46-54.

Reference ID: 20486

Notes: #20486e

Abstract: Nitrous oxide (N₂O) emissions from agriculture can be tackled by reducing demand for, and consumption of, nitrogen (N) inputs via diet modification and waste reduction, and/or through technologies applied at the field level. Here we focus on the latter options. Opportunities for mitigating N₂O emissions at the field level can be advanced by a clearer scientific understanding of the system

complexities leading to emissions, while maintaining agricultural system sustainability and productivity. A range of technologies are available to reduce emissions, but rather than focus specifically on emissions, the broader management and policy focus should be on improved N use efficiency and effectiveness; for lower N₂O emissions per unit of crop and animal product, or per unit of land area.

Hoffmann M. P., A. Castaneda Vera, M. T. van Wijk, K. E. Giller, T. Oberthür, C. Donough, and A. M. Whitbread. 2014. Simulating potential growth and yield of oil palm (*Elaeis guineensis*) with PALMSIM: Model description, evaluation and application. *Agricultural Systems*, 131:1-10.

Reference ID: 20487

Notes: H 8.1.1.11 #20487e

Abstract: Reducing the gap between water-limited potential yield and actual yield in oil palm production systems through intensification is seen as an important option for sustainably increasing palm oil production. Simulation models can play an important role in quantifying water-limited potential yield, and therefore the scope for intensification, but no oil palm model exists that is both simple enough and at the same time incorporates sufficient plant physiological knowledge to be generally applicable across sites with different growing conditions. The objectives of this study therefore were to develop a model (PALMSIM) that simulates, on a monthly time step, the potential growth of oil palm as determined by solar radiation and to evaluate model performance against measured oil palm yields under optimal water and nutrient management for a range of sites across Indonesia and Malaysia. The maximum observed yield in the field matches the corresponding simulated yield for dry bunch weight with a RMSE of 1.7 Mg ha⁻¹ year⁻¹ against an observed yield of 18.8 Mg ha⁻¹. Sensitivity analysis showed that PALMSIM is robust: simulated changes in yield caused by modifying the parameters by 10% are comparable to other tree crop model evaluations. While we acknowledge that, depending on the soils and climatic environment, yields may be often water limited, we suggest a relatively simple physiological approach to simulate potential yield, which can be usefully applied to high rainfall environments and is considered as a first step in developing an oil palm model that also simulates water-limited potential yield. To illustrate the application possibilities of the model, PALMSIM was used to create a potential yield map for Indonesia and Malaysia by simulating the growth and yield at a resolution of 0.1. This map of potential yield is considered as a first step towards a decision support tool that can identify potentially productive, but at the moment degraded sites in Indonesia and Malaysia.

Naher U. A., R. Othman, and Q. A. Panhwar. 2013. Beneficial Effects of Mycorrhizal Association for Crop Production in the Tropics - A Review. *International Journal of Agriculture & Biology*, 15:1021-1028.

Reference ID: 20488

Notes: #20488e

Abstract: Mycorrhiza plays a significant role in sustainable agriculture and has mutualistic symbiotic association with plant roots. There are several species of mycorrhiza and among the species studied *Glomus mosseae* is well known to colonize several vegetables, fruits, cereals and industrial crops. This paper highlighted the symbioses and beneficial effects of arbuscular mycorrhiza fungi (AMF) with tomato (*Solanum lycopersicum*), brinjal (*S. melongena*), potato (*S. tuberosum*), lady's finger (*Abelmoschus esculentus*), cucumber (*Cucumis sativus*), bean (*Phaseolus vulgaris*), pepper (*Capsicum annum*), wheat (*Triticum aestivum*),

aerobic rice (*Oryza sativa*), corn (*Zea mays*), durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), pineapple (*Ananas comosus*), citrus (*Citrus sinensis*), banana (*Musa acuminata*), oil palm (*Elaeis guineensis*) and kenaf (*Hibiscus cannabinus*). Application of AMF increased nutrient uptake, water relations and perform as bio-protectants against pathogens and toxic stresses. In order to further improve their benefits, it is necessary to ensure the management practices comprising low tillage, abridged use of chemical fertilizers, especially the phosphatic fertilizers.

Liew V. K., Z. A. Rahman, M. H. Musa, and A. Hussein. 2012. Effects of severing oil palm roots on leaf nutrient levels and P uptake. *Journal of Oil Palm Research*, 24:1343-1348.

Reference ID: 20489

Notes: #20489e

Abstract: Physical damage to oil palm roots affects the palm's ability to acquire nutrients. In spite of this huge impact on the palm, the effects of root loss on palm nutrient status are unknown and this is unfortunate because optimal palm nutrient status is an important factor in fruit production. In trying to understand the effects of damage to the roots and the consequent effects on the palms, the impact of root damage was simulated by severing roots within 0%, 25% and 50% of the palm circle. Five months after the roots were severed, changes in leaf nutrient levels in the various treatments were observed. Each treatment was replicated five times, using one palm per replicate. The impact of losing 25% of the roots within the palm circle changed the leaf K concentration and also the N:K ratio significantly ($p < 0.05$) compared with a loss of 50% of the roots within the palm circle. However, palms which lost 25% and 50% of the roots within the palm circle did not show any significant change ($p > 0.05$) in the N, P, Mg and B leaf concentrations compared to control. Further assessment of the impact of root loss on nutrient uptake by the palm, especially by the surviving tertiary roots, was made using P-32 isotope. Five surviving tertiary roots from each treatment were placed in contact with the P-32 solution, and the amount of isotope absorbed by the palms from the various treatments over a fixed time was measured. No difference in the amount of the isotope absorbed was observed.

Law C. C., A. R. Zaharah, M. H. A. Husni, and A. Siti Nor Akmar. 2012. Evaluation of Nitrogen Uptake Efficiency of Different Oil Palm Genotypes Using ^{15}N Isotope Labelling Method. *Pertanika Journal of Tropical Agricultural Science*, 35:755-766.

Reference ID: 20490

Notes: #20490e

Abstract: High demands for palm oil world wide induce the expansion of oil palm plantations in Malaysia. Malaysian soils which are highly weathered require high nitrogen fertilizer input in order to maintain high yield output, resulting in increase in production cost as well as inducing negative impacts to the environment. It is crucial to understand the performance of different oil palm genotypes in taking up nitrogen to increase nitrogen use efficiency, minimize environmental pollution caused by leached nitrate and maximize plantation profit, while maintaining sustainable agriculture practices. ^{15}N labelling method was utilized in a greenhouse study to quantify the nitrogen up-take performance of nine oil palm genotypes at 6 and 9 months after planting. Measurements of total dry matter, total N, and percentage N derived from fertilizer (%NdFF) were carried out during the study. At 6 month old, oil palms of different genotypes did not show any difference in nitrogen uptake with and

without P fertilizer applications. However, 9 months old oil palms demonstrated significant differences between the genotypes in total dry matter production and total N taken up, hence, resulting in significant differences in N derived from fertilizer among genotypes. Oil palms at 9 months old also showed significant effects in the N uptake as affected by P fertilizer application. Genotype A (14/34 x 2367/17) demonstrated significantly higher nitrogen uptake compared to other genotypes, except for genotype F (9/103 x 2318/17). Thus, the ¹⁵N labelling technique could serve as a useful assessment to the nitrogen uptake abilities of oil palm genotypes.

Shanmuganathan S., A. Narayanan, M. Mohamed, R. Ibrahim, and H. Khalid. 2014. A Hybrid Approach to Modelling the Climate Change Effects on Malaysia's Oil Palm Yield at the Regional Scale. Recent Advances on Soft Computing and Data Mining Advances in Intelligent Systems and Computing, 287:335-345.

Reference ID: 20491

Notes: #20491e

Abstract: Understanding the climate change effects on local crops is vital for adapting new cultivation practices and assuring world food security. Given the volume of palm oil produced in Malaysia, climate change effects on oil palm phenology and fruit production have greater implications at both local and international scenes. In this context, the paper looks at analysing the recent climate change effects on oil palm yield within a five year period (2007-2011) at the regional scale. The hybrid approach of data mining techniques (association rules) and statistical analyses (regression) used in this research reveal new insights on the effects of climate change on oil palm yield within this small data set insufficient for conventional analyses on their own.

Tan N. P., A. R. Zaharah, A. Siti Nor Akmar, and N. Jamaluddin. 2010. Evaluating the Variability of Gafsa Phosphate Rock Uptake by Oil Palm Genotypes at Nursery Stage. Pertanika Journal of Tropical Agricultural Science, 33:223-231.

Reference ID: 20492

Notes: #20492e

Abstract: The application of phosphate fertilizer in crops accounts for 90% of the total world's mineral phosphate mined and the reserve of phosphate rock in the world continues to deplete. Thus, it is imperative to understand the potential of different oil palm genotypes in taking up added phosphate fertilizers in order to conserve this particular non-renewable resource. In this study, the P-32 reverse isotope dilution method was used in a greenhouse to assess nine different oil palm genotypes in taking up phosphate fertilizer (Gafsa Phosphate Rock) for a period of 6 months. The measurements of the dry weight and P accumulation in plant were conducted during the course of the study. However, the two measurements did not clearly show the difference in the phosphate uptake after the application of Gafsa Phosphate Rock. In more specific, the accumulation of phosphate in the different genotypes only demonstrated significant difference between the genotypes (25/49 x 2367/17 and 9/103 x 2318/17) in the first three months. However, the P-32 reverse dilution method revealed a significant difference in the phosphate fertilizer uptake for the genotypes at 0-3 and 3-6 months. Over the six month` period, the genotypes were observed to take up around 14 to 46 percent of the phosphate added fertilizer. The potential of the different oil palm genotypes to take up phosphate from fertilizer, according to the P-32 reverse isotope dilution method, could be ranked as 2/35 x 2367/17 ³ 19/19 x 2367/17 ³ 2/209 x 2367/17 > 25/49 x 2367/17 ³ 9/103 x 2318/17 ³ 33/17 x 2318/17 > 14/34 x 2367/17 ³ 23/34 x 2367/17 ³ 1/39 x 2318/17. Therefore,

the P-32 reverse isotope dilution method could serve as a useful means of assessing the phosphate uptake potential of oil palm seedlings. This study implies that oil palm seedlings, with better phosphate uptake efficiency from fertilizer, can help to reduce fertilizer wastage and contamination of water source, and obtain a better ability to cope with phosphate deficiency.

Jipelos J. M. 1989. Uptake of nitrogen from urea fertiliser for rice and oil palm-the Malaysian experience. Pages 187-203.

Reference ID: 20493

Notes: #20493 < S 1.8 #444

Abstract: Research results on the efficiency of applied urea-N to rice and oil palm under Malaysian conditions are reported. Flooded rice is normally planted in alluvial soils (marine and riverine) while oil palm is planted in alluvial and sedentary soils. Recovery of applied N from urea by rice varied between 22 to 65%. Leaching losses as high as 43.3% were reported while volatilization losses of ammonia were between 6-10%. Despite this low recovery of applied N, urea is still the preferred source of nitrogen for rice. In the case of oil palm, urea is used in the alluvial soils although ammonium sulphate is slightly superior. In the sedentary soils, urea is only used in areas where volatilization losses of ammonia can be minimized. Volatilization losses of ammonia as high as 38% in sedentary soils were reported. In a comparison study between urea and ammonium sulphate, volatilization losses from urea-N of 22.5% N on sandy loam soils and 16.5% N on clay soils were observed compared to 0.1% and 0.4% in the case of ammonium sulphate for the sandy loam and clay loam respectively.

Forde St. C. M. 1972. Effect of Dry Season Drought on Uptake of Radioactive Phosphorous by Surface Roots of the Oil Palm (*Elaeis guineensis* Jacq.). Agronomy Journal, 64:622-623.

Reference ID: 20494

Notes: #20494e

Abstract: The hypothesis that the feeding roots of the oil palm (*Elaeis guineensis* Jacq.) die back because of the effects of pronounced dry season drought in Nigeria was tested using radioactive T as a tracer to study P uptake as influenced by different levels of soil moisture. Two trials were carried out in 1964 and 1965, respectively, with the three treatments being: (A) no irrigation during the dry season and T applied in solution to the soil; (B) one irrigation of 50.8 mm of water shortly before application of ³²P; and (C) irrigation at the rate of 50.8 mm of water per palm per week throughout the dry season and ³²P applied to the soil. Leaf samples were taken and the activity of T was determined. In both trials the uptake of ³²P in treatment C was significantly higher than either treatment A or B and supported the hypothesis that the lower activity was caused by the dieback of the absorbing roots during the dry season drought.

Oosterveer P. 2014. Promoting sustainable palm oil: viewed from a global networks and flows perspective. Journal of Cleaner Production, 1-8.

Reference ID: 20495

Notes: #20495e

Abstract: Global demand for palm oil is increasing to fulfil worldwide needs for cooking oil, food ingredients, biofuels, soap and other chemicals. In response, palm oil production is rapidly expanding which promotes economic growth in producing countries but also leads to serious environmental and social problems such as

destruction of tropical forests, climate change and threats to small-holder livelihoods. For these reasons, palm oil production and use have become highly controversial. However, the global character of palm oil production and consumption, the number of different actors involved and its multiple uses makes promotion its sustainability highly complex. Individual nation-states can no longer control and regulate a global flow like palm oil and alternative governing networks appear involving private companies and NGOs. Acknowledging the roles of such governance networks with different forms of power means that relying only on economic and political power to explain current dynamics in the palm oil sector is inadequate. In global networks like palm oil supply, encompassing transnational material flows and multiple actors, the relevance of each actor relates to his position in the network. Power in global palm oil supply is therefore not only related to their position in the (vertical) supply chains, but also to their role in the horizontal networks. New forms of power in networks arise from steering the networks (programming) and from connecting different networks (switching). In the multiple networks that compose global palm oil provision today, different programmers and switchers play critical roles. This is briefly illustrated in this paper on the basis of different cases of active steering in global palm oil provision.

Shorrocks V. M. 1997. The occurrence and correction of boron deficiency. *Plant & Soil*, 193:121-148.

Reference ID: 20496

Notes: #20496e

Abstract: Positive responses to B application, which provide clear evidence of B deficiency, have been reported in over 80 countries and on 132 crops over the last 60 years. It is estimated that about 15 million ha are annually treated with B. In a few regions in the world, B deficient soils exist over a wide area, as for example in eastern and southern China. Elsewhere B deficiency is restricted to particular soil types and crops. Acrisols and Podzols and to a much lesser extent Andosols, Luvisols and Ferralsols, appear to be the soil groups most likely to produce B deficient crops. Soil parent material and texture are considered to be the major soil factors associated with the occurrence of B deficiency. For many crops it is the B requirement for successful fertilisation that is of critical importance; even crops with a small B requirement, such as the cereals, can suffer impaired seed set due to B shortage at a critical time. Climate, particularly high light intensity and low temperature are factors that need to be considered in relation to the occurrence of B deficiency. Boron deficiency can be readily prevented and corrected by both soil and foliar applications. Most reliance is placed on refined sodium borates, but crushed ores are used both in the manufacture of boronated fertilisers and on their own. Depending on the ore, its particle size and method of application, B supply may be extended by using an ore which dissolves slowly.

Pallas B., I. Mialet-Serra, L. Rouan, A. Clement-Vidal, J.-P. Caliman, and M. Dingkuhn. 2013. Effect of source/sink ratios on yield components, growth dynamics and structural characteristics of oil palm (*Elaeis guineensis*) bunches. *Tree Physiology*, 33:409-424.

Reference ID: 20497

Notes: #20497e

Abstract: Source/sink ratios are known to be one of the main determinants of oil palm growth and development. A long-term experiment (9 years) was conducted in Indonesia on mature oil palms subjected to continuous bunch ablation and partial

defoliation treatments to artificially modify source/sink ratios. During the experiment, all harvested bunches were dissected and phenological measurements were carried out to analyse the effect of source/sink ratios on yield components explaining variations in bunch number, the number of fruits per bunch and oil dry weight per fruit. An integrative variable (supply/demand ratio) describing the ratio between the assimilate supply from sources and the growing organ demand for carbohydrate was computed for each plant on a daily basis from observations of the number of developing organs and their sink strength, and of climate variables. Defoliation and bunch ablation affected the bunch number and the fruit number per bunch. Variations in bunch number per month were mainly due to variations in the fraction of aborted inflorescence and in the ratio between female and male inflorescences. Under fluctuating trophic conditions, variations in fruit number per bunch resulted both from changes in fruit-set and in the number of branches (rachillae) per inflorescence. For defoliated plants, the decrease in the number of developing reproductive sinks appeared to be sufficient to maintain fruit weight and oil concentration at the control level, without any major decrease in the concentration of non-structural carbohydrate reserves. Computation of the supply/demand ratio revealed that each yield component had a specific phase of sensitivity to supply/demand ratios during inflorescence development. Establishing quantitative relationships between supply/demand ratios, competition and yield components is the first step towards a functional model for oil palm.

Khamis A., Z. Ismail, K. Haron, and A. T. Mohammed. 2006. Neural Network Model for Oil Palm Yield Modeling. *Journal of Applied Sciences*, **6**:391-399.

Reference ID: 20498

Notes: #20498e

Abstract: This research presents a study on the development of a model for oil palm yield using neural network approach. The structure of this neural network requires the identification of the input variables and the output. We identified that the percentages of nitrogen, phosphorus, potassium, calcium and magnesium in leave were used as input variables and fresh fruit bunch was used as the target variable. An investigation of the combinations of activation function in the input layer to the hidden layer and the hidden layer to the output layer found that each combination also affects the neural network performance. The effect of the learning rate, momentum term, number of runs and number of hidden nodes was also investigated. The number of hidden nodes was found to significantly affect the neural network performance. However, the learning rate, momentum term and number of runs were found to have an insignificant effect on the neural network performance. Using R² values the suitability of the models were measured. Results demonstrate that the neural network model outperformed regression analysis, which can be considered as alternative in modeling of oil palm yield.

Mat Arshad A. 2014. Effect of soil parent materials on oil palm yield. *Journal of Biology, Agriculture and Healthcare*, **4**:20-24.

Reference ID: 20499

Notes: #20499e

Abstract: The research aimed to analyze performance of oil palm production induced by its soil parent materials. Soil samples were collected from granite soils and basalt soils and were completely analyzed in laboratory. The research results showed that soil properties characters of granite soil is more acid, has very low to low chemical soil fertility and is dominated by sand fraction, furthermore basalt soil is

acid, has low to moderate chemical soil fertility and is dominated by clay fraction. Granite and basalt soils are able to produce fresh fruit bunches of oil palm (FFB) 13-18 ton/ha in a year and 19-24 ton/ha in a year respectively.

Berdugo A. E. B. and N. F. R. Lopez. 2010. Effect of arbuscular mycorrhizal fungi in *Elaeis guineensis* (Palmaceae) seedlings with high phosphorus level in the soil. Acta Biol.Colomb., 15:105-114.

Reference ID: 20500

Notes: #20500e

Abstract: The arbuscular mycorrhizal fungi (AMF) facilitate the absorption of nutrients to the host plants. These microorganisms therefore, fulfill a fundamental roll in the operation of agroecosytems. The aim of this work was to evaluate the effect between native and commercial arbuscular mycorrhizal fungi and *Elaeis guineensis* seedlings in greenhouse conditions with high P level. Plants of three months of the age were put under four treatments: Native inoculate (NI), Foreign inoculate (FI), Mixture (M) and control (TA). Total dry weight of the plant, root and aerial part dry weight, height of the plant, relative growth rate (RGR), mycorrhizal colonization and spores number were evaluated. At 45 and 90 days after the transplant these variables were evaluated. An initial sampling dry mass was taken to determine RGR. The data were analyzed by ANOVA or Kruskall-Wallis according to the behavior of the data, followed of a test of averages of Duncan or a modified test of Tuckey for nonparametric data. Significant differences in the spores number between the treatments NI, FI, M and TA and between NI and M at 45 days were found. In the colonization mycorrhizal differences between the treatments FA and TA were observed at 45 days and between all the treatments with respect to the TA at 90 days. Although the P level in the soil was high, mycorrhizal colonization at the two evaluated times was also high. Through time the treatment NI worked better in the soil edaphic conditions used in this experiment.

Edwards F. A., D. P. Edwards, S. Sloan, and K. C. Hamer. 2014. Sustainable Management in Crop Monocultures: The Impact of Retaining Forest on Oil Palm Yield. Plos One, 9:1-8.

Reference ID: 20501

Notes: #20501e

Abstract: Tropical agriculture is expanding rapidly at the expense of forest, driving a global extinction crisis. How to create agricultural landscapes that minimise the clearance of forest and maximise sustainability is thus a key issue. One possibility is protecting natural forest within or adjacent to crop monocultures to harness important ecosystem services provided by biodiversity spill-over that may facilitate production. Yet this contrasts with the conflicting potential that the retention of forest exports dis-services, such as agricultural pests. We focus on oil palm and obtained yields from 499 plantation parcels spanning a total of Å23,000 ha of oil palm plantation in Sabah, Malaysian Borneo. We investigate the relationship between the extent and proximity of both contiguous and fragmented dipterocarp forest cover and oil palm yield, controlling for variation in oil palm age and for environmental heterogeneity by incorporating proximity to non-native forestry plantations, other oil palm plantations, and large rivers, elevation and soil type in our models. The extent of forest cover and proximity to dipterocarp forest were not significant predictors of oil palm yield. Similarly, proximity to large rivers and other oil palm plantations, as well as soil type had no significant effect. Instead, lower elevation and closer proximity to forestry plantations had significant positive impacts on oil palm yield. These findings suggest

that if dipterocarp forests are exporting ecosystem service benefits or ecosystem dis-services, that the net effect on yield is neutral. There is thus no evidence to support arguments that forest should be retained within or adjacent to oil palm monocultures for the provision of ecosystem services that benefit yield. We urge for more nuanced assessments of the impacts of forest and biodiversity on yields in crop monocultures to better understand their role in sustainable agriculture.

Rance K. A., S. Mayes, Z. Price, P. L. Jack, and R. H. V. Corley. 2001. Quantitative trait loci for yield components in oil palm (*Elaeis guineensis* Jacq.). Theoretical and Applied Genetics, 103:1302-1310.

Reference ID: 20502

Notes: #20502e

Abstract: The development of an oil palm RFLP marker map has enabled marker-based QTL mapping studies to be undertaken. Information from 153 RFLP markers was used in combination with phenotypic data from an F2 population to estimate the position and effects of quantitative trait loci (QTLs) for traits including yield of fruit and its components and measures of vegetative growth. The mapping population consisted of 84 palms segregating for the major gene influencing shell thickness. Marker data were analysed to produce a linkage map consisting of 22 linkage groups. The QTL mapping analysis was carried out by interval mapping and single-marker analysis for the unlinked markers; significance thresholds were generated by permutation. Using both single-marker and interval-mapping analysis significant marker associated QTL effects were found for 11 of the 13 traits analysed. The results of interval-mapping analysis of fruit weight, petiole cross section and rachis length, and ratios of shell:fruit, mesocarp:fruit and kernel:fruit indicated significant ($P < 0.05$) QTLs at the genome-wide threshold. The putative QTLs were associated with between 8.2% and 44.0% of the phenotypic variation, with an average of 27% for the single-marker analysis and 19% for the interval-mapping analysis. The higher percentage of phenotypic variation explained in the single-marker analysis, when compared to the interval-mapping analysis, is likely to be due to the lower stringency associated with the single marker analysis. Large dominance deviations were associated with a sizeable proportion of the putative QTLs. The ultimate objective of mapping QTLs in commercial populations is to utilise novel breeding strategies such as marker-assisted selection (MAS). The potential impact of MAS in oil palm breeding programmes is discussed.

Alizadeh F., A. Siti Nor Akmar, P. P. Chong, and A. B. Selamat. 2014. Expression Analysis of Fatty Acid Biosynthetic Pathway Genes during Interactions of Oil Palm (*Elaeis guineensis* Jacq.) with the Pathogenic *Ganoderma boninense* and Symbiotic *Trichoderma harzianum* Fungal Organisms. Plant Mol.Biol.Rep., 32:70-81.

Reference ID: 20503

Notes: #20503e

Abstract: The fatty acid (FA) signaling pathway is emerging as an important mechanism in plant responses during interactions with microbial organisms. For a comprehensive evaluation of key FA biosynthetic pathway genes during interactions of oil palm (*Elaeis guineensis* Jacq.) with the pathogenic *Ganoderma boninense* and symbiotic *Trichoderma harzianum* fungal organisms, a lane-based array analysis of gene expression in artificially inoculated oil palm seedlings was performed. The results obtained demonstrated that acetyl-CoA carboxylase (ACC), beta-ketoacyl-ACP synthases (KAS) II and III, palmitoyl-ACP thioesterase (PTE), oleoyl-ACP thioesterase (OTE) and glycerol-3-phosphate acyltransferase (ACT) showed

identical responses in root and leaf tissues for the same fungi. The expression of these genes was up-regulated in both root and leaf tissues at 21 days post-inoculation (dpi) during interaction of oil palm with *G. boninense*. Thereafter, production of physical symptoms occurred at 42 and 63 dpi concomitantly with suppression of expression of these genes. An increase in the expression level of these genes was observed in both tissues at 3-63 dpi, which correlated with the colonization of roots and promotion of plant growth by *T. harzianum*. These data suggest that FA biosynthetic pathway genes are involved in the defense response of oil palm to infection. Identical plant responses by FA biosynthetic pathway genes may lead to enhanced resistance against *G. boninense* and could be a useful marker to contribute towards early detection of infection. The distinct expression profile during symbiotic interaction demonstrated its role in plant resistance mechanisms and growth promotion by *T. harzianum*.

Cristancho R. J. A., M. M. Hanafi, S. R. Syed Omar, and M. Y. Rafii. 2011. Variations in oil palm (*Elaeis guineensis* Jacq.) progeny response to high aluminium concentrations in solution culture. *Plant Biology*, 13:333-342.

Reference ID: 20504

Notes: #20504e

Abstract: Aluminium (Al) phytotoxicity is an important soil constraint that limits crop yield. The objectives of this study were to investigate how growth, physiology, nutrient content and organic acid concentration is affected by Al, and to assess the degree of Al tolerance in different oil palm progeny (OPP). Four OPPs ['A' (Angola dura x Angola dura), 'B' (Nigerian dura x Nigerian dura), 'C' (Deli dura x AVROS pisifera) and 'D' (Deli dura x Dumpy AVROS pisifera)] were grown in different Al concentrations (0, 100 and 200 μm) in aerated Hoagland solution, pH 4.4, for 80 days. We observed a severe reduction (57.5%) in shoot dry weight, and root tips were reduced by 46.5% in 200 μm Al. In 'B' and 'C', the majority of macro- and micronutrients in plants were reduced significantly by 200 μm Al, with Mg being lowered by more than 50% in roots and shoots. The 200 μm Al treatment resulted in a 56.50% reduction in total leaf area, a 20% reduction in net photosynthesis and a 17% reduction in SPAD chlorophyll value in the third leaf. Root tips (0-5 mm) showed a significant increase in oxalic acid content with increasing Al concentration (similar to 5.86-fold); progeny 'A' had the highest concentration of oxalic acid. There was a significant interaction between Al concentration x OPP on total leaf number, root volume, lateral root length, Mg and K in root and shoot tissues, and Ca and N in shoots. The OPPs could be ranked in their tolerance to Al as: 'A' > 'D' > 'B' > 'C'.

Tan G. Y. and A. Rajaratnam. 1978. Genetic Variability of Leaf Nutrient Concentration in Oil Palm. *Crop Society of America*, 18:548-550.

Reference ID: 20505

Notes: #20505e

Abstract: The objective of this study was to determine the genetic variation of leaf nutrient concentration of eight elements (N, P, K, Mg, Ca, Mn, B, and Cu) and ash content of oil palm (*Elaeis guineensis* Jacq.) leaves from 20 single crosses grown in Malaysia. Measurements of general combining ability for both the paternal and maternal lines were significantly different for N, P, and Cu, while only the paternal lines deviated significantly in Mg and ash content. Specific combining ability was significantly different for K, Mg, Ca, and B. High values of narrow sense heritabilities were obtained for N (0.88 and 0.75) and P (0.97 and 0.78) as measured both parental lines, and for Mg (0.85) by parental lines only. Thus, the major portion of the

total genetic variances for N, P, and Mg were additive. Results from phenotypic and genotypic correlations indicated that the concentration of certain nutrients would simultaneously increase or decrease the concentration of other elements in the leaves. Selection for greater N concentration increased the concentration of P and Cu. Increased Ca also increased the concentration of Mg, Mn, and B. However, Mg, Ca, Mn, and B decreased with increasing concentration of K. High positive correlations were found between the concentration of N and P and yield. Further analysis of yield components revealed that N increased yield through weight of bunches, while P influenced yield through the number of bunches produced. Maximum yield could therefore be expected through simultaneous selection for high concentration of N and P in the leaves. The results also suggested that variation attributed to materials with different genetic backgrounds should be taken into consideration in the interpretation of leaf analysis data for fertilizer recommendation.

Abdul Khalil H. P. S., M. Siti Alwani, and A. K. Mohd Omar. 2006. Chemical composition, anatomy, lignin distribution and cell wall structure of Malaysian plant waste fibers. *BioResources*, 1:220-232.

Reference ID: 20506

Notes: #20506e

Abstract: The chemical composition, anatomical characteristics, lignin distribution, and cell wall structure of oil palm frond (OPF), coconut (COIR), pine-apple leaf (PALF), and banana stem (BS) fibers were analyzed. The chemical composition of fiber was analyzed according to TAPPI Methods. Light microscopy (LM) and transmission electron microscopy (TEM) were used to observe and determine the cell wall structure and lignin distribution of various agro-waste fibers. The results revealed differences in anatomical characteristics, lignin distributions, and cell wall structure of the different types of fibers investigated. Nevertheless, transmission electron microscopy (TEM) micrographs have confirmed that the well wall structure, in each case, could be described in terms of a classical cell wall structure, consisting of primary (P) and secondary (S1, S2, and S3) layers.

Onyeike E. N. and G. N. Acheru. 2002. Chemical composition of selcted Nigerian oil seeds and physicochemical properties of the oil extracts. *Food Chemistry*, 77:431-437.

Reference ID: 20507

Notes: #20507e

Abstract: Proximate composition, energy content and mineral concentrations of oil seeds used in the preparation of Nigerian diets were investigated. The paper also reports the physicochemical characteristics of the oil extracts from the seeds. Moisture content (on dry weight basis) was highest (23.13 +/- 0.44%) in coconut seeds (CNS), followed by palm kernel seeds (PKS) (14.26 +/- 0.35%) but was lowest (4.12 +/- 0.95%) in melon seeds (MS). Ash was highest (3.20 +/- 0.40%) in castor seeds (CS) followed by groundnut seeds (GNS) with a value of 2.77 +/- 0.65% and was lowest (0.43 +/- 0.32%) in CNS. Protein ranged from 6.94 +/- 0.10% in PKS to 26.5 +/- 0.27% in GNS. Dikanut seed (DNS) had the highest crude fat of 62.80 +/- 2.41%, followed by CS (57.33 +/- 1.63%), and the lowest value of 40.83 +/- 0.50% in GNS. Values for MS, oil bean seeds (OBS) and PKS did not differ significantly. Total carbohydrates were generally low in all the seeds and ranged from 12.5 +/- 0.94% in OBS to 26.9 +/- 1.01 % in CNS. The energy content, in kilocalories, per 100g sample, was highest in DNS (688) followed by MS (643) and was lowest in CNS (516). The oil seeds were found to be good sources of minerals. Copper, potassium,

sodium and sulphate were highest in OBS, chloride was highest in PKS; zinc and phosphate were highest in CS while iron ranged from 0.130 +/- 0.001 in GNS to 0.489 +/- 0.001 mg/100 g in CNS. The physical properties of the oil extracts showed the state to be liquid at room temperature (29 +/- 1 degreesC) and the colour to be pale-yellow or golden-yellow, in general. Melting point was highest in MS oil and lowest in PKS oil while setting point was highest in DNS oil, followed by CNS oil and lowest in MS oil (4.67 +/- 0.3 degreesC). Specific gravity ranged from 0.87 in PKS oil to 0.98 in MS oil. Among chemical properties of the oil extracts, acid value, saponification number, iodine number, percent free fatty acid, peroxide value and unsaponifiable matter were, respectively, highest in CS, MS, PKS, CS, DNS/CNS and GNS oils while the lowest values were, respectively, obtained in OBS, CS, GNS, OBS, PKS and OBS oils. It can be inferred that the oil seeds investigated are good sources of crude fat, crude protein, ash, energy and minerals. The oil extracts exhibited good physicochemical properties and could be useful as edible oils and for industrial applications.

Sun C. X., H. X. Cao, H. B. Shao, X. T. Lei, and Y. Xiao. 2011. Growth and physiological responses to water and nutrient stress in oil palm. *African Journal of Biotechnology*, 10:10465-10471.

Reference ID: 20508

Notes: #20508e

Abstract: The research was conducted to detect changes in growth, physiology and nutrient concentration in response to two watering regimes (well-watered and water-stress conditions) and to two nutrient regimes (with or without fertilization) of oil palm. Under stress conditions, changes in plant growth, dry matter allocation, relative water content, leaf relative conductivity, leaf N, P and K concentration are usually observed. These characteristics and related parameters were determined and the experiment results are listed as follows: (1) fertilization promoted the growth of oil palm under well-watered conditions, while under water stress conditions its effects on growth was negative. The ratio of root/shoot was increased under water stress condition; (2) relative water content and chlorophyll a/b content were gradually decreased while leaf relative conductivity was increased quickly under water and nutrient stress conditions during the experiment. It is obvious that water stress had a greater influence than nutrient stress on these parameters; (3) water and nutrient stress decreased leaf nitrogen and phosphorus concentration but increased potassium concentration; the combination of water and nutrient stress made significant effects on nitrogen and phosphorus concentration, but no significant effects on potassium concentration. Moreover, deficiency of both water and nutrients in combination had the greatest impact on changes in these traits of oil palm.

Tanaka S., S. Tachibe, M. E. B. Wasli, J. Lat, L. Seman, J. J. Kendawang, K. Iwasaki, and K. Sakurai. 2009. Soil characteristics under cash crop farming in upland areas of Sarawak, Malaysia. *Agriculture, Ecosystems & Environment*, 129:293-301.

Reference ID: 20509

Notes: #20509e

Abstract: This study discusses soil fertility under perennial cash crop farming (para rubber, *Hevea brasiliensis*; black pepper, *Piper nigrum*; oil palm, *Elaeis guineensis*) conducted by local farmers and an oil palm estate in an upland area of Sarawak, Malaysia, in comparison with the surrounding secondary forests. In the farmlands of the local farmers, rubber farming was conducted without fertilizer application, while 2-5 t ha⁻¹ of NPK compounds were applied annually on pepper farms. Soils under

rubber farming were acidic with poor nutrient contents, resembling soils in secondary forests. In pepper farms, soils were less acidic and showed high nutrient contents, especially with respect to available P and exchangeable Ca. This trend became stronger with increasing farming duration. Fertilizers applied around pepper vines appeared to migrate and spread across the fields. Bulk density and hardness of surface soils were higher in pepper farms than in secondary forests, indicating soil compaction due to field works. In the oil palm estate, annual fertilizer application rates were moderate at 0.4-0.8 t ha⁻¹ of NPK compound fertilizers. However, the soil properties in the oil palm estate were similar to those of the small-scale pepper farms. Close to the bases of the palms where fertilizers usually are applied, the contents of exchangeable Ca and available P were high. Nutrient uptake by the dense root systems of the palms seemed to prevent excessive loss of nutrients through leaching. Loss of soil organic matter and deterioration of soil physical properties were brought about by terrace bench construction, but the soils seemed to recover to some extent over time. In conclusion, technologies such as intercropping and the appropriate allocation of different crops to specific locations as well as the proper selection and dosage of fertilizers should be developed and adopted to improve fertilizer efficiency and prevent water pollution due to fertilizer wash-off from farmlands.

Hayawin Z. N., A. A. Astimar, M. Anis, M. H. Ibrahim, H. P. S. Abdul Khalil, and Z. Ibrahim. 2012. Vermicomposting of empty fruit bunch with addition of palm oil mill effluent solid. *Journal of Oil Palm Research*, 24:1542-1549.

Reference ID: 20510

Notes: #20510e

Abstract: The aim of the present study was to evaluate the quality of the nutrients of the vermicompost produced from oil palm empty fruit bunches (EFB) mixed with palm oil mill effluent (POME) solid employing an epigeic earthworm *Eisenia fetida*. The vermicomposting of EFB and in supplementation with POME solid differed in the resulting C/N ratios. The initial C/N ratios (178.1, 114.5, 153.3, 73.1, 123.1 and 38.6) for the six vermicomposters were significantly reduced to 54.0, 20.1, 19.5, 12.1, 15.5, and 10.5, respectively, after 84 days of vermicomposting. A significant increase in pH, TKN, TP and TK content was recorded in all the vermicomposters (V-1, V-2, V-3, V-4, V5, and V-6). From this study, we can conclude that of the six compositions studied, the best ratio for vermicomposting of EFB with additional POME is V-6 (50% EFB + 50% POME solid).

Amira D. R., A. R. Roshanida, M. I. Rosli, S. F. M. F. Zahrah, J. Mohd Anuar, and N. C. M. Adha. 2011. Bioconversion of empty fruit bunches (EFB) and palm oil mill effluent (POME) into compost using *Trichoderma virens*. *African Journal of Biotechnology*, 10:18775-18780.

Reference ID: 20511

Notes: #20511e

Abstract: This study shows the performance of *Trichoderma virens* as an activator for conversion of empty fruit bunches (EFB) and palm oil mill effluent (POME) into compost. EFB and POME are two abundant wastes produced by oil palm industries which keep accumulating. Since there is no proper way to dispose these wastes, a potential way is to turn them into value-added product which is compost. However, normal composting will take about 4 to 6 months and additional pure fungi on compost can reduce the time to only 21 to 45 days. It also promotes plant growth and fight plant diseases. *T. virens* is one of the potential fungus activator and the

enzyme production by this specific fungus has been studied. Biodegradation of EFB and POME supplemented with *T. virens* and organic N (chicken manure) gave significant changes as compared to EFB and POME alone. Application of *T. virens* resulted in higher xylanase and cellulase activities which lead to rapid degradation of cellulose and hemicelluloses. Compost with *T. virens* has higher xylanase activity on day 36 which is 4.43 $\mu\text{mol}/(\text{min}.\text{mg})$ as compared to the control which has 3.48 $\mu\text{mol}/(\text{min}.\text{mg})$. The cellulase activity is 13.214 FPU/mg and 11.314 FPU/mg for compost with *T. virens* and compost without bioinoculant on day 36, respectively. The N, P, K content of compost with *T. virens* increased significantly after maturation which is 1.304, 0.5034 and 0.645%, respectively. This result shows that *T. virens* played a great role by shortening the composting period of EFB and POME while producing nutrient-enriched compost.

Schuchardt F., K. Wulfert, D. Darnoko, and T. Herawan. 2007. Effect of new palm oil mill processes on the EFB and POME utilisation. Pages 44-57 MPOB, Kuala Lumpur, Malaysia.

Reference ID: 20512

Notes: #20512e

Abstract: New palm oil mill processes are characterized by advanced oil separation technologies with zero dilution water ('ECO-D' for example as a new system for oil recovery without dilution water) and continuous sterilization of the fresh fruit bunch (FFB). These processes have a deep impact on the amount and composition of waste water (POME). Compared to conventional palm oil mills the total amount of palm oil mill effluent (POME) can be reduced from 0.65 $\text{m}^3 \text{ t}^{-1}$ FFB to 0.45 $\text{m}^3 \text{ t}^{-1}$ (conventional sterilization and zero dilution water) and 0.25 $\text{m}^3 \text{ t}^{-1}$ (continuous sterilization and zero dilution water). These changes influence the treatment processes and its cost significantly. One process for the EFB and POME utilization which can fulfil the demand of a sustainable palm oil production is the co-composting of both of the materials. The Composting process is used also for biological drying of the POME. The final product of the process is compost or mulch which unifies the nutrients of both in one product. The POME can be used also for bingos production (in fixed bed reactors for POME with low dry matter content and in totally mixed reactors for ECO-D biomass) before composting. The investment cost and profitability of the composting and fermentation process is calculated in detail based on data from practise in Indonesia. The new developments of processes in palm oil mills can reduce the cost for the waste and waste water treatment up to 35%. The benefits from bingos production and composting are the energy production, saved POME treatment cost in pond systems, total utilization of the POME nutrients, reduced cost for the EFB transport and utilization, higher empty fruit bunch (FFB) yields and from clean development mechanism (CDM).

Chavalparit O., W. H. Rulkens, A. P. J. Mol, and S. Khaodhair. 2006. Options for environmental sustainability of the crude palm oil industry in Thailand through enhancement of industrial ecosystems. *Environ Dev Sustain*, 8:271-287.

Reference ID: 20513

Notes: #20513e

Abstract: The crude palm oil industry plays an important role in the economic development of Thailand and in enhancing the economic welfare of the population. Despite obvious benefits of this industrial development, it also significantly contributes to environmental degradation, both at the input and the output sides of its activities. On the input side, crude palm oil mills use large quantities of water and

energy in the production process. On the output side, manufacturing processes generate large quantities of wastewater, solid waste/by-products and air pollution. Current industrial wastes and recoverable materials are empty fruit bunches, fibers, shells and ash. It is estimated that in 2003, a total of 2.1 million ton of solid wastes/by-products and 2.5 million m³ of wastewater were generated. The concept of the industrial ecosystem points at the potential of industrial waste recycling resembling food chains, food webs and nutrient cycles of nature. Following the notion of industrial ecology crude palm oil mills can develop a number of waste recycling and reuse systems. This paper analyzes the nature of these industrial ecosystems, divided in in-plant ecosystems (clean technology options) and external waste exchange between crude palm oil industries and other economic activities in Thailand.

Singh R. P., M. K. Ibrahim, N. Esa, and M. S. Iliyana. 2010. Composting of waste from palm oil mill: a sustainable waste management practice. *Rev.Environ.Sci.Biotechnol.*, 9:331-344.

Reference ID: 20514

Notes: #20514e

Abstract: Malaysia is blessed with abundant natural resources and bears a favorable climate for commercial cultivation of crops such as oil palm. In Malaysia the total plantation area of oil palm was 4,487,957 ha in 2008. It has been reported that in 2005 there was a total of 423 palm oil mills having production capacity of approximately 89 million tonnes of fresh fruit bunch (FFB) per year. Waste from the oil palm mill process include palm oil mill effluent (POME), generated mainly from oil extraction, washing and cleaning up processes. POME contains cellulosic material, fat, oil, and grease. Discharging untreated effluent into water streams may cause considerable environmental problems. The solid wastes generated are mainly decanter cake, empty fruit bunches, seed shells and fibre from the mesocarp. POME as well as the solid wastes may rapidly deteriorate the surrounding environment if not dealt with properly. Hence there is an urgent need for a sustainable waste management system to tackle these wastes. As these wastes are organic in origin, they are rich in plant nutrients. Composting of waste generated from palm oil mills can be good practice as it will be helpful in recycling useful plant nutrients. This review deals with various aspects of waste management practices in palm oil mills and the possibility of composting the wastes.

Baharuddin A. S., M. Wakisaka, Y. Shirai, S. Abd-Aziz, N. A. Abdul Rahman, and M. A. Hassan. 2009. Co-composting of empty fruit bunches and partially treated palm oil mill effluents in pilot scale. *International Journal of Agricultural Research*, 4:69-78.

Reference ID: 20515

Notes: #20515e

Abstract: The main objective of this study was to investigate the physicochemical changes of the co-composting empty fruit bunch (EFB) with partially treated palm oil mill effluent (POME) in pilot scale. The partially treated POME from anaerobic pond was sprayed onto the shredded EFB throughout the treatment. The composting materials were turned over one to three times per week for aeration. Temperature and oxygen were monitored at different depths of the composting piles. Parameters such as C, N, pH, nutrients, heavy metals and total bacteria count were also determined. The temperature was increased up to 58.5°C at day three of treatment, after that fluctuated between 50 to 62°C and then decreased in the latter stage of the process. The pH of the system (7.75-8.10) did not vary significantly during the

treatment period while moisture content was reduced from 65-75% to about 60% at the end of the treatment. The initial C:N ratio of 45 was significantly reduced to 12 after 60 days of composting. The final cured compost contained a considerable amount of nutrients (carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron) and trace amounts of manganese, zinc, copper. In addition, very low levels of heavy metals were detected in the compost. The number of bacteria involved in the composting process was decreased at the end of the composting period. The results obtained indicated that pilot scale of co-composting EFB with partially treated POME gave acceptable quality of compost and ease in operation. The compost product may be useful in palm oil plantation as fertilizer and soil amendment.

Isaac M. E. and A. A. Kimaro. 2011. Diagnosis of Nutrient Imbalances with Vector Analysis in Agroforestry Systems. *Journal of Environmental Quality*, 40:860-866.

Reference ID: 20516

Notes: #20516e

Abstract: Agricultural intensification has had unintended environmental consequences, including increased nutrient leaching and surface runoff and other agrarian-derived pollutants. Improved diagnosis of on-farm nutrient dynamics will have the advantage of increasing yields and will diminish financial and environmental costs. To achieve this, a management support system that allows for site-specific rapid evaluation of nutrient production imbalances and subsequent management prescriptions is needed for agroecological design. Vector diagnosis, a bivariate model to depict changes in yield and nutritional response simultaneously in a single graph, facilitates identification of nutritional status such as growth dilution, deficiency, sufficiency, luxury uptake, and toxicity. Quantitative data from cocoa agroforestry systems and pigeonpea intercropping trials in Ghana and Tanzania, respectively, were re-evaluated with vector analysis. Relative to monoculture, biomass increase in cocoa (*Theobroma cacao* L.) under shade 935-80%) was accompanied by a 17 to 25% decline in P concentration, the most limiting nutrient on this site. Similarly, increasing biomass with declining P concentrations was noted for pigeonpea [*Cajanus cajan* (L). Millsp.] in response to soil moisture availability under intercropping. Although vector analysis depicted nutrient responses, the current vector model does not consider non-nutrient resource effects on growth, such as ameliorated light and soil moisture, which were particularly active in these systems. We revisit and develop vector analysis into a framework for diagnosing nutrient and non-nutrient interactions in agroforestry systems. Such a diagnostic technique advances management decision-making by increasing nutrient precision and reducing environmental issues associated with agrarian-derived soil contamination.

Isaac M. E., F. Ulzen-Appiah, V. R. Timmer, and S. J. Quashie-Sam. 2007. Early growth and nutritional response to resource competition in cocoa-shade intercropped systems. *Plant and Soil*, 298:243-254.

Reference ID: 20517

Notes: #20517e

Abstract: Intercropping is often promoted for effective mutualism between species, thus compensating for external inputs. However, for optimal farm design resulting in superior production and nutrition, an accurate assessment of plant inter- and intra-specific competition is required. In predominant shade tree-cocoa (*Theobroma cacao*) systems, inconclusive evidence remains on species interactions, limitations to resource availability and subsequent growth and nutritional response, particularly

in early growth. We examined cocoa biomass and foliar nutrition as well as nutrient supply through rates of decomposition and N mineralization after 1-year growth. Our approach employed fertilization and mixed planting treatments in an additive design of cocoa in monoculture (control), under artificial shade, and intercropped under two separate shade species (*Terminalia superba* and *Newbouldia laevis*). Intercropping had no effect on cocoa biomass production in comparison to monoculture cocoa. However, artificial shading stimulated foliage and root production both with and without fertilization, suggesting strong effects of light regulation on growth in the absence of belowground competition. Nutritionally, intercropping suppressed K uptake in cocoa foliage as K concentration was reduced by 20-25%, signifying dilution of this nutrient, presumably due to interspecific competition for mobile elements. Foliar N content under *N. laevis* was raised, where N concentration kept up with growth under this intercropped species. Intercropping also delayed decomposition rates, suggesting slower but sustained release of available nutrients into the topsoil. Cocoa under artificial shade, both with and without fertilization, exhibited the greatest nutrient responses as compared to unfertilized monoculture cocoa, where P uptake was stimulated most (175 and 112%), followed by K (69 and 71%), and then N (54 and 42%). Intercropping with shade trees failed to increase cocoa biomass, however, nutrient uptake was sustained for N and P, suggesting low interspecific competition. When fertilizers are undesirable or unavailable, intercropping of appropriately selected shade trees will not competitively suppress early growth of cocoa but will improve light regulation and nutritional status of cocoa saplings.

Isaac M. E., V. R. Timmer, and S. J. Quashie-Sam. 2007. Shade tree effects in an 8-year-old cocoa agroforestry system: biomass and nutrient diagnosis of *Theobroma cacao* by vector analysis. *Nutr Cycl Agroecosyst*, 78:155-165.

Reference ID: 20518

Notes: #20518e

Abstract: Farm product diversification, shade provision and low access to fertilizers often result in the purposeful integration of upper canopy trees in cocoa (*Theobroma cacao*) plantations. Subsequent modification to light and soil conditions presumably affects nutrient availability and cocoa tree nutrition. However, the level of complementarity between species requires investigation to minimize interspecific competition and improve resource availability. We hypothesized beneficial effects of upper canopy trees on cocoa biomass, light regulation, soil fertility and nutrient uptake. We measured cocoa standing biomass and soil nutrient stocks under no shade (monoculture) and under three structurally and functionally distinct shade trees: *Albizia zygia* (D.C.) Macbr, a nitrogen fixer; *Milicia excelsa* (Welw.), a native timber species; and *Newbouldia laevis* (Seem.), a native small stature species. Vector analysis was employed to diagnosis tree nutrition. Cocoa biomass was higher under shade (22.8 for sole cocoa versus 41.1 Mg ha⁻¹ superscript stopfor cocoa under *Milicia*), and declined along a spatial gradient from the shade tree ($P < 0.05$). Percent canopy openness differed between the three shade species ($P = 0.0136$), although light infiltration was within the optimal range for cocoa production under all three species. Soil exchangeable K was increased under *Newbouldia*, while available P decreased and total N status was unaffected under all shade treatments. Nutrient uptake by cocoa increased under shade (43-80% and 22-45% for N and P, respectively), with K (96-140%) as the most responsive nutrient in these multistrata systems. Addition of low-density shade trees positively affected cocoa biomass close to the shade tree, however proper management of upper stratum trees is required for

optimum cocoa productivity and sustainability.

Chulan H. A. 1991. Effect of fertilizer and endomycorrhizal inoculum on growth and nutrient uptake of cocoa (*Theobroma cacao* L.) seedlings. *Biology and Fertility of Soils*, 11:250-254.

Reference ID: 20519

Notes: #20519e

Abstract: A greenhouse experiment was carried out to evaluate the influence of vesicular-arbuscular mycorrhiza (VAM) on growth and nutrient uptake of cocoa seedlings treated with five levels of palm oil mill effluent, in an unsterilized Oxisol and an Ultisol, either with or without addition of the VAM fungus *Scutellospora calospora* (Nicol. & Gred.) Walker and Sanders. Inoculation with the VAM fungi significantly increased nutrient uptake and plant growth in both soils. The dry matter yield, and the tissue N and K concentration in the plant tops increased significantly with increasing levels of palm oil mill effluent applied to both the Oxisol and the Ultisol. The maximum tissue P concentration, however, was obtained from plants grown in the Ultisol that was given 50.0 g palm oil mill effluent per kg while the maximum P recovery of 26% was obtained from plants given only 16.7 g effluent per kg. Overall, the percentage of P recovery decreased with the addition of increasing levels of palm oil mill effluent. In the Oxisol, the tissue P concentration increased with the addition of increasing levels of palm oil mill effluent, but the maximum recovery of P was recorded from plants given only 0.3 g effluent per kg. The percentage P recovery decreased with subsequent additions of the effluent.

Kahkola A.-K., P. Nygren, H. A. Leblanc, T. Pennanen, and J. Pietikainen. 2012. Leaf and root litter of a legume tree as nitrogen sources for cacaos with different root colonisation by arbuscular mycorrhizae. *Nutr Cycl Agroecosyst*, 92:51-65.

Reference ID: 20520

Notes: #20520e

Abstract: Traditionally cacao (*Theobroma cacao* L.) is cultivated under legume shade trees, which produce N-rich litter that improves soil organic matter content, microbial activity, and recycles N to the crop. Arbuscular mycorrhiza forming fungi (AMF) are known to play an important role in plant nutrient uptake, yet their role in plant N uptake from organic residues in tropical agroforestry systems is not clear. We studied root and leaf litter of the legume shade tree *Inga edulis* Mart. as a source of N for cacao and the importance of AMF colonisation in the uptake of litter N under controlled conditions. Leaf and root litter of *I. edulis* enriched with N-15 was added to cacao pots filled with field soil. Half of the cacao saplings were AMF-inoculated and the soil of non-inoculated saplings was treated with fungicide to suppress AMF. During the 10-week experiment, young cacao leaves were sampled for N-15 analyses and at the end of the experiment whole plants were harvested. Microbial populations in the soil were determined using phospholipid fatty acid (PLFA) analysis, and AMF structures in the roots were quantified. Fungicide treatment decreased AMF structures in roots and increased bacterial populations, but did not affect the decomposition rate of either litter type. Inoculated and non-inoculated cacao saplings used 2.6 and 2.1%, respectively, of N added to the pots in leaf litter and 12.1 and 7.1% of N available in root litter indicating that root litter of *I. edulis* may be a more efficient N source than leaf litter for cacao. Although the fungicide treatment did not completely suppress AMF in non-inoculated pots, it created sufficient contrast in root AMF colonisation for concluding that AMF significantly enhanced cacao N use from both litter types. The role of root litter of shade trees as

a N source in agroforestry should not be neglected.

Isaac M. E., E. O. Adjei, R. N. Issaka, and V. R. Timmer. 2011. A strategy for tree-perennial crop productivity: nursery phase nutrient additions in cocoa-shade agroforestry systems. *Agroforestry Systems*, 81:147-155.

Reference ID: 20521

Notes: #20521e

Abstract: Shade tolerant species response to nutrient additions and light regulation by canopy trees in perennial agroforestry systems has been well documented. However, accelerated early growth, particularly in cocoa-shade systems, may be offset by competition for limited resources on nutrient poor sites. To date, few agroforestry management strategies focus on nutrient manipulation of the shade tree component or strategies for precision nutrient application. Our research objective was to diagnose interactions between nutrient supplied shade trees intercropped with cocoa. We established greenhouse trials in Kwadaso, Ghana cultivating *Terminalia superba* seedlings with four fertility treatment levels: conventional rate (current practices) under linear additions, and half, full and double conventional rate under exponential additions (steady-state nutrition) to determine maximal growth and nutrient uptake. After 4 months of additions in the nursery, pre-fertilized *T. superba* seedlings were then out-planted into field trials with cocoa seedlings. After 4 months of intercropping, cocoa associated with half rate exponentially supplied *T. superba* had significantly larger leaf area, greater leaf number, and higher nutrition (N and P uptake) than cocoa associated with full rate conventionally supplied *T. superba*. This may be attributed to (1) more favorable light conditions under these taller shade seedlings and (2) the internal use of nutrients associated with exponentially supplied *T. superba* seedlings, which lowered stress on native soil resources. The latter is corroborated with our findings on soil fertility status. This strategy focused on reducing fertilizer inputs and developing precise plant nutrition technology for on-farm use. Our findings suggest that shade seedlings under steady state nutrition can mitigate early growth competition in the field.

Baligar V. C. and N. K. Fageria. 2005. Soil aluminum effects on growth and nutrition of cacao. *Soil Science and Plant Nutrition*, 51:709-713.

Reference ID: 20522

Notes: #20522e

Abstract: In acid soils, Al toxicity and nutrient deficiencies are main constraints for low yield of cacao (*Theobroma cacao* L.). A controlled growth chamber experiment was conducted to evaluate the effect of three Al saturations (0.2, 19, and 26%) adjusted by addition of dolomitic lime on growth and nutrient uptake parameters of cacao. Overall, increasing soil Al saturation decreased shoot and root dry weight, stem height, root length, relative growth rate, and net assimilation rate. However, increasing soil Al saturation increased leaf area, specific leaf area (total leaf area/total leaf dry wt), and leaf area ratio (total leaf area/ shoot+root wt). Increasing soil Al saturation decreased uptake of elements. Nutrient influx (IN) and transport (TH) decreased significantly for K, Ca and Mg, and showed an increasing trend for S and P as soil Al saturation increased. However, increasing soil Al saturation significantly increased nutrient use efficiency ratio (ER, mg of shoot weight produced per mg of element in shoot) of Ca, Mg and K and decreased ER for other elements. Reduction of soil acidity constraints with addition of lime and fertilizers appear to be key factors in improving cacao yields in infertile, acidic, tropical soils.

Ribeiro M. A. Q., J. O. da Silva, W. M. Aitken, R. C. R. Machado, and V. C. Baligar. 2008. Nitrogen use efficiency in cacao genotypes. *Journal of Plant Nutrition*, 31:239-249.

Reference ID: 20523

Notes: #20523e

Abstract: Cacao (*Theobroma cacao* L.) is mostly grown on soils with low natural fertility. On such soils nitrogen (N) is one of the most yield limiting nutrients for cacao. Information is lacking on N use efficiency in cacao. A greenhouse experiment was conducted to evaluate growth response and N use efficiency by two cacao genotypes. The genotypes used were TSH-565 and ICS-9 and N rates adapted were 0, 120, 240, 360, and 480 mg N /pot. In both genotypes, increasing levels of applied N improved growth (stem girth, dry weight of shoot and roots and shoot/root ratio), and concentration and uptake of N. Genotypes differed significantly for stem girth and ICS -9 produced greater stem girth compared with TSH-565. Nitrogen uptake had a linear relationship with root dry weight of the two genotypes. In both genotypes, increasing levels of applied N overall increased N-uptake efficiency (NEFF = N concentration in shoot x shoot/root), but decreased N-use efficiency by shoot and roots (NUE = g dry matter of shoot or root/mg N) and N-use efficiency of carbohydrate (NUEC = mg of total carbohydrates in shoot/mg of N in shoot). Both genotypes responded differently to applied N, despite the existence of close genetic relatedness between them. The method used here appears to be suitable method for identification of cacao genotypes that are efficient in uptake and utilization of N.

Smiley G. L. and J. Kroschel. 2010. Yield development and nutrient dynamics in cocoa-gliricidia agroforests of Central Sulawesi, Indonesia. *Agroforestry Systems*, 78:97-114.

Reference ID: 20524

Notes: #20524e

Abstract: In the Napu and Palolo Valleys of Central Sulawesi, Indonesia, a chronosequence sought to identify the relationship between tree age, nutrient dynamics and cocoa (*Theobroma cacao* L.) yield in association with gliricidia (*Gliricidia sepium* (Jacq.) Steud.). The chronosequence surveyed cocoa-gliricidia plantations with a maximum age of 8 and 15 years, respectively, in Napu and Palolo. The characteristics of the valleys were also quite different, with an altitude of 1,139-1,166 m a.s.l. in Napu and 592-651 m a.s.l. in Palolo. Annual rainfall was 1,543 mm in Napu and 1,811 mm in Palolo. The yield of cocoa increased fairly steadily, with growth rates higher in Palolo than in Napu. Whereas a higher level of bean P led to a higher single bean weight (g d.w.) in Napu, a higher level of bean K led to a lower single bean weight in Palolo. The relatively high level of K appeared to have coincided with immature growth stages of cocoa. As trees matured, their increased rate of C assimilation was seen in the form of higher single bean weight. We found no statistically significant change in the soil's carbon-nutrient levels when viewed over the entire timeframe of 8 and 15 years in the 2 valleys. In addition, there was no correlation between the soil's carbon-nutrient levels and the single bean weight. Nor did we find any correlation between the soil's carbon-nutrient levels impacting the bean's carbon-nutrient levels. Of regression lines, P had the steepest slope and was considered the most limited nutrient relative to the other nutrients although its correlation was insignificant. The farmers' estimation of cocoa yield was about 68% less than our measured bean weight per area per year (kg d.w. ha⁻¹ year⁻¹), implying a more refined definition of ripeness. In a cocoa agroforest, income could be supplemented by durable tree crops instead of growing gliricidia which is

removed after several years of growth. This removal and the shallow rooting of cocoa indicate that the cocoa production would be sustainable only in the immediate future.

Kass D. C. L., R. Sylvester-Bradley, and P. Nygren. 1997. The role of nitrogen fixation and nutrient supply in some agroforestry systems of the Americas. *Soil Biology & Biochemistry*, 29:775-785.

Reference ID: 20525

Notes: #20525e

Abstract: There are a large number of agroforestry systems practiced in the Americas in which nitrogen-fixing trees are used to supply nitrogen and organic matter as well as to make other contributions to improve growth conditions for non-nitrogen-fixing components, including annual crops, perennial crops or animals. These systems can be divided into traditional systems, whose origins were before the European conquest of the Americas, natural systems which may have existed previous to human occupation of the Americas about 20 000 years ago, and systems devised by agricultural scientists in the last 100 years. An attempt is made to evaluate nitrogen fixation and the source of nutrients in over 10 such traditional and synthetic systems. Controlled experiments over a sufficient time to establish an accurate picture of nitrogen fixation and decomposition of organic residues generally are lacking. Systems with low nutrient removal, in which trees are allowed to grow for long periods without being pruned, would be expected to make greater contributions to the improvement of soil conditions. Measurements from systems such as shaded plantations and alley farming, in which trees are frequently pruned and rates of removal of nutrients is high, generally show only a slow buildup of nitrogen, soil organic matter, levels of available nutrients and improvements in soil physical conditions. Perhaps nonequilibrium conditions from pruning, burning and nutrient removal in crops lead to faster accumulation of nutrients through nitrogen fixation and other processes characteristic of "stressed" systems. The success of agroforestry systems may be favored by the maintenance of such nonequilibrium conditions.

Adejuwon J. O. and O. Ekanade. 1988. A comparison of soil properties under different landuse types in a part of the Nigerian cocoa belt. *Journal of Soil Science-Hydrology-Geomorphology*, 15: 319-331.

Reference ID: 20526

Notes: #20526e

Abstract: The changes that take place in topsoil properties after the tropical rain forest has been replaced by fallow (resulting from food crops cultivation) and tree crops are considered in a part of southwestern Nigeria known for the cultivation of food crops, cocoa and kola on separate plots. The study clearly shows that water holding capacity, organic matter content, total nitrogen, calcium, magnesium and cation exchange capacity (C.E.C.) under fallow, cocoa and kola differ significantly from those under forest. These results indicate that once the tropical rainforest is removed the soil-vegetation system is disrupted significantly. The study also shows that water holding capacity, calcium, potassium and C.E.C. are significantly different between fallow and the tree crops while no soil property differs significantly between cocoa and kola. These results serve to show that under fallow soil appears better protected than under cocoa and kola while the latter tree crops could be deemed to be similar in their absorption pattern of soil nutrients. The reasons for these significant differences are discussed.

Hartemink A. E. 2005. Nutrient Stocks, Nutrient Cycling, and Soil Changes in Cocoa Ecosystems: A Review. *Advances in Agronomy*, 86:227-253.

Reference ID: 20527

Notes: #20527e

Abstract: It is generally assumed that agricultural systems with perennial crops are more sustainable than systems with annual crops. Soil erosion is negligible and perennial crops have more closed nutrient cycling. Moreover, inorganic fertilizers are used more commonly in cash crops such as perennial crops so that soil fertility decline and nutrient mining are less likely to occur. In the past decades, considerable research has been devoted to the quantification of nutrient stocks and nutrient cycling in agro-ecosystems. This article reviews the main stocks and flows of nutrients in cocoa ecosystems for several cocoa-growing regions in the tropics. Most of the nitrogen is found in the topsoils, and less than 10% of the total N stock is in the cocoa and shade trees. Nitrogen in the annual litter fall is about 20 to 45% of the total N in the vegetation and 2 to 3% of the total N in the soil. The accumulation of potassium is low in cocoa ecosystems, and in most systems the total amount in the biomass is equivalent to the available P content in the topsoil. Phosphorus in the annual litter fall is about 10 to 30% of the total P in the vegetation and 10 to 40% of the available P in the soil. Potassium is a major nutrient in mature cocoa. Stocks of exchangeable K in the topsoil vary from 100 to 550 kg ha⁻¹, and high K levels in the soil correspond to high K levels in the vegetation and litter. Partial nutrient balances were calculated that compares the losses, addition, and transfer of N, P, and K. The nutrient balance is negative in the absence of inorganic fertilizers, especially for K. Rainwash and litter fall are key components in the cycling of nutrients of cocoa ecosystems. The amount of nutrients transferred by rainwash is less than 8 kg ha⁻¹ for N and P but varies from 38 to more than 100 kg ha⁻¹ year⁻¹ for K. Most soils under cocoa had a lower fertility when compared to primary forest, although soil chemical properties seem to settle at equilibrium levels. This review shows that large amounts of nutrients in cocoa ecosystems are transferred each year and that such nutrient cycling is essential for maintaining cocoa production.

Espinosa, J., Mite, F., Cedeno, S., Barriga, S., and Andino, J. GIS-Based Site-Specific Management of Cocoa. *Better Crops With Plant Food* 90[1], 36-39. 2006. IPNI.

Reference ID: 20528

Notes: #20528e

Abstract: Two goals of site-specific management are to describe the spatial variability of nutrients at the field-scale and design management practices most suited to that landscape. The characteristics of established cocoa plantations often make this a challenging task.

Ndufa J. K., K. D. Shepherd, R. J. Buresh, and B. Jama. 1999. Nutrient uptake and growth of young trees in a P-deficient soil: Tree species and phosphorus effects. *Forest Ecology and Management*, 122:231-241.

Reference ID: 20529

Notes: #20529e

Abstract: Phosphorus deficiency is widespread in the subhumid highlands of eastern Africa but there are few data on the effect of P deficiency on the growth of agroforestry tree species. We studied the effect of P application on growth, nutrient uptake and dry matter partitioning in young trees of *Calliandra calothyrsus*, *Cedrela serrulata*, *Eucalyptus grandis*, *Grevillea robusta*, *Markhamia lutea*, *Senna*

spectabilis, and *Sesbania sesban* on a P-deficient soil (Kandiudalfic Eutrudox, bicarbonate-EDTA extractable $P=1\text{mgkg}^{-1}$) in western Kenya. The trees were grown at two P levels (control and $500\text{kg added Pha}^{-1}$) at 1m^2 spacing in a randomized complete block design with three replications. Leaf K concentrations were in the low range for all species ($5\text{--}9\text{mgg}^{-1}$) and K deficiency may have limited responses to P. Averaged over species, P addition increased aboveground shoot dry matter by a factor of 2.6 at 62 and 124 days, but the response decreased to 1.3 at 325 days. The increases at 62 days were large in sesbania (5.4) and eucalyptus (3.2) but small in calliandra (1.4) and markhamia (1.1). Relative response to P was more strongly correlated with shoot growth rate per unit root length among species than with shoot growth rate alone. Calliandra, which had high early growth rate but low response to added P, had an exceptionally high root length (6.0kmm^{-2}) compared with the other species ($0.3\text{--}2.1\text{kmm}^{-2}$). P addition increased N and P content but decreased final shoot K content in sesbania and calliandra, and had little effect on K content in the other species. The high-yielding species (eucalyptus, sesbania and calliandra) accumulated more than 30g N and 2g Pm^{-2} in shoots in 325 days of growth. The proportion of total shoot N in wood (branch+stem) was in a higher range (67–75%) in the shrubby species (sesbania, calliandra, senna) than in the upperstorey tree species (38–43%). Slow early shoot growth relative to total root length, and high specific root length (root length per unit root mass) are proposed as criteria for the selection of species and provenances that are well adapted to P deficient soils.

Dawoe E. K., M. E. Isaac, and S. J. Quashie-Sam. 2010. Litterfall and litter nutrient dynamics under cocoa ecosystems in lowland humid Ghana. *Plant and Soil*, 330:55-64.

Reference ID: 20530

Notes: #20530e

Abstract: There have been few studies quantifying litterfall, standing litterstock and gross litter decomposition following forest conversion to plantation crops such as cocoa. Additionally, an assessment of changing processes occurring in forest floor litter systems with plantation age is lacking. We investigated litterfall production, standing litter changes and litter decomposition along a chronosequence of shaded cocoa farm fields (secondary forest, 3, 15 and 30-year-old) in the moist semi-deciduous forest belt in the Ashanti Region of Ghana in West Africa over 24 months. Mean annual litterfall production differed significantly among study sites and ranged from 5.0 to 10.4Mg DM ha^{-1} . Similarly, standing litter differed significantly between land-use /plot ages. The results showed significant differences in quality between litter from forest and litter from cocoa plantations. Litterfall from forests had higher concentrations of nitrogen and lower concentration of soluble polyphenols and lignin compared to litter from cocoa systems. Monthly decomposition coefficients (k) estimated as $\frac{\Delta L}{L_0}$, where A is litterfall production during the month, L_0 is the standing litterstock at the beginning of the month and L_1 is the standing litterstock at the end of the month. Annual decomposition coefficients (k_L) were similar in cocoa systems ($0.221\text{--}0.227$) but higher under secondary forests (0.354). Correlations between litter quality parameters and the decomposition coefficient showed nitrogen and lignin concentrations as well as ratios that include nitrogen are the best predictors of decomposition for the litters studied. Our results confirm the hypothesis that decomposition decreases following forest conversion to shaded cocoa systems because of litter quality changes and that decomposition rates correlate to litter quality differences between forest and cocoa ecosystems. The study also showed that standing litter pools and litterfall production in recently converted cocoa

plantations are low compared to secondary forests or mature cocoa systems. Management strategies involving the introduction of upper canopy species during plantation development with corresponding replacement of tree mortality with diverse fast growing species will provide high quality and quantity litter resources.

Cuenca G., R. Herrera, and E. Meneses. 1990. Effects of VA mycorrhiza on the growth of cacao seedlings under nursery conditions in Venezuela. *Plant and Soil*, 126:71-78.

Reference ID: 20531

Notes: #20531e

Abstract: The effects of vesicular-arbuscular mycorrhizae inoculation on the growth of cacao seedlings (*Theobroma cacao* var. *Ocumare 60*) grown for 5 months in a nursery were studied. The effects of introduced VAM fungi (*Glomus occultum*, *Acaulospora appendicula*, *Glomus manihotis*, *Acaulospora morrowae* and *Scutellospora pellucida*) in soils treated with copper oxychloride or methyl bromide, were compared with the indigenous VAM and with their respective non-inoculated controls. Cacao seedlings responded well to indigenous VAM fungi, which included *Scutellospora calospora* as the dominant species, inducing increases significant in height, dry weight and foliar uptake of P, Cu and Zn in relation to the sterile control. *G. occultum* and *A. appendicula* increased the height of cacao seedlings but to an extent not yet statistically significant through the duration of the experiment. *S. pellucida* and *A. appendicula* doubled the phosphorus uptake of cacao seedlings. The methyl bromide sterilization induced the lowest Cu and Zn uptake in the cacao seedlings but this effect was ameliorated with VAM inoculation. Manifest deficiency symptoms were not observed in the treatments. Copper oxychloride treatment depressed growth to the same level as the sterile control although its residual effects did not kill VAM. It could change the competitive relations among the VAM species and in this case seemed to affect adversely the more efficient native fungi. The influence of the presence and long permanence of large cotyledons in cacao on the results obtained is discussed.

Kummerow J., M. Kummerow, and W. Souza Da Silva. 1982. Fine-root growth dynamics in cacao (*Theobroma cacao*). *Plant and Soil*, 65:193-201.

Reference ID: 20532

Notes: #20532e

Abstract: Fine-root density in a mature cacao plantation in Bahia/Brazil was monitored at weekly intervals from October, 1980 until March, 1981. About 40 g m⁻² of fine roots (diameter < 1 mm) were found during this period. The relative stability of this value over the six months period contrasted with significant changes in the number of growing root tips per unit of soil volume. These changes were not conditioned by the rainfall pattern although low root tip values were counted at the end of a minor drought period. A significant negative correlation was found between a shoot growth flush in January and the activity of the fine-root system as measured by the number of new root tips.

Baligar V. C., J. A. Bunce, B. A. Bailey, R. C. Machado, and A. W. V. Pomella. 2005. Carbon dioxide and photosynthetic photon flux density effects on growth and mineral uptake of cacao. *Journal of Food, Agriculture & Environment*, 3:142-147.

Reference ID: 20533

Notes: #20533e

Abstract: In recent years, carbon dioxide concentration [CO₂] in the atmosphere has

risen to $370 \mu\text{mol mol}^{-1}$, with levels expected to double by the end of the 21st century. A climatically-controlled greenhouse experiment was undertaken to assess the influence of $[\text{CO}_2]$ and photosynthetic photon flux density (PPFD) on the growth, mineral nutrient uptake and mineral nutrient use efficiency parameters of cacao (*Theobroma cacao* L) in its early growth stages. Plants were grown in two greenhouses and maintained at two levels of $[\text{CO}_2]$ (380 and $700 \mu\text{mol mol}^{-1}$). In each greenhouse, three levels of PPFD (65, 190, $1050 \mu\text{mol m}^{-2} \text{s}^{-1}$) were achieved by constructing mini shade frames covered with various layers of plastic shade cloth. Plants were grown for 57 days. At all levels of PPFD, with few exceptions, increasing $[\text{CO}_2]$ tended to increase shoot and root growth parameters (dry wt. of roots, stem and leaves, stem height, leaf area, shoot/root ratio, leaf area ratio and relative growth rate). At both $[\text{CO}_2]$, increasing PPFD from 65 to $190 \mu\text{mol m}^{-2} \text{s}^{-1}$ increased shoot and roots growth, relative growth rate and net assimilation rate. At both $[\text{CO}_2]$, PPFD of $1050 \mu\text{mol m}^{-2} \text{s}^{-1}$ was detrimental to growth and to mineral nutrient uptake parameters; however, its effects were more severe at 380 than $700 \mu\text{mol mol}^{-1}$ of $[\text{CO}_2]$. At all PPFD with few exceptions, increasing $[\text{CO}_2]$ increased the uptake of all mineral nutrients. With some exceptions, at both $[\text{CO}_2]$ levels increasing PPFD increased nutrient influx (IN) for Na, B, Mn and Zn and decreased IN for other mineral nutrients. With some exceptions, at both $[\text{CO}_2]$ levels increasing PPFD decreased nutrient transport (TR) for Na and S and increased TR for Mg, B, and Zn only. At both $[\text{CO}_2]$ with the exception of nutrient use efficiency ratio (ER) for B, increasing PPFD increased ER for N, Na, S and Zn and decreased ER for other mineral nutrients. At all PPFD levels, with few exceptions, overall, increasing $[\text{CO}_2]$ increased ER for N, Na, Mg, Cu, Mn and Zn and decreased ER for other mineral nutrients. Growth, mineral nutrient uptake parameters and nutrient use efficiency ratios in cacao were influenced by $[\text{CO}_2]$ and PPFD. Overall, PPFD of $190 \mu\text{mol m}^{-2} \text{s}^{-1}$ appears to be a desirable light intensity and combined with increasing $[\text{CO}_2]$ are beneficial in improving cacao growth and mineral nutrient uptake and use efficiency.

Santana M. B. M. and P. Cabala-Rosand. 1982. Dynamics of nitrogen in a shaded cacao plantation. Plant and Soil, 67:271-281.

Reference ID: 20534

Notes: #20534e

Abstract: Studies of nitrogen mineralization and leaching were conducted in the cacao-growing region in the south of Bahia, Brazil, on plots fertilized with N, P and K and on plots without fertilizer in plantations 3~40 yrs old on CEPEC soil (Tropudalf) over a period of one year. Mini-lysimeters were installed at depths of 10, 20 and 40 cm and the leachate was collected weekly or after heavy rain. Net mineralization was measured in soil samples taken at depths of 0-5 and 5-15 cm and incubated for 30 days in plastic bags placed at the site of collection. The degree of leaching was correlated with the amount of rainfall and, although it is difficult to quantify the losses per unit area, we estimate that these losses are minor. Ammonification and nitrification were both high during most of the year; nitrification was very rapid and was especially intensive on the fertilized area. Analyses of Erythrina and cacao litter show that these components make a considerable contribution to the nitrogen recycled in a cacao plantation. High concentrations of total nitrogen were detected in soil samples taken close to shade trees and, on average, the soil of shaded areas had more than $480 \text{ mg N kg soil}^{-1}$ than soil of non-shaded areas. Removal of nitrogen in harvest can also be considerable. It is advisable to take nitrogen-cycle data into account when compiling tables of fertilizer recommendations.

Aikpokpodion P. E. 2010. Nutrients Dynamics in Cocoa Soils, Leaf and Beans in Ondo State, Nigeria. J Agri Sci, 1:1-9.

Reference ID: 20535

Notes: #20535e

Abstract: Soil samples, young but matured foliage and Cocoa beans were collected from the farms of some Cocoa farmers across Idanre, Owena and Bamikemo in Ondo State. Samples were prepared according to standard procedure and analyzed chemically in the laboratory to determine the nutrient status of the samples. Result showed that the soils were deficient in Magnesium and Phosphorus. Foliar samples had some of the vital nutrients below critical level. Potassium was found limiting in the foliage which is at variance with K content in the soil. The findings showed that, old cocoa soils in the studied area were depleting in some vital soil nutrients which is a consequence of continuous mining of nutrient from the soil by cocoa without replacement. Result also showed that, leaf litter may not be sufficient to replace the lost nutrient. However, to correct the nutrient deficiency in the investigated soils for optimal Cocoa yield and quality, farmers within the area investigated need to adopt the use of inorganic fertilizer which must be applied according to recommendation.

Ahenkorah Y. 1975. Use of radio-active phosphorus in determining the efficiency of fertilizer utilization by cacao plantation. Plant and Soil, 42:429-439.

Reference ID: 20536

Notes: #20536e

Abstract: Both P^{32} labelled phosphate solution and superphosphate were used in studying (1) *in situ* root distribution and activity of 20 year old Amelonado cacao (*Theobroma Cacao* L.) during wet and dry seasons and (2) the efficiency of fertilizer utilization by the cacao plantation. The P^{32} content of the leaves was used to determine patterns of root activity. Uptake of P^{32} was greatest during the wet season and root activity highest within the upper 3 cm soil layer in both wet and dry season. Highest P^{32} activity was obtained at a distance of 120–160 cm and lowest at 91 cm from the base of the tree. For maximum utilization of phosphate fertilizer by a plantation of 20 year old Amelonado cacao, planted at 240 cm \times 240 cm spacing, the fertilizer should be broadcast during the wet season. Under low soil moisture conditions, the placement of P^{32} labelled superphosphate provides information on relative availability of the fertilizer or soil phosphorus and does not necessarily reflect the activity of the root profile. Active roots of cacao tend to be more extensive and are capable of exploring a much larger area than hitherto expected.

Murray, D. B. Response of cacao to fertilizers. Nature 182[4649], 1613. 12-6-1958.

Reference ID: 20537

Notes: #20537e

Acquaye D. K. 1963. Some significance of soil organic phosphorus mineralization in the phosphorus nutrition of cocoa in Ghana. Plant and Soil, XIX:65-80.

Reference ID: 20538

Notes: #20538e

Abstract: 1. Soil samples from a 22 NP:KMg factorial experiment, in which yield response of cocoa to NP was highly correlated to organic phosphorus content of the 0–2_ layer, were studied. 2. It was found that the organic phosphorus content ranged from 46.0 to 69.5 per cent of the total phosphorus and was correlated to the percentage total nitrogen, total phosphorus, organic carbon and pH. 3. Incubation of the soils at 50 per cent of their water holding capacity and a temperature of 27°C for

periods of 14, 28, 42, 56, and 70 days resulted in the average mineralization of organic phosphorus equivalent to 4.0, 13.6, 38.2, 50.0, and 54.0 pounds P per acre respectively. 4. More organic phosphorus was mineralized at 50°C than at 27°C or 40°C. 5. The percentage of organic phosphorus mineralized was generally higher in the plots where NP had been applied. 6. Laboratory application of nitrogen or phosphorus to the soils before incubation resulted in greater mineralization. The effect of nitrogen and phosphorus together was greater than in the presence of nitrogen alone but only in a few cases was it greater than in the presence of phosphorus alone. The effect of nitrogen and phosphorus was not additive. 7. It is concluded that although the organic phosphorus increased in the NP-treated plots, increased mineralization occurred concurrently; and the effect of nitrogen and phosphorus application in increasing the mineralization of the soil organic phosphorus during laboratory incubation explained the high correlation found between cocoa yield response and organic phosphorus content of the top soil.

Ibiremo O. S., O. O. Oduwole, J. A. Fagbayide, and B. A. Nduka. 2011. Effect of Root Mat Management and Phosphorus Fertilizer Application on the Field Establishment of Cocoa in Ondo State, Nigeria. *Libyan Agriculture Research Center Journal International*, 2:259-264.

Reference ID: 20539

Notes: #20539e

Abstract: A study was carried out to evaluate the effect of root mat management and P-fertilizer application on the field establishment of cocoa in Ondo State, Nigeria. Six treatment combinations were formed from two levels of root mat treatments (with and without root mat) and three types of phosphate fertilizer application (no P, Single Super phosphorus and Sokoto Rock Phosphate). The root mat management (treatments) and phosphate fertilizer application were done during cocoa seedling transplanting. The treatments were arranged in a RCBD with three replications. The height, stem diameter, number of leaves and leaf area of the transplanted cocoa Seedlings were regularly taken on a monthly basis. Seedlings with root mat intact (not removed) significantly ($p < 0.05$) consistently enhanced the height of cocoa seedlings at 3, 6, 9, 12 and 15 months after transplanting (MAT). Similarly, the stem diameter of cocoa seedlings at 3 MAT was significantly improved as a result of nonremoval of root mat. However, the influence of root mat removal on the stem diameter of cocoa seedlings was not consistently higher than those with root mat intact at 6 and 9 MAT, it gave higher stem diameter through 12 and 15 MAT. Root mat removal did not significantly affect the number of leaves and leaf area of the cocoa seedlings throughout the period of study. P-fertilizer application did not show significant effect on the various growth parameters of cocoa seedlings throughout the period of study. Similarly, the pH, organic carbon and the level of available P accumulation of the soil were not significantly affected by phosphate fertilizers and root mat management. It can be concluded that the extra effort of removing the root mat of cocoa seedlings before transplanting and application of phosphate fertilizer did not confer any advantage in terms of growth on the transplanted cocoa seedlings on the field.

IPNI. Better crops with plant food Vol.98 (2014, No.3). Better Crops With Plant Food 98[3], 1-27. 2014. IPNI.

Reference ID: 20540

Notes: #20540e

Hang X., X. Zhang, C. Song, Y. Jiang, A. Deng, R. He, M. Lu, and W. Zhang. 2014. Differences in rice yield and CH₄ and N₂O emissions among mechanical planting methods with straw incorporation in Jianghuai area, China. *Soil & Tillage Research*, 144:205-210.

Reference ID: 20541

Notes: #20541e

Abstract: Mechanical planting is replacing manual transplanting in the major Asian rice cropping areas, however, few are known about the impacts of mechanical planting on rice yield and greenhouse gas (GHG) emission. Therefore, a two-year experiment was conducted to examine the impacts of dry direct-seeding (MDS), wet direct-seeding (MWS) and transplanting (MTP) in Jianghuai area, China. The results showed that CH₄ emission was significantly lower in the MDS than the MWS and MTP both with and without straw incorporation. No significant difference in N₂O emission was found among the planting methods. Straw incorporation significantly stimulated CH₄ emission in the MWS and MTP, but not in the MDS. The lowest rice yield was found in the MWS, while there was no significant difference in grain yield between the MDS and MTP methods. The area-scaled emission of CH₄ and N₂O in CO₂-equivalent unit was respectively 78.5 and 89.6% lower in the MDS than those in the MWS and MTP without straw incorporation, and 87.7 and 94.1% lower with straw incorporation. The yield-scaled emission was correspondingly 80.4 and 88.1% lower without straw incorporation, and 89.0 and 93.4% lower with straw incorporation, respectively. Our results indicate that MDS can get an acceptable yield with a large reduction in GHGs emissions in the test location.

Marhalil M., M. Y. Rafii, M. M. A. Afizi, I. W. Arolu, A. Noh, A. Mohd Din, A. Kushairi, A. Norziha, N. Rajanaidu, M. A. Latif, and M. A. Malek. 2013. Genetic variability in yield and vegetative traits in elite germplasm of MPOB-Nigerian *dura* × AVROS *pisifera* progenies. *Journal of Food, Agriculture & Environment*, 11:515-519.

Reference ID: 20542

Notes: #20542e

Abstract: Genetic variability study on vegetative and yield traits was carried out through long-term evaluation of eleven MPOB-Nigerian *dura* × AVROS *pisifera* (D×P) progenies at MPOB (Malaysian Palm Oil Board) research station located in Kluang, Johor, Malaysia. The D × P progenies were laid out in randomized complete block design in two blocks with 352 oil palm plants occupying a total area of 2.59 hectares. Data on both vegetative and yield traits such as plant height (HT), leaflet number (LN), leaflet length (LL), leaflet width (LW), rachis length (RL), petiole cross-section, leaf area (LA), leaf area index (LAI), fresh fruit bunch (FFB), average bunch weight (ABW), oil yield (OY), kernel yield (KY), mesocarp to fruit (MTF), kernel to fruit (KTF), oil to bunch (OTB), kernel to bunch (KTB) were collected over the years following the standard method. Analysis of variance of the data showed a significant variation among the progenies performance for both vegetative and yield traits, revealing their differences in their genetic origin. Also significant differences were observed for G×R interactions in all the traits collected except for PCR, KPY and ABW. The progenies plant height ranges from 1.53 (PUP1328) to 2.26 m (PUP1328). Also among the traits is PCS with highest value found in progeny PUP 1174 (32.16 cm²), while the lowest reading was found in PUP 1358 (20.54 cm²). The fresh fruit bunch weight for the progenies ranged from 121.03 to 175.16 kg/ palm/yr. Progeny PUP 1303 was found to have the highest value for FFB (175.16 kg/palm/yr), KPY (7.9 kg/palm/yr) and OPY (38.87 kg/palm/yr). From the correlation study, it was found that FFB, which is the most important yield trait, was positive and highly

significant with all other yield and vegetative traits except for MTF, KTF, OTB and KTB where the association was non-significant. In this study, great variability has been found to be present among these progenies and this will be of immense benefit for improvement program. Progeny PUP 1303 and PUP 1246 have been identified as the potential parent and they have been selected for further evaluation trial.

Ginting E. N., A. Sutandi, B. Nugroho, L. T. Indriyati, and H. Santoso. 2013. Diagnosis keseimbangan hara N, P, K, Ca, Mg daun tanaman kelapa sawit (*Elaeis guineensis* Jacq.) dengan menggunakan metode DRIS (Diagnosis and Recommendation Integrated System). J.Pen.Kelapa Sawit, 21:22-30.

Reference ID: 20543

Notes: #20543e < S 8.1.1 #20544

Abstract: Diagnosis and recommendation integrated system (DRIS) merupakan salah satu metode untuk mendiagnosis status dan keseimbangan hara tanaman berdasarkan hasil analisis jaringan tanaman. Metode DRIS memiliki banyak kelebihan dibandingkan metode diagnosis lainnya, salah satunya adalah kemampuannya untuk mengurutkan hara berdasarkan yang hara paling ditubuhkan tanaman. penelitian ini bertujuan untuk mengetahui keseimbangan hara daun untuk tanaman kelapa sawit. Penelitian menggunakan metode survei eksplorasi dengan mengumpulkan data hasil analisis daun dan data produksi kelapa sawit dari beberapa perkebunan kelapa sawit yang ada di Indonesia. Hasil penelitian menunjukkan nilai kisaran nisbah hara yang dinaggap seimbang adalah 14.87-16.98 untuk rasio hara N/P; 2.31-2.76 untuk rasio hara N/K; 3.52-4.21 untuk rasio hara N/Ca; 8.97-11.28 untuk rasio hara N/Mg; 5.86-6.84 untuk rasio hara K/P; 3.81-4.53 untuk rasio hara Ca/P; 1.42-1.81 untuk rasio hara Mg/P; 1.36-1.75 untuk rasio hara K/Ca; 3.52-4.57 untuk rasio hara K/Mg dan 2.31-2.99 untuk rasio hara Ca/Mg. Dari total 2.705 sampel yang diamati, hara P merupakan hara yang paling banyak memiliki nilai indeks DRIS negatif yaitu sebanyak 60%, sementara hara Mg merupakan hara yang paling sedikit memiliki nilai indeks DRIS negatif yaitu hanya sekitar 28% dari keseluruhan data yang diamati. Hara yang memiliki nilai indeks DRIS negatif menunjukkan hara tersebut berada dalam kondisi kekurangan secara relatif terhadap hara yang lainnya, sementara nilai indeks DRIS hara yang positif mengindikasikan hara tersebut berada pada kondisi yang relatif berlebih. Untuk hara yang memiliki nilai indeks DRIS negatif maka dosis pupuk untuk hara tersebut perlu dinaikkan dari dosis sebelumnya, sebaliknya bila indeks DRIS suatu hara bernilai positif maka dosis pupuk untuk hara tersebut perlu dikurangi dari dosis pemupukan sebelumnya.

IOPRI. Jurnal Penelitian Kelapa Sawit. Jurnal Penelitian Kelapa Sawit 21[1], 1-48. 2013. Medan, Indonesia.

Reference ID: 20544

Notes: S 8.1.1 #20544

Wan Daud W. N. 2013. Rubber plantation soil management & nutritional requirement, Universiti Putra Malaysia Press, Serdang, Selangor.

Reference ID: 20545

Notes: S 8.1.2 #20545

UPM 2011. Recent advances in crop science Vol.1, Universiti Putra Malaysia Press, Serdang, Selangor.

Reference ID: 20546

Notes: S 8 #20546

Low E.-T. L., H. Alias, S. H. Boon, E. M. Shariff, C.-Y. A. Tan, L. C. L. Ooi, S. C. Cheah, A.-R. Raha, K.-L. Wan, and R. Singh. 2008. Oil palm (*Elaeis guineensis* Jacq.) tissue culture ESTs: Identifying genes associated with callogenesis and embryogenesis. BMC Plant Biology, 8:62-80.

Reference ID: 20547

Notes: #20547e

Abstract: Background: Oil palm (*Elaeis guineensis* Jacq.) is one of the most important oil bearing crops in the world. However, genetic improvement of oil palm through conventional breeding is extremely slow and costly, as the breeding cycle can take up to 10 years. This has brought about interest in vegetative propagation of oil palm. Since the introduction of oil palm tissue culture in the 1970s, clonal propagation has proven to be useful, not only in producing uniform planting materials, but also in the development of the genetic engineering programme. Despite considerable progress in improving the tissue culture techniques, the callusing and embryogenesis rates from proliferating callus cultures remain very low. Thus, understanding the gene diversity and expression profiles in oil palm tissue culture is critical in increasing the efficiency of these processes. **Results:** A total of 12 standard cDNA libraries, representing three main developmental stages in oil palm tissue culture, were generated in this study. Random sequencing of clones from these cDNA libraries generated 17,599 expressed sequence tags (ESTs). The ESTs were analysed, annotated and assembled to generate 9,584 putative unigenes distributed in 3,268 consensi and 6,316 singletons. These unigenes were assigned putative functions based on similarity and gene ontology annotations. Cluster analysis, which surveyed the relatedness of each library based on the abundance of ESTs in each consensus, revealed that lipid transfer proteins were highly expressed in embryogenic tissues. A glutathione S-transferase was found to be highly expressed in nonembryogenic callus. Further analysis of the unigenes identified 648 non-redundant simple sequence repeats and 211 putative full-length open reading frames. **Conclusion:** This study has provided an overview of genes expressed during oil palm tissue culture. Candidate genes with expression that are modulated during tissue culture were identified. However, in order to confirm whether these genes are suitable as early markers for embryogenesis, the genes need to be tested on earlier stages of tissue culture and a wider range of genotypes. This collection of ESTs is an important resource for genetic and genome analyses of the oil palm, particularly during tissue culture development.

Phalan B., M. Bertzky, S. H. M. Butchart, P. F. Donald, J. P. W. Scharlemann, A. J. Sattersfield, and A. Balmford. 2013. Crop Expansion and Conservation Priorities in Tropical Countries. Plos One, 8:1-13.

Reference ID: 20548

Notes: #20548e

Abstract: Expansion of cropland in tropical countries is one of the principal causes of biodiversity loss, and threatens to undermine progress towards meeting the Aichi Biodiversity Targets. To understand this threat better, we analysed data on crop distribution and expansion in 128 tropical countries, assessed changes in area of the main crops and mapped overlaps between conservation priorities and cultivation

potential. Rice was the single crop grown over the largest area, especially in tropical forest biomes. Cropland in tropical countries expanded by c. 48,000 km² per year from 1999-2008. The countries which added the greatest area of new cropland were Nigeria, Indonesia, Ethiopia, Sudan and Brazil. Soybeans and maize are the crops which expanded most in absolute area. Other crops with large increases included rice, sorghum, oil palm, beans, sugar cane, cow peas, wheat and cassava. Areas of high cultivation potential-while bearing in mind that political and socio-economic conditions can be as influential as biophysical ones-may be vulnerable to conversion in the future. These include some priority areas for biodiversity conservation in tropical countries (e.g., Frontier Forests and High Biodiversity Wilderness Areas), which have previously been identified as having 'low vulnerability', in particular in central Africa and northern Australia. There are also many other smaller areas which are important for biodiversity and which have high cultivation potential (e.g., in the fringes of the Amazon basin, in the Paraguayan Chaco, and in the savanna woodlands of the Sahel and East Africa). We highlight the urgent need for more effective sustainability standards and policies addressing both production and consumption of tropical commodities, including robust land-use planning in agricultural frontiers, establishment of new protected areas or REDD+ projects in places agriculture has not yet reached, and reduction or elimination of incentives for land-demanding bioenergy feedstocks.

Sander B. O., M. Samson, and R. J. Buresh. 2014. Methane and nitrous oxide emissions from flooded rice fields as affected by water and straw management between rice crops. *Geoderma*, 235-236:355-362.

Reference ID: 20549

Notes: #20549e

Abstract: Rice fields in the tropics can vary in water regime before production of rice on flooded soil, but relatively little is known about the effects of soil water regime and crop residue management between rice crops (i.e., fallow period) on methane (CH₄) and nitrous oxide (N₂O) emissions during a subsequent rice crop. We measured CH₄ and N₂O emissions during two cropping seasons in the Philippines from field plots exposed to contrasting treatments during the fallow before land preparation for rice cultivation. The fallow treatments were continuous soil flooding (flooded), soil drying with exclusion of rainfall (dry), soil drying with dry tillage (dry + tillage), and a control with soil drying and wetting from rainfall (dry and wet). All plots were subdivided into removal of all aboveground rice residues from the previous crop (without residue) and retention of standing biomass after harvest of the previous rice crop (with residue). Emitted gas was collected weekly using chambers. Fallow treatments greatly influenced greenhouse gas (GHG) emissions during rice growth. Methane emissions and global warming potential (GWP) in both cropping seasons were highest following the flooded fallow, intermediate following the dry and wet fallow, and lowest following dry and dry + tillage fallows. The GWP was higher with than without residue across all fallow treatments. Nitrous oxide emissions were small during the season, and CH₄ emissions contributed more than 90% of the cumulative GWP during the rice crop regardless of fallow and residue management. Soil drying between rice crops in the tropics can reduce CH₄ emissions and GWP during the subsequent rice crop.

Stevenson J. R., N. Villoria, D. Byerlee, T. Kelley, and M. Maredia. 2013. Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production. PNAS, 110:8363-8368.

Reference ID: 20550

Notes: 20550e

Abstract: New estimates of the impacts of germplasm improvement in the major staple crops between 1965 and 2004 on global land-cover change are presented, based on simulations carried out using a global economic model (Global Trade Analysis Project Agro- Ecological Zone), a multicommodity, multiregional computable general equilibrium model linked to a global spatially explicit database on land use. We estimate the impact of removing the gains in cereal productivity attributed to the widespread adoption of improved varieties in developing countries. Here, several different effects-higher yields, lower prices, higher land rents, and trade effects-have been incorporated in a single model of the impact of Green Revolution research (and subsequent advances in yields from crop germplasm improvement) on land-cover change. Our results generally support the Borlaug hypothesis that increases in cereal yields as a result of widespread adoption of improved crop germplasm have saved natural ecosystems from being converted to agriculture. However, this relationship is complex, and the net effect is of a much smaller magnitude than Borlaug proposed. We estimate that the total crop area in 2004 would have been between 17.9 and 26.7 million hectares larger in a world that had not benefited from crop germplasm improvement since 1965. Of these hectares, 12.0-17.7 million would have been in developing countries, displacing pastures and resulting in an estimated 2 million hectares of additional deforestation. However, the negative impacts of higher food prices on poverty and hunger under this scenario would likely have dwarfed the welfare effects of agricultural expansion.

Loh S. K. and V. Subramaniam 2012. Oil palm biomass energy resource data, MPOB, Bangi, Selangor.

Reference ID: 20551

Notes: H 8.1.1 #20551

Susanto A., H. Priwiratama, and Dja'far. 2013. Program replanting dipercepat pada kebun kelapa sawit terhadap *Ganoderma* . J.Pen.Kelapa Sawit, 21:10-19.

Reference ID: 20552

Notes: #20552e

Abstract: Laju infeksi penyakit busuk pangkal batang yang disebabkan jamur *Ganoderma boninense* pada saat ini sangat cepat. kejadian penyakit *Ganoderma* yang tinggi tidak hanya pada generasi kedua atau lebih tetapi sekarang juga terjadi pada generasi satu kebun kelapa sawit. Pada saat ini teknik pengendalian penyakit *Ganoderma* pada tanaman yang sudah terinfeksi baik preventif maupun kuratif belum memberikan hasil yang optimal. Pada kebun kelapa sawit umur remaja atau dewasa dengan kejadian penyakit yang relatif tinggi akan sangat sulit menentukan kebijakan pengendalian penyakit ini. Replanting dipercepat merupakan salah satu solusi mengendalikan penyakit *Ganoderma* agar kerugian tidak terus bertambah dan sumber inokulum juga semakin banyak di lapangan. Suatu analisis diperlukan untuk menentukan apakah suatu kebun sudah layak replanting dipercepat atau tidak. Penelitian ini dilaksanakan di kebun kelapa sawit dengan kejadian penyakit relatif tinggi di Kabupaten Asahan Sumatera Utara. Pengamatan dilakukan terhadap dua kelompok lahan, terdiri dari lahan eks karet tahun tanam 1994 dan eks kelapa sawit tahun tanam 1997 dan 1998. Hasil penelitian menunjukkan bahwa kedua kelompok

lahan seluas 370.48 ha layak replanting dipercepat dengan pertimbangan estimasi produktivitas tanaman semakin menurun meskipun analisis finansial menunjukkan tanaman masih memberikan profit berdasarkan nilai $B/C > 1$. Pada tahun 2012 produksi TBS hanya berkisar 17.23 ton TBS/ha/tahun dan diperkirakan produktivitas tanaman pada tahun 2013 akan menurun 10% serta 15% tahun 2014 menjadi 13.22 ton TBS/ha/tahun. Penurunan produksi ini disebabkan oleh perkembangan penyakit Ganoderma yang sangat cepat dan tinggi yaitu 62.41%, penurunan tegakan per hektar hingga tersisa 76 tegakan per ha dengan komposisi 30% tanaman sudah terinfeksi penyakit Ganoderma.

van der Vossen, H. A. M. Towards more efficient selection for oil yield in the oil palm (*Elaeis guineensis* Jacquin). 1-107. 10-3-1974. Wageningen, Centre for Agricultural Publishing and Documentation.

Reference ID: 20553

Notes: #20553e

Abstract: Detailed studies are made of the variability and heritability of a number of components of oil yield in the oil palm using published data of the breeding programme of the NIFOR in Nigeria and results of a number of experiments carried out at the OPRC in Ghana during the period 1965-1971. Estimations of h^2 for oil yield components are presented. Values are very high for some of the fruit quality components. A fairly high negative genetic correlation ($r_{YA} = -0.58$) was found to exist between the two most important components, number of bunches and single bunch weight. Maximum selection progress for increased bunch yield may be obtained by intercrossing widely divergent subpopulations. Experimental evidence is produced of the nature of inheritance of the ratios shell to fruit and mesocarp to fruit in oil palm fruits. Consequently, selection for these components requires considerable revision. The efficiency of determinations of the oil-to-mesocarp ratio, an important oil yield component with a rather low heritability, can be enhanced considerably by applying a modified indirect method based on the fact that the dry fibre-to-mesocarp ratio has a high heritability. The effect of different periods of water stress on bunch yield and its two components, as well as on vegetative growth of the oil palm was investigated. The implications of the results of these studies for oil palm selection are discussed in detail and outlines of a modified breeding programme assuring continued selection progress are given. Essential are (1) the re-establishment of new, genetically highly variable and very divergent subpopulations, (2) the estimation of genotypic values of all components of oil yield from the first 3-4 years of production when the disturbing influence of competition for light between palms is still negligible, (3) information from special plant density-progeny trials about the optimum combination of genotype and spacing in a particular environment, required for a continued high production level beyond the first four years.

Villoria N. B., A. Golub, D. Byerlee, and J. Stevenson. 2013. Will yield improvements on the forest frontier reduce greenhouse gas emissions? A global analysis of oil palm. American Journal of Agricultural Economics, 95:1301-1308.

Reference ID: 20554

Notes: #20554e

Villoria N. B., D. Byerlee, and J. Stevenson. 2014. The effects of agricultural technological progress on deforestation: what do we really know? *Applied Economic Perspectives and Policy*, 36:211-237.

Reference ID: 20555

Notes: #20555e

Abstract: Increasing agricultural yields seem an obvious way to satisfy increasing demands for food and fuel while minimizing expansion of agriculture into forest areas; however, an influential literature worries that promoting agricultural innovation could enhance agriculture's profitability thereby encouraging deforestation. Clarifying the effects of agricultural technological progress on deforestation is therefore crucial for designing effective policy responses to the challenges faced by global agriculture. In this article we review the empirical evidence on these effects and synthesize estimates of future global cropland expansion. Our main insights are that: (i) the empirical evidence on a positive link between regional technological progress and deforestation is much weaker than what seems generally accepted; (ii) at a global level, most analysts expect broad based technological progress to be land saving; however, composition effects are important as low-yield, land-abundant regions are likely to experience further land expansion. Toward the future, empirical work understanding how localized technological progress in agriculture transmits through international trade and commodity markets will help to bridge the gap between the findings of local, econometric, studies on the one hand and global, model based, studies on the other.

Adejobi K. B., O. S. Akanbi, o. Ugioro, S. A. Adeosun, I. Mohammed, B. A. Nduka, and D. O. Adeniyi. 2014. Comparative effects of NPK fertilizer, cowpea pod husk and some tree crops wastes on soil, leaf chemical properties and growth performance of cocoa (*Theobroma cacao* L.). *African Journal of Plant Science*, 8:103-107.

Reference ID: 20556

Notes: #20556e

Abstract: Relative effect(s) of some organic wastes as fertilizers on growth performance, soil and leaf chemical composition of cocoa seedlings (*Theobroma cacao* L.) in the nursery. The experiment comprised of five treatments: Cowpea Pod Husk (CPH) (2.5 t/ha), cocoa pod husk ash (CPHA) (2.5 t/ha), kola pod husk (KPH) (2.5t/ha), NPK15-15-15 (2.5 t/ha) and control (no fertilizer application). Each treatment was applied to 2.5 kg of soil filled polythene bags containing cocoa seedlings. The experiment was arranged in completely randomized design (CRD) with three replications. The organic wastes increased significantly ($P > 0.05$) the plant height, stem diameter, leaf area, number of leaves, fresh root and shoot weights and dry root and shoot weights of cocoa seedlings. The treatments also increased significantly ($P > 0.05$) soil and leaf N, P, K, Ca, Mg, Na, soil pH and organic matter (OM) content relative to the control. Kola pod husk (KPH) was the most effective in improving cocoa growth, leaf and soil chemical composition.

Ndubuaku U. M. and A. Kassim. 2003. Use of organic and inorganic fertilizers to improve the rate of cocoa seedling establishment in the field in Nigeria. *Forests, Trees and Livelihoods*, 13:101-106.

Reference ID: 20557

Notes: 20557e

Abstract: This investigation studied the effect of poultry manure, green manure, urea and single super phosphate on the field establishment of F 3 Amazon cocoa seedlings in the Ago-Iwoye area, northeast of Ijebu-Ode in south-western

Nigeria. The organic fertilizers were applied at the rate of 0.56 tonnes/ha (500 g/seedling); urea and single superphosphate (SSP) were applied at rates of 0.26 and 0.11 tonnes/ha respectively. There was a decrease in leaf number and leaf area of the seedlings in the first few weeks after transplanting due to leaf abscission. Later, poultry manure gave the highest rate of leaf emergence on the seedlings, followed by green manure, urea and single super phosphate in that order. No mortality was recorded except in the control treatment. Stem height, stem diameter, leaf number and leaf area of the seedlings increased with the application of all the fertilizers. By 32 weeks after planting, the poultry manure and the green manure treatment plants were significantly ($p=0.05$) larger (height, stem diameter, leaf emergence and leaf area) than those in the urea and single super phosphate treatments.

Lockard R. G. and J. C. Burridge. 1965. The Levels of Manganese, Sodium, Aluminium, Iron, Boron, Zinc, and Copper in the Leaves of Cacao (*Theobroma cacao* L.) as Affected by Shade, Fertilizer, Irrigation and Season. *Annals of Botany*, 29:283-292.

Reference ID: 20558

Notes: #20558e

Abstract: The results are given of chemical analyses of leaves collected over a period of one year from cacao trees in a field trial receiving fertilizer, shade, and irrigation treatments. The greatest variation in concentration of the elements under study was found to be due to the time of year at which the leaves were collected. The lowest concentrations of zinc and copper were found in the leaves collected during the peak of the main season crop. The lowest concentrations of manganese, aluminium, and iron were found in leaves collected about a month after the end of the main harvest. The levels of most elements rose sharply after reaching a minimum, and the maximum levels were usually reached before completion of flowering for the next main season crop. The effects of the treatments on the nutrient levels in the leaves were generally small. The fertilizer treatment tended to increase the levels of manganese, aluminium, iron, sodium, and zinc and to decrease the level of boron. The shade treatment tended to increase the levels of sodium, copper, and zinc and to decrease the levels of manganese, aluminium, and iron. The irrigation treatment had no substantial effect on the level of any element. The levels of iron, manganese, and boron, were found to be positively correlated with the level of aluminium.

Lockard R. G. and J. C. Burridge. 1965. Levels of macro- and micronutrients in beans of cacao (*Theobroma cacao* L.) in relation to shade, fertilizer, irrigation and season. *Annals of Botany*, 29:377-382.

Reference ID: 20559

Notes: #20559e

Abstract: The levels of nutrients in ripe beans collected over a period of 16 months from a field trial were not affected by shade and irrigation treatments, but addition of fertilizer increased the levels of phosphorus and manganese and decreased the levels of copper and molybdenum in the beans. The levels of nutrients in the beans did not vary appreciably throughout the period. Potassium was the only element which showed a systematic seasonal variation of content, with the highest level in March and a steady decline to the lowest level in October. The mean ash content and levels of twelve nutrients in the beans are reported, as well as the seasonal maxima and minima.

Burridge J. C., R. G. Lockard, and D. K. Acquaye. 1964. The levels of nitrogen, phosphorus, potassium, calcium and magnesium in the leaves of cacao (*Theobroma cacao* L.) as affected by shade, fertilizer, irrigation and season. *Annals of Botany*, 28:401-417.

Reference ID: 20560

Notes: 20560e

Abstract: The results are given of chemical analyses of leaves collected over a period of two years from cocoa trees in a field trial receiving fertilizer, shade, and irrigation treatments. The greatest variation in concentration of nutrients in the leaves was due to the time of year the leaves were collected. The lowest concentrations of nitrogen, phosphorus, and potassium were found in the leaves collected during the peak of the main season harvest. The highest levels of these elements were found in leaves collected near the end or a few weeks after the end of the main harvest. The levels of calcium in the leaves were just opposite, with the highest levels coinciding with harvest and the lowest levels occurring just after the harvest period. The levels of magnesium showed no marked variations between seasons. Shade increased the levels of nitrogen, phosphorus, and potassium, and decreased the levels of calcium in the leaves. Fertilizer increased the levels of nitrogen, phosphorus, calcium, and magnesium, and decreased the level of potassium in the leaves. The effect of irrigation was small, but it decreased the levels of nitrogen, potassium, calcium, and magnesium in the leaves. The levels of nitrogen, phosphorus, and potassium in the leaves over the 21 harvesting times were found to be positively correlated with each other, and all three were negatively correlated with the levels of calcium in the leaves over the same period. None of the levels of these four elements was significantly correlated with the levels of magnesium in the leaves over the period.

Cunningham R. K. and P. W. Arnold. 1962. The shade and fertilizer requirements of cacao (*Theobroma cacao*) in Ghana. *Journal of the Science of Food and Agriculture*, 13:213-221.

Reference ID: 20561

Notes: #20561e

Abstract: Experiments to examine the shade and nutrient requirements of cacao: are described and preliminary results are presented. A significant response to phosphate was obtained under shade when pests, diseases and weeds were controlled. Removing shade results in highly significant increases in yield with a positive interaction between increased light and applied nutrients. Fertilised, unshaded cacao gave yields double that previously considered to be the maximum for A4melonado cacao. The application of these results to farmers' shaded cacao and to a more intensive system of growing the crop without shade are discussed. Attention is drawn to the dangers of removing shade and to the importance of associated factors such as pest distribution, incidence of weeds, adverse dry season effects and soil degradation.

Szott L. T. and D. C. L. Kass. 1993. Fertilizers in agroforestry systems. *Agroforestry Systems*, 23:157-176.

Reference ID: 20562

Notes: #20562e

Abstract: This review encompasses results of fertilization experiments on several agroforestry systems—alley cropping, perennial shade systems, home gardens—in which fertilizer use is a likely management alternative. Fertilizer response was found

to be most common in alley cropping, variable in perennial shade systems, and rarely reported in home gardens. Level of nutrient removal in harvested products is probably the overriding factor in determining fertilizer response; greater accumulation of organic residues, slower growth under shade, and longer periods of nutrient uptake probably also contribute to the relatively smaller fertilizer response of the perennial shade systems and home gardens. Considerable knowledge gaps exist regarding the breakdown of organic residues, and interactions between mineral and organic amendments. Systems based on annual crops (e.g., alley cropping) are likely to be less nutrient-efficient and sustainable than systems based on perennial crops, due to reduced fixation and transfer of N to the crops, the tendency of the trees to compete for and sequester nutrients, relatively high P requirements of the crops, and the high labor cost of tree management. The possible benefits of fertilization of specific components in home gardens, and relative advantages of including low-value tree legumes, high-value shade trees, and fertilization in shaded perennial systems are only beginning to receive research attention.

Cunningham, R. K. and Lamb, J. Cocoa Shade and Manurial Experiment in Ghana. *Nature* 182[4628], 119. 1958.

Reference ID: 20563

Notes: #20563e

Abstract: Contrary to general experience with other world crops, cocoa grown in West Africa had never been shown to respond to fertilizer, for reasons discussed by T. N. Hoblyn¹. The recent successful control of capsid pests and the availability of uniform cocoa, however, has now made accurate experimentation possible.

Bentley J. W., E. Boa, and J. Stonehouse. 2004. Neighbor Trees: Shade, Intercropping, and Cacao in Ecuador. *Human Ecology*, 32:241-270.

Reference ID: 20564

Notes: #20564e

Abstract: Previous studies have shown that shade trees in cacao and coffee are important habitats for inter-American migratory birds. A survey of 21 cacao farmers along the northern, central, and southern Pacific Coast of Ecuador found that shade trees are associated with unirrigated, traditional cacao varieties and low levels of chemical inputs. Farmers stressed the importance of shade for managing soil moisture and soil fertility, and for managing some weeds and diseases. Most of the shade trees were not wild forest trees, but had been planted and protected by the farm families. Many other trees are intercropped with cacao for economic reasons, not related to shade. Chocolate manufacturers, consumers, and environmental activists can encourage farmers to maintain shade canopies by paying a premium for the traditional, shade-loving, high-quality aromatic cocoa varieties.

Cunningham R. K. 1963. The effect of clearing a tropical forest soil. *Journal of Soil Science*, 14:334-345.

Reference ID: 20565

Notes: #20565e

Abstract: Organic matter in tropical soils under forest is delicately balanced, the continuous addition of fresh material being offset by decomposition. The forest was removed from a soil in Ghana and three degrees of exposure were tested. Chemical and physical properties were measured from 1957 to 1960. Much organic C, total N, and organic P was lost from the soil of fully exposed plots, because soil temperatures increased and fresh organic matter was no longer provided by the

forest. Rate of decomposition lessened with time. Decomposition under shade, though still rapid, was significantly slower than in exposed soil. After three years' exposure the soil produced less mineral N and had smaller cation exchange capacity, exchangeable K, and lower pH than the shaded soil. Exposure also compacted the soil, impeded drainage through the 2–6 in. layer and made the soil erode more easily.

Ofori-Frimpong, K., Asase, A., Mason, J., and Danku, L. Shaded versus un-shaded cocoa: implications on litter fall, decomposition, soil fertility and cocoa pod development. 2007.

Reference ID: 20566

Notes: #20566e

Abstract: Traditionally, cocoa is grown in Ghana in conjunction with a diverse selection of trees that provide shade and habitat for a variety of wildlife forms thus enhancing biodiversity. In recent years, more cocoa plantations are being managed intensively and in full sun. A study was carried out to examine the implications of growing cocoa under different shade regimes provided by forest trees and in full sun on litter fall, decomposition of the litter, soil fertility and cocoa pod development over one year period in Ghana. Series of parallel transects of up to 1 km long and spaced 200m apart were laid through contiguous: (i) Cocoa farms with heavy overhead shade. (ii) Cocoa farms with medium overhead shade. (iii) Cocoa farms without overhead shade. (iv) Remnant native forest. Shade regimes significantly ($p < 0.05$) influenced litter production in the cocoa farms. Cocoa litter production ranged from 3,096kg/ha to 5112kg/ha with the un-shaded cocoa farms recording significantly ($p < 0.05$) higher litter production than the shaded farms. Litter production from the shade trees ranged from 970kg/ha to 2080kg/ha with the heavy overhead shade producing the highest litter. The rates of decomposition of cocoa leaf litter were significantly ($p < 0.05$) faster in the shaded farms than in the un-shaded farms. About 61.2 and 64.6% of the initial mass of cocoa leaf litter in the heavy and medium shaded farms were lost during the initial six months of decomposition as opposed to 18.0% for the un-shaded farms. The pattern of the release of the nutrients related positively with the mass loss of the litter where litter from the shaded farms released more NPK during the period of decomposition. Cocoa cultivation generally decreased the organic C, total N, available P and exchangeable K contents of the soils when compared with the remnant native forest. The decrease in the nutrient concentrations in the soil was more pronounced in the un-shaded farms. Significantly ($p < 0.05$) higher total number of pods were recorded on trees in the un-shaded farms. Incidence of cherelle wilt on the farms ranged from 24 to 44% and was significantly ($p < 0.05$) higher in the un-shaded farms than in the shaded farms. It is concluded that shaded farms could enhance efficient nutrient cycling processes, improve the nutrient status of soils and reduce the stress on the development of cocoa pods.

Miyaji K.-I., W. S. Da Silva, and P. de T. Alvim. 1997. Productivity of leaves of a tropical tree, *Theobroma cacao*, grown under shading, in relation to leaf age and light conditions within the canopy. New Phytologist, 137:472.

Reference ID: 20567

Notes: #20567e

Abstract: The photosynthetic and respiratory activities of the leaves of a tropical tree, cacao, *Theobroma cacao* L., grown under shading, were determined in relation to leaf age and light conditions within the canopy, in order to gain a deeper insight into characteristics of the leaf population composing a canopy. The specific leaf

weight and leaf water content varied with the height of leaves from the ground and/or the irradiance. The net photosynthetic rate also varied markedly depending on leaf age and irradiance. The leaves in full or nearly full irradiance (< 70% full daylight) attained the maximum rate. 60 d after the leaves emerged, and the rate decreased to nearly zero at a leaf age of c. 270 d. The nocturnal leaf respiratory activity was proportional to the photosynthetic activity during the day, but the proportional ratio was not constant throughout the survival period of leaves. Within the closed canopy, the upper leaves, which had much higher ratios of respiratory to photosynthetic activity, under full or nearly full irradiance, tended to have much shorter mean longevities (c. 160 d) than the lower leaves under a lower irradiance (c. 310 d).

Herzog F. 1994. Multipurpose shade trees in coffee and cocoa plantations in Côte d'Ivoire. *Agroforestry Systems*, 27:259-267.

Reference ID: 20568

Notes: #20568e

Abstract: Coffee and cocoa are the main cash crops of Côte d'Ivoire. They are mainly produced by small farmers in a rather extensive way. The shade trees used are mostly wild forest species yielding many different products. In the Baoulé region, an inventory of those trees and their, often multiple, uses was established. Of the 41 tree species, 22 are used as firewood and 16 as timber for local constructions. Nineteen furnish pharmaceutical products for traditional medicine and 15 have edible parts (fruits, leaves, flowers, palm wine). Those products are essential in daily life and play an important role in the local economy. The plantations can therefore be considered as agroforestry systems. Part of the world-wide research on coffee and cocoa should be reoriented to such systems, adapted to small farmer holdings, where few inputs are available and conditions of production are less favourable.

Uribe, A., Mendez, H., and Mantilla, J. Effect of Balanced Fertilization on Cocoa Yield. *Better Crops International* 15[2], 3-5. 2001. IPNI.

Reference ID: 20569

Notes: #20569e

Abstract: A long-term study on cocoa fertilization demonstrates the benefits of building soil fertility levels for plantation crops. Cocoa is either grown in low production systems under shade of other vegetation or in intensive production systems where trees are completely exposed to sunlight. Fertilization of shade cocoa commonly produces only modest yield increments. Fertilization of sunlight-exposed plantations generally results in significant yield responses because of greater photosynthetic activity. Despite their higher yield potential, sunlight-exposed plantations grown without fertilizer experience rapid yield declines with time and often suffer from early senescence. Research on cocoa response to fertilization is scarce in Colombia. This study was designed to evaluate response to balanced nutrition over five consecutive years.

Ekanade O. 1987. Spatio-temporal variations of soil properties under cocoa interplanted with kola in a part of the Nigerian cocoa belt. *Agroforestry Systems*, 5:419-428.

Reference ID: 20570

Notes: #20570e

Abstract: Spatio-temporal variations in soil properties under cocoa interplanted with kola in 15- and 40- year-old plots were considered in a part of the Nigerian Cocoa Belt. The study shows that no significant variations occur in soil properties when both

cocoa and kola are 15 years old. However, significant variations in many soil properties are recorded when cocoa and kola are 40 years old. At that time, soil conditions from sample points directly under kola and between kola and cocoa were similar while soil from the sample point directly under cocoa differed significantly, in most respects, from the other two points. Soil properties appear to improve under kola over time while the converse is the case under cocoa. It is adduced that these differences result from apparent differences in growth habit and nutrient extraction of kola and cocoa over time.

Koko L. K., D. Snoeck, T. T. Lekadou, and A. A. Assiri. 2013. Cacao-fruit tree intercropping effects on cocoa yield, plant vigour and light interception in Côte d'Ivoire. *Agroforestry Systems*, 87:1043-1052.

Reference ID: 20571

Notes: #20571e

Abstract: A major challenge for cocoa producers in Côte d'Ivoire is to seek alternative shade trees or crop associations to adapt their planting devices and techniques to the shortage of forests. The recent tendency developed by farmers is to plant simplified orchards combining cacao and fruit trees. An on-farm trial was set up in a 5-year-old cocoa farm to compare a cacao monocrop planted at densities of 1,115treesha⁻¹ with cacao intercropped with orange or avocado trees, both at 44treesha⁻¹. Observations were done on incident light received by the cacao, vigour, growth and cocoa yields. On average, the cacaos received 100% light in the monocrop, 89.6% under orange trees and 80.6% of incident light under avocado trees. They yielded 64.0podstree⁻¹year⁻¹ in the monocrop (equivalent to 2.54kg dry cocoa beans tree⁻¹), 30.3podstree⁻¹ when combined with orange trees and 28.3podstree⁻¹ with avocado trees. The two combinations allowed cocoa yields equivalent to those observed in the region (0.58kg dry cocoa beans tree⁻¹). Vigour and yield were very highly correlated with the incident light received. Both the yield and the incident light are a logistic function of the planting distance from the shade tree. The inflexion point of the logistic functions corresponds to the minimum planting distance between the cacao and the intercropped fruit trees. On this basis, we suggest that the cacaos should not be planted closer than 6.50±0.2m to the orange or avocado trees.