An Introduction

IPNI Plantation Intelligence

Incorporating Estate-Scale Experimentation

Sustainable Intensification

Improved certainties, improved yield

IPNI SEAP
Contribution No. PS2014-2

An Opportunity for Oil Palm

The oil palm industry is at an inflection point. The last two decades of spectacular growth through unrestricted land acquisition cannot go on forever. Plantation owners now face not only a lack of suitable land but also declining value, yield ambiguity, labor shortage, and a lackluster public image. The industry needs to find a new footing. Devise better processes. Do more with less. It needs to develop a new future for oil palm as a credible contributor to local and global food, energy, and environmental security. The promise of Plantation Intelligence is about implementing and accelerating this change, through “big data” generation and analysis.

What is Plantation Intelligence

Data-mining to boost yield and profit

Plantation Intelligence (PI) is an adaptive learning process based on the analysis of a large database of crop performance data to achieve better yield.

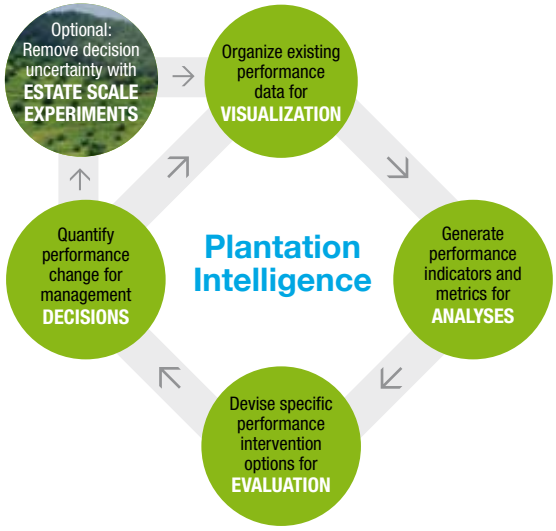
Participating plantation managers will learn how to deal with various factors affecting yield. Some of these factors cannot be controlled, such as climate and soil, while others can be manipulated, such as fertilization and harvesting protocols. This knowledge will help plantation managers make better day-to-day decisions to realize productivity gains.

The database analyses will produce a portfolio of intervention recommendations. These can then be tested in an estate-scale experiment to further verify their effectiveness. Unlike traditional lab-based experiments, this experiment is carried out as part of a commercial plantation's routine operation, with minimum disruption to its daily activities. The most promising intervention recommendations can be easily and immediately implemented.

Over time, as new data are added, the manager will have an increasingly reliable set of numbers to work with, and will be able to more reliably maximize output for each plot of cultivated land regardless of the site's original characteristics. This gives him a more targeted yield-boosting strategy and better accountability.

Change, profit, sustainability

Plantation Intelligence is an analytical tool to examine existing data and processes to develop new ideas and site-specific innovations that can be applied estate-wide.



How PI benefits plantation managers

- Better understand how blocks perform
- Reduce uncertainties for better decision-making
- Communicate transparently with management levels
- Achieve better use of resources
- Implement innovation based on objective insights rather than biases

The difference between conventional R&D and PI

Conventional R&D

Prefers "**clean**" data from **controlled** plots (on-line)

Works in **experimenters' domain**

Provides "**generally true**" information

Plantation Intelligence

Accepts **commercial** data from **fields** (off-line)

Works in **decision-makers' domain**

Provides **site-specific** information

Helps to explain and **upscale conventional R&D**

OTHER INDUSTRIES **Using data to improve outcomes**

"Big data" are transforming many industries. In healthcare, data are routinely collected and analyzed to improve outcomes. Healthcare providers follow a framework similar to Plantation Intelligence to identify the best opportunities for quality and cost improvement. These opportunities take the form of intervention options such as a new work flow, a new medication regime or a combination of actions.

Similar to Plantation Intelligence, by studying variation over time, healthcare providers look for a relationship between process change and improved outcomes. The cycle of evaluation and validation takes time because the effectiveness of an intervention action may not manifest itself readily. Continuous data collection is therefore key to sustaining improvement.

In the highly competitive IT industry, similar continuous-improvement concepts have long been a mainstay. They have enabled corporations to achieve ever higher productivity targets through process change.

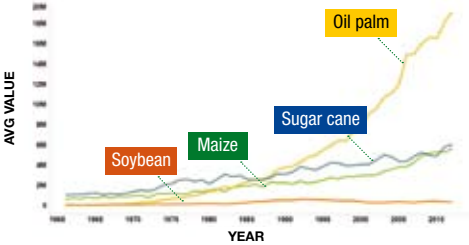
The Reason for PI

The promise

The oil palm industry in Southeast Asia is at the tail-end of a spectacular growth phase that started decades ago. Food and Agriculture Organization (FAO) data indicates that the production of Crude Palm Oil (CPO) grew from 1.5 million tonnes in 1961 to about 56 million tonnes in 2013/2014. Its corresponding value grew from US$1.3 billion to more than US$40 billion. Few expect this trend to continue.

Value of oil palm production in Southeast Asia

The value of oil palm globally has grown from well under 1 billion in 1960 to over $40 billion in 2013/14 [USDA estimate]. Growth has been most spectacular in Southeast Asia.



Source: FAO

The push

The growth rate of the past is not sustainable. The decline in real value of commodities over time due to ever-increasing prices of labor and inputs—known as "terms of trade"—suggests that producers will face mounting business, environmental, and social pressures. To stay competitive, the industry and its suppliers of inputs must explore opportunities for intensification.

The way forward

The "unmanaged variation" in oil palm plantations presents a great opportunity for innovation through PI. The data itself holds the key to better agronomic practices, better resource allocation, and better management decisions. PI will enhance a plantation manager's skills by clarifying the effects of various inputs and overcoming natural biases in judgement.

The opportunity

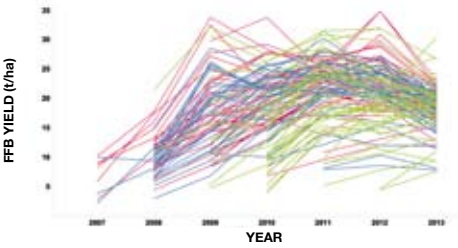
Oil palm production is a data-rich but information-poor activity. The industry collects vast amounts of data but relatively little are analyzed to improve management—a lost opportunity. IPNI's experience suggests that it is fairly straightforward for commercial plantations to adopt PI. Among the benefits: an accurate assessment of performance, return-on-investment, and obstacles to efficient production.

Variability in crop performance

- Variability is itself a database, which can be analyzed to produce yield-enhancing insights. PI is an opportunity for plantation owners to data-mine their records to achieve **certainty of benefits**.
- Variability in yield is not always agronomy-related. **Labor** and **geography** can also significantly affect yield. From a PI project in Indonesia, it was discovered that when there are not enough workers to deploy during harvest, fruit bunches were left unharvested on the trees.

Variation visualized

Plantation management data, when visualized, reveal new insights.



Source: IPNI SEAP

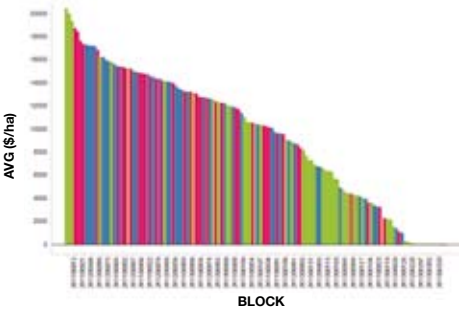
- A plantation owner's **accounting calendar** may affect perception and behavior on fertilizer use, simply because it does not sync with a crop's natural growth pattern or other non-agronomic factors. To avoid fertilizer use becoming a hit-and-miss affair, the agronomist and accountant need to work closely to set purchasing decisions.

Consequences of variability

- **Uncertainties between and within estates**
  A common observation when analyzing the historical data of an oil palm plantation is the dramatic **variability between and within estates**. Not only is there a great difference in yield between estates, there are also great differences between blocks within an estate. This is borne out by a "naive" gross margin analysis which disregards the effects of factors such as inflation. This simplified interpretation suggests that the actual variability in performance is even more dramatic, making the estate in the example a prime candidate for a PI study.
- **The challenge of making the right decision**
  How does a plantation manager make a better decision when there are so many factors at play? PI can help plantation managers consider each factor systematically and derive an insight to guide decision-making. Understanding variability will result in more informed action.

Quantifying performance

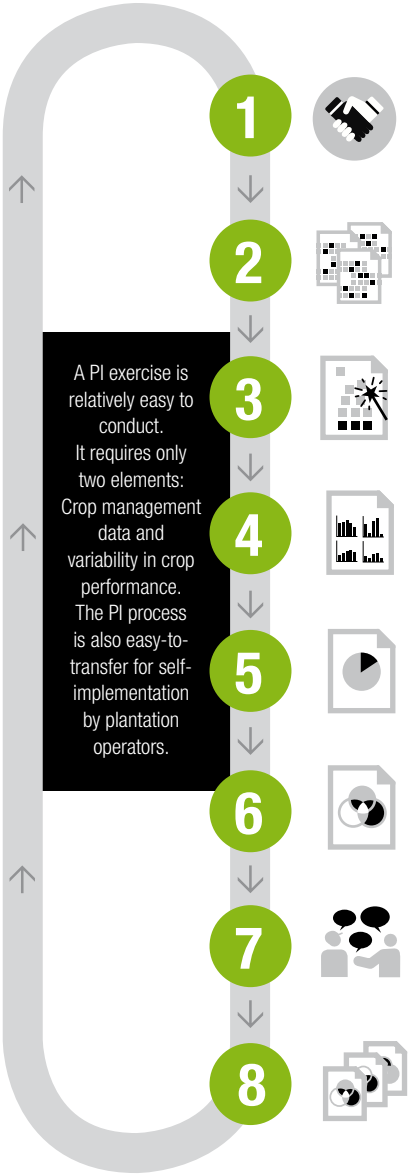
In this chart, each color is one estate, and each bar a block. It is evident that each estate is a motley mix of "top guns," "steady performers," and "slow coaches" despite having the same management.



Source: IPNI SEAP

The Process for PI

The process of generating PI is the same for all plantation managers. The exercise may be designed in such a way that it reflects the priorities of a plantation's management or its board of directors.



Engage senior management Engaging senior management is essential to ensure commitment throughout the organization. PI is a long-term exercise that requires on-going commitment.

Acquire large pools of data Many plantation operators already have internal accounting or control systems that capture this. Data must include inputs and outputs for each block of cultivated land.

Clean and assemble data Use data that is routinely available, not "special" experiment data. Anticipate some effort for this step, particularly for the first cycle of analysis.

Organize data Set up a common database structure. This may require several cycles before a final structure is established.

First analysis Show management the results of first analysis to seek feedback on future analyses. Note that interpretation will become more certain with each cycle of analysis.

Follow-up analysis Expand data sets to include new partners and data from their new and old plantations. Anticipate large variations. Optional: a plantation manager may conduct an estate-scale experiment to test a new idea.

Discuss with field managers Review and share ideas with field managers regularly on both familiar and unfamiliar data. The goal is to interpret the data to produce actionable recommendations.

Review and repeat To keep the PI exercise relevant, an annual review is recommended. Ideally, it should become part of regular board meetings where management can be briefed on the insights gained and decide on the best activities to be introduced in the next production cycle.

Options for Change

Based on information from a PI analysis, the plantation manager will gain a better understanding of the various variables affecting yield. He will then make a judgement on which among the portfolio of intervention options to implement, if any. He may hold off intervention until data from a few more cycles are analyzed. These analyses may be simple or complex. The following case studies show three levels of complexity:

- Labor + Fertilizer
- Soil + Fertilizer
- Soil + Climate + Fertilizer

CASE STUDY 1

Labor + Fertilizer Interaction

A PI study on labor intensity and fertilizer in an oil palm plantation suggests that a minimum intensity of about 10 harvest man-days per hectare year is necessary to fully appreciate the effects of fertilizer use.

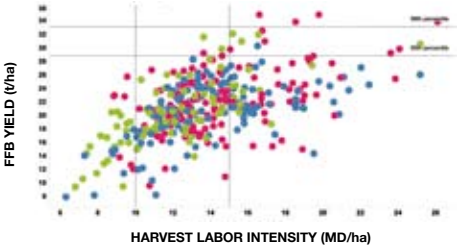
Labor shortage will obscure fertilizer efficacy if fruit bunches are left unharvested. Finetune labor input to ensure a thorough harvest. By understanding the optimal rate of labor input, plantation managers will be able to make better decisions on labor allocation against other tasks.

Possible action

Manage labor to reap nutrition benefits. Allocate at least 10 harvest man-days per hectare year to recover yields in mature blocks.

What is the optimum rate of labor input?

The dense center of this chart suggests that ideal labor input is between 10 and 15 man-days during harvest.



Source: IPNI SEAP

CASE STUDY 2

Soil + Fertilizer Interaction

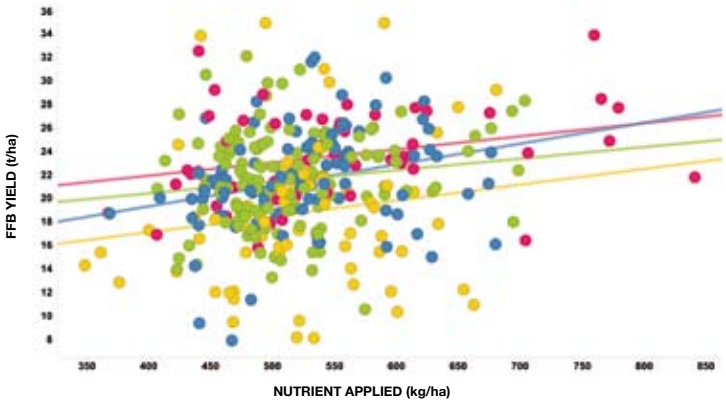
Every soil type reacts differently to fertilizer. By studying the responsiveness of each to incremental fertilizer input, a plantation manager will gain another set of performance data. He may then review and examine each site and devise a range of interventions that account for the particular responsiveness of each soil type.

Possible action

Investigate highly responsive blocks to see if increasing fertilizer will continue to increase yield. For soils that respond weakly or unpredictably, reexamine foliar data to decide if specific fertilizers are holding back yield.

How soil and fertilizer affect yield

Different soils respond differently to the same fertilizer. In this diagram from a PI project, each soil type is marked by a colour. While the fertilizer —applied over two years prior to harvest—generally improved yield across all soil types, the most responsive soil delivers 18 kg more fruit for each kilogram of fertilizer added, compared to about 10 kg of fruit for other soils. The poorest soil type (yellow line) lags behind others by about 5 t/ha.



Source: IPNI SEAP

CASE STUDY 3

Soil + Climate + Fertilizer Interaction

To a plantation manager, a soil/climate/fertilizer analysis often appears too complex to undertake. However, this is no longer as daunting an enterprise as it once was because a PI exercise is able to study a plantation's database in multiple dimensions, taking into account the interaction of soil type, climate, and time. The diagram below illustrates the results from a PI project where the yield from various blocks within one estate are tabulated over time.

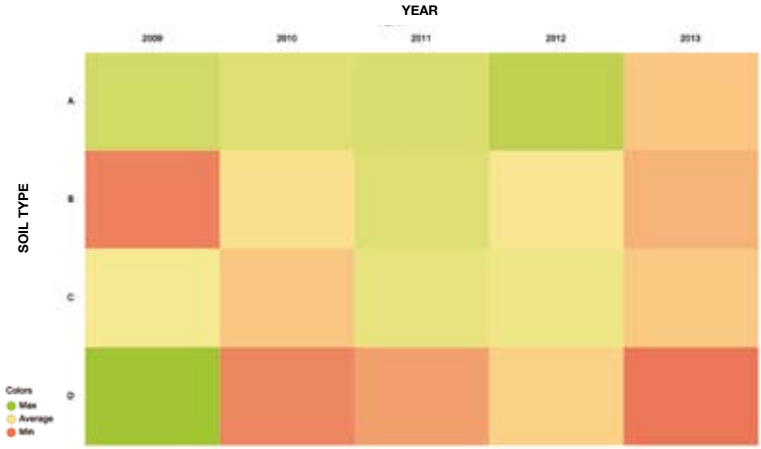
It was obvious that yield had been unpredictable and susceptible to wild swings. This variation in performance can be observed in both "good" and "poor" soils. The insight: soils that perform well in a "normal" year may perform badly in an El Niño or La Niña year when extreme climate is common, and vice versa.

Possible action

Take long-term climate forecasts into account when determining fertilizer rates and timing.

Climate affects fertilizer uptake on every soil type

Some soils [e.g. A, top row] are nearly always better than others. Some [e.g. D, bottom row] tend to perform more poorly. Some years are better than others, for example 2013 was difficult for all soils. These patterns interact. Analyzing data to characterize this interaction improves the certainty of management.



Source: IPNI SEAP

PI and Fertilizer

In Southeast Asia, fertilizer is a liquid asset that can be easily withheld because it is often applied by faith. Plantation operators are not always able to attribute results to fertilizer use. By examining the quantity, composition, timing, and application method, a PI analysis will be able to establish an evidence-based argument to recalibrate fertilizer use. This will enable fertilizer-purchasing decisions to be made based more on plant nutrition and site-specific factors rather than a plantation owner's accounting cycle or housekeeping schedule.

By understanding a plant's nutritional needs and its natural responsiveness to fertilizers throughout its lifespan, the plantation operator will be able to:

- Bring newly planted blocks into production rapidly
- Maintain high productivity in mature plantations
- Improve production on degraded soil

IPNI's data from hundreds of blocks going back to 2006 suggest that oil palm responds strongly to fertilizer, with yield also influenced by tree age, soil type, seasonal climate, and labor availability.

"**Fertilizer complacency**" describes the disconnect between the knowledge of crop behaviour and fertilizer use. Decisions on fertilizer are often made based on short-term impacts, which disregards a crop's long-term responsiveness to nutritional input. This discrepancy leads many plantation managers to suspect the true ROI of fertilizers, which in turn shapes the general attitudes of plantation owners towards fertilizers.

Working with IPNI

A collaboration between adviser and operator

IPNI International Plant Nutrition Institute

To initiate a PI project is straightforward. IPNI's role is to help plantation managers analyze existing data and identify associations between variables such as labor intensity, fertilizer use, and yield. This will include the use of IPNI's proprietary yield/fertilizer response analysis protocol.

- A plantation operator signs an agreement brokered by IPNI to become a data-sharing PI partner. An IPNI manager visits the partner's plantation.
- The first analysis will explore yield averages, yield trends, and estimates of revenue growth. Data interpretation begins.
- Within eight months, with more data analyzed, a follow-up meeting will review yield patterns, variations between blocks, and yield-age profiles. High-performing and non-performing blocks will be revealed. Subsequent analyses will factor in fertilizer and labor inputs.
- Based on the evidence of fertilizer response, a PI partner will have the option to conduct an estate-scale experiment.
- A PI exercise may quantify what some plantation managers suspected all along, but it may also reveal insights on various inputs. The PI process is on-going and will produce many insights. These insights will form the foundation for a systematic approach to increase yield at the partner's plantation.

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What Happens Next?

All estate-scale experiments are able to generate meaningful analyses over time because they are based on a **range of improved certainties**.

Estate-scale experimentation

All plantation managers face huge uncertainties that hinder good decision-making. For example, how many know the actual effects of a fertilizer, or the effectiveness of one type of fertilizer over another? How responsive is a particular site to nutritional inputs? An estate-scale experimentation can produce reliable block-by-block insights on inputs such as labor and fertilizer that go a long way in improving yield.

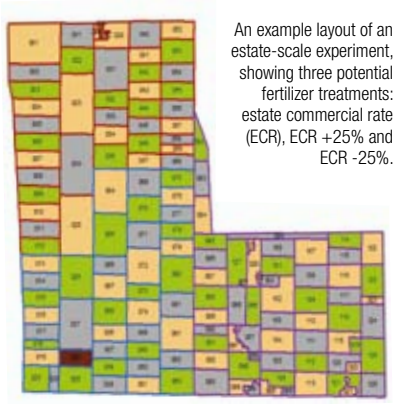
The experiment is easy to implement: introduce a deliberate variation of inputs and measure the response. Because the scale is large, the results are almost always significant. And because the experiment occurs at the same scale as routine management, the results are also real and measurable.

An estate-scale experiment involves the entire production domain (plantation), and accepts variations due to weather, site, soil, pest, disease, and plant nutrition. This approach considers the operational unit itself a worthy object of scientific analysis. Through PI, such analysis will become embedded within the decision-making and operational culture of a plantation, setting in motion a continuous improvement mindset.

Experimentation as routine operation

Upon observing the positive response of a fertilizer-related PI analysis, a PI partner in Kalimantan decided to launch an estate-scale experiment, matching the rate of application to sensitivity to yield. Because it was implemented as part of routine operations, the exercise incurred zero additional input cost. The outcome: more responsive blocks are identified throughout the estate. Possible follow-up action: a more targeted use of fertilizer to raise yield.

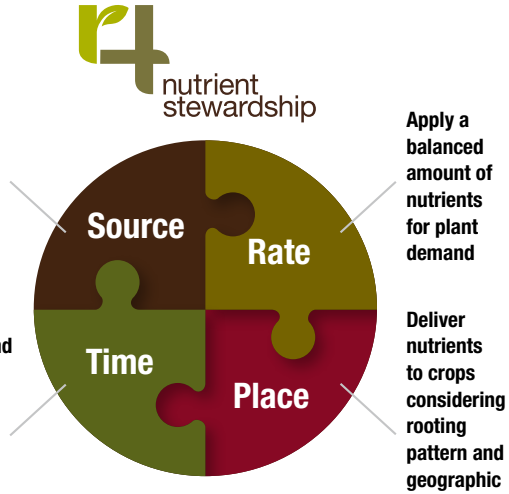
Differentiated fertilizer application



An example layout of an estate-scale experiment, showing three potential fertilizer treatments: estate commercial rate (ECR), ECR +25% and ECR -25%.

The IPNI 4R Nutrient Stewardship

IPNI's **4R Nutrient Stewardship** concept defines the right **source**, **rate**, **time**, and **place** for fertilizer application as those producing the economic, social, and environmental outcomes desired by all stakeholders to the plant ecosystem. The 4Rs are interconnected and interact with the surroundings of plant, soil, climate, and management. These variables must work in harmony to achieve the desired economic outcomes and sustainability.



Oil Palm at a Crossroads

After decades of rapid growth, the oil palm industry in Southeast Asia—dominated by the world's top two producers Indonesia and Malaysia—is now at a crossroads. The industry now has to choose between plodding along business-as-usual with stagnant productivity and ambiguous return-on-investment, and making an earnest effort to introduce innovation, improve ROI, and demonstrate that the full potential of oil palm has yet to be realized.

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