Estate Scale Experiments (ESE):

Continuously improving response to fertilizer in large commercial oil palm operations

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Working out how inputs generate profits

Fertilizer is a major expense to plantations, the largest variable cost to plantation managers. Few doubt its importance to continued high productivity. After decades of trials, we know about its general benefits to sustained high productivity. However, how much do managers really know about the payback from fertilizer on their estates? Knowing the general effect of an input and knowing its specific effect, under normal production conditions are two completely different things. In practice, agronomists can say little about the effect of fertilizer on specific estates on which they have not trialed because the effects of soil, climate and interactions with management factors, such as harvest processes, introduce huge uncertainties. Managers are unlikely to tolerate uncertainty about worker productivity: workers with low productivity are not on the payroll for long! Yet managers continue to tolerate uncertainty about the specific benefits of fertilizer. They do so because, until now, they had no way of estimating the specific effects of fertilizer. The idea behind ESE is to enable managers to see how fertilizer performs on their own plantations, under operational conditions, taking into account the real-world conditions of the production system. ESE applies to the same areas that managers apply fertilizer and at the same scale that they need to make decisions. We design the ESE so that it imposes minimal additional costs and can be adopted in ever-larger production areas, thereby producing a stream of intelligence about the return on variable costs to operations.

The principle of ESE for fertilizer use is simple: introduce a deliberate variation into the pattern of fertilizer input and analyze its effect in production. The results are real, they have clear meaning to managers and agronomists and it fosters the confidence to make changes. In practice, the process is a dialogue between estate managers, senior managers and agronomists. This dialogue could involve fertilizer suppliers who want to understand and then take responsibility for the profitability of their product. So, a partnership between IPNI's Southeast Asia Programme, Canpotex Limited and Wilmar International was born to realise this bold idea in the test bed of Wilmar's plantation in Central Kalimantan.

The history of ESE

ESE is a form of on-line experimentation. On-line experimentation is proving very popular in modern info-tech industries, but has a history in manufacturing (for process control), medicine (for understanding diseases and treatments) and other economic activities. The difference with conventional agricultural experimentation is the on-line aspect. Since the late 19th century, conventional agricultural experimentation has dealt almost wholly with 'pots and plots', experimentations on abstractions from field production systems, rather than the system itself. Here we observe experimentations in the production system. This has not been easy before for three basic reasons: (1) varying input was not possible over most large production systems, (2) measuring output was not possible over large areas for most production systems, and (3) there was no conventional method of socializing the results from ESE for management change.

In broad acre cropping systems the first two limitations were removed by the introduction of precision agriculture technology. Variable rate technology enabled inputs to be controlled according to an experimental plan. Yield monitors recorded output precisely for all cropped areas. On farm experiments (OFE) could be installed easily over entire production units. Despite the ease with which farmers can implement OFE, relatively few do so. This, we believe, is not a consequence

Figure 1. IPNI's Donough and Oberthur discuss ideas with Wilmar managers

> *On-line experimentation is proving very popular in modern info-tech industries*

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.

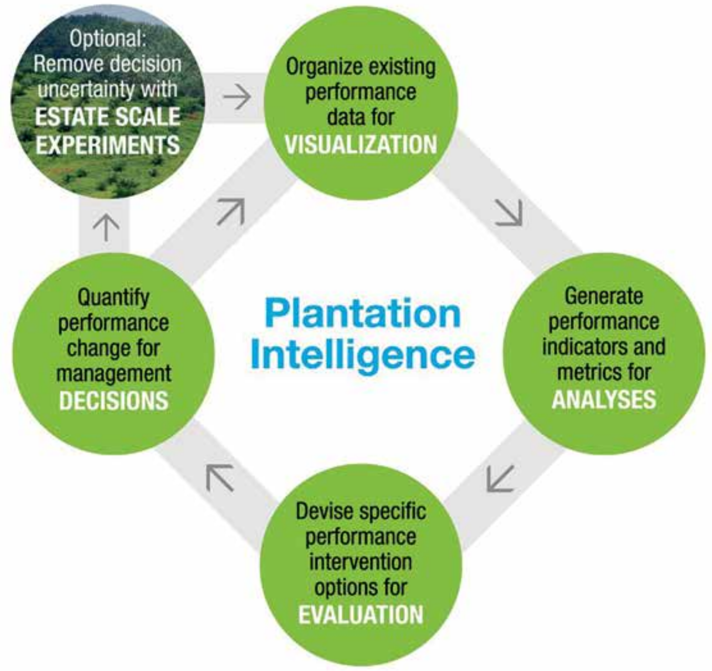


Figure 2. The IPNI Plantation Intelligence Concept supports ESE

of inadequate technological capacity but of lack of support to analyze and interpret the data from OFE, and the model for change remains a powerful limitation. The first two limitations do not apply to oil palm, which has a history of detailed recorded keeping of inputs and outputs at the block level. The third limitation applies, but less so, since large plantation operators, at least, are organized to manage the flow of information and to act accordingly. Agronomists are included in this flow and so are available to provide science-based interpretations of plantation performance and to support decisions.

In practice, getting value out of ESE is not trivial. Information flow in oil palm production systems is often complex and hierarchical. Managers complain about drowning in data, while being starved of information. As in many industries, decisions are often intuitive, made without full analysis and subject to all the normal cognitive biases. To help address this and enable ESE, we also initiated a process of Plantation Intelligence (PI). PI is a process of data capture, analysis and interpretation of plantation operations to provide evidence for improved decision-making. It is the appropriate vehicle to support ESE.

The ROI from ESE

What is the return of investment of ESE? Firstly, consider the investment. The cost of ESE is actually very small. ESE is designed to impose minimal additional costs to managers beyond analysis. ESE uses Standard Operating Procedure (SOP) whenever possible and is developed with managers to ensure that risks are minimal. The benefits accrue through better management. Better management comes from the improved insight provided by ESE. The insight is improved because the results apply directly to the plantation in which ESE was installed. The detailed and specific insight will help managers focus on more certain winners. For example, suppose the ESE identified 20% of the plantation that produced 2t/ha more with an additional 50 kg/ha of fertilizer per hectare. For a plantation of 6,000 ha, this represents an additional productivity valued at

> *'PI' is the process of data capture, analysis and interpretation*

about USD300,000 each year. If the ESE also identified the area where fertilizer could be reduced by a similar quantum, this change comes at virtually no cost, since inputs are merely shifted from low to higher responsive areas. In most of the cases, the ESE will prove the beliefs that the managers already have. But it does so with hard numbers, that can be presented to senior managers to support the case for change. Moreover, the gain in knowledge is progressive and specific. Managers become increasingly knowledgeable about their own production areas.

Operationalizing ESE

Having accepted the principle, partners start to look at practical details of experimentation:

Figure 3. Harvested bunches from a 6,000ha estate scale experiment in a Wilmar operation

Figure 4. IPNI Advisors and Wilmar managers review findings directly in the field

Figure 5. IPNI and Wilmar Senior management meet regularly on progress

- What area to experiment with? The bigger the better from a data point of view, though the managers likely need to balance the benefit of such insight with the risks of experimentation.
- How much to vary the experimental factor and whether to include zero treatments? Agronomists will want to get clear results, while the manager will want to reduce risks. Perhaps a compromise can be reached to include zeros over a small area, and to gradually increase variation in treatment factors.
- What experimental layout to apply and how many observations to make? The analyst will likely ask for as many as possible observations done in a layout that enables easy definition of results. The manager will insist that the layout is easy to apply, and no additional work is required for taking observations.

The process of designing and installing the ESE is almost always a

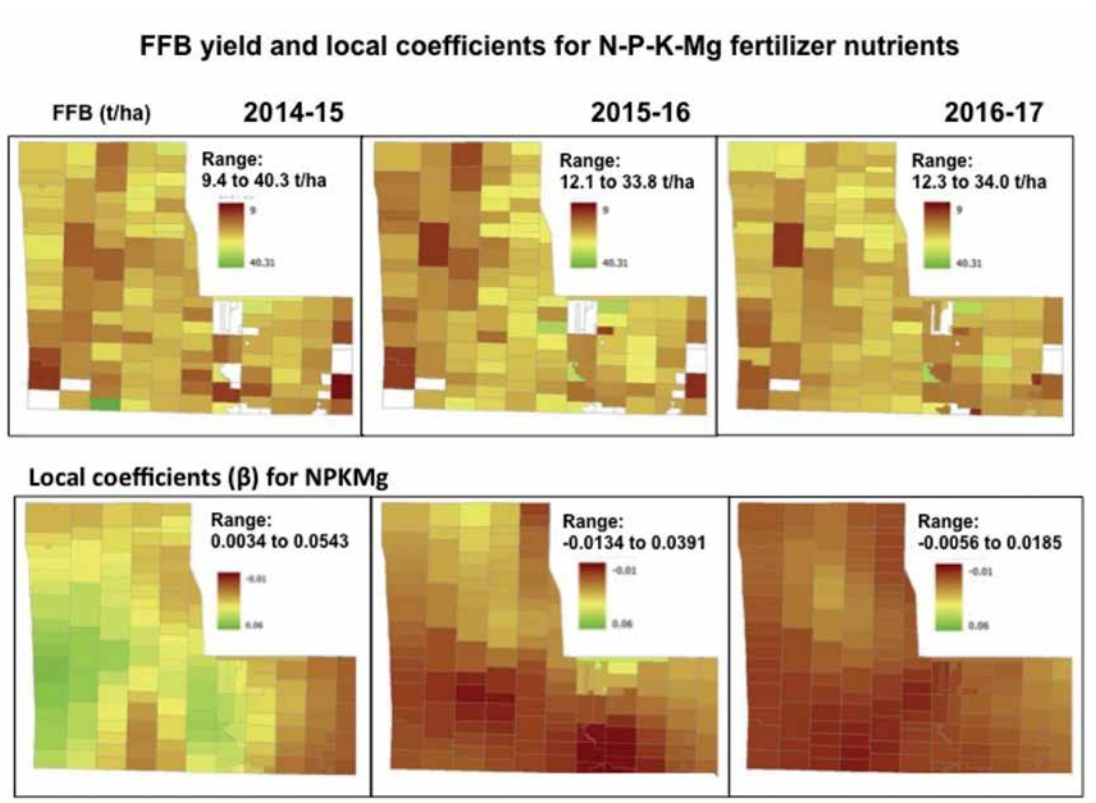
> *ESE provides a powerful stimulus to learning about fertilizer response*

dialogue in which various options are being considered by analysts, agronomists and plantation managers. It is necessary that senior management fully signs on and champions the change process. Key component of this dialogue is to determine how managers and advisors interpret the information and how they use the information to support decisions. Few managers will implement major changes immediately on reviewing a single result because, amongst other reasons, they know that response varies with season. Nevertheless, ESE provides a powerful stimulus to learning about fertilizer response.

How to analyze results

Our analyses use monthly yield data, although annual summaries of monthly data may suffice depending on the aim of the ESE. Implementers may look at different response variables to fertilizer input. These may include fresh fruit bunch yield (FFB). While FFB is the most obvious target, a full expression of fertilizer response is unlikely before the third year when the effect of nutrition on new bunch formation is realized. Average bunch weight (ABW) and derived variables are an alternative. ABW is likely to be sensitive to improved nutrition in the later stages of fruit development and changes may be captured soon after starting the ESE.

Figure 6. Different analytical methods are developed to analyse the results of an ESE



Yet, ABW is subject to many factors, including increases in ABW with tree age, efficiency of crop recovery and mixing of fruit from different blocks on their way to the mill. On the other hand, the number of harvested bunches (BNo) is assigned to each block, and ratios of ABW:FFB and ABW:BNo can be used to get a better feel for this.

The first step in the analyses is to look for treatment effects using conventional analysis of variance. This is unlikely to show a clear picture, especially in early years, as the block-to-block variation over a large area of several thousand hectares is likely to overwhelm the effect of fertilizer which, in any case, may take up to three years to fully express itself. Some spatial variance can be removed using fields within a soil type or a management zone as a blocking variable in the statistical model.

Spatial analysis promises a clearer method of assessing fertilizer response over large areas because it removes a large proportion of the spatial variation from analysis. It looks for areas where fertilizer is effective, rather than mixing good and bad areas in a single analysis. IPNI and partners are currently trialing various methods. All are experimental as there is no single agreed upon method for analyzing this type of data. To our knowledge, such analysis has never been undertaken with commercial oil palm data. Geographically weighted regression, Bayesian probability statistics and the use of homologous events are now in the final evaluation period and all have produced promising results.

Anticipated insights will lead to the identification of 'sure win areas' i.e. areas with a high likelihood of positive response to fertilizer, while high risk areas identify blocks with a low likelihood of positive response, based on prior analysis. Meanwhile, puzzle areas identify areas that fail to respond for no clear reason and further detailed (trial) work is needed.

Such insights on specific block actual yield responsiveness to fertilizer should permit better fertilizer rate decisions for the entire commercial area contributing data towards the analysis process, compared to the current practice of using extrapolations from fertilizer experiments and reliance on plant tissue nutrient concentrations. The latter, while useful to identify nutrient deficiencies, does not help in situations where nutritional status of palms under management are already in the optimal range. ■

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