IPNI Southeast Asia Program

PLANT NUTRITION

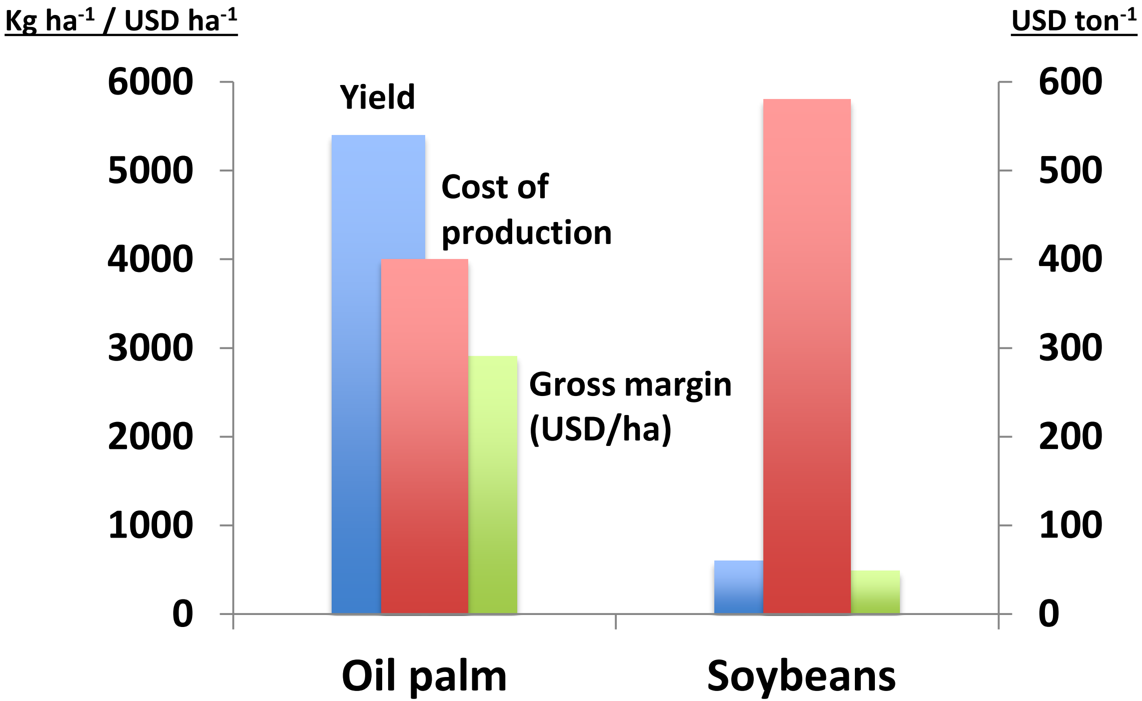
Plantation Intelligence®

Getting more value from Estate data

C. Donough, T. Oberthür, S. Cook, J. Cock, S.P. Kam, Y.L. Lim and H. Sugianto

IJM Plantations Berhad Oil Palm Seminar Part II, Sandakan, Sabah, Malaysia, November 4, 2016

Profitable, Eco-efficient Oil Palm



Zimmer et al (2009) Agri Benchmark. Cash crop report 2009. Benchmarking farming systems workdwide.

Oil Palm vs Soya

- *Higher yield*
- *Lower cost*
- *Bigger margin*
  - ➢ *More attractive investment*

- *Uses less land*
  - ➢ *More eco-efficient*

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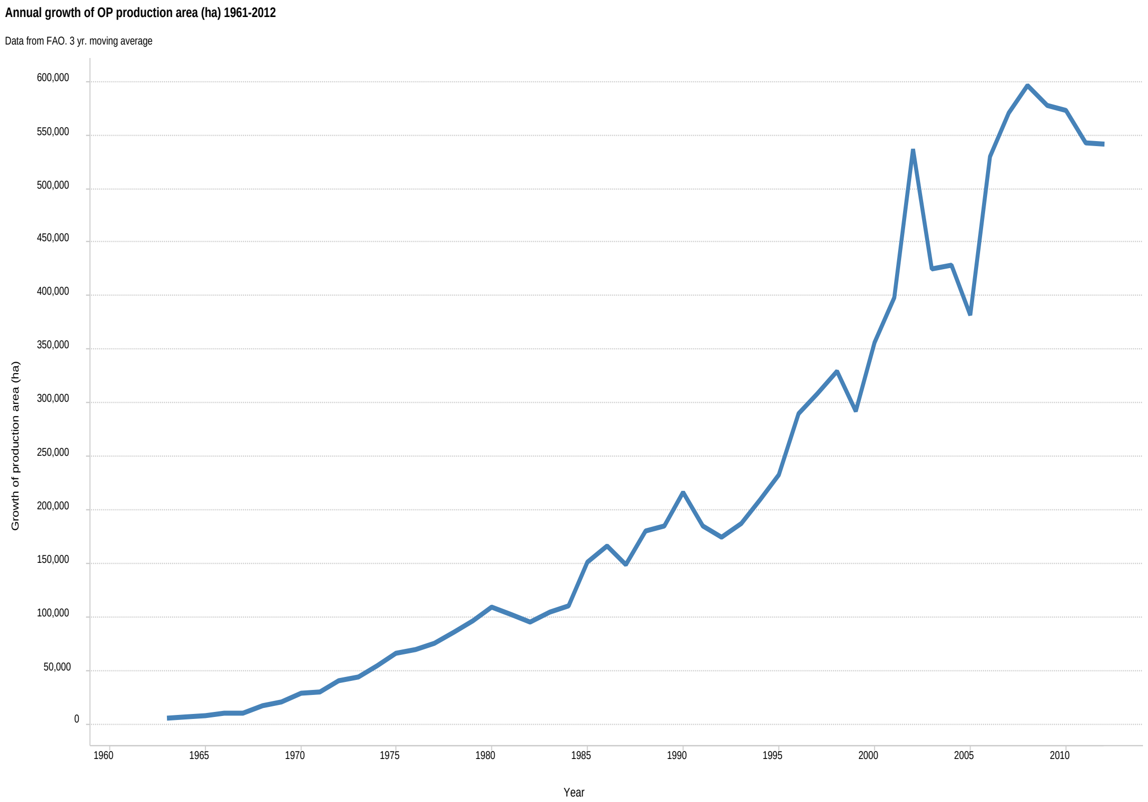
Rapid expansion driven by SE Asia

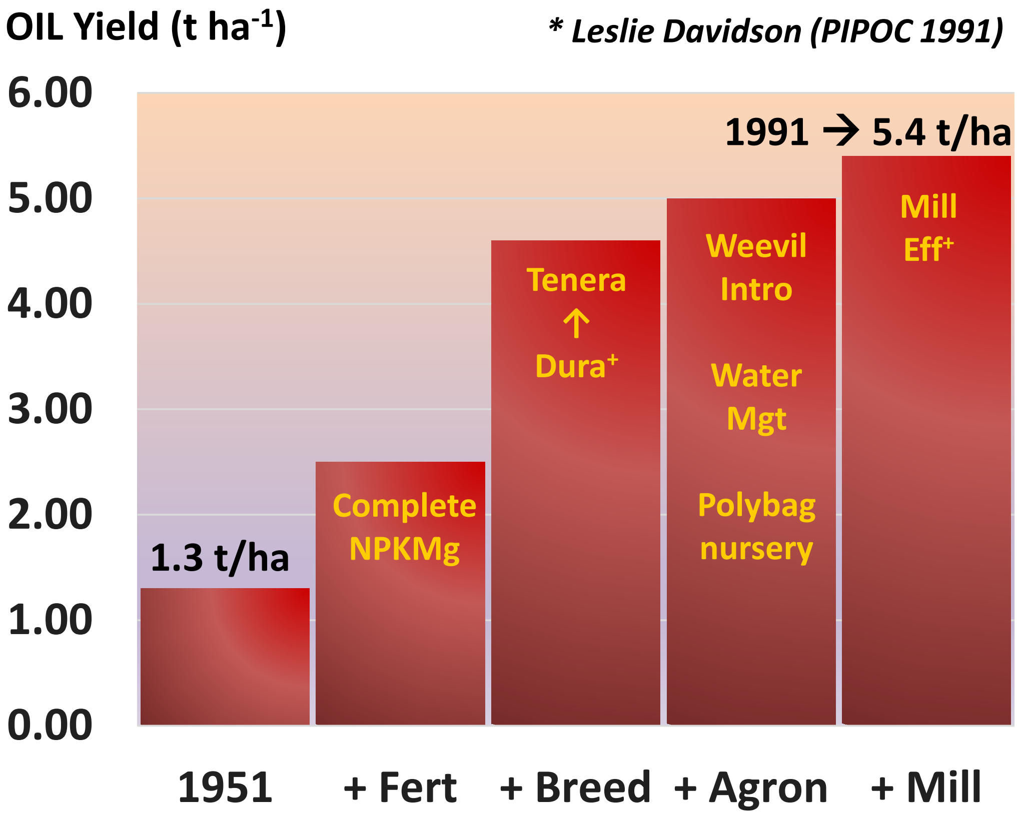


Annual growth in oil palm production area 1961-2012*

- *Over 500K ha per year in 1990s into 2000s*
- *In Sabah, Sarawak*
- *In Indonesia*

***** FAO statistics***

Yield improvement 1951-1991



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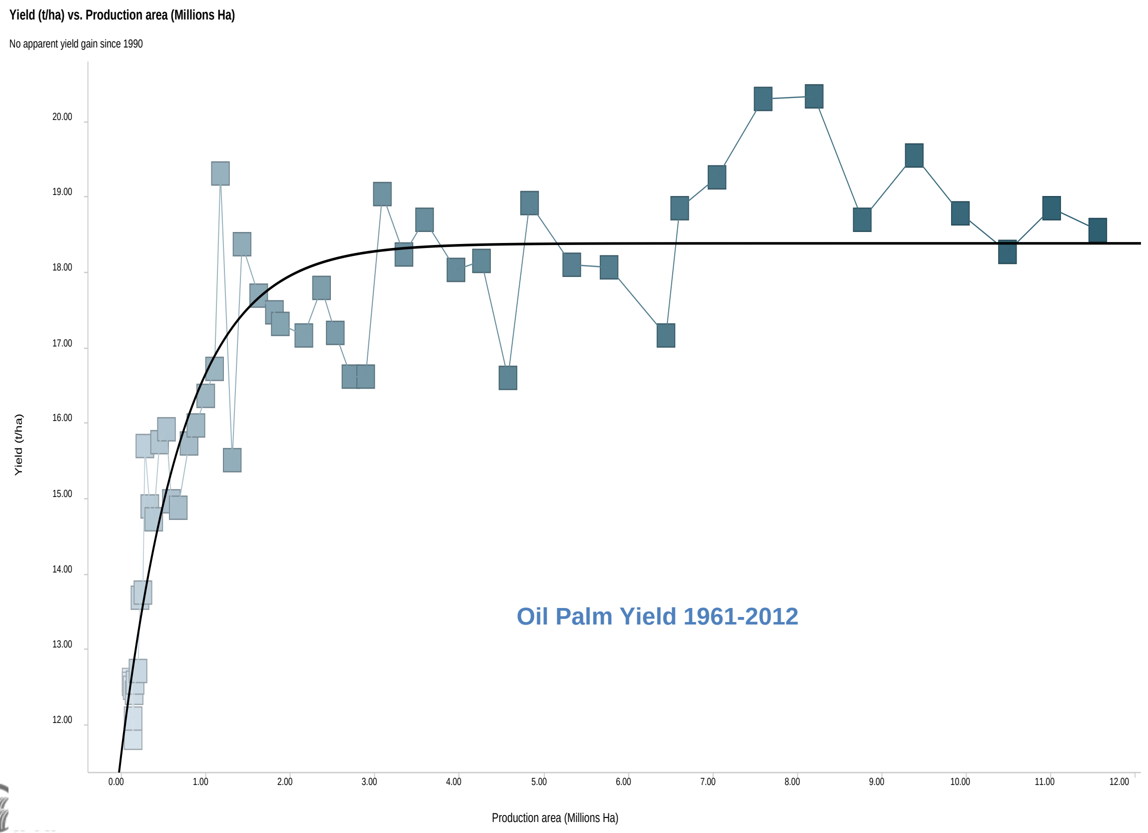
Yield improvement in early years of expansion due to:

- *Better fertilizing*
- *Change from DxD to DxP*
  - *30% from fertilizer*
  - *50% from breeding*

- *Use of polybag nurseries*
- *Introduction of pollinating weevil*
- *Better water management*
- *Higher milling efficiency*

Yield stagnant since 1990s*



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5.4 t/ha oil yield achieved 1991

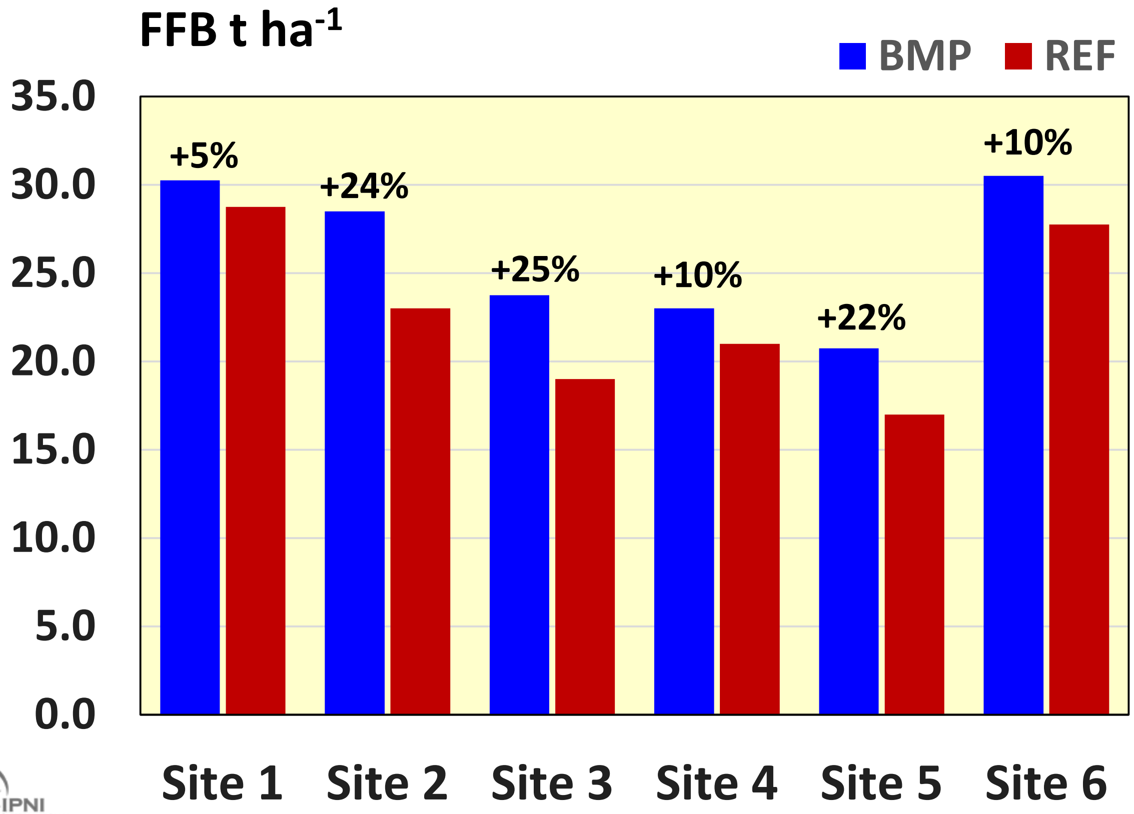
Davidson

Since then not much better

** FAO statistics*

- *Managers oversee ever larger areas*
- *Agronomists struggling to understand huge areas of 'new' land*

Yield improvement with better implementation of BMP*



Better FFB yield at commercial scale with better implementation of BMPs

- *Indonesia 2006-2011*
  - *N & S Sumatra*
  - *W, C & E Kalimantan*
- *Overall 12% higher yield*
- *Best blocks in Sumatra & Kalimantan – over 38 t/ha*

***** Donough et al (PIPOC 2011)***

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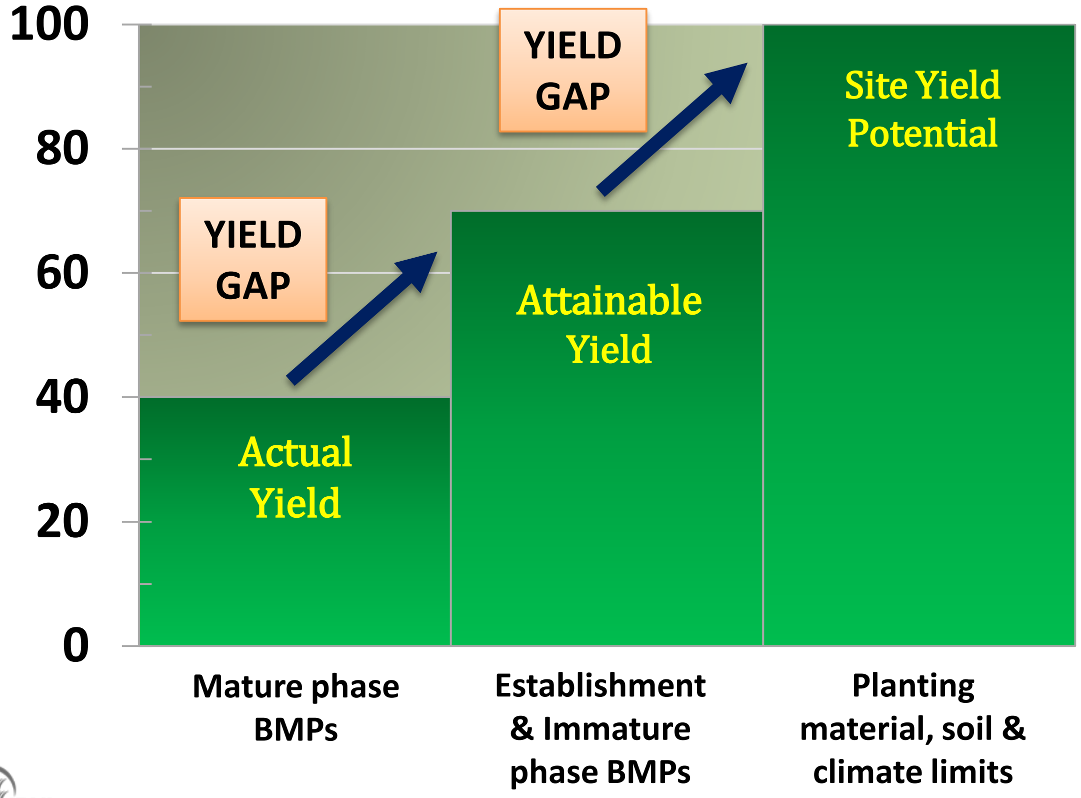
Sub-optimal implementation of BMP → Yield gaps



BMPs developed by field experimentation

- *Small scale, controlled conditions*
- *Practices tested one-by-one*

Variable results with BMPs at commercial scale

- *BMPs applied together*
- *Large site differences*
- *Different standards of implementation*

Decision Making Uncertainty

Complex interactions in an agronomic system render outcomes of any management decision

Uncertain

Problems – manpower

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Skilled labour in short supply

- *Over 200 million tons FFB per year collected by hand*
- *Almost all fertilizer applied by hand*
- *Not just workers in short supply – also:*
  - *Lower – middle management*
  - *Skilled agronomists*

Decision Making Uncertainty

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METRIC
Uncertainty about rate & placement of fertilizer to support a yield target

TRANSLATIONAL
Uncertainty from external factors that reduce fertilizer performance, e.g. harvest, mill and transport efficiency

Example:

ROI in Fertilizer

TEMPORAL
Uncertainty about timing of fertilizer applications, e.g. drought interference

STRUCTURAL
Uncertainty from internal factors that influence fertilizer efficiency, e.g. EFB applications

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Cook et al. Better Crops ***97,*** *17 - 20 (2013)*

New Business Model

- Learn from commercial data
- Not just from trials

System is Monitored
in Extraordinary Detail

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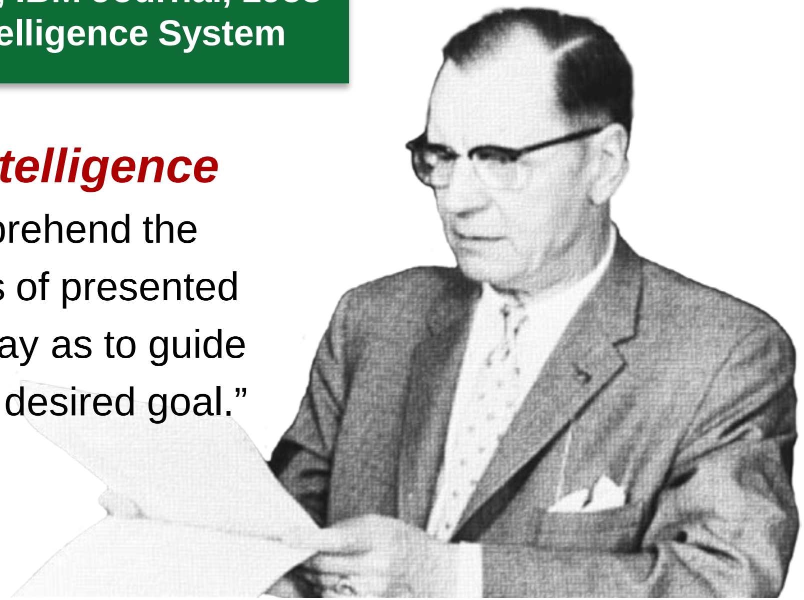
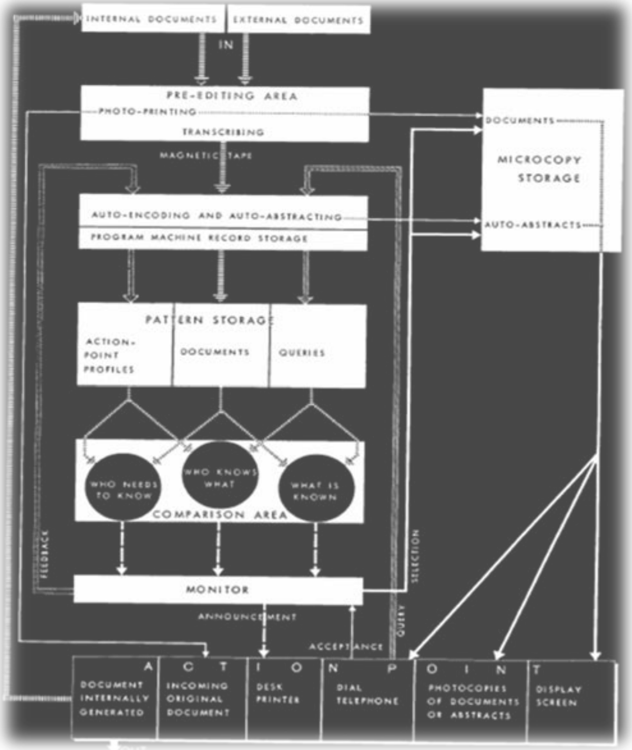
Business Intelligence

Hans Peter Luhn, IBM Journal, 1958
A Business Intelligence System

(business) intelligence

"the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal."





http://www.bireports.co.uk/blog/tag/hans-peter-luhn/

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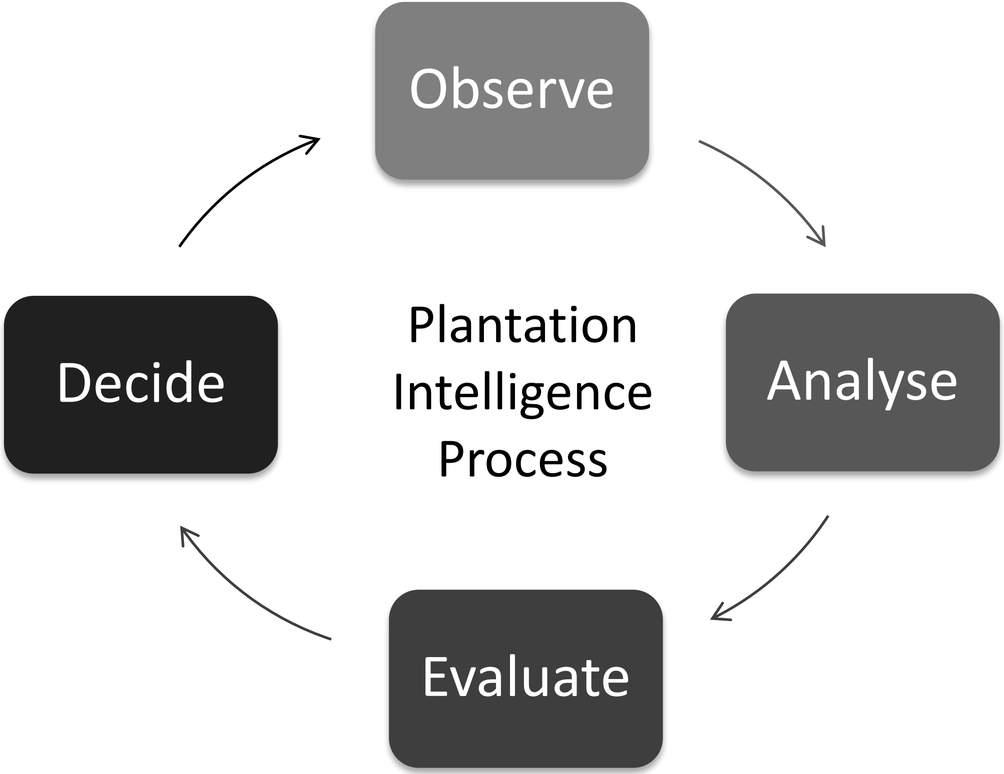

Cook et al (Int'l Oil Palm Conf , Bali, 2014

Plantation Intelligence®

Simply a process to use estate data to support decisions

A cyclical process that does not stop → continuous improvement

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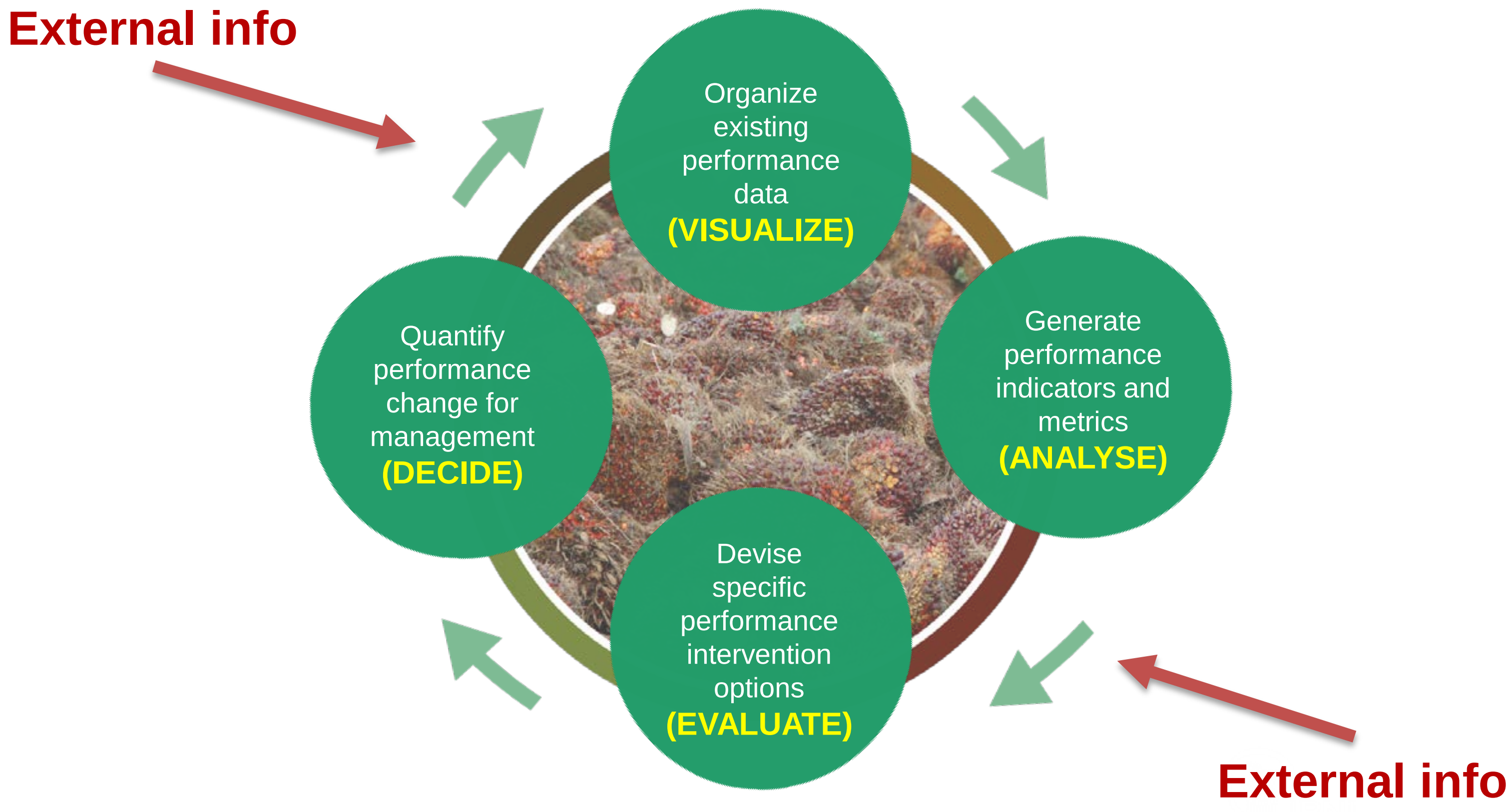


Plantation Intelligence (PI) Analyses

Concepts, Protocols, Application Examples

Analyses for examples with data from IPNI partner plantations

Analyses implemented in “Spotfire” of TIBCO Software Inc.

Data management in Excel spreadsheets, including a spatial visualization component “PI Mapper”

Current Protocols

7

Yield Age Profiling

Yield Trends

Naïve Gross Margins

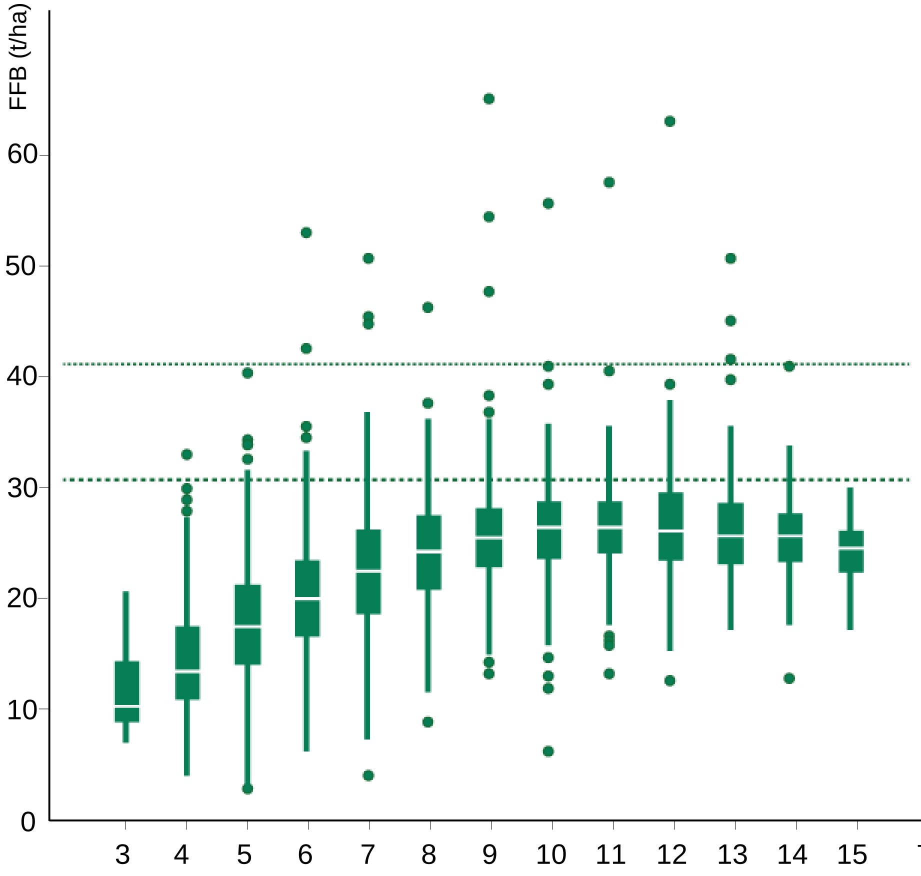
Yield Soil Interactions

Yield Soil Climate Interactions

Yield Labor Interactions

Fertilizer Response Analyses

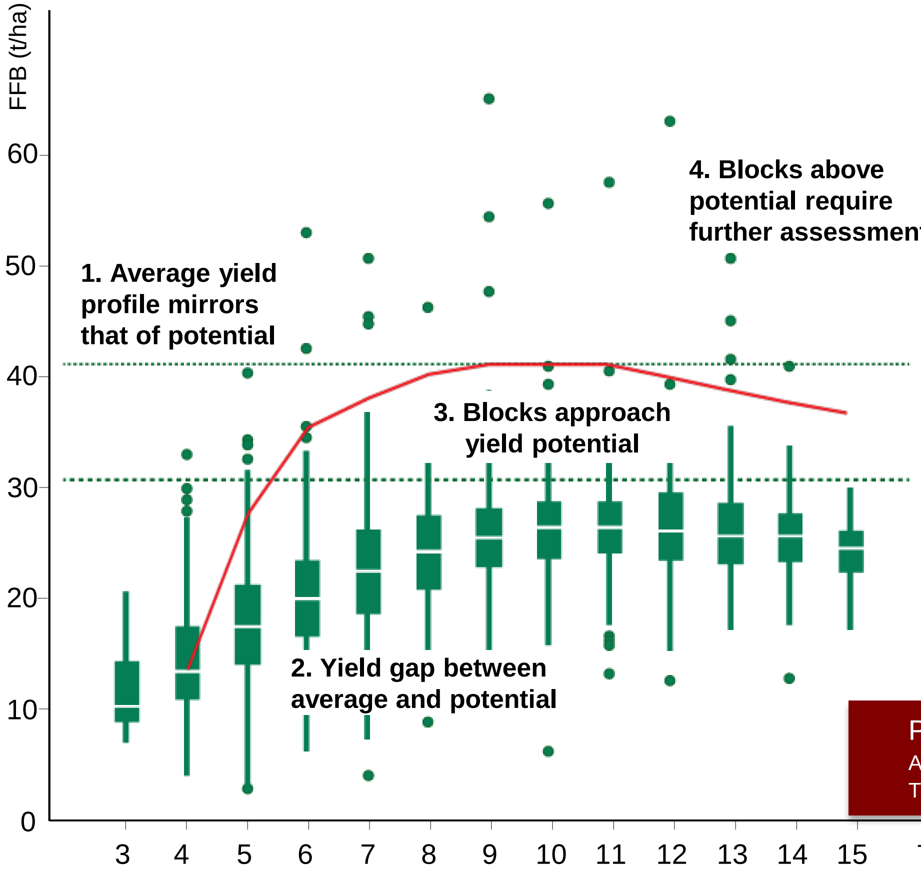
Yield Age Profiling

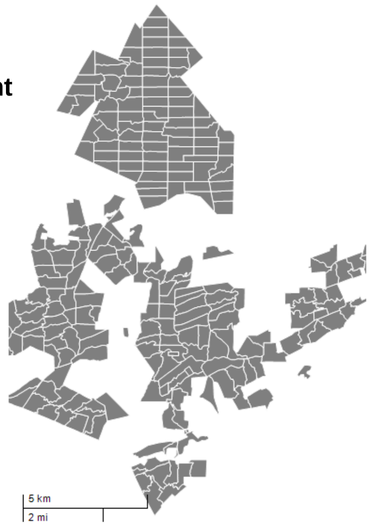


Yield Age Profiling

Yield development over oil palm growth period, FFB per year, as average and variation and outliers

Yield Benchmarking





PALMSIM Model

Agricultural Systems, 131:1-10 (2014)

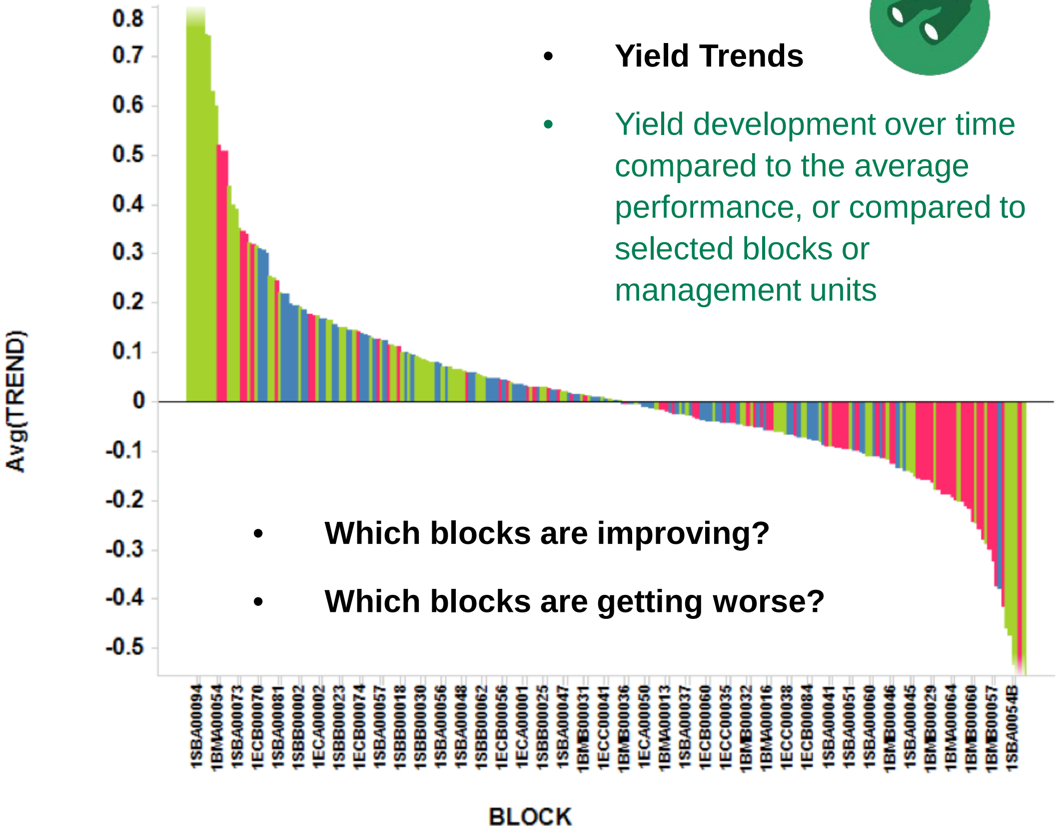
The Planter, 91: 81-96 (2015)

Yield trends analysis

Map Chart

Yield trends

1.0 sd represents ~5 t/ha per year +/-



- **Yield Trends**
- Yield development over time compared to the average performance, or compared to selected blocks or management units

- **Which blocks are improving?**
- **Which blocks are getting worse?**

Block-by-block profitability

Naïve Gross Margins

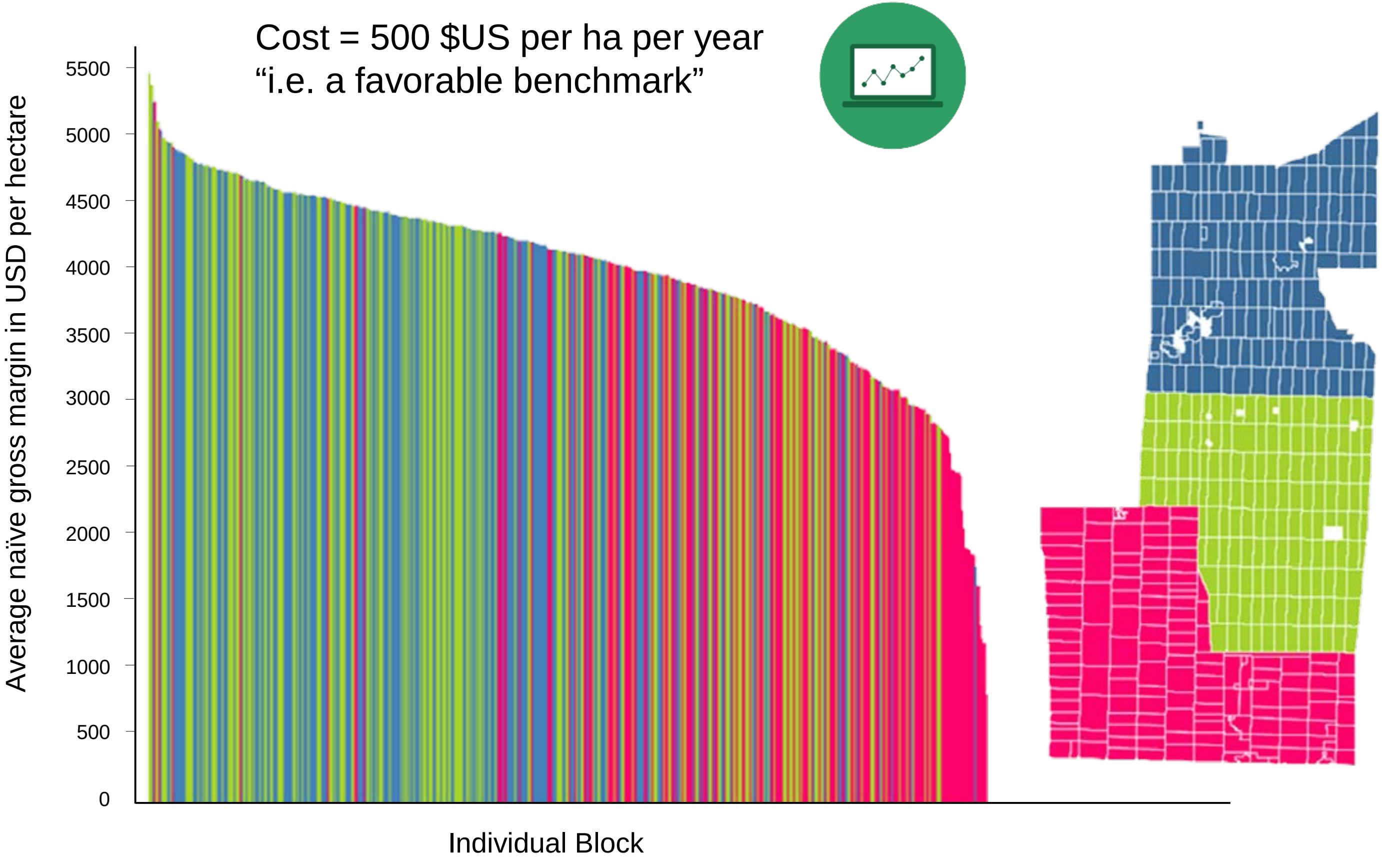
Simple estimate of profit margins per ha

with estimated* block cost

and actual variable oil price

** Can be actual block cost → then will be actual Gross Margin, not naïve*

Naïve Gross Margins



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Naïve Gross Margins

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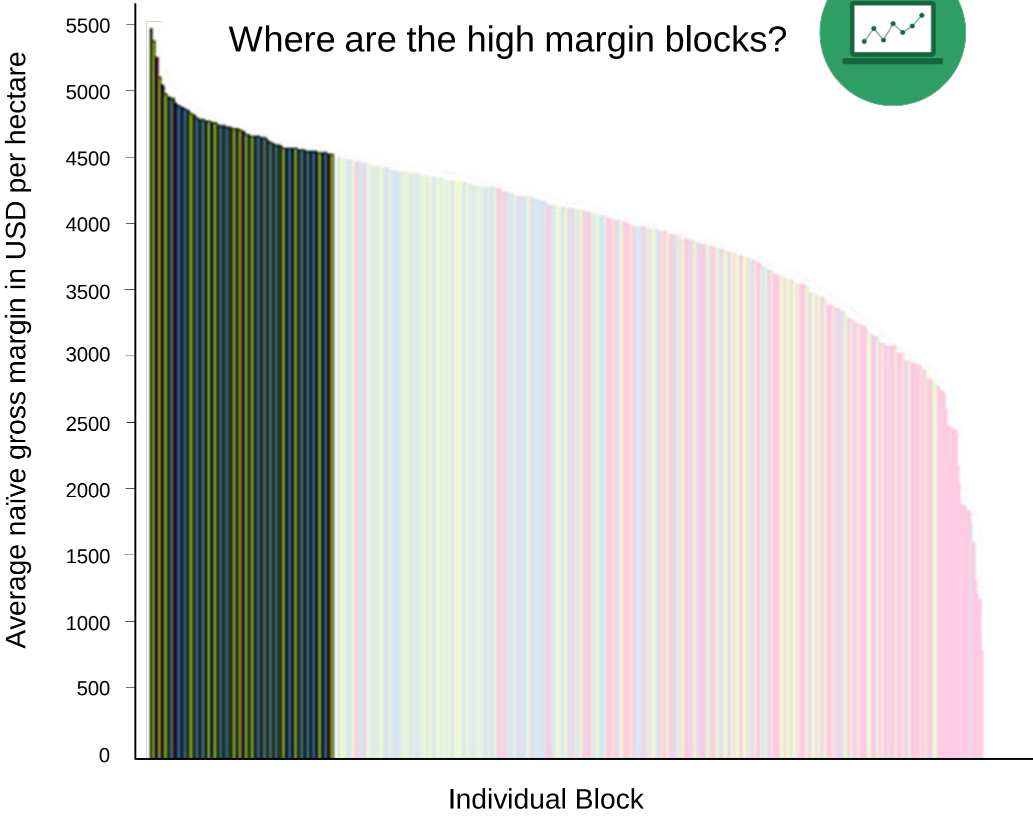
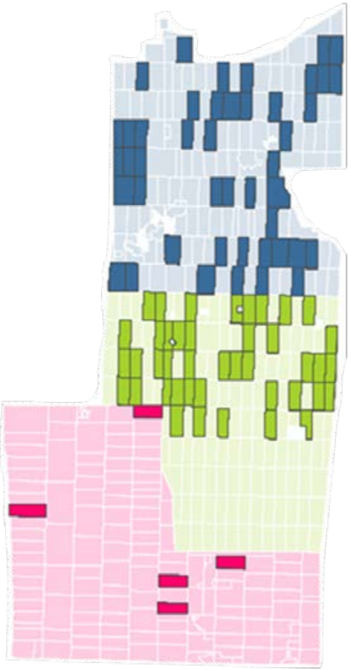
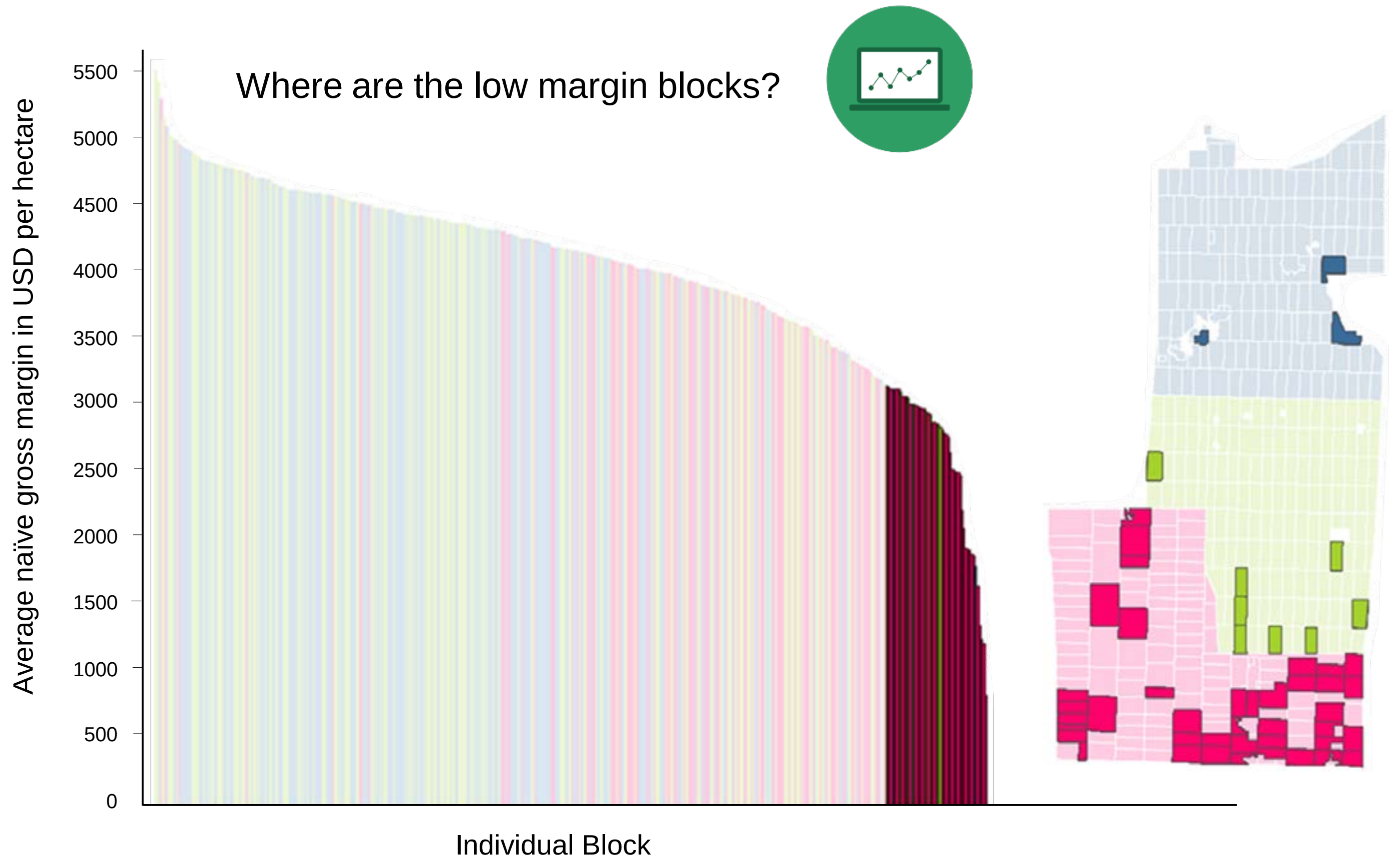
Where are the high margin blocks?





Naïve Gross Margins



Hard (impossible?) to manage factors – climate, soil

Yield Soil Climate Interactions

Linking yield of FFB (t/ha) to certain soil and climate conditions

Including combined effects of soil & climate

Can we separate the effect of management practices from environmental factors?

- Planters (farmers) learn from their own experiences.
- Yet, when an exceptionally good (or bad) yield occurs, one is rarely absolutely sure that it was due to –
  - *chance (environment), or*
  - *the practices that were implemented, or*
  - *a combination of the practices and the environmental conditions.*

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Defining soil-climate combinations → Homologous events (HE)

- **HE** = yield events with similar non-controllable factors occurring
  - *Block-by-block → accounts for soil type & topography*
  - *Over a 3-year period before and including the year of harvest*
    - *Because it takes about 3 years for bunches to develop*
- If a **many** blocks are classified into sets with similar **HE**
  - *it should be possible to **link yield to management** (e.g. fertilizer) under specific environmental conditions*

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Water = most important climate factor

- Most important climate factor for oil palm in the humid tropics → rainfall → **excessive** and / or **insufficient**
  - **Insufficient** = ***Deficit:*** *below 150mm per month*
  - **Excess*:*** *more than 600 mm per month*

- In the two years before, as well as the year of the yield
- In any block, the effect of water excess and / or deficit depends on topography and soil

Wetness of each year

A particular year can have –

- No excess or deficit = Normal (**N**) year, or
- Deficit but no Excess = Dry (**D**) year, or
- Excess but no deficit = Wet (**W**) year, or
- Deficit and Excess = Extreme (**E**) year

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Building 3-year HE for individual blocks

HE-0 = HE of the current year of yield

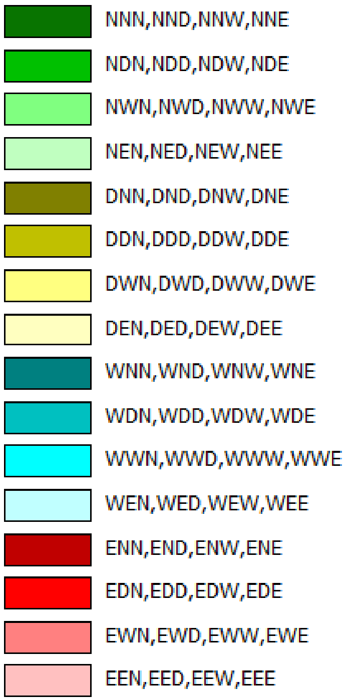
HE-1 = HE of the previous year, and

HE-2 = HE of the 2 years ago

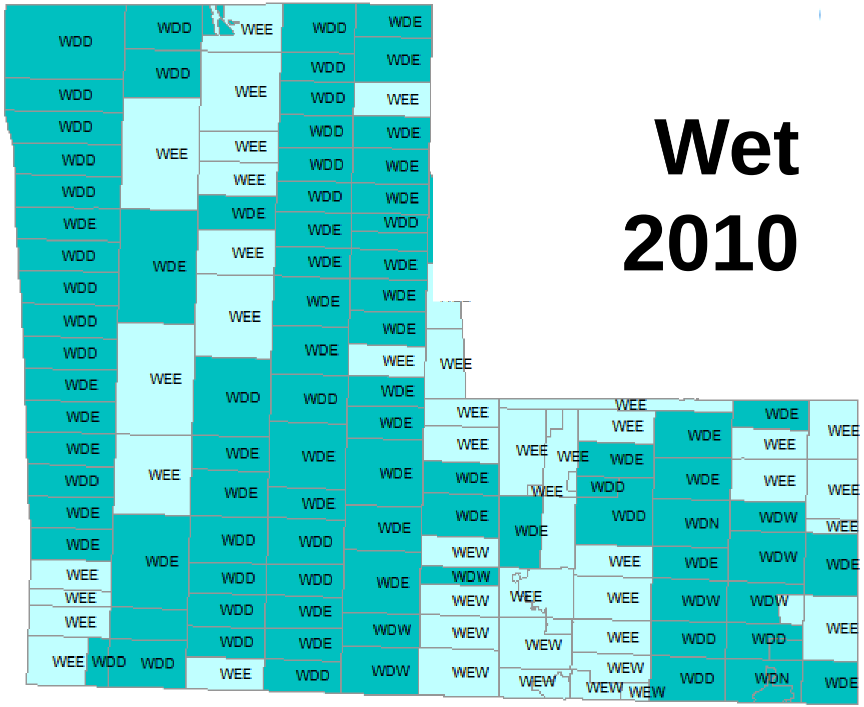
<u>*Example for a bloc*</u>k:

HE-2 = **D**, HE-1 = **W**, and HE-0 = **N**, then the block HE class = **DWN** …

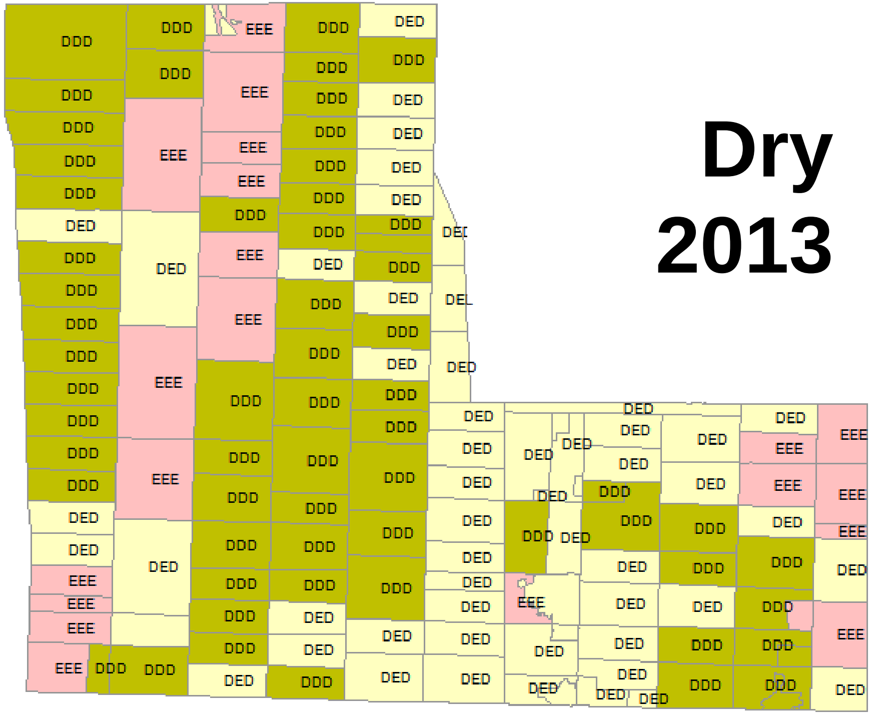
There are 64 (=4^3) possible unique HE classes



Homologous Events - examples



Wet
2010



Dry
2013

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HE link to yield

HE class	FFB Yield change (t/ha)	Compared to
HE-2 D (*Dry 2 years ago*)	-6.1	HE-2 N (*Normal 2 years ago*)
HE-2 W (*Wet 2 years ago*)	-5.5	
HE-2 E (*Extreme 2 years ago*)	-8.5	

Yield for dry, wet and extreme HE two years before current year of yield compared to a normal year HE 2 years ago.
Harvest data from 2009-2013, weather data from 2007-2013.

Cock et al (2016) Learning from commercial crop performance: oil palm yield response to management under well-defined growing conditions. Agricultural Systems 149:99-111

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Implications

- Planters know yield can be reduced due to dry periods
- Now we know excess water has a similar effect on future yield
- Knowing the HE effects, and having data of past rainfall, may make it possible for fertilizer rate decisions to be based on more accurate expectations of future yield.

Relating harvesting labour to yield

Yield Labor Interactions

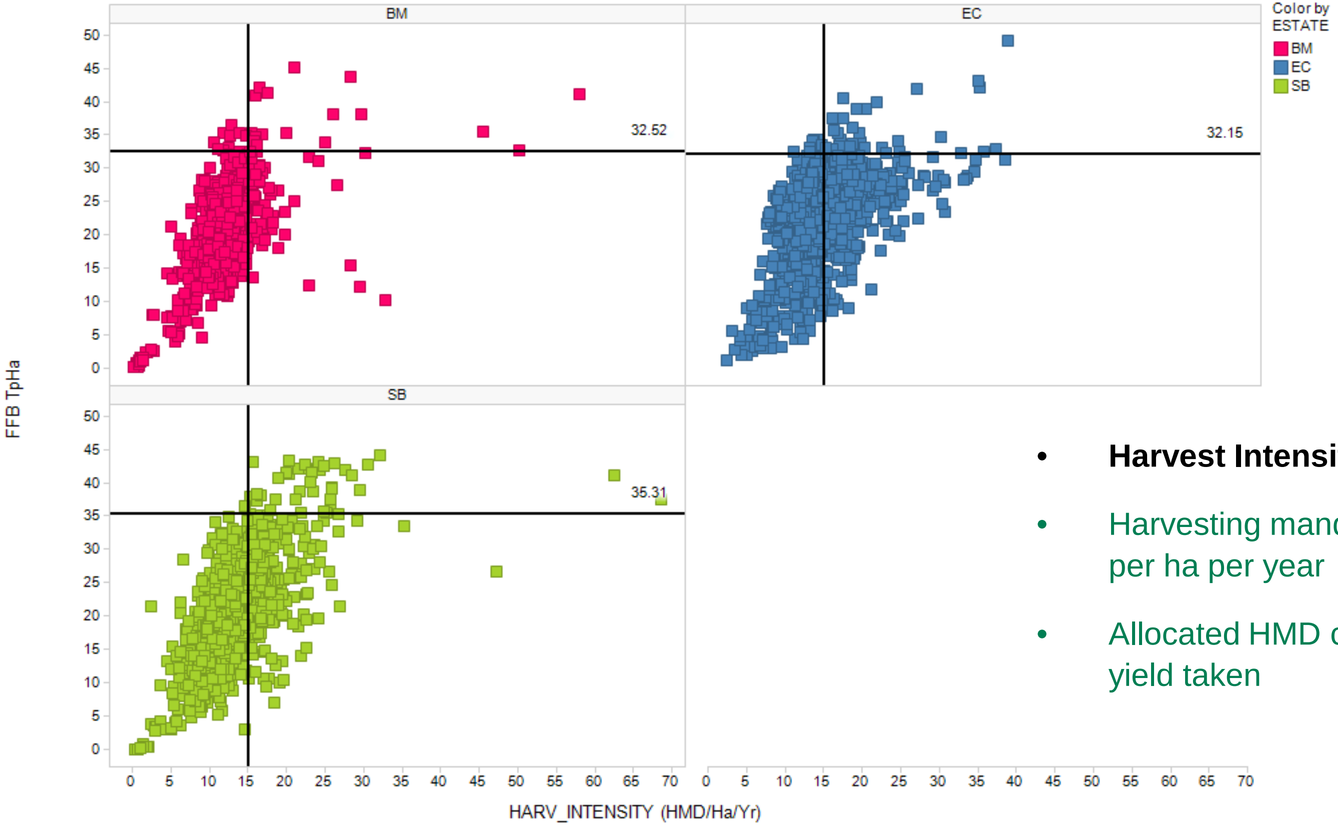
Relationship between harvested yield (taken yield) and deployment of man power for FFB and loose fruit harvest

Yield Made

VS.

Yield Taken

FFB TpHa vs. HARV_INTENSITY (HMD/Ha/Yr)



- **Harvest Intensity (HI)**
- Harvesting mandays (HMD) per ha per year
- Allocated HMD can influence yield taken

Filter Settings

- YEAR: (2003 <= YEAR <= 2013) without empty values
- FFB TpHa: (0.09 <= FFB TpHa <= 50.30) and empty values

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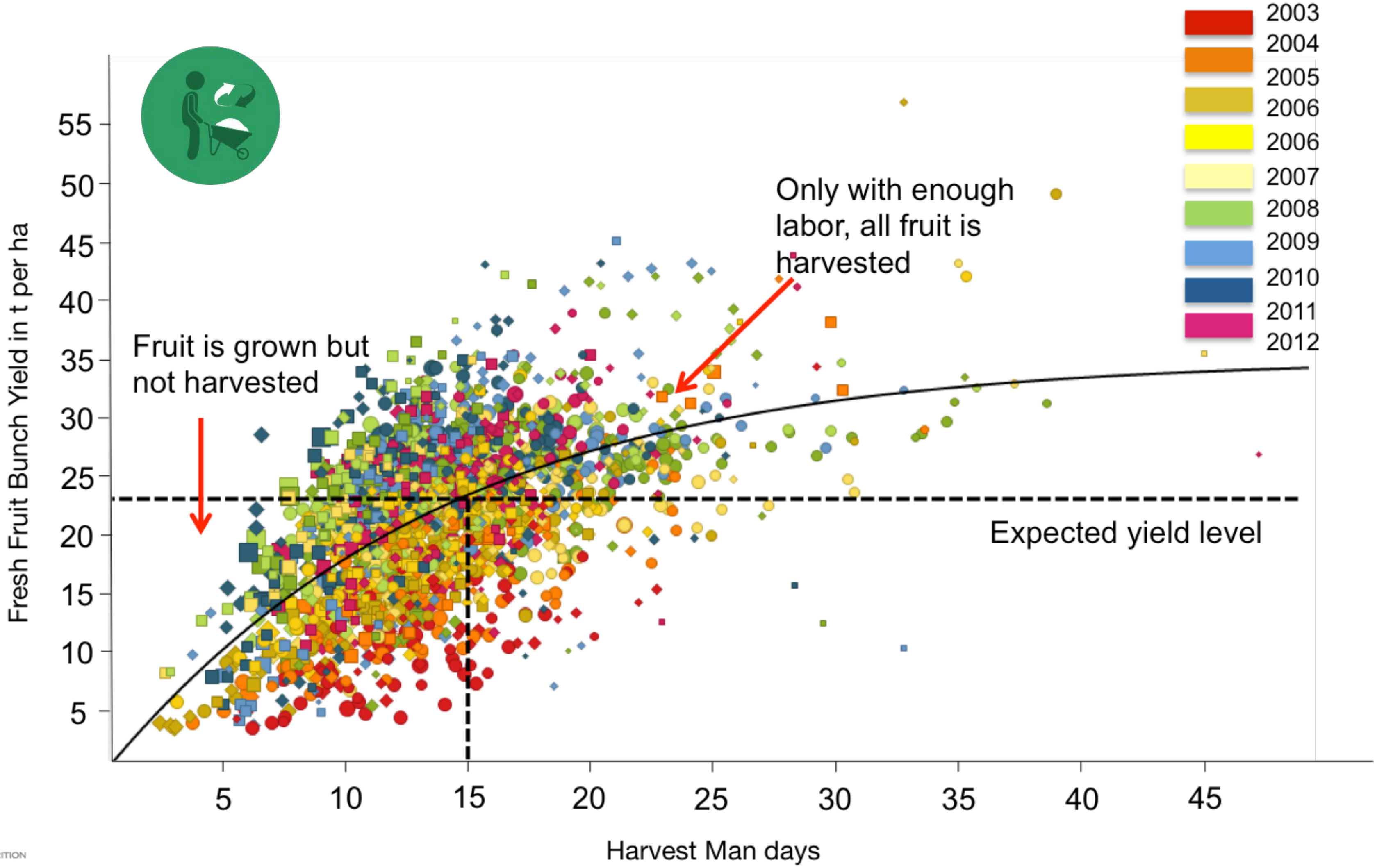

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Yield response to fertilizers applied

Crop Response to Fertilizer

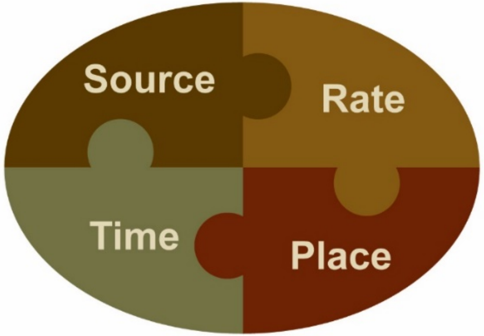
- Estimate of return on investment in NPKMg fertilizer
- Measured in kg of FFB per kg of fertilizers applied
- Fertilizer input is calculated over a two year period, from 2.5 to 2 years before harvest

Oil palms need fertilizer

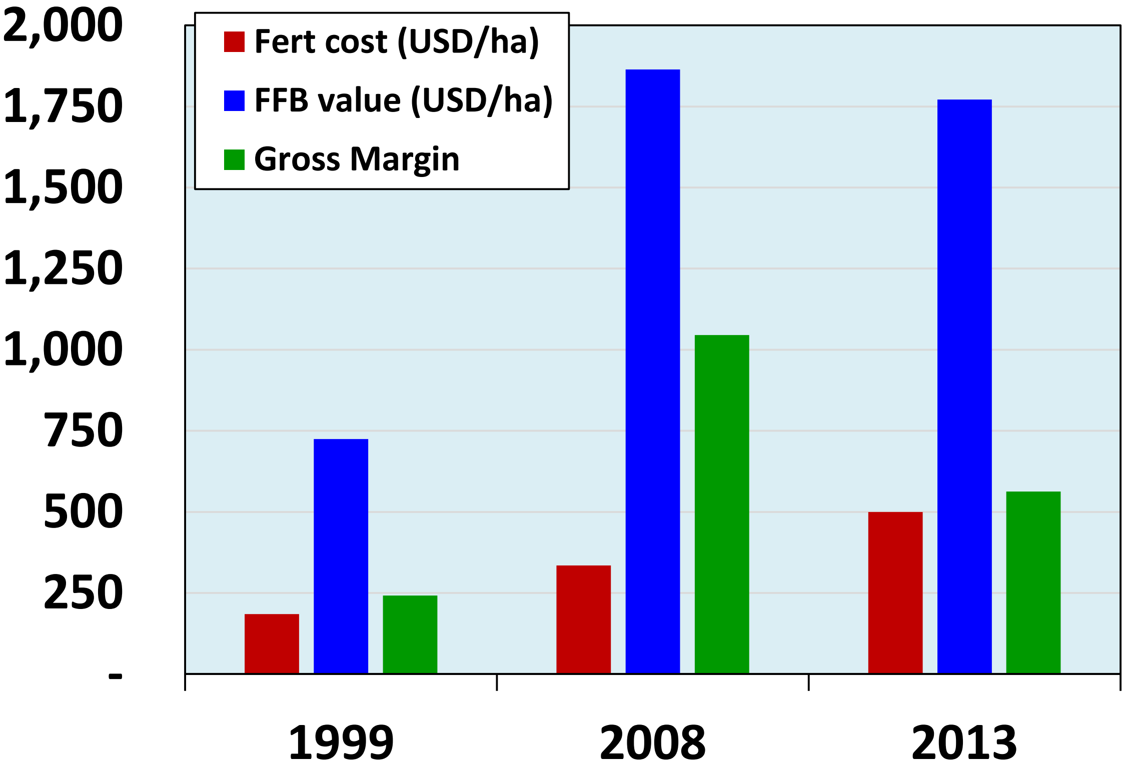
- High fruit bunch (FFB) yield → *removes nutrients from fields*
- *Nutrients needed for palm growth*
- Low soil fertility → *insufficient to meet crop demand*
- Recycling of nutrients (post-mill) → *insufficient for all cropped areas*
  → *insufficient for all crop needs*

Nutrient management BMPs based on 4R principles

4R nutrient stewardship



Profitability of fertilizer application



Adapted from Mutert (2001)

- Fertilizer cost increasing
- Crop value falling
- Pressure on margin at farm level

Fertilizer use efficiency (FUE)

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Apparent FUE → Actual Yield (kg) per kg fertilizer applied in last 3 years

Break-even FUE → based on FFB price & cost of fertilizer applied

- Cost still the MAJOR issue
- Fertilizer management process compartmentalized
  - *Agronomists work out rates*
  - *Cut or add based on budget*
  - *Purchasing buys*
  - *Estates receive & apply*
- No attempt to estimate yield response in estates

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Fertilizer use efficiency FUE)

BREAK–EVEN

point

8kg ~ 10kg fresh fruit

bunches per kg fertilizer

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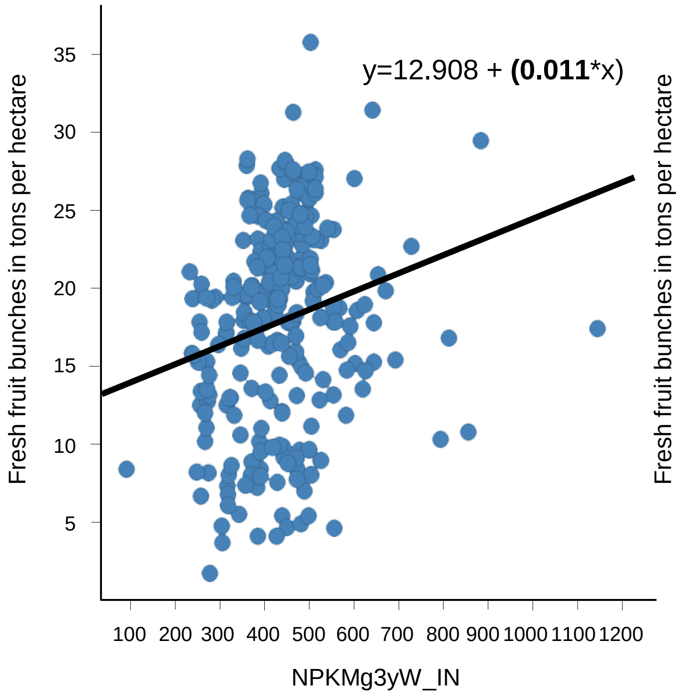
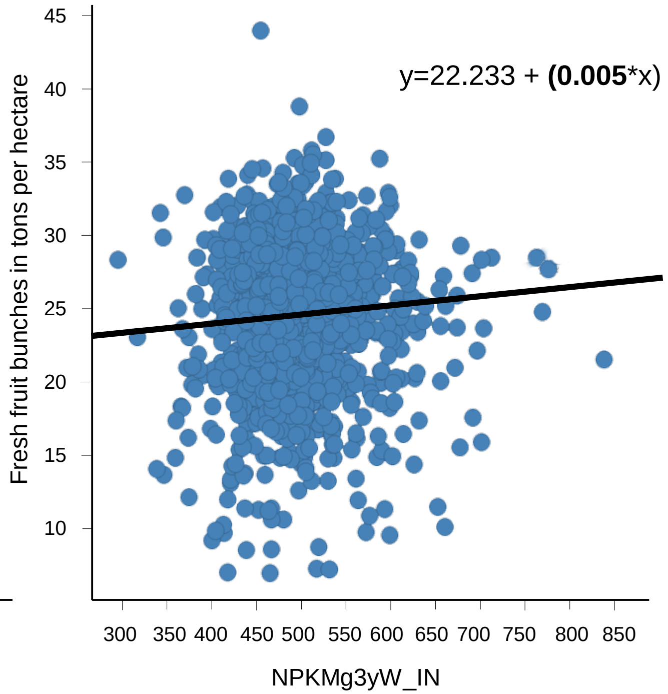
Tree Age Effects

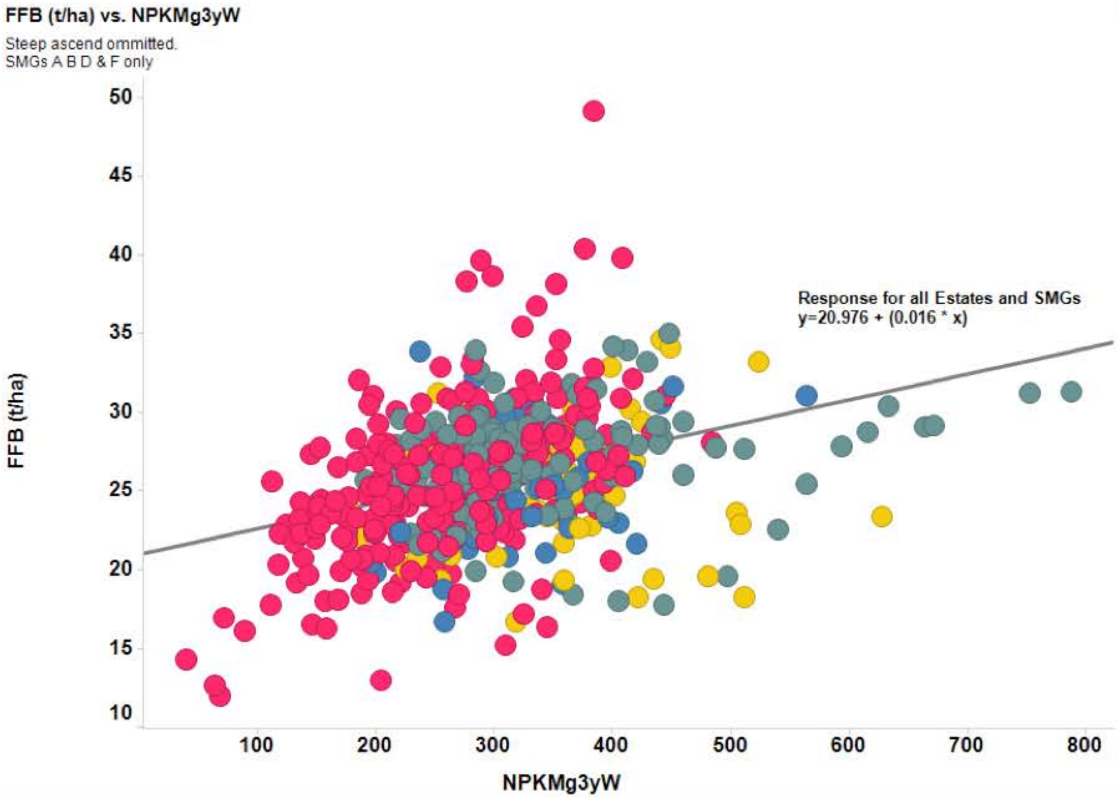
Steep Ascent : Palm age from 3-5



Plateau : Palm age from 6-13



Fertilizer response overall



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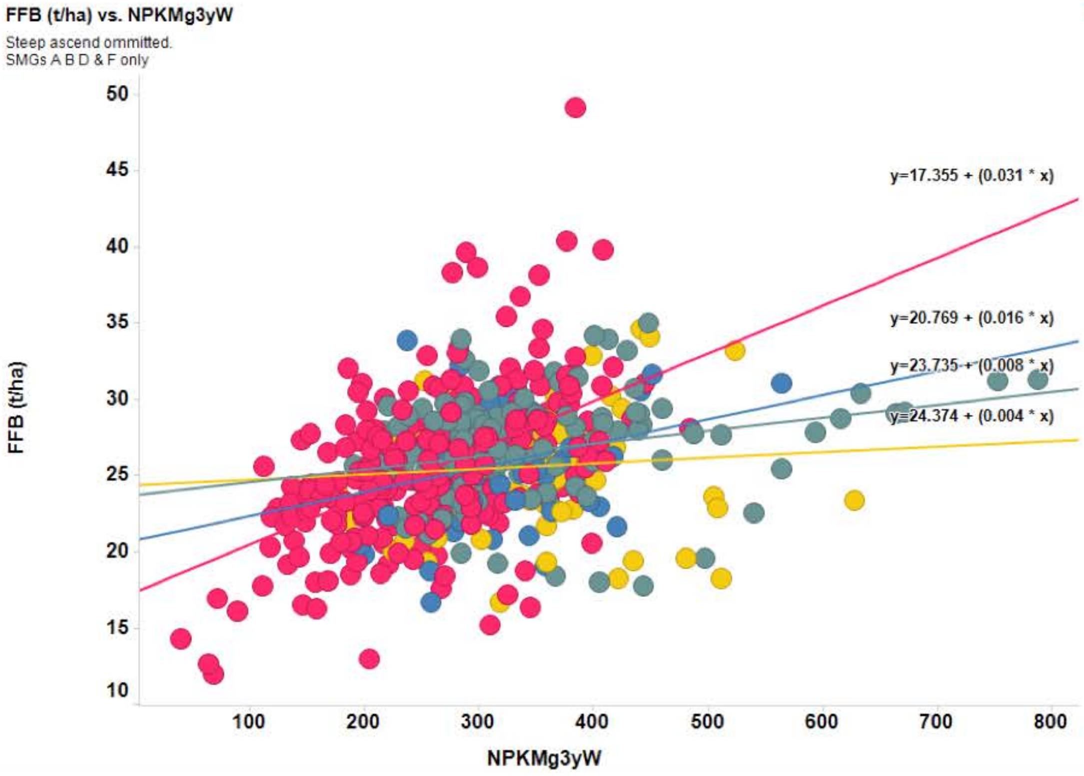
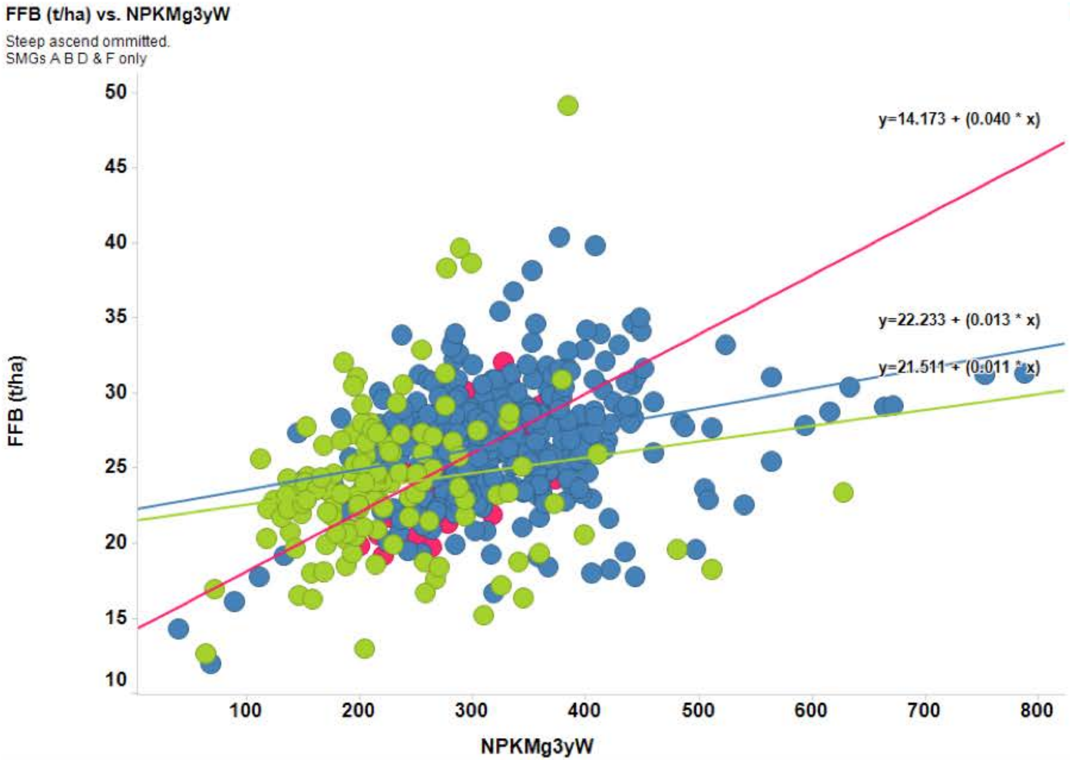
Fertilizer response by soil groups



Fertilizer response by individual estates



Continuous Improvement with Experimentation

1. No intervention for further action identified
2. Possible management interventions identified

Continuous Improvement with Experimentation

Possible Interventions

① Change Management in the Full Commercial Operation
② Trial Management Change with Estate Scale Experimentation (ESE)
③ Assess Management Change with Best Management Practices (BMP) Trials

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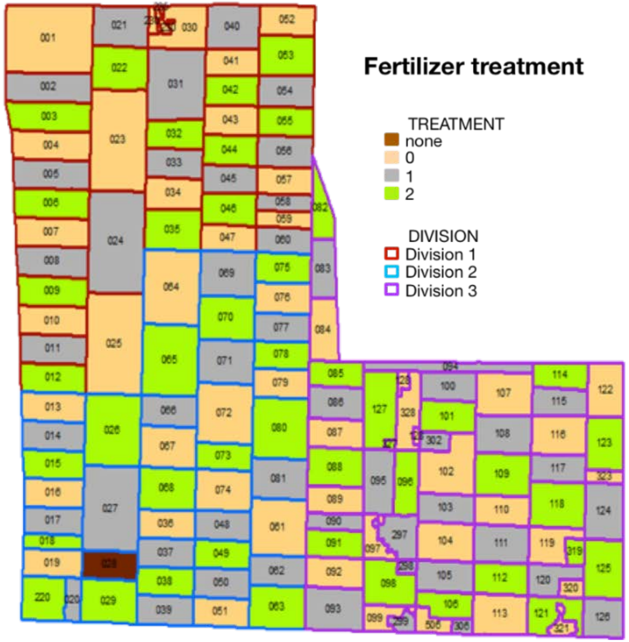
Continuous Improvement with Experimentation



Estate Scale Experimentation

1. Assumption that FFB yield response is different in different places in an estate
2. Apply fertilizer rates in a spatial pattern to Identify pattern in response
3. Adjust fertilizer rates accordingly
4. Continue process …

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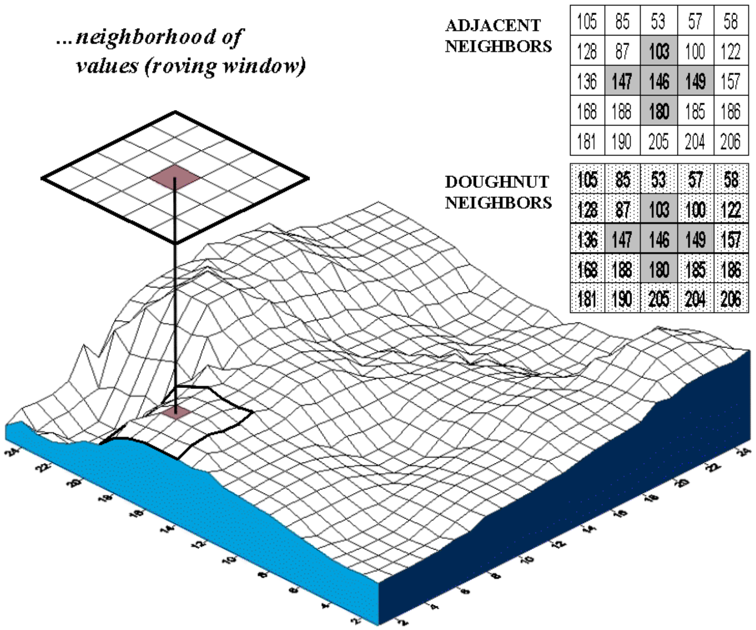
Continuous Improvement with Experimentation

Geographically Weighted Statistics (GWS):

- GWS is a technique that can identify local response that is significantly different from the global average.
- It looks for local variation by moving a weighted window over the data, estimating one set of statistical coefficients values at every chosen ‘fit’ point.



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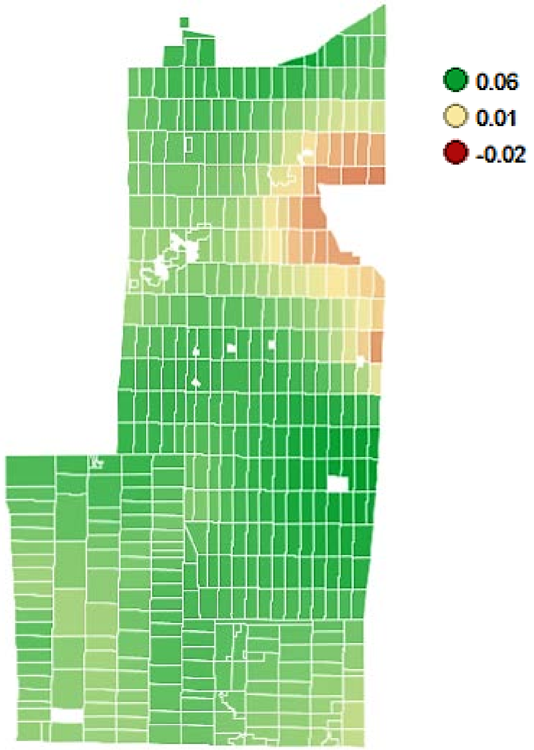
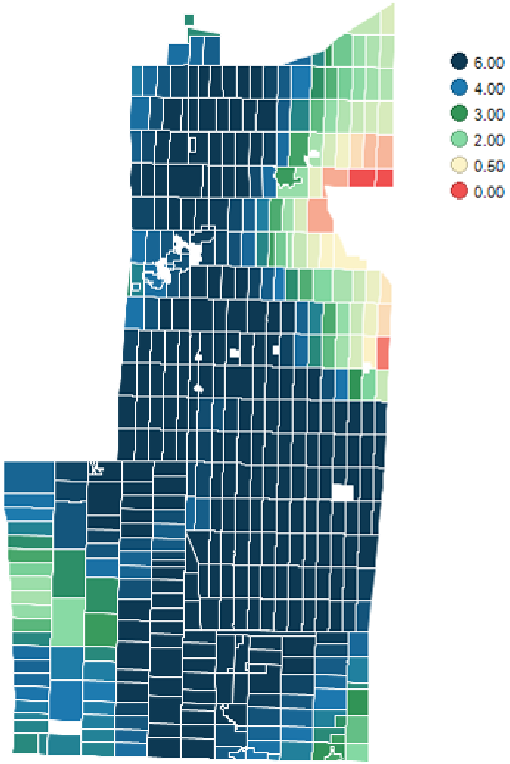
Estimated FFB yield response to NPKMg applied and confidence level in 2015

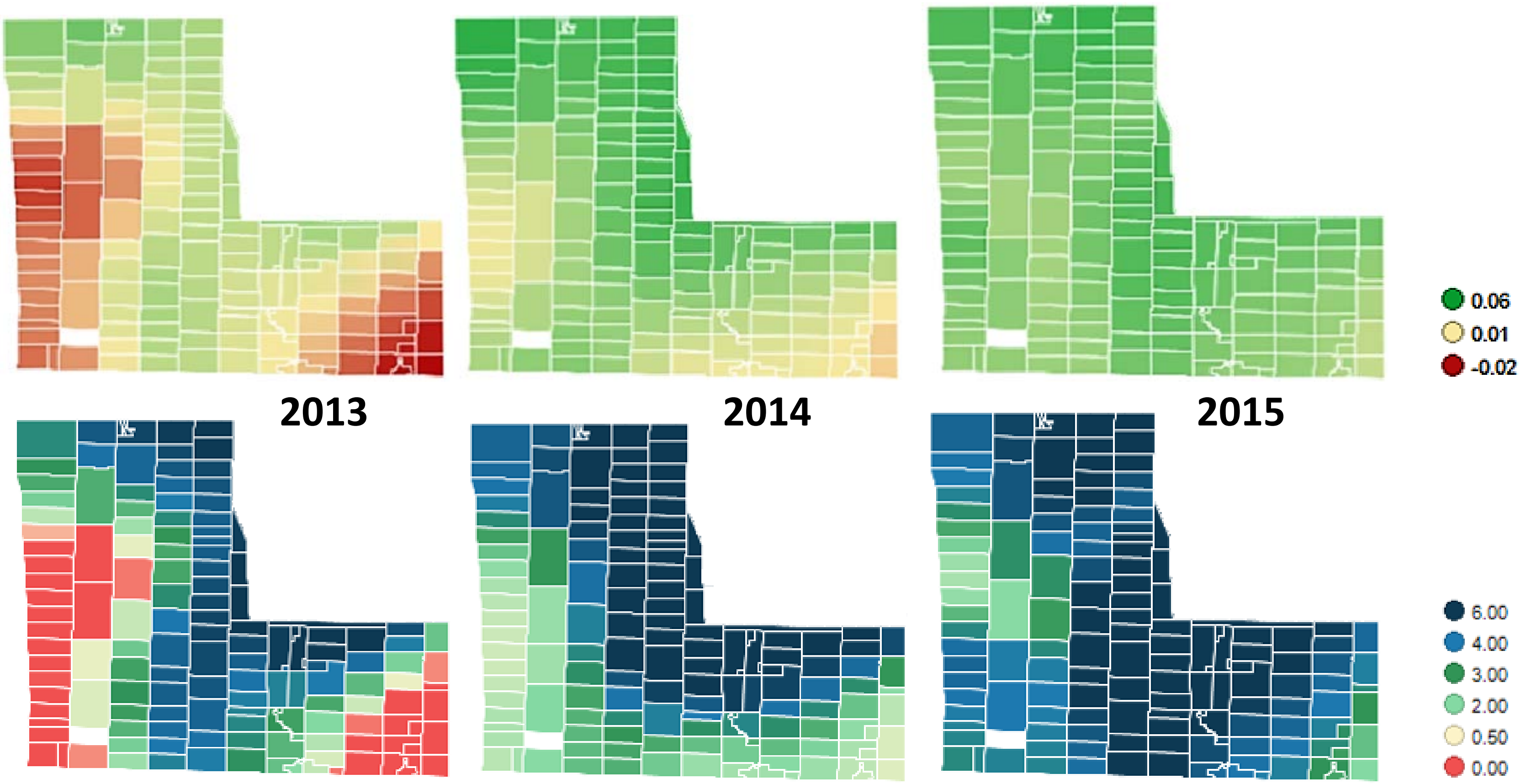
FFB Yield response



Confidence Level



FFB Yield Response



Confidence level of FFB Yield Response

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ENABLING ACTION – An Example

FERTILIZER RATE – DECISION MATRIX

Based on last 3-years scores

Yield Response	Positive		Negative	
Consistence	**All 3 Years**	**Inconsistent**	**All 3 Years**	**Inconsistent**
High Confidence (t value >2)	↑ Rates	Smaller rate ↑, or maintain	↓ Rates	Smaller rate ↓, or maintain
Low Confidence (t value <2)	Smaller rate ↑, or maintain	Maintain rate	Smaller rate ↓, or maintain	Maintain rate

- *In low confidence/inconsistent areas/blocks, investigate other (non-NPKMg) factors*

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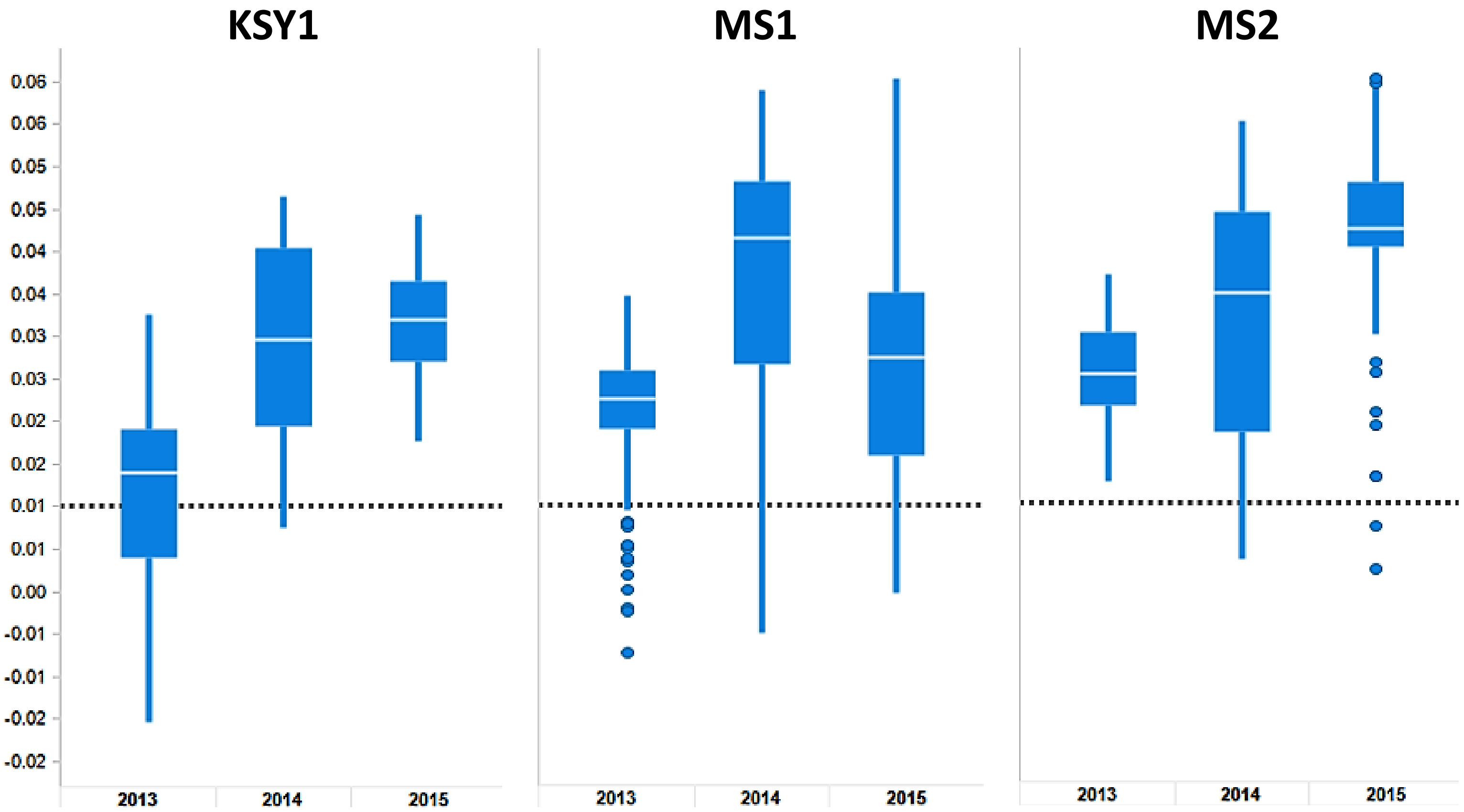
Return on Investment in fertilizer – size of response

FFB Yield (ton/ha) response to NPKMg applied (kg/ha)



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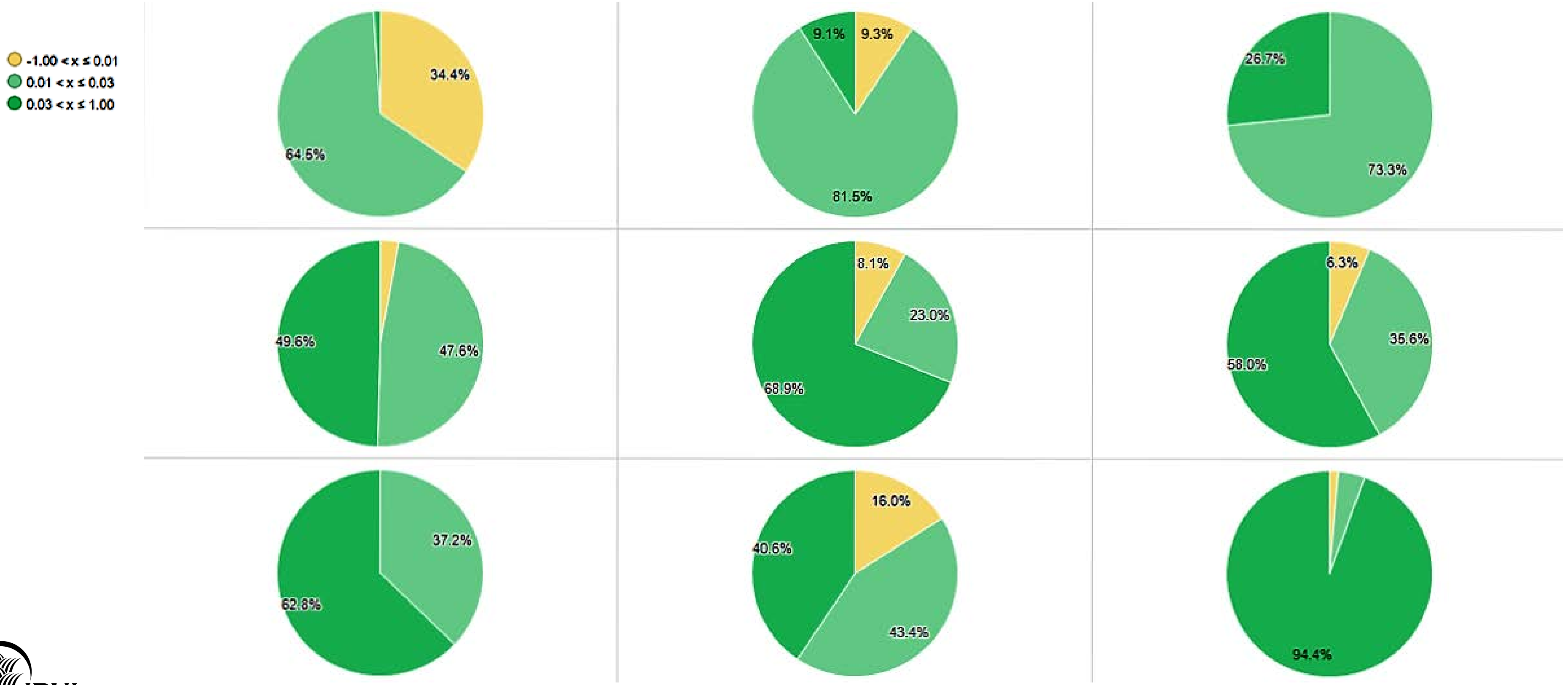
Return on Investment in fertilizer – % planted area



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Driving profitability of the whole enterprise

- Start by estimating yield response to applied fertilizers
- Enable response to be measured spatially to differentiate blocks
- Adjust fertilizer decision-making to take into account spatial response
- By doing so –
  - o Increase overall response to applied nutrients, and
  - o Increase proportion of managed area to higher profitability

Plantation Intelligence® & conventional R&D

PLANTATION INTELLIGENCE

Conventional R&D

- Prefers 'clean' data from plots or pots
- Works in experimenters' domain
- Aims to provide 'generally true' information

Plantation intelligence

- Accepts commercial data from blocks
- Works in the decision-makers' domain
- Aims to provide relevant information

Reflection

2 approaches:
Highly complementary

Commercially oriented approach needed by a rapidly expanding Oil Palm sector

But supported by sound theoretical insights

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PLANTATION INTELLIGENCE

BEST MANAGEMENT PRACTICE

ESTATE SCALE EXPERIMENTATION

IPNI SEAP Training Course on 4R Nutrient Stewardship in Oil Palm

15th – 17th November 2016, Penang

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Thanks to Seminar Organizers

&

Thank You All for Listening