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From Bioinformatics to Geoinformatics: Big Data in Oil Palm R&D

Presented by
Sharifah Shahrul Rabiah Syed Alwee, Phd
Date: 5th December 2017
ICBAA 2017

Felda Global Ventures: Introduction

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- Felda Global Ventures Holdings Berhad (FGV) is a **global, diversified and sustainable integrated agri-business leader.**

- **Incorporated in Malaysia in 2007**, FGV progressed into a diverse agri-business company and rapidly established itself as Malaysia's leading global agri-business player.

- Today we are the world's **largest producer of crude palm oil (CPO)**, a **leader in Malaysia's sugar industry** and a pioneer of cutting edge green technologies, anchored by a 18,000 strong workforce and a global integrated supply chain.

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An Expanding Presence

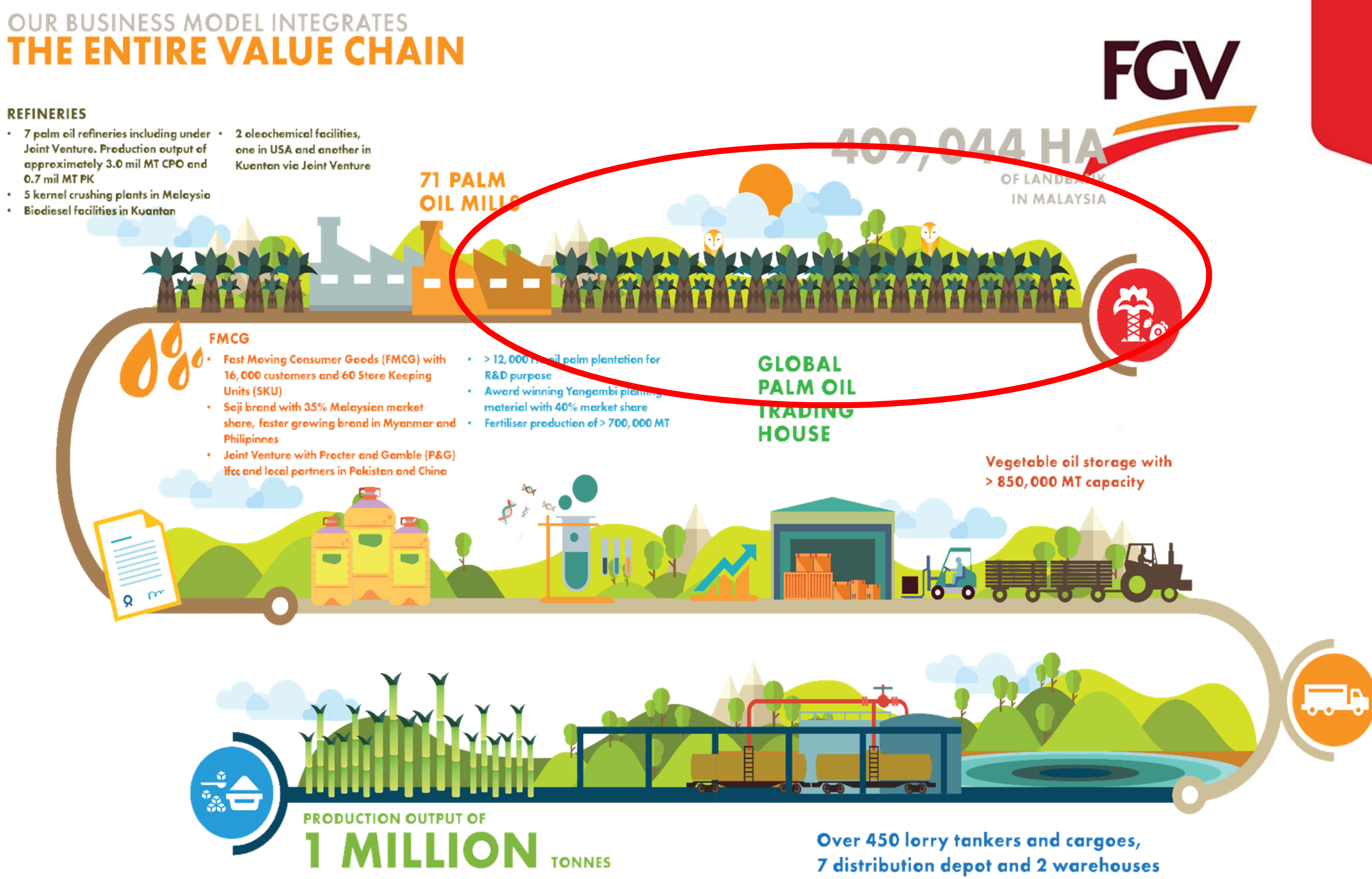
Plantation sector
Palm, R&D and Trading

Logistics & others sector
Integrated supply chain support

Sugar sector
Malaysia's leading
refined sugar producer

Felda Global Ventures Holdings Berhad (FGV) operates under three main business sectors namely Plantation sector, Logistics & Others (LO) sector and Sugar sector.

With operations in more than 10 countries across North America, Europe, Asia and the Middle East, FGV aspires to be one of the top 10 agri-business conglomerates in the world by 2020.



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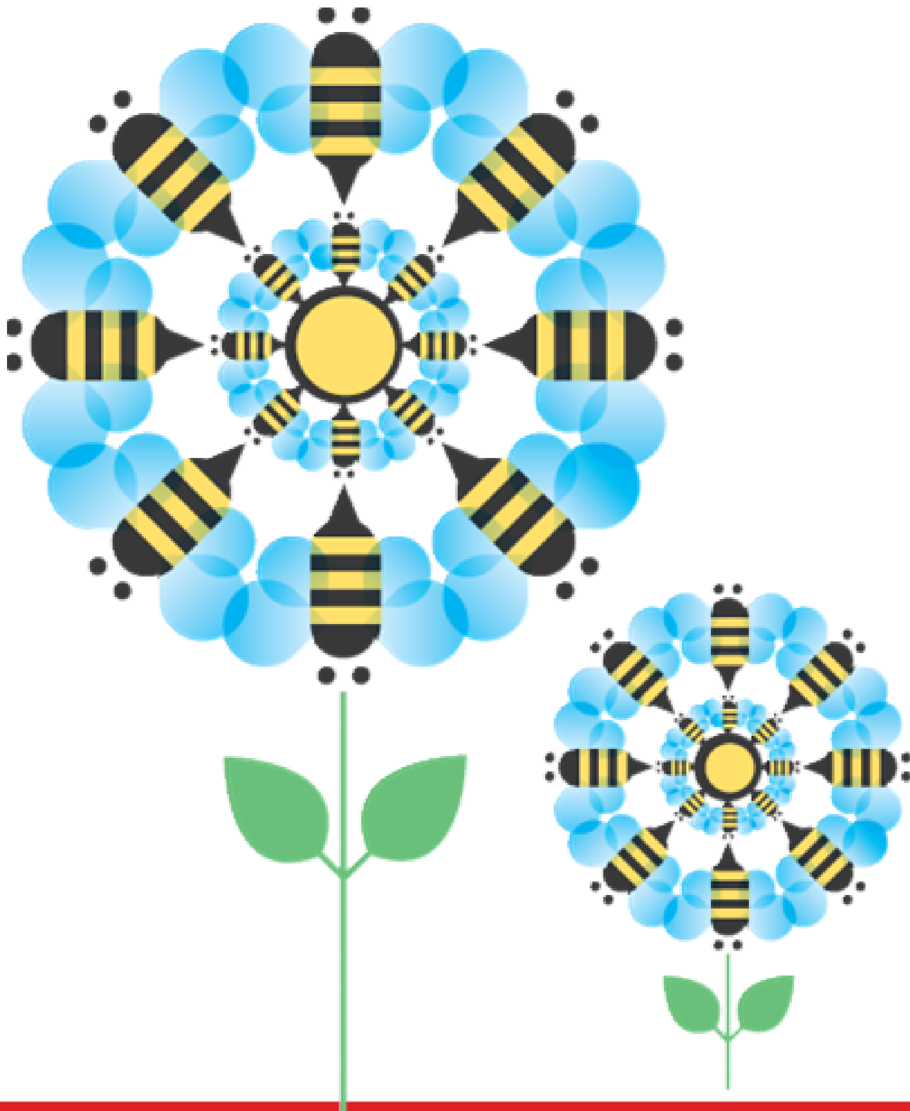
Plantation Sector -
R&D and Agri-Services Cluster



Utilizing cutting-edge technologies across all facets of FGV

FGV’s world class R&D and Agri-Services Cluster is anchored on four decades of research and development. The Cluster’s key objective is to generate cutting-edge agri-business technologies to enhance operational performance and commercial utilisation across all facets of FGV. The company’s award-winning Yangambi oil palm planting material, which has 40 percent market share in Malaysia, is just one of R&D’s innovative products.

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Big Data in Agriculture

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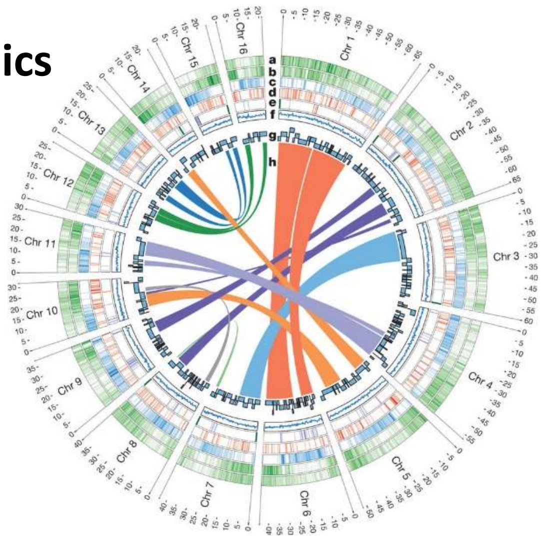
Big Data in Agriculture

Genomics



Agronomy

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Genetics/Breeding

Farm management

Connected assets covering a broad range of agricultural activities

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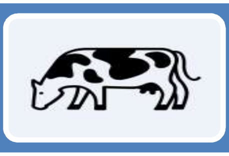
Soil

- Soil moisture sensors enable more precise and efficient irrigation management.
- Chemical analysis enables fertilizer optimization, including informing variable rate prescriptions for fertilizer applications.

Plants

- On-plant sensors for hydration monitoring,minimize drought-related yield and quality losses.
- Remote imaging sensors can monitor (and often predict) nutrient deficiencies, insect pest infestations, and disease outbreaks.



Livestock

- Geolocation sensors attached to livestock animals can prevent theft and wandering losses.
- Sensors monitoring internal temperature and rumen pH can predict fast-moving diseases.
- Behavior analysis through movement tracking can accurately predict estrus for breeding.

Environment

- Weather sensing combined with modeling offers growers advance notice of weather events.
- Intra-field sensors help orchards identify temperature inversion areas with high frost risk.
- Precipitation monitoring is a valuable data point in irrigation planning models.

Equipment

- Engine monitoring sensors allow service providers to offer predictive maintenance services.
- Geolocation sensors on machines allow for fleet tracking, efficiency monitoring, and theft prevention.
- Real-time activity and performance sensors on ag equipment enable automation.

Farmers

- Geolocation sensors in/on individual workers feed data into ERP software platforms for accurate tracking.
- Connected data-entry systems help workers input activities in real-time, minimizing errors.
- Sensor-enabled workforce management automates the record-keeping process for regulatory compliance.

Source: Lux Research, *The Internet of Agricultural Things*, June, 2016

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Challenges in

Managing Breeding Data

i. Component Breeding Research

28 Parameters

Germplasm

Mother palm

Research project

Crossing Process

Trial Information

Father palm

Yield Improvement

Bagging

Location

Ortets

Germplasm improvement

Control pollination

New Crosses/ Progeny

Clonal

Commercial Deli Dura

Seed process

Research Data

Introgression Improvement

Germination

Specific Traits study

Seed Store

Yield Component: BNO & BWT

Pollen Store

Bunch Component: MSW,MFW,MKW,etc.

Oil Content:GLC

Nursery and Field Planting

Vegetative component : Height, rachis, leaf number, etc.

Fruit colour, Palm census, Abnormal

ii. Complexity : Seed Production Processes
16 Steps

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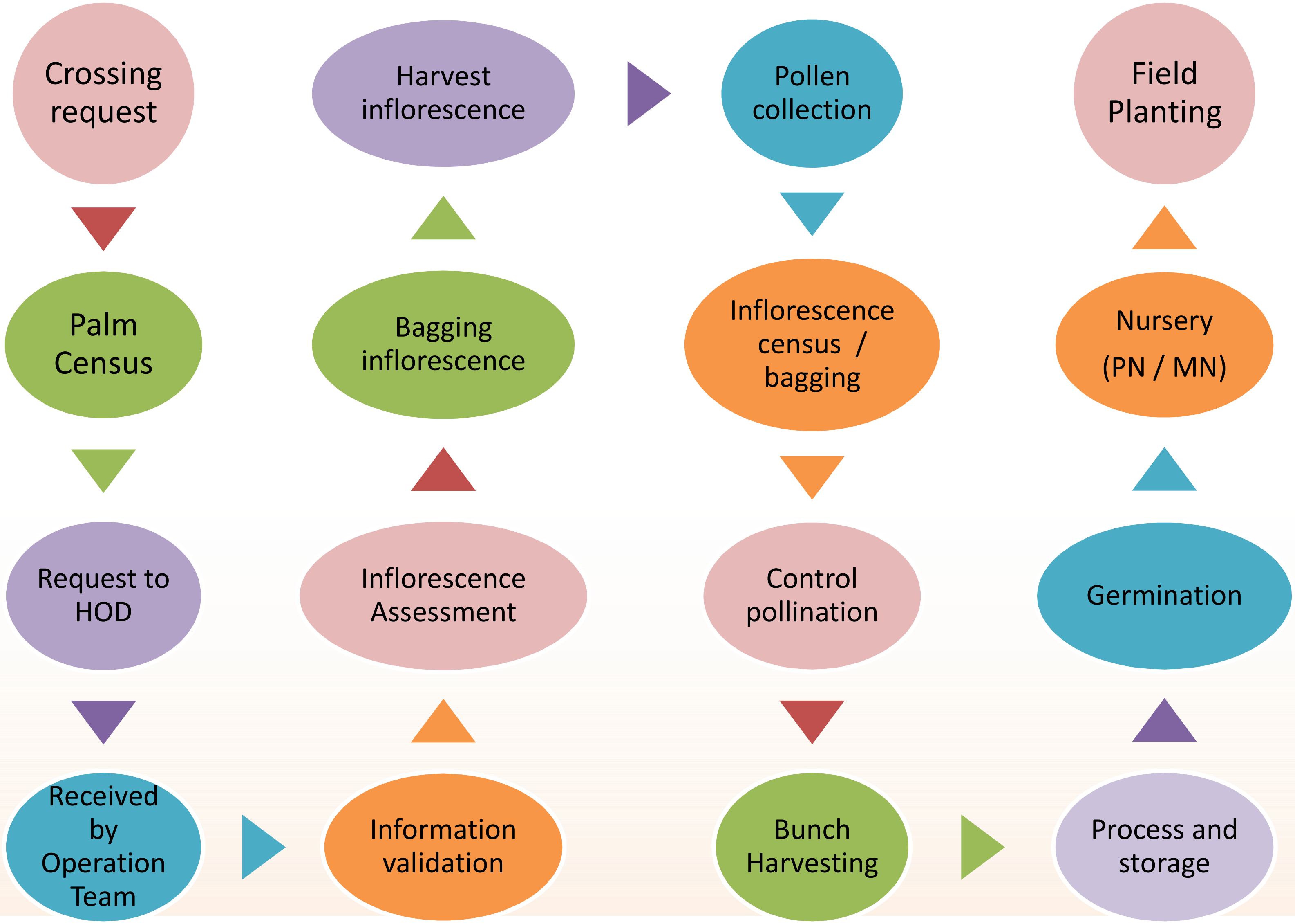

iii. Exponential Growth of Breeding Data

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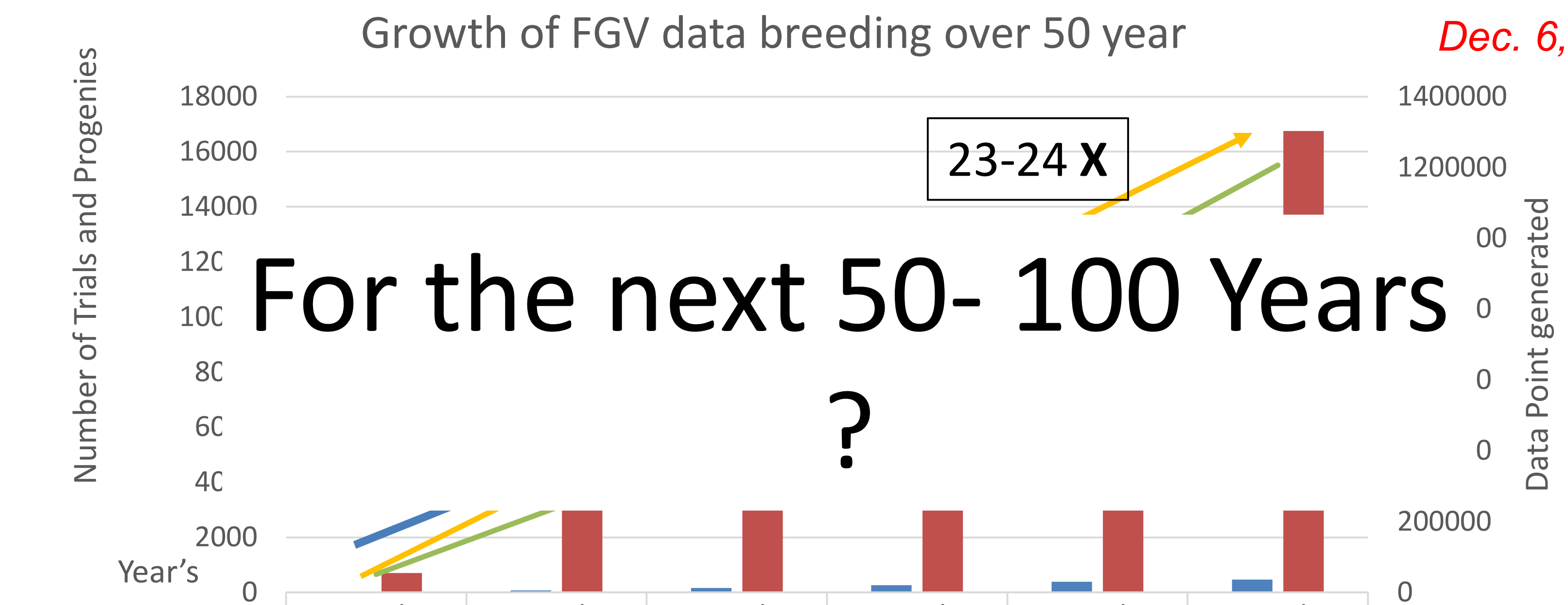


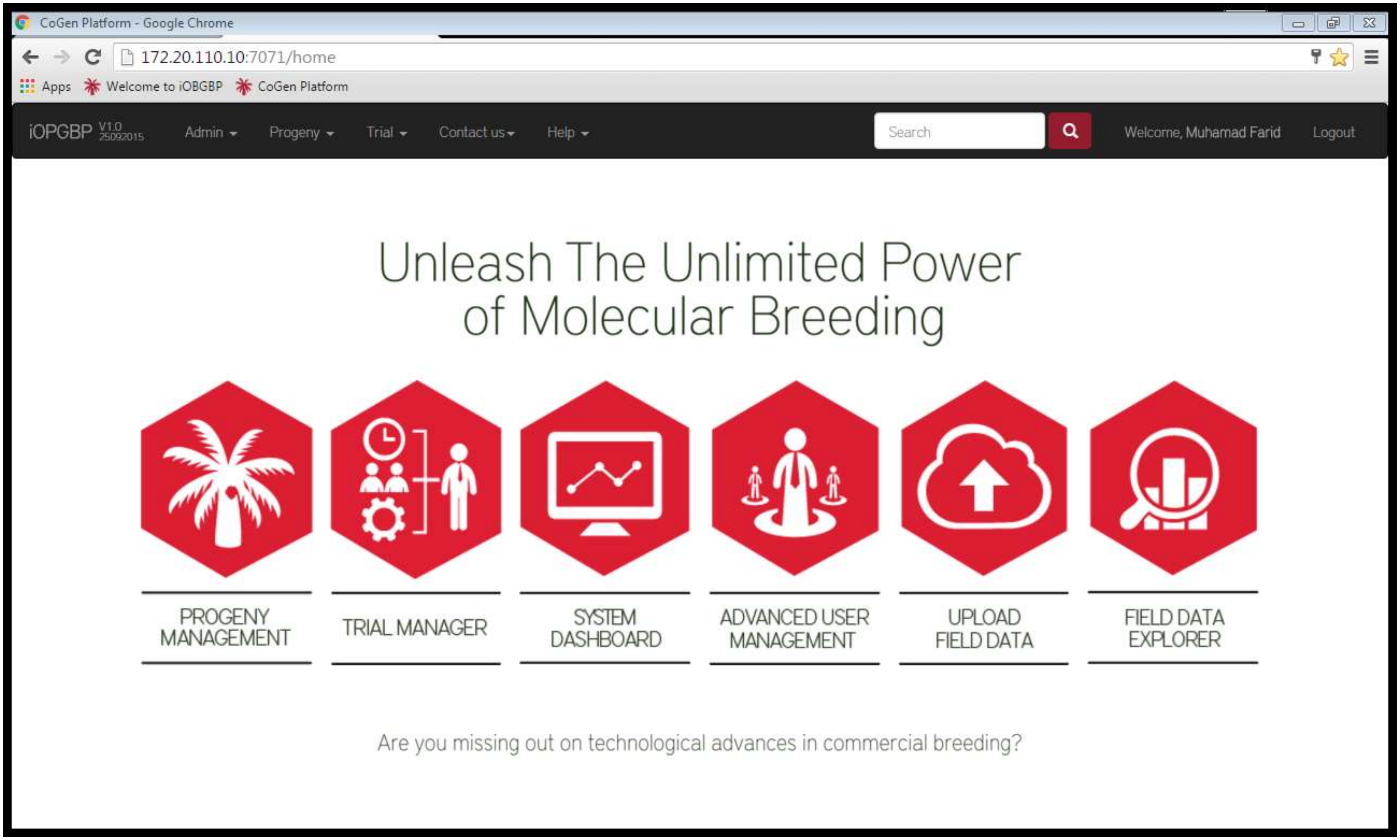
	1960's	1970's	1980's	1990's	2000's	2010's
Number Trial	19	75	160	269	387	472
Number Progeny	708	3322	6191	9215	12902	16749
Data Point	50976	239184	445752	663480	928944	1205928

For the next 50- 100 Years ?

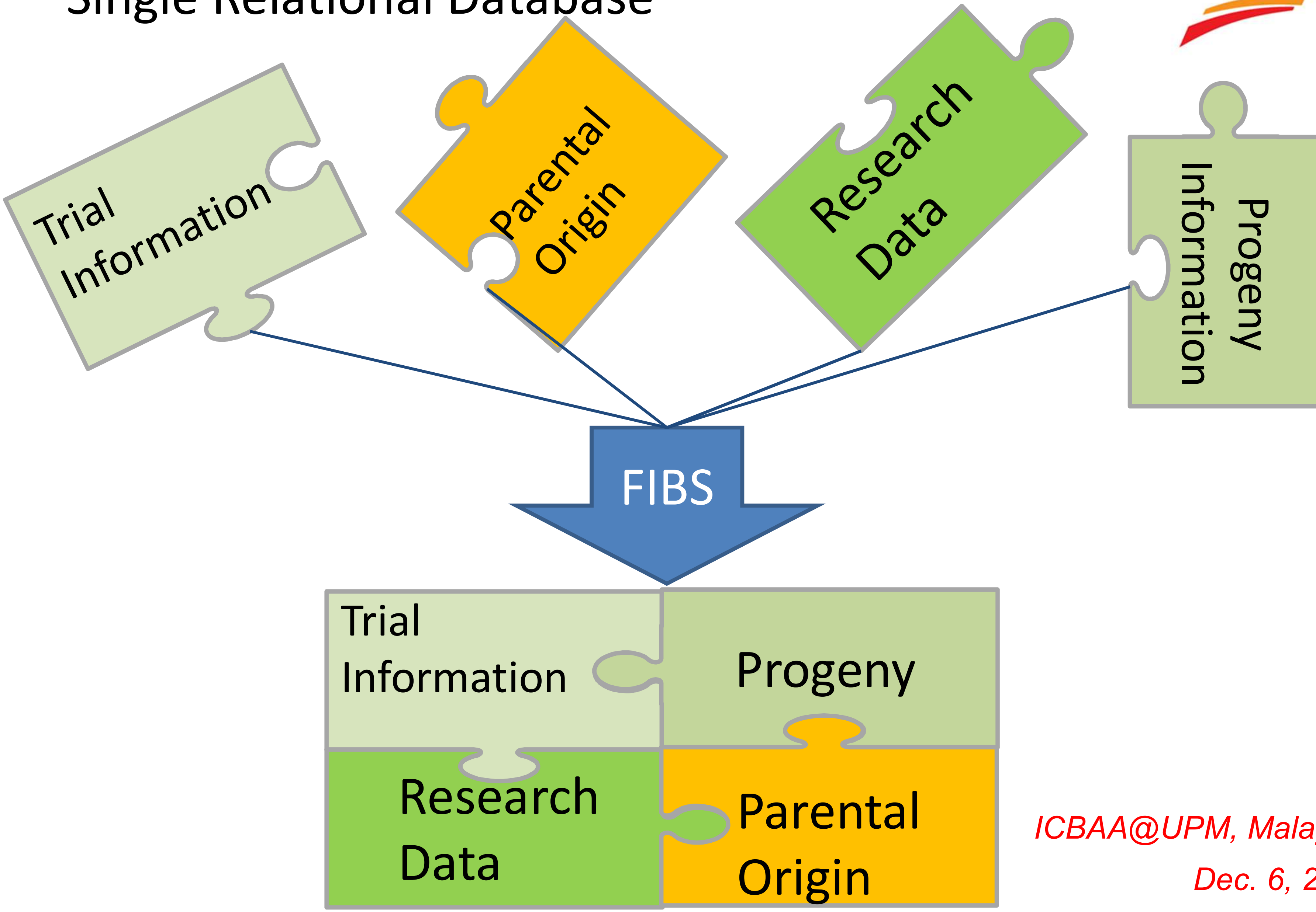
iv. Big Data Criteria: 3 V's

Volume	Variety	Velocity
Number and size of data generated	Various types of data generated	Speed of data connectivity and accessibility
Consist of 11 Project & 150 Active trial, Image, Document	Yield, Bunch, Progeny, Origins	Seamless connectivity

FGV Integrated Breeding System (FIBS)



iv. Integration of Multiple Parameters – Single Relational Database



Component I : Breeding Information Management

Matrix of Progeny | Details

Trial Information | Progeny | Location | Documentations | Remarks

State	Pahang
Station	JENGKA 25- 1B
Stage	Jengka 25, Pkt B
Block	1
Location Size	10
Soil Type	INLAND

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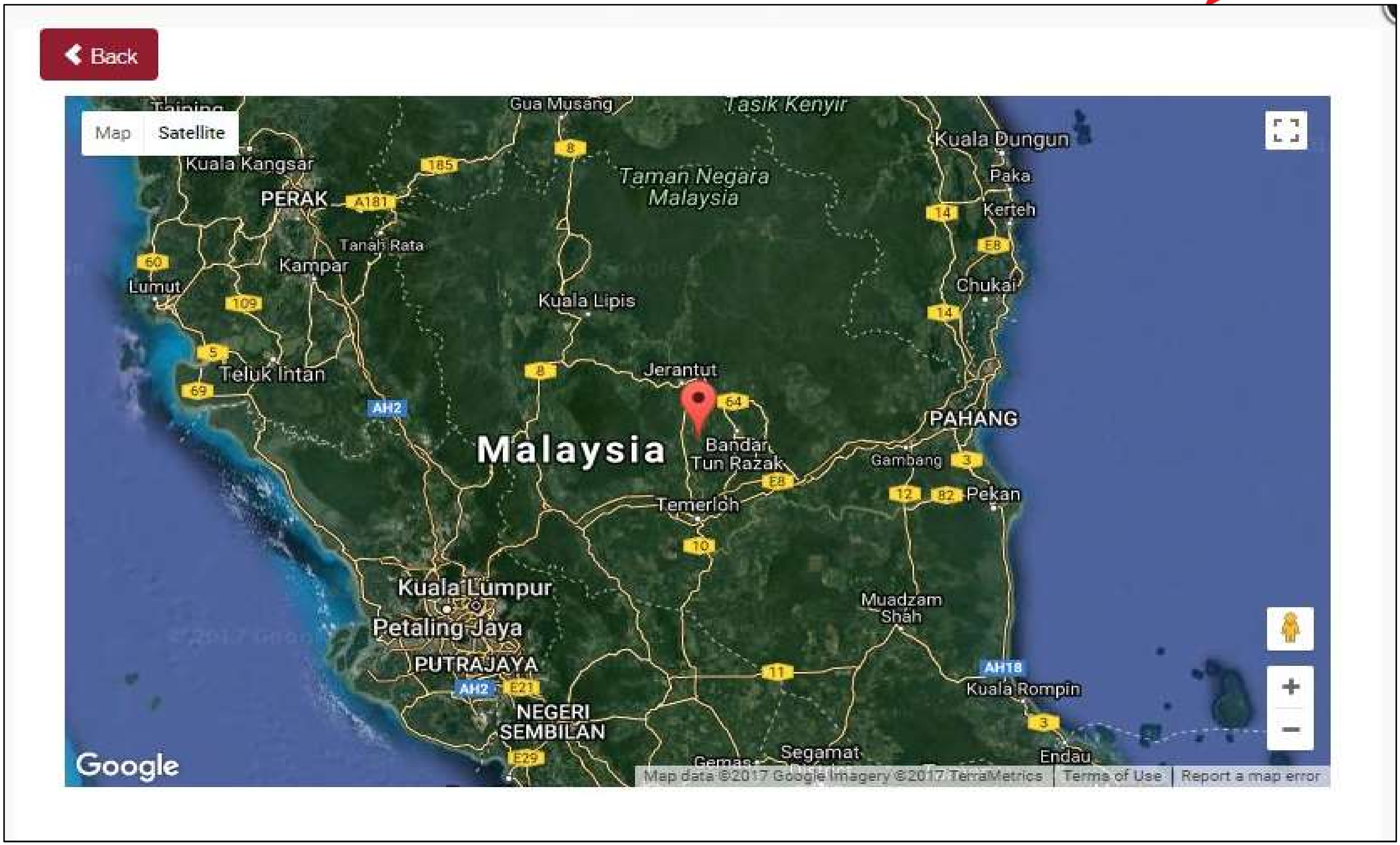
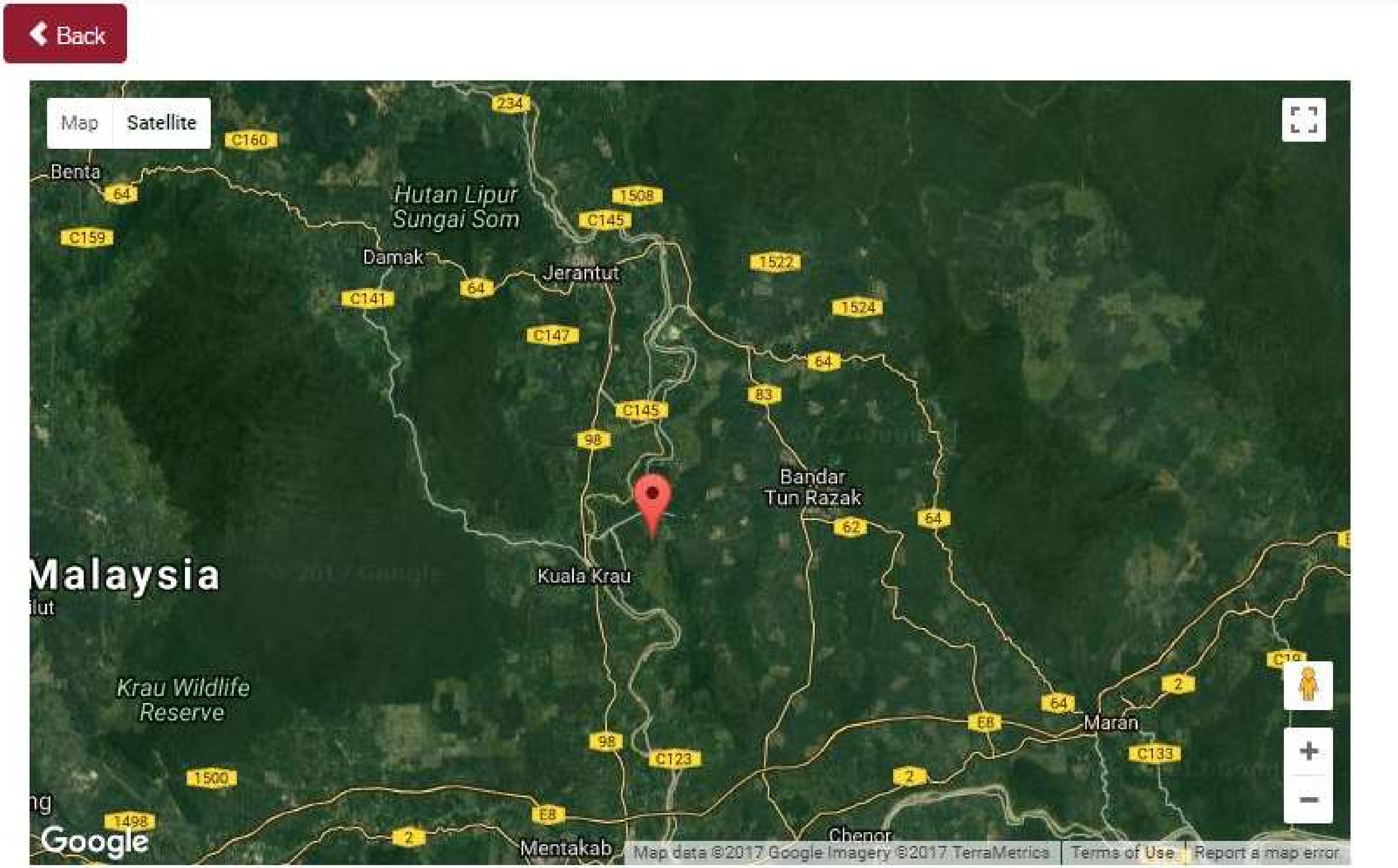
Component I : Breeding Information Management



Component I : Breeding Information Management



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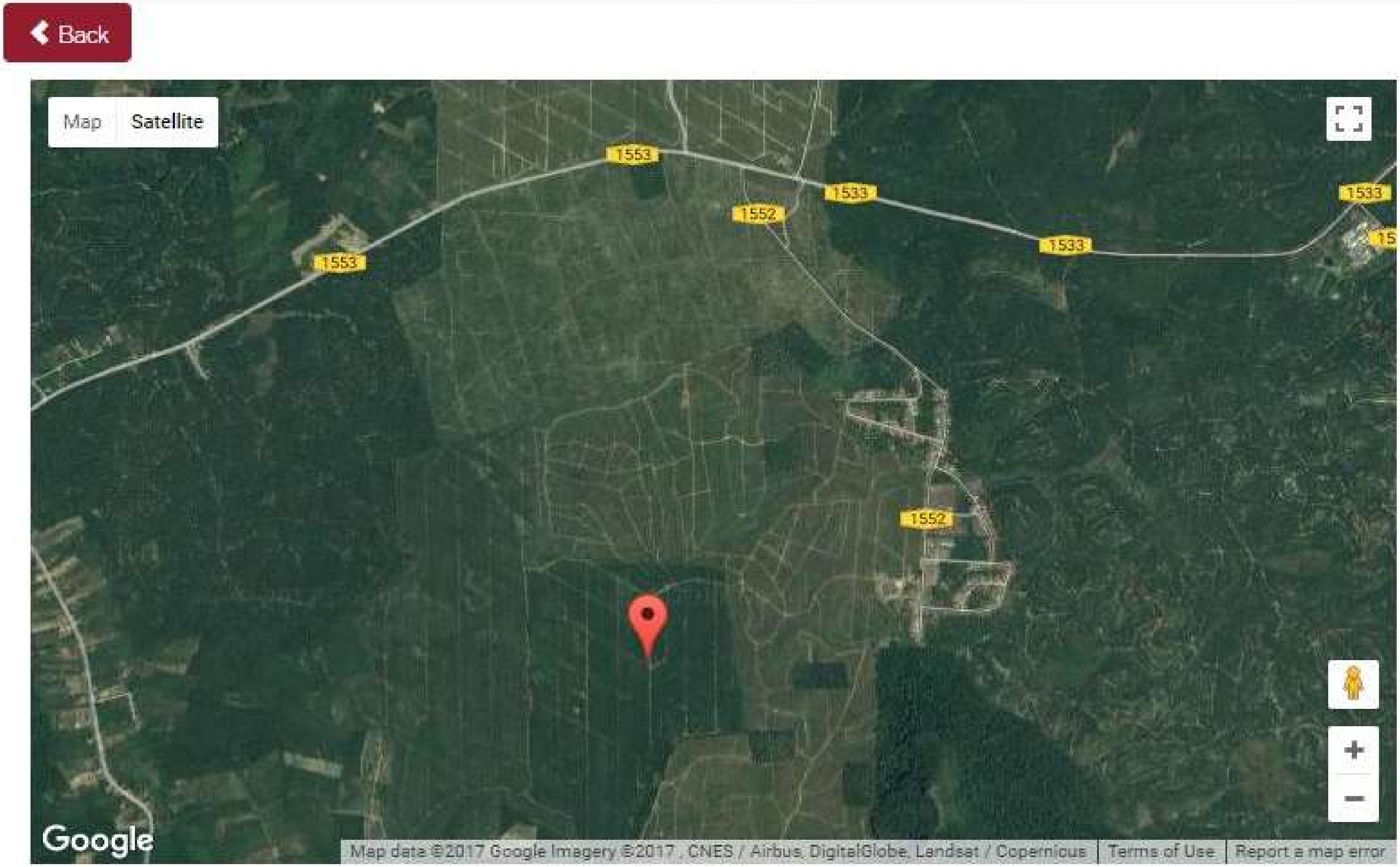
Component I : Breeding Information Management



Component I : Breeding Information Management

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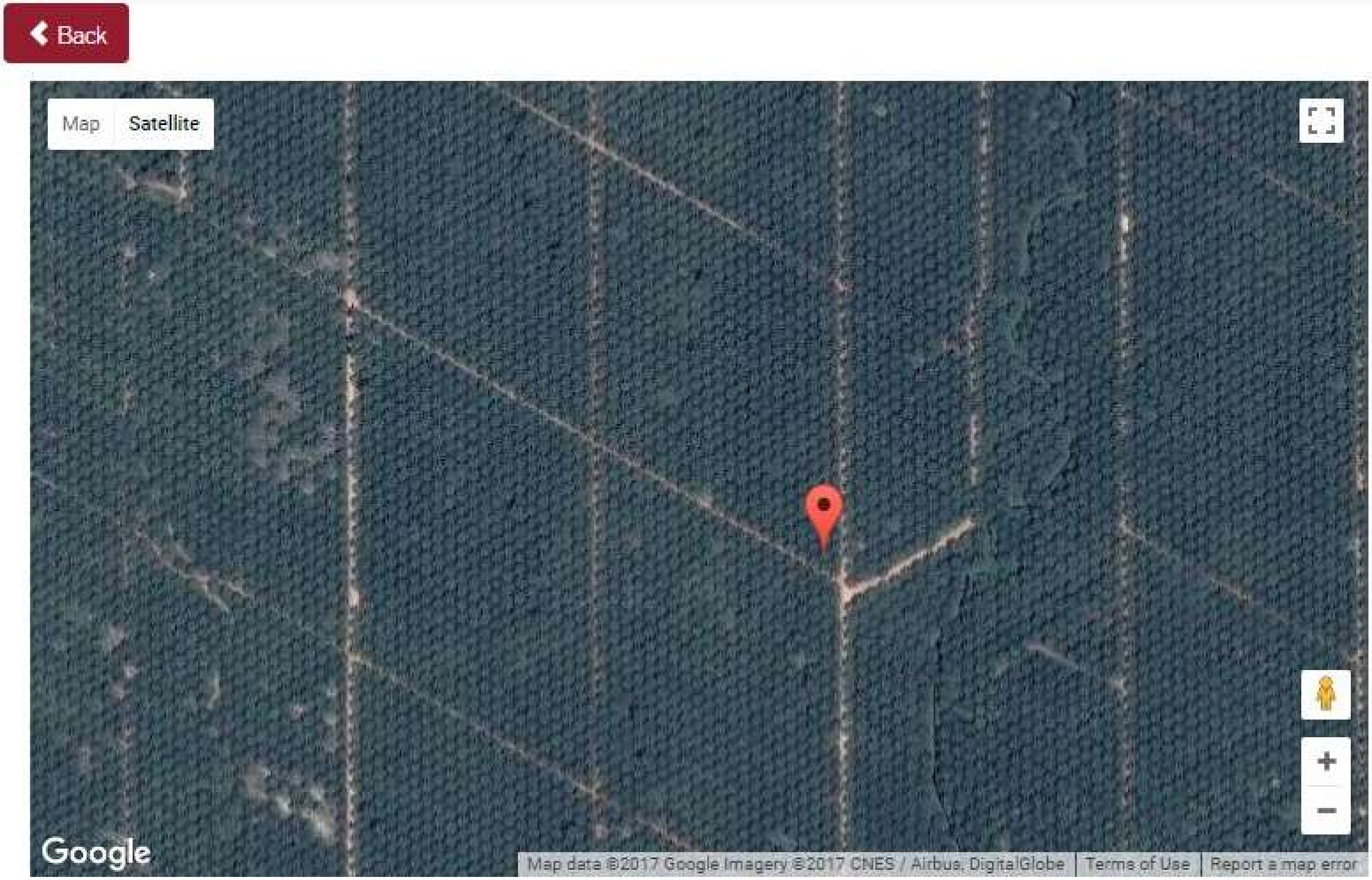

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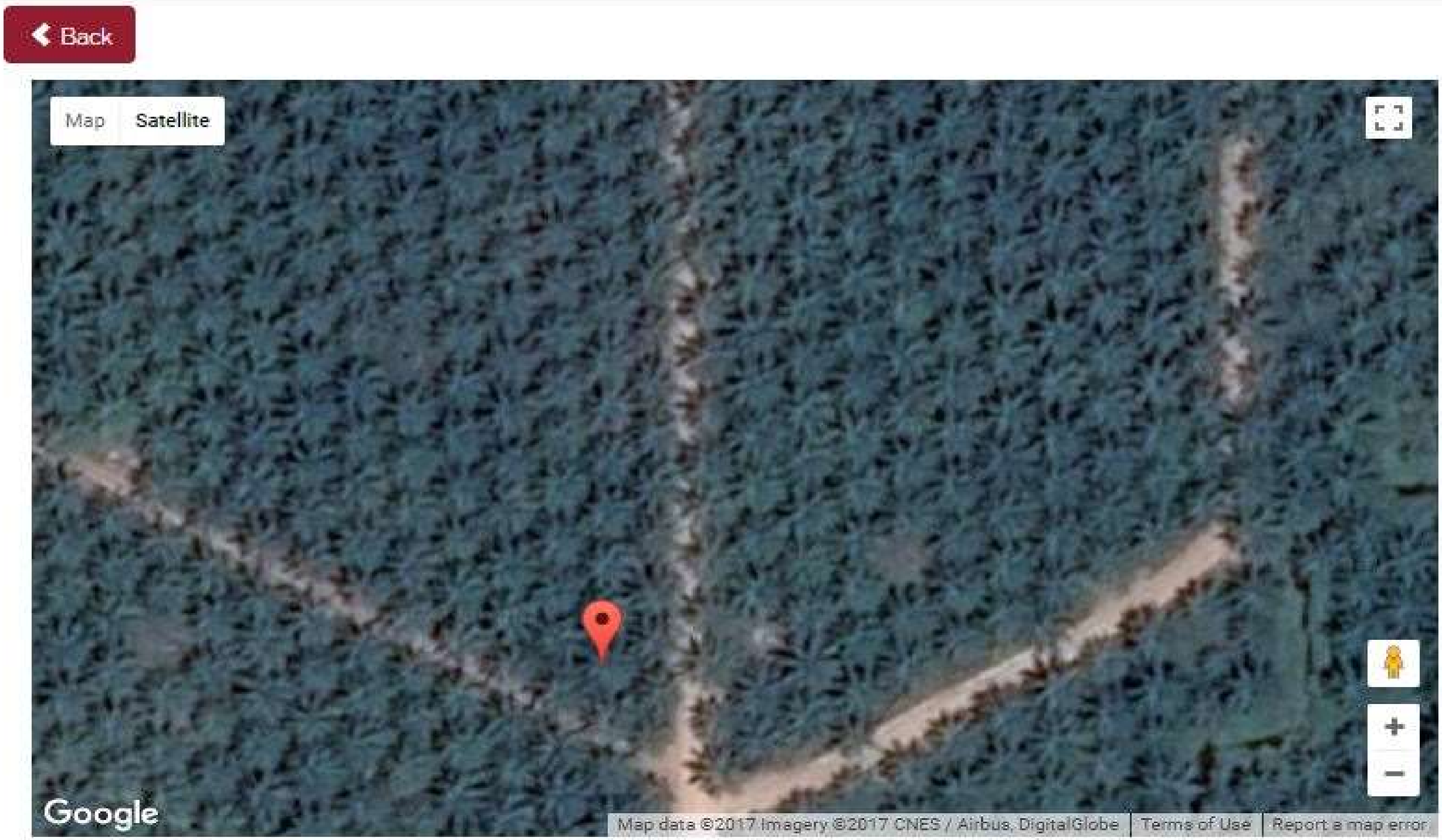
Component I : Breeding Information Management



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Parental Database

PARsumA.csv - Microsoft Excel

Archivo Inicio Insertar Diseño de página Fórmulas Datos Revisar Vista

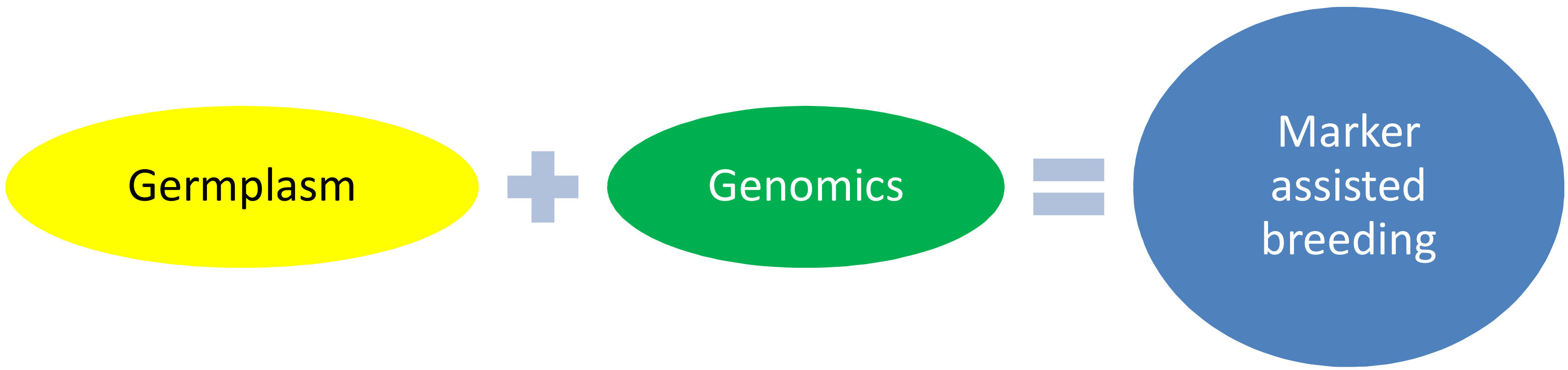
A1 ALL available Parents

ALL available Parents

No:	Name	1-mEgCIR0257		2-mEgCIR0408		3-mEgCIR0886		4-mEgCIR0894		5-mEgCIR2569		6-mEgCIR3281		7-mEgCIR3382		8-mEgCIR3428		9-mEgCIR3569		10-mEgCIR3633		11-mEgCIR3693		12-mEgCIR3711		13-mEgCIR3886		14-sEg00011		15-sEg00038	
1	AA1-108	284	296	202	217	161	177	204	216	238	248	244	244	120	122	173	183	243	259	137	151	295	295	174	174	196	196	154	154	184	18
2	AB1-10	284	284	--	--	177	177	204	216	--	--	--	--	--	--	173	173	259	259	--	--	--	--	--	--	192	196	154	154	187	18
3	AB1-15	284	290	202	211	177	177	200	216	248	248	232	232	120	120	173	183	259	259	137	153	298	298	174	178	192	196	154	158	184	18
4	AB1-18	284	290	202	217	177	177	204	216	248	256	232	232	120	120	173	183	259	259	137	151	298	298	174	174	192	192	154	154	184	18
5	AB1-23	284	290	--	--	177	177	200	200	--	--	--	--	--	--	173	183	259	259	--	--	--	--	--	--	192	196	154	154	184	18
6	AB1-28	290	290	--	--	177	177	200	204	--	--	--	--	--	--	173	173	259	259	--	--	--	--	--	--	192	198	154	154	187	18
7	AB1-31	284	290	--	--	177	177	200	204	--	--	--	--	--	--	183	183	259	259	--	--	--	--	--	--	192	198	154	154	184	18
8	AB1-6	290	290	211	217	161	177	204	216	238	248	265	265	120	120	183	183	259	259	151	153	298	298	174	178	192	192	154	158	184	18
9	ARK86	304	306	202	202	161	177	200	206	250	256	232	238	122	134	185	185	239	245	137	145	300	306	174	178	192	198	154	160	184	19
10	B36-35	284	306	202	202	175	177	216	220	248	256	240	240	120	130	183	185	247	247	145	151	296	296	176	178	196	196	154	158	187	19
11	BAK-10	296	306	--	--	161	161	200	206	--	--	--	--	--	--	181	185	245	245	--	--	--	--	--	--	198	206	154	154	184	18
12	BB1-123	304	306	202	202	161	177	206	206	250	250	232	238	122	134	185	185	239	245	145	145	300	306	174	178	196	198	154	154	184	19
13	BB1-224	304	306	--	--	161	161	200	206	--	--	--	--	--	--	185	185	245	245	--	--	--	--	--	--	192	198	154	160	184	19
14	BB2-67	290	304	202	202	161	177	200	204	256	256	238	238	120	122	173	185	243	259	135	137	296	300	176	178	192	198	154	160	184	18
15	BQ6-21	290	308	--	--	161	163	204	216	--	--	--	--	--	--	183	183	257	259	--	--	--	--	--	--	198	198	154	156	184	19
16	C2-1	296	306	211	211	173	177	196	206	240	258	238	238	120	140	183	183	245	249	127	145	300	300	174	174	198	198	154	156	184	18
17	C2-114	296	306	211	211	161	161	194	196	240	248	244	244	120	132	183	183	245	245	127	145	300	300	178	178	198	198	154	154	184	18
18	C2-27	298	304	211	211	161	177	194	202	240	248	238	244	132	140	181	181	245	249	137	145	300	300	174	174	198	198	154	154	196	19
19	C2-35	298	304	211	211	161	177	194	196	240	248	238	244	120	120	183	183	245	249	137	145	300	300	174	174	198	198	154	154	184	19
20	C2-79	--	--	202	202	--	--	--	--	240	248	238	238	120	140	181	183	--	--	137	145	300	300	178	178	--	--	--	--	--	--
21	C39-12	302	304	202	202	161	173	200	206	240	248	232	244	120	134	181	185	245	245	135	145	298	298	178	178	198	198	154	156	184	18
22	C39-3	298	304	211	211	161	173	200	200	248	250	232	244	120	122	181	185	245	247	135	135	295	295	178	178	198	198	154	156	184	18
23	C39-45	290	304	202	202	161	179	200	216	248	250	246	246	120	122	173	181	245	247	135	145	298	300	178	178	192	196	154	154	187	19
24	C39-8	302	304	202	211	161	173	200	200	250	250	246	246	120	122	181	181	245	247	135	145	298	298	178	178	198	198	154	156	184	19
25	CDM-18	306	306	211	211	161	161	206	206	250	256	238	238	122	122	185	185	245	245	137	137	300	300	178	178	196	196	154	160	184	18
26	CDN-95	306	308	211	211	161	177	200	206	240	240	238	238	122	122	181	185	245	245	135	145	296	300	174	178	198	198	154	154	184	19
27	CEN-118	302	302	211	211	171	175	190	204	240	248	248	250	136	136	171	189	253	253	161	161	302	308	174	188	194	202	152	152	193	19
28	CEN-43	302	302	211	211	171	175	192	204	248	252	250	250	134	136	171	171	253	253	131	145	302	308	174	188	194	202	152	158	199	19
29	DD13-51	304	306	211	211	161	161	200	204	240	240	238	238	122	134	181	185	245	245	135	145	300	307	178	178	196	198	154	154	184	19
30	DD16-2	304	304	211	211	161	161	200	204	240	240	238	238	122	140	181	181	243	245	135	145	300	307	178	178	196	198	154	154	184	19
31	DD16-27	304	304	211	211	161	161	200	204	240	250	238	238	122	134	181	185	245	245	137	145	300	307	178	178	198	198	154	154	184	19
32	DD3-10	304	308	211	211	161	179	200	200	240	246	246	246	122	134	183	185	245	245	137	145	300	306	176	178	198	198	154	158	184	19
33	DD3-6	304	308	211	211	177	179	200	200	240	246	238	238	122	136	183	185	245	245	127	145	298	300	174	176	198	198	154	158	184	19
34	DD9-63	304	308	211	211	161	161	200	206	240	240	238	238	122	134	181	181	245	245	145	145	296	300	178	178	198	198	154	154	190	19
35	DD9-89	304	308	211	211	161	177	200	206	240	240	238	238	122	122	181	185	245	245	135	145	296	296	174	178	192	198	154	154	184	19

PARsumA

Listo



Building on the oil palm genome

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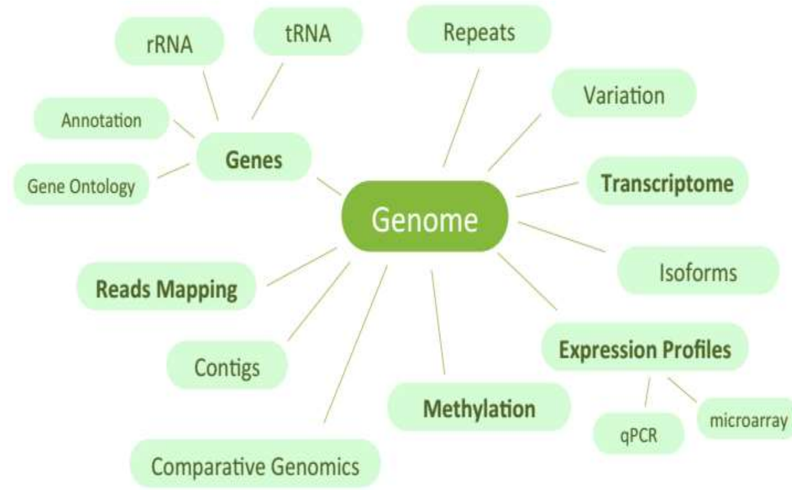
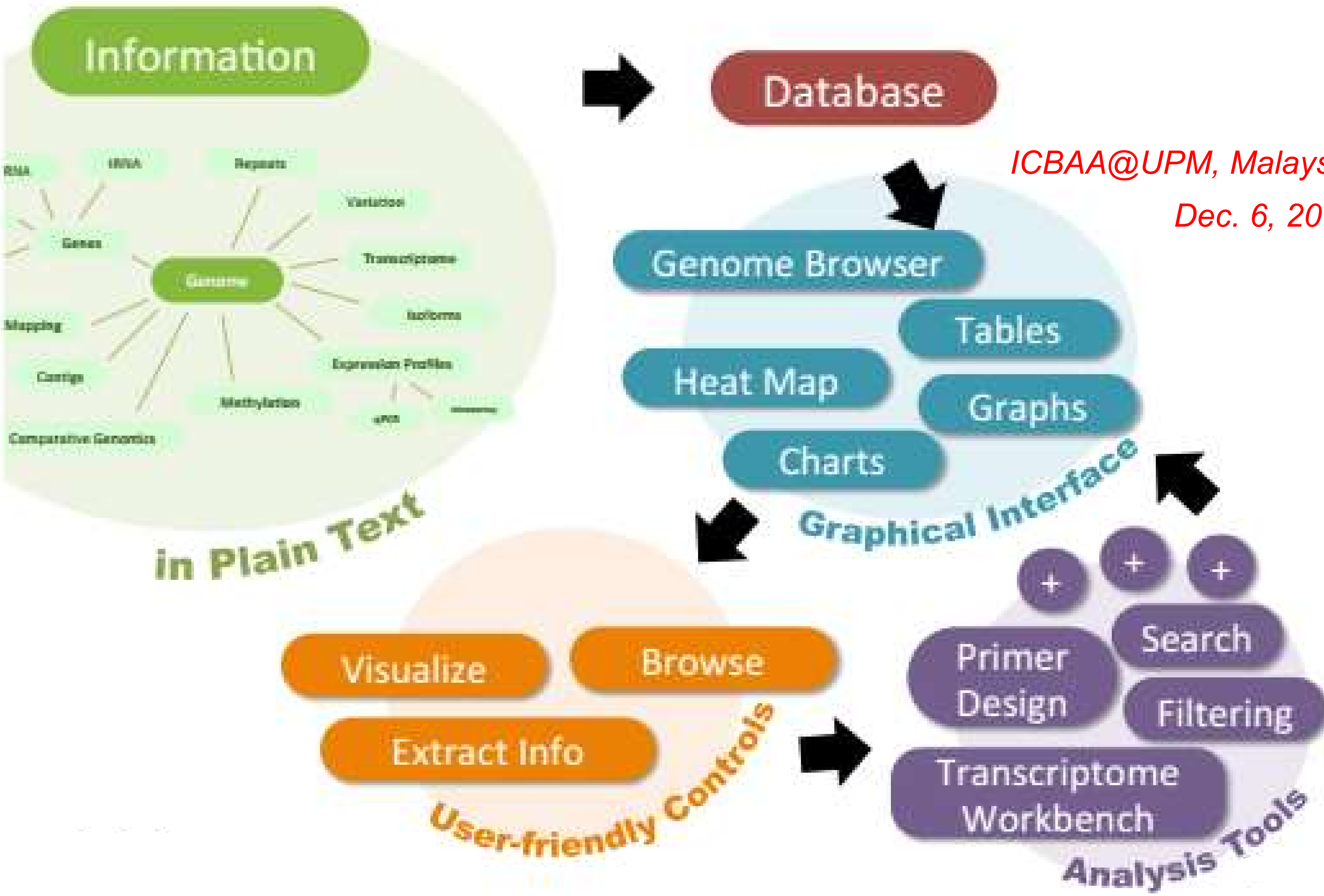
- Development of visualisation capability



ElaiesBase Objective

- To host biological data (genome, transcriptome, gene models, markers, etc) into a systematic database
- To allow biologists in navigating the genome for downstream analyses (visualisation)


Information
Repeats
Variation
Genes
Genome
Transcriptome
Isoforms
Mapping
Contigs
Expression Profiles
Methylation
Comparative Genomics
in Plain Text
Database
Genome Browser
Tables
Heat Map
Graphs
Charts
Graphical Interface
Visualize
Browse
Extract Info
User-friendly Controls
+
+
+
Search
Primer Design
Filtering
Transcriptome Workbench
Analysis Tools

GENOMICS + BREEDING + FIELD SCIENCE (AN EXAMPLE)

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Ganoderma Tolerance Seeds (Yangambi GT1)

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Development of Ganoderma Molecular Marker(s)

Characteristics of GTM Markers

a) GTM markers were designed to target a fragment of NBS-LRR disease resistance protein homologue within an oil palm.

b) Either individual or in combinations of GTM primers will able to predict the susceptibility of oil palm against *Ganoderma* BSR disease.

Example of PCR Results with FP3 Marker

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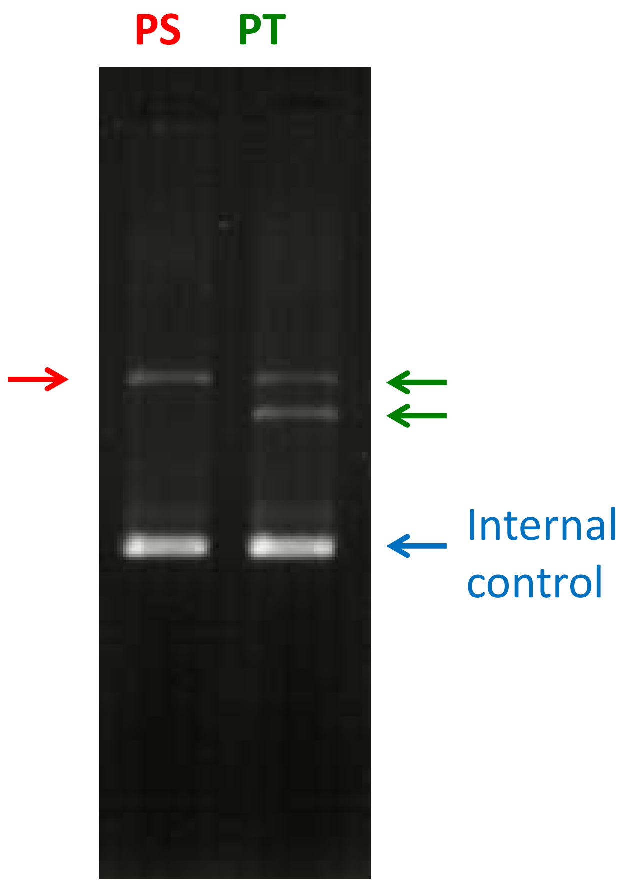

- Potential Tolerant (PT): both bands are present (green arrows)
- Potential Susceptible (PS): either one or both bands are absent (red arrow)
- Internal control – control indicator for PCR

Patent Pending: Markers for *Ganoderma* Disease Diagnosis and a Use of Thereof (PCT Application No.:PCT/MY2011/000228)

Ganoderma marker (Correlation)

- A total of 5,295 phenotypes data from 5 different nursery trials were analysed.
- Ganoderma marker Vs Nursery phenotype = **70.31%**
- The combinations of YangambiGT1 and the patented marker allow FGV to make a more systematic and pragmatic approach.

Ganoderma Nursery Screening

Dedicated 8.40 hectare nursery located at Ulu Belitung (Johor)

High Throughput *Ganoderma* Nursery Trials

- Screening capacity for planting materials (35 + 6 control crosses)
- Conventional strategies to identify resistant / partial resistant PM
- Platform to validate the *Ganoderma* tolerant marker (GTM) – genomics

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High Tolerance Palms

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Susceptible Palms

crosses

TK5818
TK5816
TK5729
TK5857
TK5849
TK5853
TK5815
TK5728

TK5820
TK5822
TK5737
TK5809
TK5819
TK5821
TK5727
TK5750
TK5717

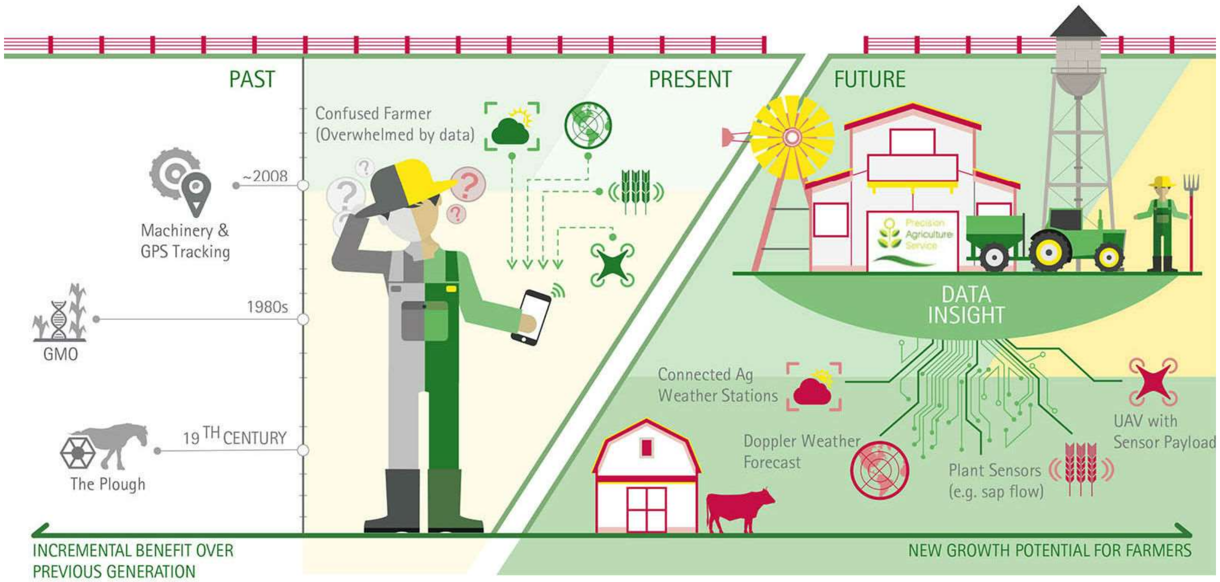
Relative To

138% - 168%

114% - 131%

Mean Tolerant for *Ganoderma* control crosses (100%)

Evolution of Digital Agriculture



https://www.accenture.com/cn-en/insight-accenture-digital-agriculture-solutions

Accumulated large amount of dataset in the Cloud:

- Agronomic data
- Environmental data
- Genetic-based data

Modelling:
Data-driven operational decision to optimize yield and boost revenue.

Minimizing:

- Operational expenses
- Crop failure (wrong genetic background for different soil/environment)
- Environmental impact (nutrient run-off)

Understanding agriculture: Complex and differing applications

- Different crop types have unique growing environments and requirements, which create unique sets of priorities within each application.
- Digital ag alignment of a digital ag solution to these priorities will dictate if the solution is a good fit.

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1. Broad acre row crops

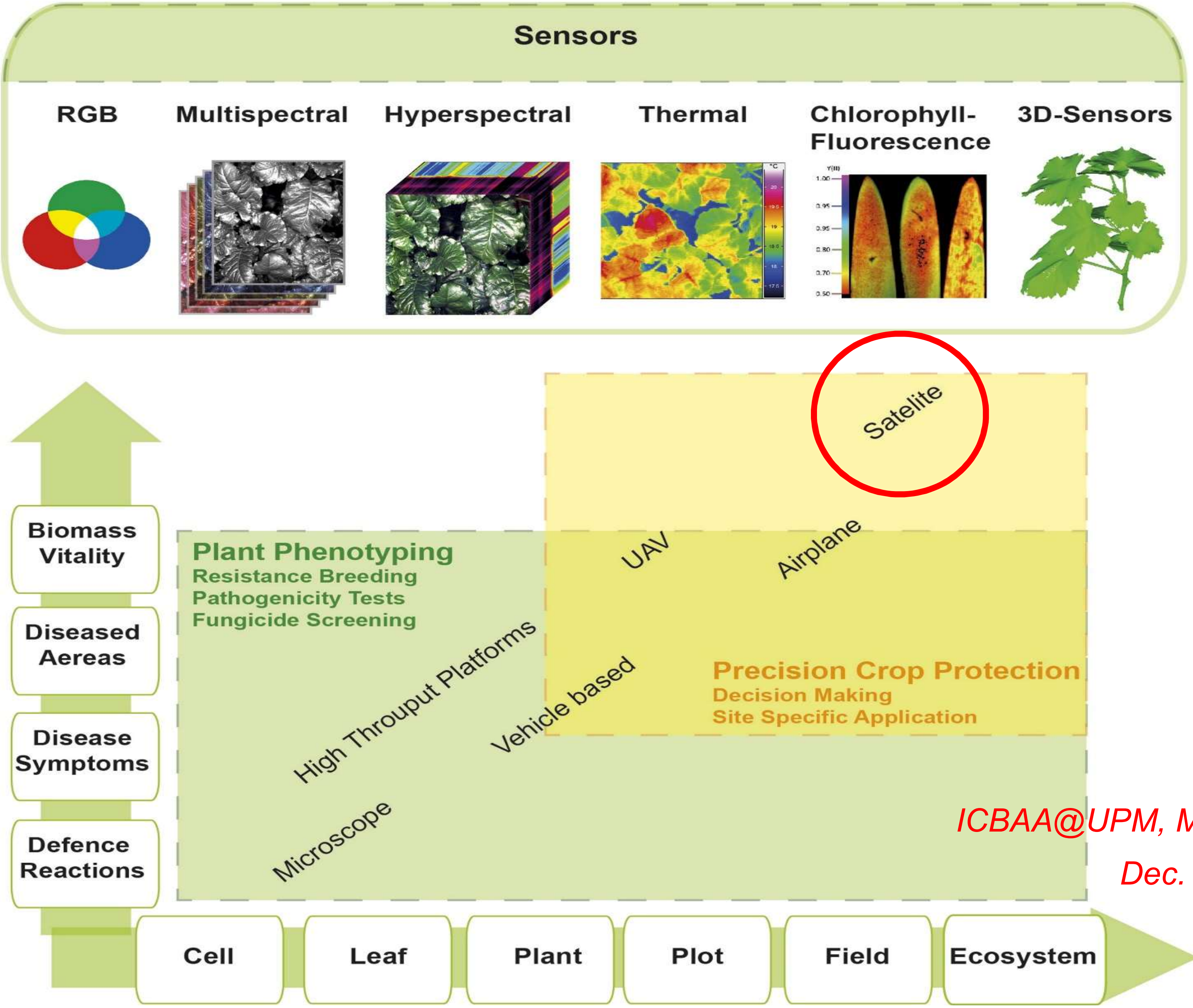
2. Permanent crops

3. Premium crops

4. Fruit and vegetable row crops

5. Greenhouse crops

6. Research and development



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Adapted from Mahlein (2016)

Space Applications For Environment (SAFE) Prototype

"Efficient Oil Palm Management Prototyping Using 3D GIS For Replanting Program"

A Collaboration with UPM, Japanese Aerospace Exploration Agency (JAXA), Keio University & University of Tokyo

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Purposes of Oil Palm Replanting Program:

- To replace un-economic and old palms (>25 years old);
- To improve inherent estate infrastructures;
- To optimize the land within the allocated cost;
- To apply GAP aspects for better yield performance for the next 25 years.

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Example of **mistakes** and **irrelevant condition** of oil palm replanting from the previous planting activity that leads to loss of productivity, cost and time:

1. Wrong direction and distance of stacking row.

Effect : Slow degradation of chipped trunk.

2. Bending of planting lining & vacant point.

Effect : Inefficient light interception & reduced palm stand.

3. Uneven terrace alignment.

Effect : Waterlog in palm circle.

4. Palms are planted on the wrong lines.

Effect : Additional cost on development process to transfer the pile of chopped trunks

Importance of this prototype :

1. To improve current hard work method with new easier mapping technologies
2. To improve and assist on planning of replanting blueprint
3. To improve in terms of accurate geo-location for planning and implementation on site

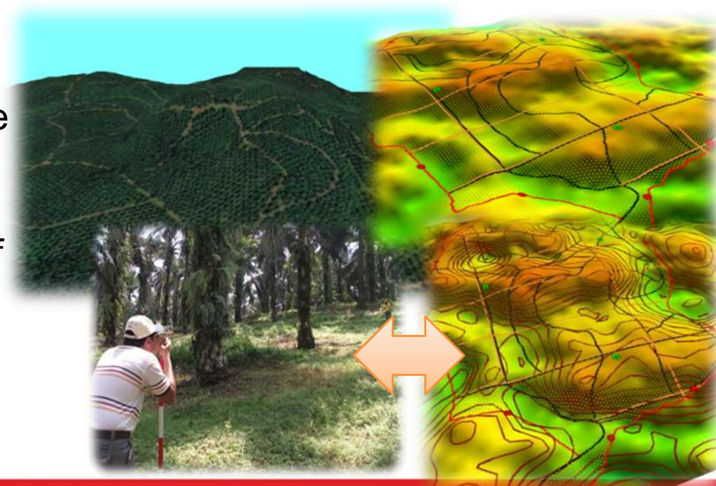
1. Design Phase		2. Planting Phase		3. After Planting Phase
Blueprint Preparation (Assist by GIS & RS)	+	**Geo-location tagging on site** (Assist by GPS/Multi-GNSS/RTK/ UHF)	=	**Complete accurate replanting program with Good Agricultural Practice (GAP)** (Assist by GIS & RS)

Objectives of this prototype :

1. To create **DIGITAL 3D MODEL** for efficient representations of the plantation

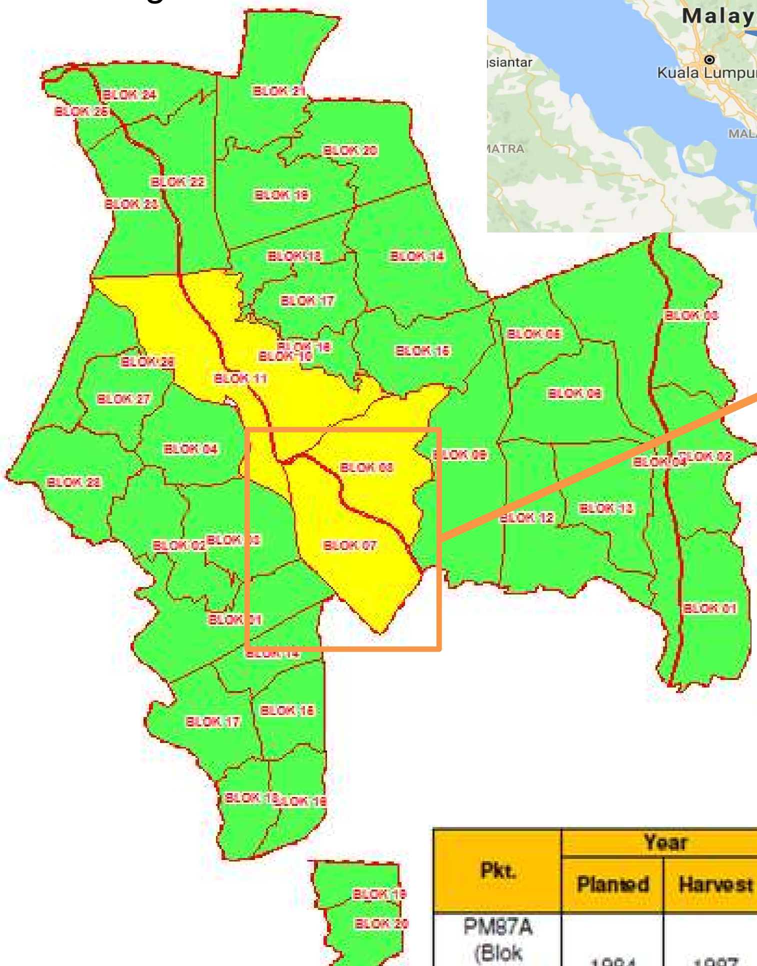
2. To **IMPROVE** the conventional replanting method by using state of the art methods of terrain representation.

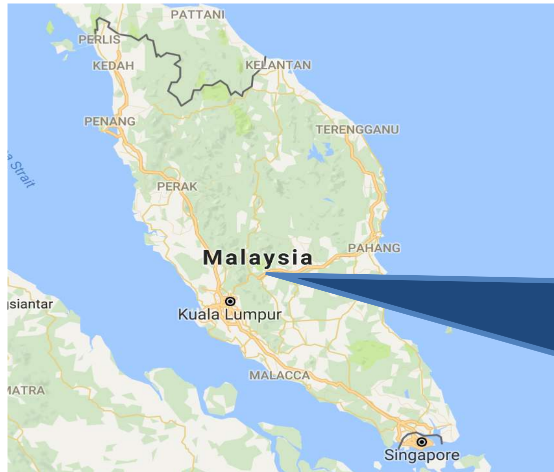
3. To **COMPARE** the conventional method with the new 3D GIS & remote sensing technique



Test Site :

- FGVPM Krau 2 Estate,Bentong, Pahang





Test Block

BIL	BLOCK	PERIMETER AREA (Ha)	PLANTED AREA (Ha)
1	Blok 7	121.28	89.23
2	Blok 8	112.09	92.64
3	Blok 9	166.66	143.19
4	Blok 10	122.43	93.15
5	Blok 11	123.97	87.83
TOTAL		646.43	506.04

Block	Palm Age (2016)	Estimated Period		Palm Stand (palm/ha)	
		Planting	Harvesting	Current	Future
7-11	32 years old	2016	2020	115	136

Pkt.	Year		Area (ha)		Previous Stand (palm/ha)	Topography (%)				Soil Series	Rainfall	SYP (t/ha)
	Planted	Harvest	Planted	Harvest		L	F	M	H			
PM87A (Blok 7,8,9,10 & 11)	1984	1987	506.04	506.04	115	16	8	12	64	Bungor/*Typic Paleudult* Durian/*Plinthaquic Paleudult*	M	24

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Oil Palm Replanting flow of works:

GanodermaSanitation

Rats Baiting

Stone Border & Infrastructure data Collection

Pre-lining

Felling & Chipping

Blanket Spray

Palm Lining (flat/undulating)

Agricultural Road Packing

Terrace Packing

Palm Lining (Terrace)

Drainage

Field Planting

Pest & Disease Management

Complete planned replanting program with Good Agricultural Practice (GAP) applied

Completed with new technologies

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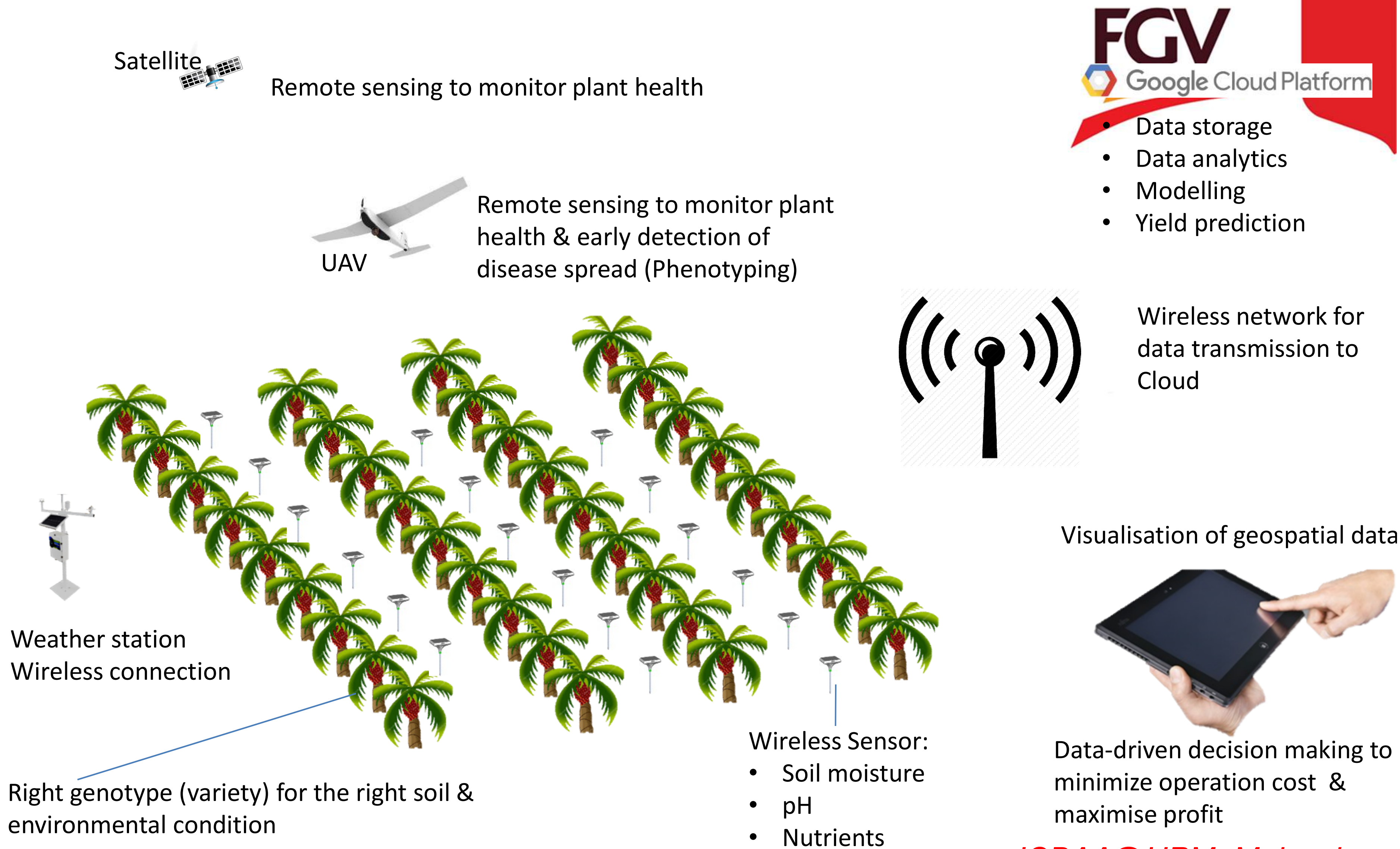
Putting it all together



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In summary….

- Big-data in R&D
  - Collecting various types of data
  - Curating
  - Analysis and interpretation
  - Translating into meaningful information
- Opportunities for value-added service
  - Increasing yield potential
  - Right input, right time, right location

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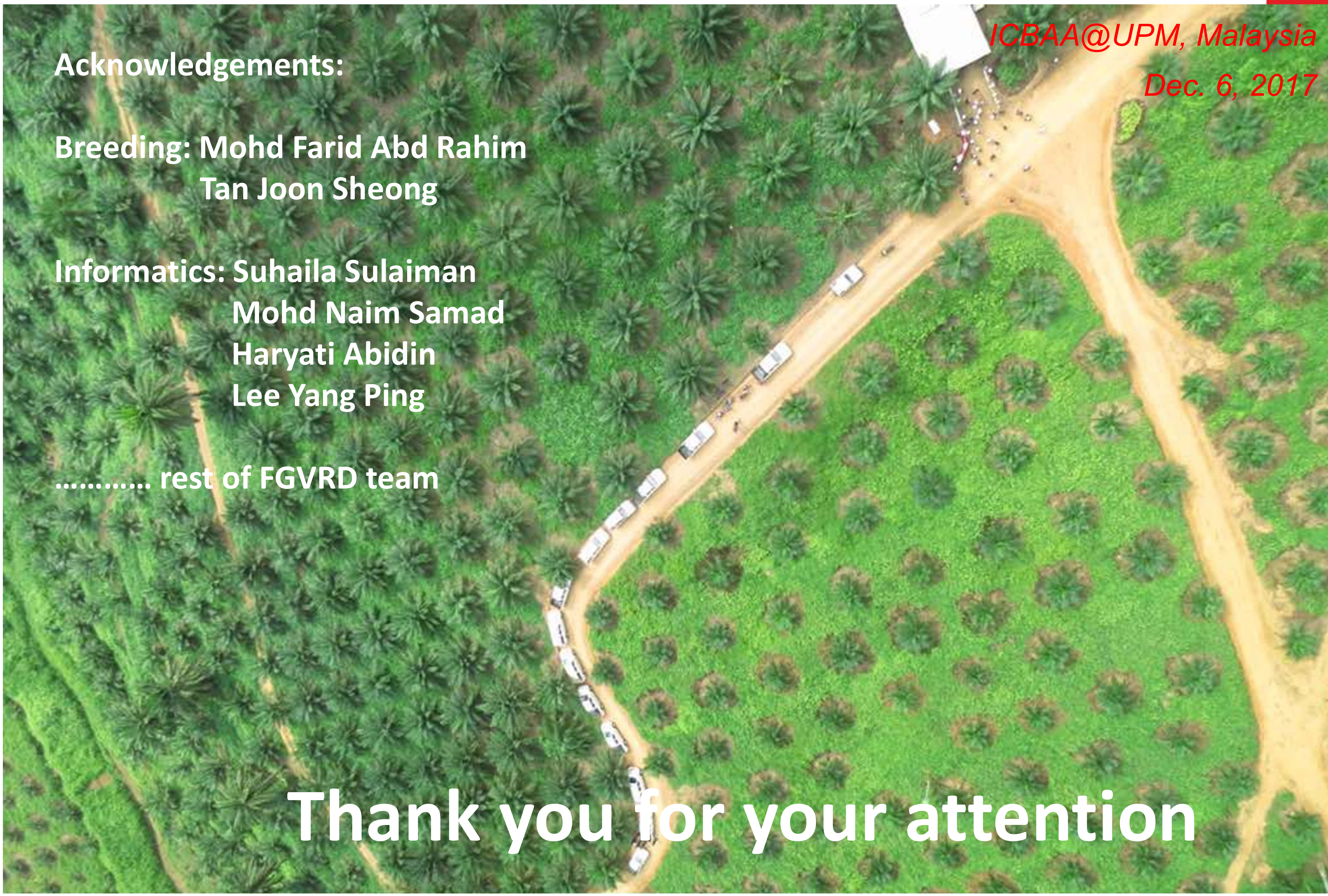

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Tan Joon Sheong

Informatics: Suhaila Sulaiman
Mohd Naim Samad
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……….. rest of FGVRD team

Thank you for your attention