

Yield Performance of Commercial Topaz DxP Series 2 Oil Palm Plantings on Various Sites in Indonesia

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Based on results from breeding trials, Topaz DxP Series 2 progenies have a genetic yield potential of 33.5 tonnes fresh fruit bunch (FFB) per hectare, 9.3 tonnes crude palm oil (CPO) per hectare and estimated mill oil extraction rate (OER) of 27.8 per cent. However, actual performances in large scale commercial plantings can differ from trials due to variation in site characteristics (soil, topography, climate) and consistency in management inputs. This paper reports on the commercial performance of Topaz DxP Series 2 progenies planted over 11 032 hectares in six sites located over four provinces in Indonesia.

In spite of low to moderate rainfall and annual soil moisture deficits in Site 1 (North Sumatera), high FFB (32.8 tonnes/ha) and CPO (8.2 tonnes/ha) yield was still achieved. Site 2 (North Sumatera) having significantly higher rainfall attained even better yields (34.7 tonnes FFB/ha, 8.7 tonnes CPO/ha) over its entire 1 737 ha. Its smaller neighbouring sister estate (270 ha) recorded the highest yields (42.3 tonnes FFB/ha, 10.6 tonnes CPO/ha) as early as the fifth year of harvesting. At both sites, FFB yield more than 30 tonnes per hectare and CPO yield more than 7 tonnes per hectare had been consistently attained over the last 4 years.

The good adaptability of Topaz DxP Series 2 to marginal soils was observed in an oil palm to oil palm replant (1,350 ha) on second generation deep peat (Site 3, North Sumatera). FFB yield more than 30 tonnes per hectare and CPO yield more than 7 tonnes per hectare were attained as early as 5-6 years after planting. Equally impressive yields of 35.1 tonnes FFB per hectare and 8.7 tonnes CPO per hectare were recorded from Series 2 progenies planted over 1 892 hectares on sandy loam to loamy sand textured soils in Riau province (Site 4).

Slightly lower crop yields were recorded in Site 5 (Jambi) and Site 6 (Central Kalimantan) due to sub-optimal agricultural conditions at the early stages of development. Upon upgrading, FFB and CPO yields ranging from 29-32 tonnes per hectare and 7.2-7.4 tonnes per hectare respectively, have subsequently been attained.

Mill OERs of 25.0-25.5 per cent in three sites (1, 2, 6) have confirmed the good oil content in the Topaz Series 2 fruit bunches. The lower mill OERs (22.8-24.9%) recorded in Sites 4 and 5 were primarily due to the mills processing a mixed crop from Gen-1 (48%) and Gen-2 (52%) plantings.

Keywords : CPO, FFB, oil palm, Topaz.

Oil palm research station Topaz (OPRS-Topaz) commenced its oil palm breeding programme 22 years ago with the importation of the ABRO germplasm from ASD de Costa Rica. The

availability of a genetically diverse germplasm enabled the development of an extensive and comprehensive breeding programme allowing OPRS-Topaz not only to tap the best DxP

combinations for commercial seed production but also laid the foundation for the development of new genetic materials (Mukesh *et al.*, 2016). Full details on various aspects of the breeding programme and evaluation of over 400 DxP test crosses in progeny trials sited on two major soil types (mineral, peat) and in two provinces (North Sumatera, Riau) have been documented previously by Ang *et al.* (2002; 2003). The outcome of these breeding programmes has been the release of four oil palm varieties (Topaz 1, Topaz 2, Topaz 3, Topaz 4) collectively referred to as Topaz DxP Series 2 to the general public in 2004 (Ang *et al.*, 2018).

Performances of the Topaz DxP Series 2 in progeny trials sited on both mineral and peat soils has been very promising. The genetic potential of Series 2 was recorded to be 33.5 tonnes fresh fruit bunch (FFB) per hectare and 9.3 tonnes crude palm oil (CPO) per hectare. These elite planting materials also had high oil content in their FFB (32.5%) with potential mill oil extraction rate (OER) greater than 27 per cent (Ang & Sri, 2007).

Although small scale progeny trials can evaluate and accurately indicate the genetic yield potential of the developed planting materials, actual performances in large scale commercial plantings can somewhat differ due to significant variation in site characteristics (soil type, topography), climatic conditions and consistency in management inputs. This paper reports on the yield performance of the Topaz DxP Series 2 planted commercially in six sites located over four provinces in Indonesia.

Site details

Full details of the six sites are given in *Appendices 1A-1F* with a summary provided below.

Site 1 North Sumatera Province, volcanic soil,

flat to undulating topography, low to moderate rainfall, cocoa to oil palm replant, Asian Agri (AA) estate.

Site 2 North Sumatera Province, alluvium and shallow peat, flat topography, high rainfall, logged over secondary forest, external client estate.

Site 3 North Sumatera Province, second generation deep peat, flat topography, low to moderate rainfall, oil palm to oil palm replant, AA estate.

Site 4 Riau Province, sandy inland soil, undulating to rolling to hilly topography, sufficient rainfall, rubber to oil palm replant, AA estate.

Site 5 Jambi Province, sandy clay inland soil, undulating to rolling to hilly topography, sufficient rainfall, oil palm to oil palm replant, AA estate.

Site 6 Central Kalimantan, sandy clay inland soil, flat to undulating topography, sufficient rainfall, logged over secondary forest, external client estate.

Sites 1, 3, 4 and 5 were AA estates whilst Sites 2 and 6 belonged to external clients of AA's Research and Development (R&D) department. Apart from buying Topaz DxP seed, the clients also used AA R & D's agronomic and fertiliser recommendation services.

Field upkeep and maintenance in all six sites were as per AA standard operating procedures (SOP) which utilises the zero-burning land preparation technique and the concept of best management practices (BMP) for oil palm cultivation. In Site 6 which is located in Central Kalimantan, social issues and labour shortages resulted in sub-optimal agricultural standards, incomplete fertiliser programmes and significant palm supplying in the first four years of establishment. Thereafter, agricultural standards were brought up to specifications.

YIELD PERFORMANCE

North Sumatera Province (Sites 1, 2 and 3)

Site 1 consisted of 904 hectares of Topaz DxP Series 2 planted on volcanic soils from 2006 to 2010 (*Appendix 1A*). In spite of the low to moderate rainfall and annual soil moisture deficit (average: 232 mm/year), the oil palm showed early precocity and high yield potential. Almost all ages of plantings recorded first year yields more than 21 tonnes FFB per hectare and between 23-32 tonnes FFB per hectare in the second year of harvest. Highest or peak yields of 32.8 tonnes FFB per hectare and 8.24 tonnes CPO per hectare were recorded in 2017. Over the last 5 years (2014-2018), average CPO yield over the entire 904 hectares has consistently been maintained above 7.0 tonnes per hectare. The high oil content of Topaz DxP Series 2 FFB was reflected in mill OER being consistently above 25 per cent over the last 5 years (*Table 1*).

In contrast, Site 2 located in Tapanuli Tengah district can be classified as a very high rainfall area with annual rainfall ranging from 3 799 - 5 249 mm (*Appendix 1B*). At times, such excessive rainfall can also be deemed limiting to oil palm production in view of its negative effects on pollination, excessive cloud cover and insufficient solar radiation (Paramanathan, 2011). Planted on flat alluvial soils and shallow peat (< 1.0 m depth), initial yields in Estate ABC (1,737 ha) were low due to inadequate drainage and management inputs. Once these problems were rectified, oil palm yield increased exponentially, with peak yield of 34.7 tonnes FFB per hectare and 8.7 tonnes CPO per hectare being recorded in 2017. Over the last 4 years (2015-2018), the estate has consistently yielded more than 30 tonnes FFB per hectare and 8.0 tonnes CPO per hectare (*Table 2*).

TABLE 1
PERFORMANCE OF TOPAZ DxP ON VOLCANIC SOILS, NORTH SUMATERA PROVINCE (SITE 1)

Year of planting	Area (ha)	Current SPH ¹	Yield parameters (tonnes/ha)	Year of crop harvesting									
				2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2006	232	121	FFB CPO	23.45 4.87	31.95 6.86	32.89 7.42	27.88 6.50	26.62 6.41	29.72 7.55	30.17 7.53	27.10 6.83	32.66 8.20	33.40 8.51
2007	317	129	FFB CPO	- -	22.11 4.74	25.70 5.80	25.66 5.98	26.16 6.30	26.26 6.67	26.92 6.72	27.44 6.91	32.79 8.23	31.91 8.13
2008	286	135	FFB CPO	- -	- -	21.71 4.90	23.86 5.56	29.14 7.02	30.08 7.64	29.58 7.38	26.87 6.77	33.07 8.30	28.79 7.34
2010	69	137	FFB CPO	- -	- -	- -	- -	17.50 4.21	27.43 6.97	32.60 8.13	28.94 7.29	32.70 8.21	25.23 6.43
Average	904	129	FFB CPO OER	23.45 4.87 20.76	26.27 5.64 21.46	26.33 5.94 22.57	25.64 5.98 23.31	26.55 6.39 24.08	28.46 7.23 25.40	29.03 7.24 24.95	27.29 6.88 25.20	32.83 8.24 25.10	30.41 7.75 25.49

¹ Stand per hectare (originally planted at 136 palms/ha)

TABLE 2
PERFORMANCE OF TOPAZ DxP ON ALLUVIAL / PEAT SOILS, NORTH SUMATERA PROVINCE (SITE 2)

Estate	Year of planting	Area (ha)	Current SPH¹	Soil type	Yield parameters (tonnes/ha)	Year of crop harvesting										
						2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
ABC	2006	805	143	Alluvial	FFB	8.60	14.10	17.90	22.50	26.90	29.70	33.80	32.20	34.80	34.20	
					CPO	1.40	2.80	3.90	5.40	6.60	7.30	8.50	8.10	8.70	8.60	
	2006	283	141	Peat (< 3.0 m)	FFB	10.80	16.50	20.60	22.60	25.50	29.80	33.00	31.70	33.80	33.10	
					CPO	1.70	3.30	4.50	5.40	6.20	7.30	8.30	7.90	8.50	8.30	
	2007	462	143	Alluvial	FFB	-	7.20	12.30	17.80	22.70	26.90	31.80	31.60	35.70	34.20	
					CPO	-	1.40	2.70	4.30	5.60	6.60	8.00	7.90	8.90	8.60	
2007	187	141	Peat (< 3.0 m)	FFB	-	4.20	9.10	16.20	22.40	25.50	28.70	28.60	33.30	32.80		
				CPO	-	0.80	2.00	3.90	5.50	6.30	7.20	7.20	8.30	8.20		
Average	1 737		142	Alluvial and peat	FFB	6.80	11.60	15.90	20.60	25.10	28.50	32.60	31.60	34.70	33.90	
					CPO	1.10	2.30	3.50	4.90	6.20	7.00	8.20	7.90	8.70	8.50	
XYZ	2011	270	145	Alluvial	OER	16.02	20.00	22.00	24.00	24.50	24.50	25.00	25.00	25.00	25.00	
					FFB	-	-	-	-	-	16.90	28.80	30.20	36.90	42.30	
					CPO	-	-	-	-	-	2.70	6.30	7.40	9.00	10.60	
					OER	-	-	-	-	-	16.00	22.00	24.50	24.50	25.00	

¹ Stand per hectare (originally planted at 143 palms/ha)

Topaz DxP Series 2 achieved even higher yields in the smaller neighbouring sister Estate XYZ (270 ha). Planted much later in 2011, it has already achieved FFB yield of 42.3 tonnes per hectare and CPO yield of 10.6 tonnes per hectare by only the fifth year of harvesting (*Table 2*). Mill OER ranged from 24.5 - 25.0 per cent, further confirming the good oil content of the FFB processed.

The good adaptability of Topaz DxP Series 2 to “marginal” soils was observed in the performances of oil palm to oil palm replants on second generation deep peat (> 3.0 m depth) in Site 3 (*Appendix 1C*). FFB yield more than 30.0 tonnes per hectare and CPO yield more than 7.0 tonnes per hectare was attained as early as 3-4 years after commencing of harvesting (*Table 3*). Mill OER was 23.2 per cent and is expected to improve with increase in bunch weight as the palms get older. In addition, oil content in FFB derived from peat is 1.5-2.0 per cent lower than FFB harvested from mineral soils (Sidhu, 2012).

Riau Province (Site 4)

Equally impressive results were obtained from Topaz DxP Series 2 planted in a rubber to oil palm replant on sandy inland type soils in the Pelalawan district (*Appendix 1D*). The replant totalling 1 892 hectares was completed over a 3-year period (2010-2012). In the earliest replant (OP 2010-594 ha), FFB yield of 32.4 tonnes per hectare and CPO yield of 7.5 tonnes per hectare were achieved as early as the third year of harvesting. The youngest replant (OP 2012-688 ha) performed equally well, yielding 29.9 tonnes FFB per hectare and 6.9 tonnes CPO per hectare in only the second year of harvesting. By 2018 (6-8 years after planting) average FFB and CPO yields over the entire 1 892 hectares was 35.1 tonnes per hectare and 8.7 tonnes per hectare

respectively. Even the 2011 replant (610 ha) which comprised 70 per cent planting on terraces, yielded 32.8 tonnes FFB per hectare and 8.2 tonnes CPO per hectare. However, the highest FFB (36.6 tonnes/ha) and CPO (9.1 tonnes/ha) yields were achieved by the 2010 replant which was sited on undulating to gently rolling terrain (*Table 4*).

Mill OER of 24.9 per cent once again confirmed the high oil content of Topaz DxP Series 2 fruit bunches. Both CPO yield and mill OER would have been significantly higher if the mill had been receiving crop only from the Topaz DxP Series 2 replants. In actuality, the mill processes FFB from both the replants (60%) and 20 to 23 year old generation one plantings (40%). Based on internal bunch analysis investigations, the older plantings have a significantly lower oil content in their FFB (< 23% OER).

Jambi Province (Site 5)

Compared to Site 4 (Riau Province), Site 5 had higher rainfall and clay content in its soil. Topography was predominantly rolling to hilly (*Appendix 1E*). It comprised of an oil palm to oil palm replant totalling 2 092 hectares planted over a 2- year period (2007 & 2008).

In both replants, initial yields were set-back due to sub-optimal management inputs but as the latter improved, both FFB and CPO yields rose to hit 30.6 tonnes per hectare and 6.9 tonnes per hectare respectively in 2015 (fifth to sixth year of harvesting). Due to extreme dry and hazy conditions (*El Nino*) in 2015, crop yields declined by 19 per cent (5.8 tonnes FFB/ha) in the following year. Recovery commenced in 2017 and was completed in 2018 with FFB and CPO yields of 32.6 tonnes per hectare and 7.4 tonnes per hectare respectively (*Table 5*).

As the estate mill processed crop from both older Gen-1 (48%) and Gen-2 (52%)

TABLE 3
PERFORMANCE OF TOPAZ DxPON PEAT SOILS, NORTH SUMATERA PROVINCE (SITE 3)

Year of planting	Division	Area (ha)	Current SPH ¹	Yield parameters (tonnes/ha)	Year of crop harvesting			
					2015	2016	2017	2018
2012	1	197	149	FFB	17.05	23.80	23.54	33.37
				CPO	3.28	4.62	4.74	7.74
	2	267	147	FFB	13.27	19.58	22.62	30.17
				CPO	2.55	3.80	4.56	7.00
Average	1 and 2	464	148	FFB	14.87	21.37	23.01	31.53
				CPO	2.86	4.14	4.63	7.31
2013	1	245	155	FFB	-	13.79	20.30	29.11
				CPO	-	2.68	4.09	6.75
	2	227	157	FFB	-	18.08	21.16	29.99
				CPO	-	3.51	4.26	6.96
	3	414	158	FFB	-	16.58	23.87	29.52
				CPO	-	3.22	4.81	6.85
	Average	1, 2 and 3	886	FFB	-	16.19	22.19	29.53
				CPO	-	3.14	4.47	6.85
Average		1 350	154	FFB	14.87	17.97	22.47	30.22
				CPO	2.86	3.49	4.53	7.01
				OER	19.24	19.41	20.15	23.20

¹ Stand per hectare (originally planted at 150-160 palms/ha)

TABLE 4
PERFORMANCE OF TOPAZ DxPON INLAND SOILS, RIAU PROVINCE (SITE 4)

Year of planting	Area (ha)	Current SPH ¹	Yield parameters (tonnes/ha)	Year of crop harvesting					
				2013	2014	2015	2016	2017	2018
2010	594	142	FFB	14.90	22.56	32.40	28.66	30.13	36.62
			CPO	3.43	5.34	7.53	6.62	7.21	9.12
2011	610	125	FFB	-	9.95	20.91	25.59	29.33	32.83
			CPO	-	2.35	4.85	5.91	7.02	8.18
2012	688	145	FFB	-	-	14.31	29.93	28.70	35.71
			CPO	-	-	3.33	6.92	6.87	8.89
Average	1 892	138	FFB	14.90	16.17	22.12	28.13	29.35	35.07
			CPO	3.43	3.83	5.14	6.50	7.02	8.73
			OER ²	23.00	23.66	23.25	23.11	23.93	24.90

¹ Stand per hectare (originally planted at 143 palms/ha)

² Average oil extraction rate of Gen-1 (1,292 ha) and Gen-2 (1,892 ha) plantings

TABLE 5
PERFORMANCE OF TOPAZ DxP ON INLAND SOILS, JAMBI PROVINCE (SITE 5)

Year of planting	Division	Area (ha)	Current SPH ¹	Yield parameters (tonnes/ha)	Year of crop harvesting									
					2010	2011	2012	2013	2014	2015	2016	2017	2018	
2007	1	791	129	FFB	10.64	18.96	25.02	22.29	24.79	29.42	23.70	23.79	32.93	
				CPO	2.44	4.34	5.75	5.15	5.73	6.65	5.35	5.40	7.52	
	2	307	136	FFB	14.79	21.73	27.07	24.82	26.05	31.78	27.33	25.95	31.92	
				CPO	3.40	4.98	6.22	5.74	6.02	7.18	6.17	5.89	7.29	
Average	1 and 2	1 098	131	FFB	11.80	19.73	25.59	23.00	25.14	30.08	24.71	24.39	32.65	
				CPO	2.71	4.52	5.88	5.32	5.81	6.80	5.57	5.54	7.46	
2008	1	120	138	FFB	-	18.17	21.50	20.31	25.41	30.91	26.15	23.64	32.54	
				CPO	-	4.16	4.94	4.69	5.87	6.98	5.90	5.37	7.43	
	2	450	133	FFB	-	15.75	23.11	21.18	26.35	31.76	26.81	26.91	32.43	
				CPO	-	3.61	5.31	4.89	6.09	7.17	6.05	6.11	7.41	
	3	424	134	FFB	-	12.41	17.70	18.10	25.21	30.72	22.73	25.76	32.42	
				CPO	-	2.84	4.07	4.18	5.83	6.94	5.13	5.85	7.40	
Average	1, 2 and 3	994	134	FFB	-	14.61	20.60	19.76	25.75	31.21	24.99	26.02	32.43	
				CPO	-	3.35	4.73	4.57	5.95	7.05	5.63	5.91	7.41	
Average	2 092	132		FFB	11.80	17.30	23.22	21.46	25.43	30.62	24.84	25.16	32.55	
				CPO	2.71	3.96	5.34	4.96	5.88	6.92	5.59	5.11	7.43	
				OER ²	22.96	22.90	22.98	23.11	23.12	22.59	22.51	22.71	22.84	

¹ Stand per hectare (originally planted at 136 palms/ha)

² Average oil extraction rate of Gen-1 (1,661 ha) and Gen-2 (2,361 ha)

plantings, the OER recorded (22.5-23.1%) was not reflective of the potential oil content of Topaz DXP Series 2. Significantly higher OER and CPO yield could have been attained if crop from the Gen-2 plantings had been processed separately. OER's more than 25 per cent have been recorded in Sites 1, 2 and 6, where the mills only received crop from Topaz DXP Series 2 plantings.

Central Kalimantan (Site 6)

Soil, topography and rainfall details of Site 6 are given in *Appendix 1F*. It consists of 2 787 hectares of logged over secondary forest planted with Topaz DXP Series 2 progenies over a 3- year period (2005-2007).

Due to social issues and labour shortages in the early years of cultivation, initial yields were negatively affected and only breached the 25 tonnes FFB per hectare level, 5-8 years after commencement of harvesting. As in Site 5, the prolonged drought and hazy conditions in 2015 (*El Nino*) significantly depressed yields (9%) in the following year. However, recovery

was equally rapid with attainment of FFB and CPO yields above 28.0 tonnes per hectare and 7.0 tonnes per hectare respectively, in the following two consecutive years (2017 & 2018). Mill OERs over the last 5 years ranged between 24.1 to 25.2 per cent, further confirming the good extraction rates obtained with Topaz DXP Series 2 materials in other sites (*Table 6*).

CONCLUSION

The impressive yields recorded in the six commercial sites (11,032 ha) confirmed the good genetic potential of the Topaz DXP Series 2 progenies. On good sites with best management practices, FFB and CPO yields of 35-40 tonnes per hectare and 8.5-10.0 tonnes per hectare respectively were attainable. This was comparable to FFB and CPO yields attained in smaller scale progeny trials. The results also showed the good adaptability of the planting materials having performed well under differential rainfall regimes (low, sufficient, high) and on marginal

TABLE 6
PERFORMANCE OF TOPAZ DXP ON INLAND SOILS, CENTRAL KALIMANTAN PROVINCE (SITE 6)

Year planting	Area (ha)	Current SPH ¹	Yield parameters (tonnes/ha)	Year of crop harvesting								
				2010	2011	2012	2013	2014	2015	2016	2017	2018
2005	943	133	FFB	17.60	22.77	26.38	26.35	25.89	24.31	23.04	29.55	29.91
			CPO	3.83	5.33	6.37	6.25	6.25	5.90	5.62	7.25	7.54
2006	1 609	132	FFB	12.31	19.23	22.89	23.69	24.89	23.96	22.25	28.10	28.34
			CPO	2.68	4.50	5.52	5.61	6.01	5.82	5.43	6.90	7.14
2007	235	131	FFB	6.98	15.65	22.74	23.53	21.19	29.45	24.15	29.15	29.18
			CPO	1.52	3.67	5.49	5.58	5.12	7.15	5.89	7.15	7.35
Average	2 787	132	FFB	13.62	20.10	24.04	24.56	24.91	24.55	22.68	28.67	28.94
			CPO	2.97	4.71	5.80	5.82	6.01	5.96	5.53	7.04	7.29
			OER	21.77	23.42	24.13	23.70	24.14	24.28	24.44	24.54	25.20

¹ Stand per hectare (originally planted at 136 palms/ha)

TABLE 7
COMPARATIVE YIELD POTENTIAL OF TOPAZ SERIES 2, 3 AND 4

<i>Year of release</i>	<i>Topaz</i>		
	<i>Series 2</i>	<i>Series 3</i>	<i>Series 4</i>
	<i>2004</i>	<i>2014</i>	<i>2018</i>
<i>Year of harvesting 1 and 2</i>			
FFB production (tonnes/ha/year)	25.4	28.5	29.9
Bunch number (palm/year)	27.2	28.6	29.5
Average bunch weight (kg)	6.9	7.3	7.5
<i>Year of harvesting 3-6</i>			
FFB production (tonnes/ha/year)	33.5	36.1	40.5
Bunch number (palm/year)	17.5	18.1	20.6
Average bunch weight (kg)	14.1	14.6	14.4
Oil to bunch (%)	32.5	34.2	34.7
OER(%)	27.8	29.2	29.7
CPO production (tonnes/ha/year)	9.3	10.5	12.0
Kernel to bunch (%)	4.5	4.2	4.1
Total oil (tonnes/ha/year)	10.1	11.3	12.8

soils (deep peat, sandy inland, terraced sub-soil). On some sites (Sites 5 & 6), despite the initial set-backs on palm growth and yield due to sub-optimal agricultural standards, the palms have recovered to produce FFB and CPO yields more than 30 tonnes per hectare and 7.0 tonnes per hectare, respectively.

The satisfactory mill OERs (> 25%) recorded in a number of sites (Sites 1, 2, 6) also confirmed the high oil content of the Topaz DxP Series 2 fruit bunches. In other sites (Sites 4 & 5), slightly lower OERs were recorded primarily due to mixed processing of Gen-1 and Gen-2 crops. Significantly higher values would have been obtained if the Gen-2 (Topaz DxP Series 2) FFB had been processed separately.

Since release of Topaz DxP Series 2 in 2004, OPRS had made large strides in the development of new planting materials with the release of Topaz DxP Series 3 and Series 4 in 2014 and 2018, respectively. Both the latter series display a significant improvement in FFB

and CPO yield over Series 2. Topaz DxP Series 3 and 4 have a genetic yield potential of 36 to 40 tonnes FFB per hectare and 10.5 to 12.0 tonnes CPO per hectare. Mill OERs are also expected to be higher, ranging from 29.2 to 29.7 per cent (*Table 7*). With the introduction of molecular assisted breeding strategies and programmes in OPRS, it can only be envisaged that the next generation of Topaz planting materials (Topaz DxP Series 5) would encompass characteristics of high yield potential together with specific traits of interest e.g. low height increment, compact canopy, disease tolerance etc.

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APPENDIX 1A

SITE DETAILS

Site	: 1									
Estate	: KBL									
Mature area	: 951 hectares									
Location	: Serdang Bedagai, North Sumatera									
Year of planting and planting material	: 1995 - ASD Cost Rica (47 ha) 2006 - Topaz DxP (232 ha) 2007 - Topaz DxP (317 ha) 2008 - Topaz DxP (286 ha) 2010 - Topaz DxP (69 ha)									
Soil type	: Typic Dystrudept (56 %), Typic Endoaquult (12%) Typic Hapludult (32%)									
Topography	: 0-5° (14%), 6-12° (64%), 13-20° (18%), > 20° (4%)									
Rainfall	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total rainfall (mm/year)	1993	1 677	1 681	1 675	2 086	1 641	1 223	1 187	2 273	1 619
Number of raindays/year	108	115	110	100	106	91	93	102	138	132
Total dry month/year	2	4	2	4	4	6	6	8	3	4
Consecutive dry months/year	0	1x4	1x2	1x2	1x2	1x4 1x2	1x4	1x5	1x2	1x2
Soil moisture deficit (mm/year)	0	251	149	162	170	572	368	444	50	157

APPENDIX 1B

SITE DETAILS

Site	: 2
Estate	: ABC and XYZ
Mature area	: ABC (1,737 ha), XYZ (270 ha)
Location	: Tapanuli Tengah, North Sumatera
Year of planting and planting material	: 2006 - Topaz DxP (1,088 ha) 2007 - Topaz DxP (649 ha) 2011 - Topaz DxP (270 ha)
Soil type	: Typic Endoaquept (1,537 ha), Typic Haplosaprist (470 ha)
Topography	: 0-5° (100%)

<i>Rainfall</i>	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total rainfall (mm/year)	4 481	3 799	4 869	5 082	4 677	4 402	4 664	4 605	5 249	5 526
Number of raindays/year	161	196	176	179	174	177	188	19	165	167
Total dry months/year	0	0	0	0	0	0	0	0	1	1
Consecutive dry months/year	0	0	0	0	0	0	0	0	0	0
Soil moisture deficit (mm/year)	0	0	0	0	0	0	0	0	0	0

APPENDIX 1C

SITE DETAILS

Site	: 3
Estate	: KTS
Mature area	: 2 651 hectares
Location	: Labuhan Batu, North Sumatera
Year of planting and planting material	: 2012 - Topaz DxP (464 ha) 2013 - Topaz DxP (886 ha) 2014 - Topaz DxP (826 ha) 2015 - Topaz DxP (475 ha)
Soil type	: Typic Haplochemist, 1.0 - 3.0 m and more than 3.0 m depth
Topography	: 0-5° (100%)

<i>Rainfall</i>	2013	2014	2015	2016	2017	2018
Total rainfall (mm/year)	1 779	1 480	1 255	1 861	2 894	1 855
Number of raindays/year	100	86	93	99	146	113
Total dry months/year	4	4	5	4	1	4
Consecutive dry months/year	1x3	1x3	1x3	1x4	0	1x2
Soil moisture deficit (mm/year)	244	276	329	283	0	154

SITE DETAILS

Site	: 4																									
Estate	: KGD																									
Mature area	: 3.047 ha																									
Location	: Langgam, Pelalawan, Riau																									
Year of planting and planting material	: OP 1995 - ASD Costa Rica (826 ha) OP 1996 - ASD Costa Rica (66 ha) OP 1998 - Marihat (308 ha) OP 2006 - Topaz DxP (25 ha) OP 2007 - Topaz DxP (30 ha) OP 2010 - Topaz DxP (510 ha) OP 2011 - Topaz DxP (594 ha) OP 2012 - Topaz DxP (688 ha)																									
Soil type	: Typic Dystrudept (30%), Typic Endoaquult (6%), Typic Endoaquept (11%), Typic Hapludult (53 %)																									
Topography	: <table><tr><th colspan="5">Area distribution (%)</th></tr><tr><th>YOP*</th><th>0-5°</th><th>6-12°</th><th>13-20°</th><th>>20°</th></tr><tr><td>2010</td><td>24</td><td>68</td><td>8</td><td>0</td></tr><tr><td>2011</td><td>14</td><td>1</td><td>85</td><td>0</td></tr><tr><td>2012</td><td>14</td><td>47</td><td>39</td><td>0</td></tr></table>	Area distribution (%)					YOP*	0-5°	6-12°	13-20°	>20°	2010	24	68	8	0	2011	14	1	85	0	2012	14	47	39	0
Area distribution (%)																										
YOP*	0-5°	6-12°	13-20°	>20°																						
2010	24	68	8	0																						
2011	14	1	85	0																						
2012	14	47	39	0																						
<i>Rainfall</i>	<i>2013</i>	<i>2014</i>	<i>2015</i>	<i>2016</i>	<i>2017</i>	<i>2018</i>																				
Total rainfall (mm/year)	2839	2314	2658	2810	3408	2517																				
Number of raindays/year	116	99	98	143	141	126																				
Total dry month/year	1	2	3	2	0	2																				
Consecutive dry months/year	0	0	1x2	0	0	0																				
Soil moisture deficit (mm/year)	0	74	168	0	0	0																				

* YOP - Year of planting

APPENDIX 1E

SITE DETAILS

Site	: 5
Estate	: KBD
Mature area	: 4 022 ha
Location	: Tanjung Jabung Barat, Jambi
Year of planting and planting material	: Dami - 1993 (43 ha), 1994 (216 ha), 1995 (329 ha) Marihat - 1996 (403 ha), 1997 (461 ha), 1998 (101 ha) - 1999 (108 ha), 2004 (269 ha) Topaz DxP - 2007 (1,098 ha), 2008 (994 ha)
Soil type	: Typic Dystrudept (59%), Typic Hapludult (34%), Typic Hapludox (4%), Typic Endoaquept (3 %)

Topography

Area distribution (%)

YOP*	0-5°	6-12°	13-20°	>20°
2007	20	56	17	7
2008	12	44	39	5

Rainfall	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total rainfall (mm/year)	2688	3018	3070	1938	2834	2154	2848	2837	2272
Number of raindays/year	163	148	140	98	139	97	150	170	150
Total dry month/year	0	1	2	3	3	5	2	0	4
Consecutive dry months/year	0	0	0	0	1x2	1x4	0	0	1x3
Soil moisture deficit (mm/year)	0	0	0	92	94	280	0	0	47

*YOP - Year of planting

APPENDIX 1F

SITE DETAILS

Site	: 6
Estate	: KKC
Mature area	: 2 787 ha
Location	: Katingan, Central Kalimantan
Year of planting and planting material	: 2005 - Topaz DxP (973 ha) 2006 - Topaz DxP (1,609 ha) 2007 - Topaz DxP (235 ha)
Soil type	: Typic Hapludult (61%), Typic Dystrudept (33%), Typic Endoaquept (3%), Typic Haplorthod (3 %)
Topography	: 0-5° (35%), 6-12° (55%), 13-20° (10%)

Rainfall	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total rainfall (mm/year)	4100	3048	2966	2939	2213	2096	2618	2671	2824
Number of raindays/year	142	101	117	98	93	91	143	164	146
Total dry month/year	0	1	1	3	3	3	3	2	1
Consecutive dry months/year	0	0	0	1x2	1x3	1x2	0	0	0
Soil moisture deficit (mm/year)	0	0	0	120	198	249	66	0	0