Potential yield of oil palm - an update

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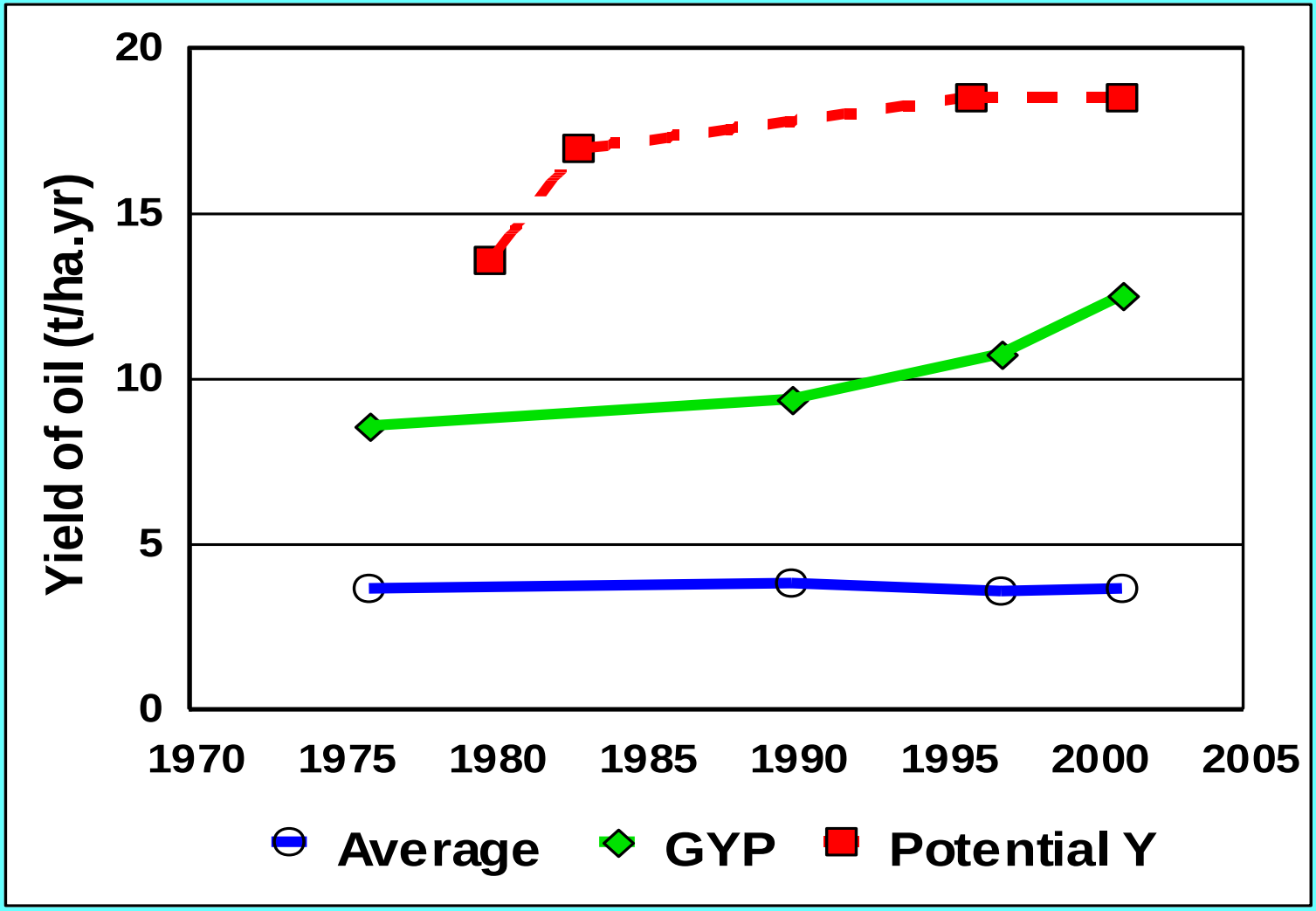
Yield potential and potential yield

- Site yield potential - current material, with good management, but site-specific limitations
- Genetic yield potential - current material under best possible conditions
- Potential yield - hypothetical genotype, combining specified physiologically plausible attributes

Potential yield, genetic yield potential and national average yields



Potential yield estimates

1980 Max. DMP x max. harvest index

= 13.6 t oil/ha.yr

1983 Potential DMP x BI x O/B

adj. for energy content = 17 t/ha

1998 As 1983, but with max. O/B from bunch components = 18.5 t/ha

Dry matter production

$$DMP = S \cdot f \cdot e / k$$

S = Total solar radiation ($MJ/m^2.yr$)

f = Fraction of radiation intercepted

e = Fraction incorporated into biomass

k = energy content of biomass (MJ/kg)

Conversion coefficient

DMP = S.f.e

S in MJ/m² e in kg/MJ

DMP = S.f.e*

e* = e adjusted for energy content of oil

DMP = S.f.e/k

e is a fraction k in MJ/kg

Palm oil production

$$Y_{oil} = S \cdot f \cdot e \cdot BI \cdot O_{dry} / k$$

BI = Bunch index

O_{dry} = oil / dry bunch weight

S - Solar radiation

Typical figures are 6000 - 6500 $MJ/m^2.yr$

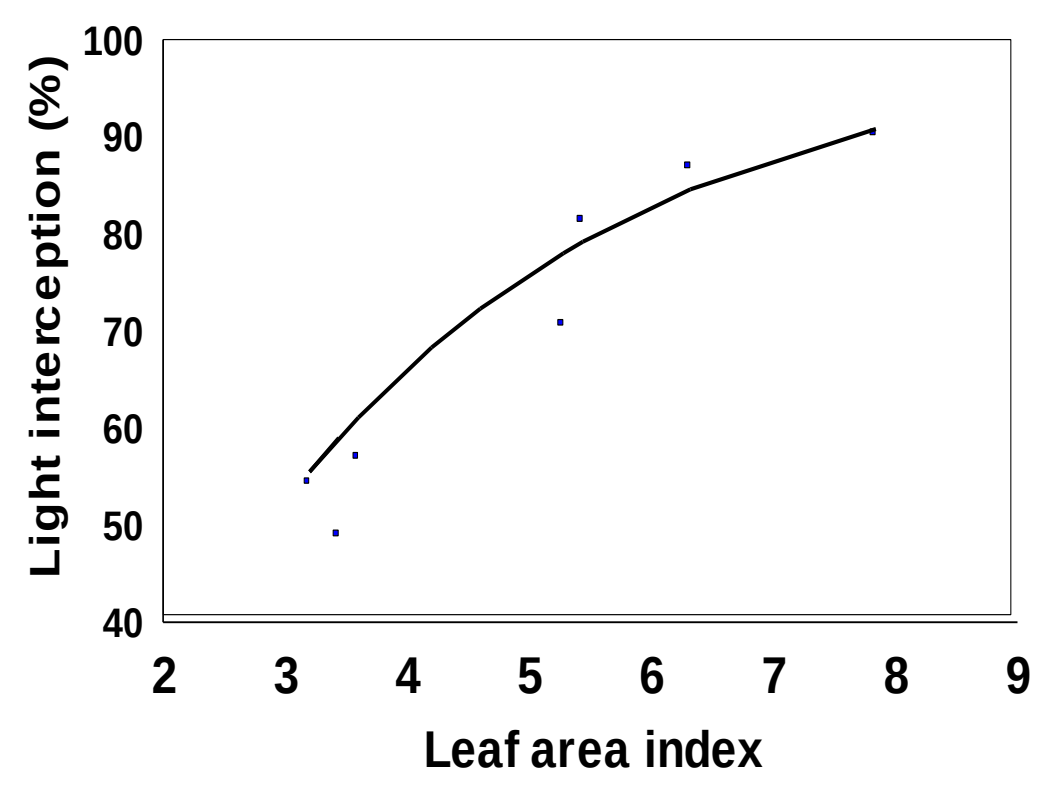
Photosynthetically active radiation (PAR) is about 50 % of total

For comparisons within a trial, 6300 MJ can be assumed

f - light interception

Depends on leaf area index, L
= leaf area x leaves/palm x palms/ha

Ln (1 - f) =
-0.34 (L - 0.3)



BI - bunch index

Proportion of dry matter in fruit bunches

$$Y_{bunch} / (Y_{bunch} + VDM)$$

Y_{bunch} usually assumed to be 53% of FFB but will be higher if fruit/bunch and oil/bunch are high.

O_{dry} - oil / dry bunch weight

O_{dry} = O to B / bunch dry matter content

Bunch dry matter may be more than 53%

- Stalk and spikelets - 30% dry matter
- Mesocarp dry matter from bunch analysis
- Shell and kernel dry matter = 100%, if nuts are dried before cracking and weighing

If F/B = 60%, M/F = 85%, DM/WM = 66%, nuts/fruit = 12%, then dry matter content = 53%

k - energy content of biomass

- Oil has higher energy content than other biomass (39.8 MJ/kg vs 18.8 MJ/kg), so k depends on BI and oil/bunch:

$$k = 39.8\ BI.O_{dry} + 18.8\ (1 - BI.O_{dry})$$

e - conversion efficiency

e is a residual term, after everything else has been calculated or estimated

$$e = \frac{Y_{oil}\,(18.8\,(1 - Bl.O_{dry}) + 39.8\,Bl.O_{dry})}{S.f.\ Bl.O_{dry}}$$

or

$$e = \frac{(18.8\,(VDM + Y_{bunch}\,(1 - O_{dry})) + 39.8\,Y_{bunch}.O_{dry})}{S.f}$$

Common misunderstandings

- Confusion between yield potential and potential yield -

  “maximum dry matter production of current material under good conditions”

  is the basis for estimating genetic yield potential, not potential yield

Common misunderstandings

- FFB yield and oil/bunch are negatively correlated. For same gross assimilate allocated to bunches:

O/B	FFB	Oil yield
50%	37 t	18.5 t
25%	52 t	13 t

DM120.025

Deli DM635.607 x DM742.207 Avros

Data from Pipae & Dumortier, 1996

Years 5 - 7 after planting

• FFB yield	276 kg/palm
	33.1 t/ha
• Bunch number	21.7 /palm.yr
• Bunch weight	12.9 kg
• Oil/bunch	36.1 %
• Oil yield	11.96 t/ha

Bunch composition, DM120.25

Component	% B.Wt	% DM	Dry as % fresh
Fruit/bunch	72.5		
Stalk + spikelets	27.5	30.0	8.2
Mesoc. (91.2 % M/F)	66.1	65.6	43.4
Kernel (5% K/F)	3.6	100	3.6
Shell (3.9% Sh/F)	2.8	100	2.8
Total dry matter			**58.0**

Vegetative measurements, DM120.25

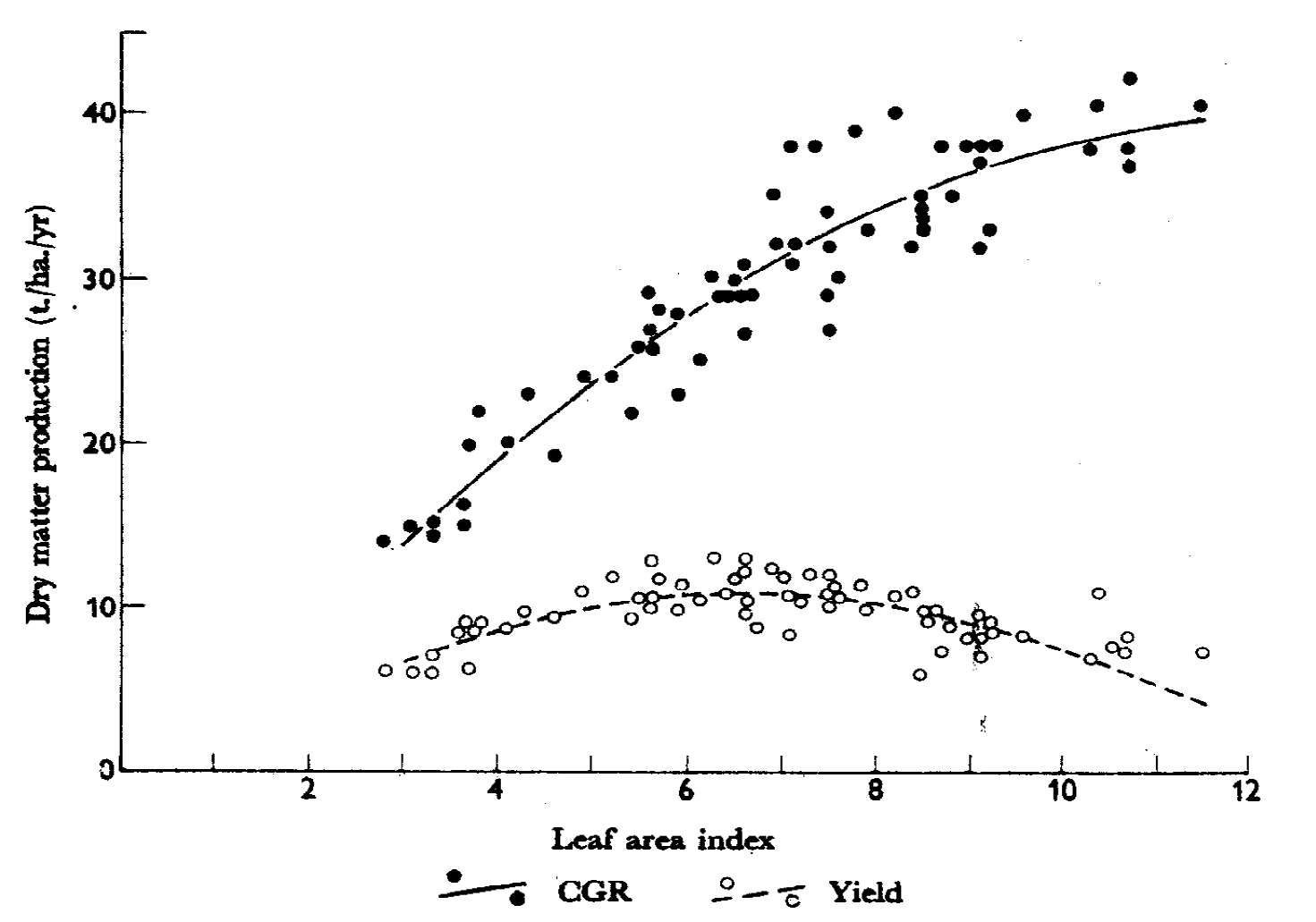
Data from Pipae & Dumortier, 1996

• Leaf area	8.04 m^2
• Planting density	120 palms/ha
• Leaf area index	4.34
• Leaf weight	2.9 kg
• Leaf production	33 /palm.yr
• Vegetative dry matter	126 kg/palm.yr

Dry matter production, DM120.25

Component	DM120.25	Ideotype
Y_{bunch} (t/ha.yr)	19.1	25.7
Total DMP (t/ha.yr)	34.2	42.1
Light interception (%)	75	91
Conversion (e, %)	1.89	2.06
VDM (kg/palm.yr)	126	91
Bunch Index (%)	56	61
Oil dry bunch (%)	62	72
Oil yield (t/ha)	11.96	18.5

Dry matter production and planting density



Can VDM of DM120.25 be reduced?

1 Bunch No. 22/yr, but leaf prod. 33/yr
so reduce male flower number:
5/palm.yr adequate for pollination

2 Increase mean bunch weight, and so reduce bunch number from 22 to 17

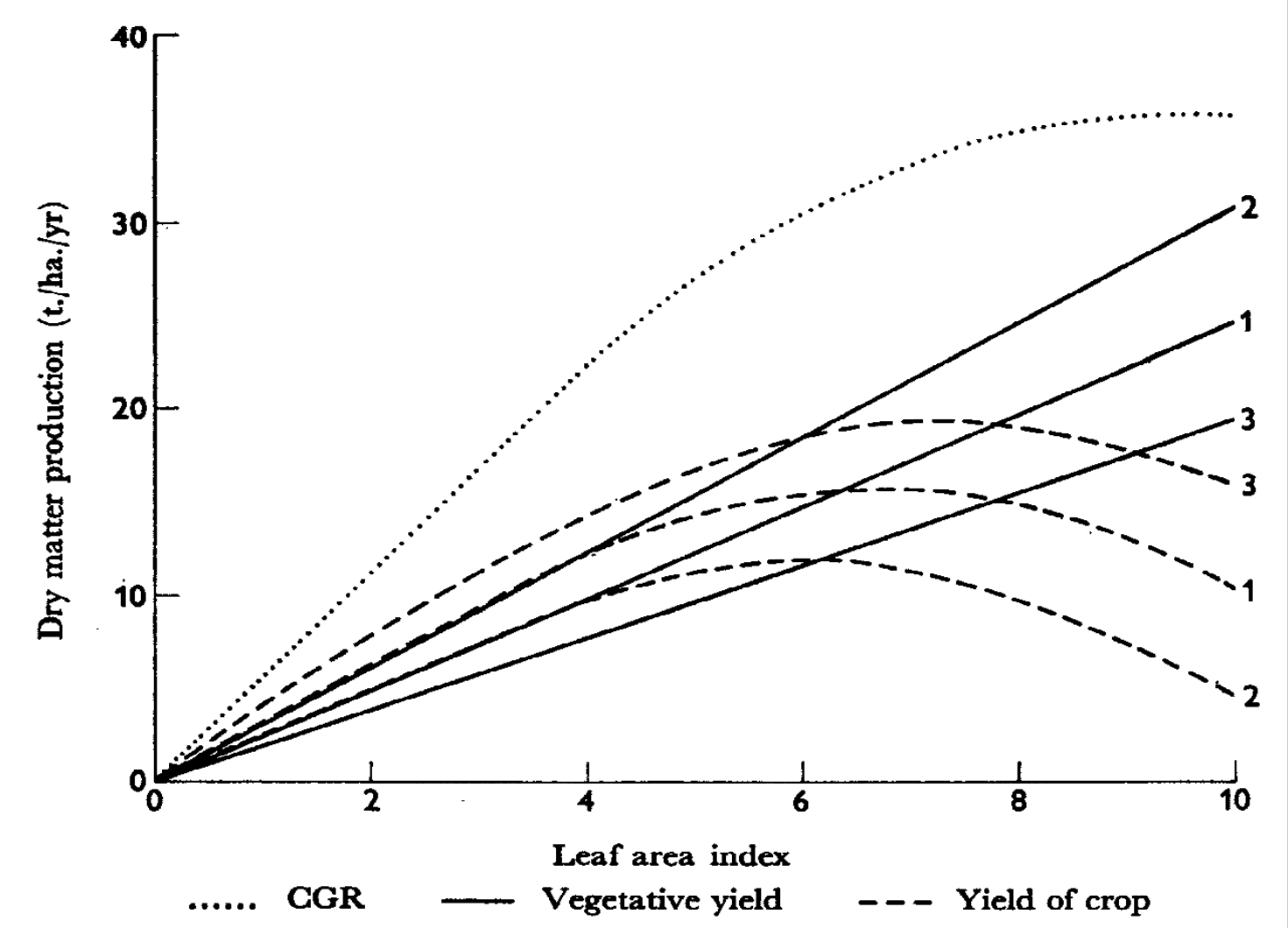
3 Therefore, reduce leaf production from 33 to 22 per year - 3.8 t/ha

4 Reduce trunk growth by 1.5 t/ha.yr

Partitioning for "DM120.25 improved"

Reduction in VDM:	5.3 t/ha
Equivalent Y_{bunch}:	3.2 t/ha
Extra oil (O_{dry} = 62%)	2.0 t/ha
Oil yield	14 t/ha
VDM (82 kg/palm)	9.8 t/ha
Y_{bunch} (38 t FFB/ha)	22.4 t/ha
Bunch Index	70%

Bunch index and optimal density



Breeding objectives

- Reduce leaf production
- High B. Wt - B. No. not too high
- Reduce trunk growth
- High oil/bunch

Conclusion

Potential yield is not just a crop physiologist’s fantasy, but can provide a useful benchmark for the plant breeder