

# **Why Epi-Genetic Effects Matter in Cocoa**

by

**Rob Lockwood**

# Is Cocoa Exceptional in Plant Breeding?

The general plant breeding experience is that when inheritance is strongly additive, as it is for yield in cocoa, the phenotype is a very good guide to the genotype.

Usually it hasn't been in cocoa. Why? We need to know because recurrent selection for yield depends on single plant = clone selection

# Cocoa Breeding Method

For the last fifty years cocoa breeding has been based on the “hybrid vigour” found in crosses involving F.J. Pound’s Upper Amazon Collection.

As the late Hille Toxopeus put it in 1971, “Cocoa breeding: a consequence of mating system, heterosis and population structure”

# “Hybrid Vigour” in Cocoa?

Additive component of genotypic variance  
( $r^2$ )

Trait

Mean  $r^2$

(over nine mating designs)

Yield

0.872

Trunk cross-sectional area

0.874

Yield efficiency

0.854

Bean weight

0.876

Source – Pang and Lockwood in preparation

$r^2$  = additive component of genotypic variance

# Yields of Standard Clone and Crosses

Genotype	Yield kg dry cocoa/ha
1985-91	(1,096 trees/ha)
BAL209 (clone)	11,233
PA7 x NA32	10,365
UIT1 x NA33	9,009

Source – Pang, Lim and Lockwood Proceedings of the 1991 Kuala Lumpur Cocoa Conference

# Vigour of Seedlings and Clones (1)

Family	Trunk Circumference mm	
	Seedlings	Clones
	(% UIT1 x NA33)	(% BAL209)
IMC67 x PA300	96	82
NA33 x "PA"35	103	
78		
		(% BR25)
SCA9 x PA13	102	89
SCA9 x PA300	95	85

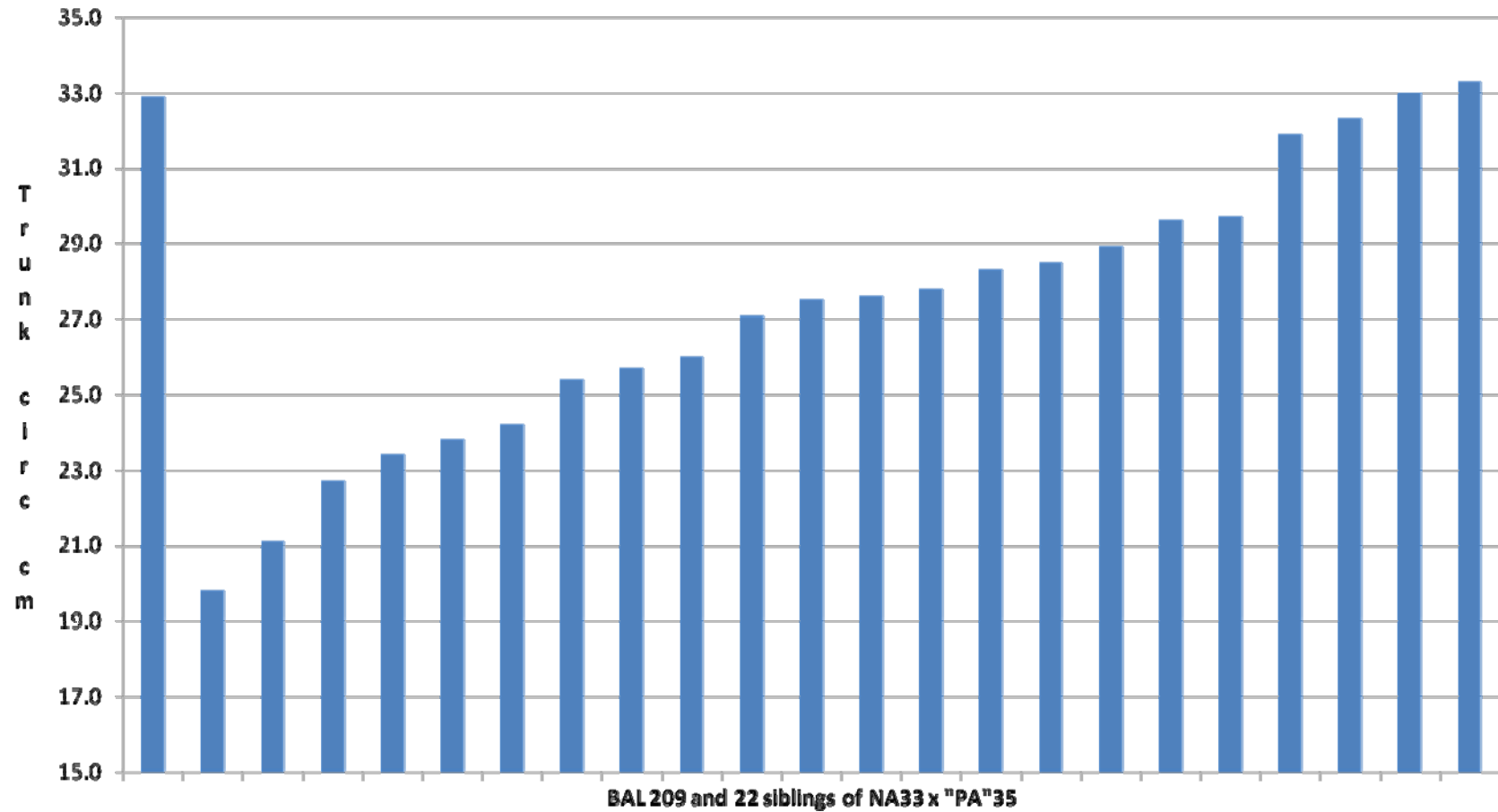
# Vigour of Seedlings and Clones (2)

12 seedlings each were taken from 10 families and grown as clones in a replicated trial.

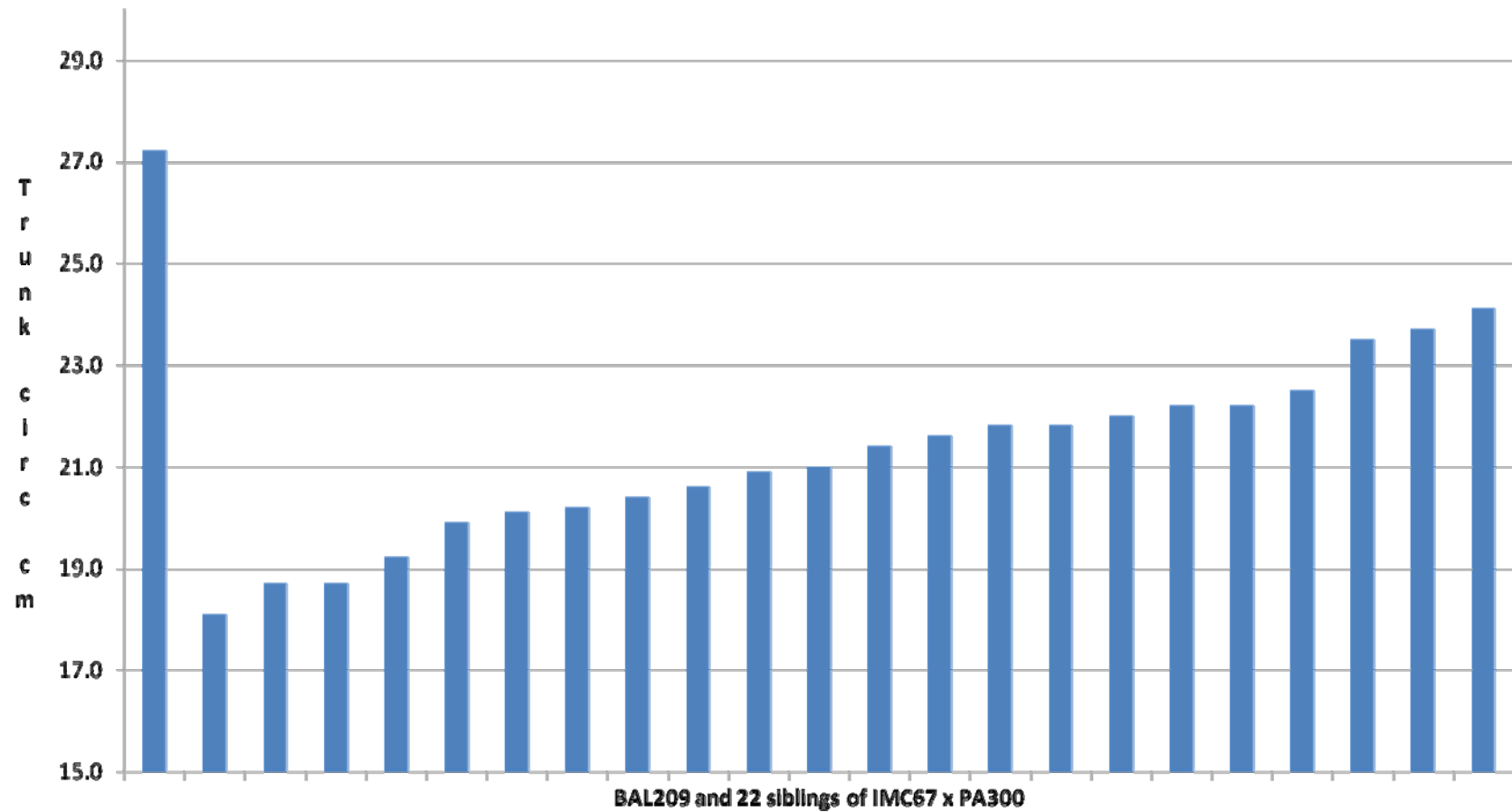
The average vigour of the families was 96% of UIT1 x NA33

Only 17 of the 120 clones were as vigorous as BAL209

# Variation in Vigour (1)



# Variation in Vigour (2)



# Adaptation to Planting Density

Can we improve the efficiency of selection by finding a way of predicting the vigour of a clone from the vigour of the source family and of the ortet?

More speculatively, could we predict yield efficiency as well?

# Recurrent Selection

- Recurrent selection depends on recombination
- Best clones will be found in best families
- Family performance depends on adaptation to planting density

# Using Known Clones as Parents (1)

## Trial 1

3 crosses with different clones per parent

Parent	Vigour as % UIT1 x
NA33	
BAL209	108
PBC123	109

Source – Pang and Lockwood, in preparation

# Using Known Clones as Parents (2)

## Trial 2

8 crosses per parent, factorial mating design

Parent	Vigour as % UIT1 x NA33
BR25 (opt 1,100/ha)	111
BAL244 (opt ~2,000/ha)	102
SCA9 (opt >3,333/ha)	95

Source – Pang and Lockwood, in preparation

opt = optimum

# Conclusions

- Clones have a markedly higher optimum planting density than the starting seedlings
- Seedlings have a markedly lower optimal planting density than the starting clones
- Breeders need physiological tools that will permit them to predict optimum planting densities from observations on families, ortets and small samples of clones

# Heterosis?

Much but perhaps not all of what has been interpreted as heterosis in cocoa is an epi-genetic effect

# Implications for Cocoa Breeding

- In seedling breeding, the parents should be selected, as clones, at a much higher planting density than the seedlings will be grown
- The recombination phase of best clones will be evaluated at much lower planting density than the next generation of clones
- Best clones at normal planting density are unlikely to be suitable parents of seedlings to be grown at the same density

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