5. DISCUSSION

5.1 The Effects of Spacing

On present evidence of clonal growth and yield performances, the significant effects of spacing/density were apparent from early establishment through to reproductive phase at maturity.

5.1.1 Growth

Although the effects of spacing on girthing were generally less apparent, it was shown in TRIAL 2 that at 32nd month, significant girth differences existed between densities and generally favouring wider spacing plantings. On height attainment, effects were more definite with all evidence pointing to greater heights with increasing densities from as early as 16 months. Associated with growth is the change in canopy habit brought about by spacing effects. The clonal trees at close spacings tended to assume more vertical branching habit which invariably led to greater mutual shading of lower foliage. At the other end, cocoa trees planted further apart had lower and wider canopy spread which allowed for greater light penetration and distribution through the canopy. This differences in canopy structure as influenced by spacing would become an important attribute in limiting productivity as canopies with lower light extinction coefficient (k) ie. greater auxillary branching allow the lower leaves to contribute to dry matter production from increased photosynthesis (Yapp & Hadley, 1991).

In the present study of hedgerow HDP system, the clonal growth performance were also directly influenced by the pruning/training practices accorded from the outset. Learning from the Philippines early mistake of training the clonal plant to a single 'stem' of 1.5 m from the outset which required much staking at the later stage due to top heaviness, the following approaches were adopted in the present study:

- budded cocoa planted with the scion facing inwards into the double hedgerows.
- little or no pruning over the first 12 - 18 months except for very low lateral branches which grew into wide interrows.
- pruning of lower branches instituted only when clonal plants could stand on its own and was done progressively.
- annual top pruning carried out after the third year to restrict vertical canopy development as well as to prevent the canopy from becoming overly crowded.

In general, the clonal plants responded favourably to the above agronomic practices as evidenced by low incidence of lodging due to top heaviness and thus required little or no staking.

Under the present shade management regime developed for mono-culture cocoa planted at conventional spacing on inland soil environment ie. *Gliricidia* shade trees planted initially at 3 x 3 m (1075 trees/ha) and thinned to 12 x 12 m final spacing (70 trees/ha) by 48 months, the hedgerow HDP system which encourages early canopy closure and self shading as mentioned earlier, tended to be overshaded as evidenced

by etiolation and active vertical canopy development. This aspect of shade x cocoa spacing interaction which is not covered in the present study, needs further validation.

Irrigation resulted in significantly better and uniform growth and hence early canopy closure.

The equidistant HDP as compared to the skewed pattern allows for more efficient and complete space exploitation for canopy development.

5.1.2 Yield

The influence of spacing on clonal growth performances in terms of girth and height attainments and the resultant changes in canopy architecture would ultimately be carried through to maturity.

All the present trial evidence on dry bean yields per ha had pointed to 2000 - 2500 trees/ha as the agronomic optimum density range under the Merlimau Estate conditions in Malacca. The less than favourable responses of clonal cocoa to densities above 2500 trees/ha were, to a certain extent, attributed to the limiting factors of the local soil and climatic conditions which were regarded as less amendable and therefore incapable of supporting any cocoa stand in excess of 2000 trees/ha. This was inspite of annual fertilisation and drip irrigation input although the

latter had been shown (TRIAL 1) to result in significant yield improvement in the hedgerow HDP systems through increased pod productions as well as better bean quality.

As the influence of density on the bean and pod characteristics was not significant, any yield increases with density was due to production at higher pod number per unit area as it was clearly established that pod production per tree significantly declined with increasing densities. This implies that under the present trial conditions, a limited density range existed within which the increased cocoa stand would result in nett gain in pod production per unit area, after compensating for the reduction in pods per tree.

The increased levels of self-shading at the higher density range as a result of induced change in canopy and branching habits would certainly have the negative effects of limiting or lowering the photosynthetic conversion efficiency resulting in decreased yield efficiency. The prevalent shade conditions which appeared on the denser side, had further restricted the full expression of clonal responses at higher density.

5.2 The Effects of Planting Material

The differences in growth and yield performances between genotypes were highly significant at any density on account of inherent genetic traits. PBC123 of relatively small stature and the most VSD tolerant of the PBC100 series clones, was

consistently the top yielder (TRIALS 3 and 4) and was also the most adaptive to a wide range of densities, especially at higher densities (3500 - 4500 trees/ha). Except for PBC130, clonal cocoa consistently out-performed the F1 hybrid UIT 1 x NA32 (regarded as high yielding) over the density range evaluated.

5.3 Genotype x Spacing Interaction

Although the genotype x spacing effects on growth and yields were generally not significant, there nevertheless were sufficient evidence to suggest that less vigorous, smaller stature clones with dispersed canopy structure eg. PBC159 and PBC123 were better adapted to higher density in excess of 3000 trees/ha as opposed to the vigorous clones with more compact canopy eg. PBC140 and PBC112 which performed best at the medium density range of 1500 to 2000 trees/ha.

5.4 The Economic Consideration of High Density Plantings

The establishment costs (first 2 years) of high density plantings in TRIAL 4 were compared with the conventional 1075 trees/ha clonal planting in Table 5.1. The higher establishment costs (10 - 85%) of the different HDPs at 1197 - 2195 trees/ha were mainly due to establishing and upkeeping proportionately more cocoa points per unit area. The Nett Present Values (NPV) computed over the 6-year trial period (Table 5.2) showed that none of the HDP systems evaluated gave superior economic

TABLE 5.1: ESTABLISHMENT COSTS OF HIGH DENSITY VS CONVENTIONAL PLANTING OF CLONAL COCOA, MALACCA - TRIAL 4

	(RM ha^{-1})					
Planting system (Initial stand/ha)	1 (1620)	2 (2150)	3 (1970)	4 (2195)	5 (1197)	Conventional (1075)
Shade establishment	161	134	161	180	180	161
Year 1 - Planting-material	1620	2151	1970	2195	1197	1075
Planting	810	1075	985	1098	599	538
Supplying	243	323	296	329	180	161
Weeding	250	280	270	280	210	200
P&D	200	240	230	250	170	160
Manuring	452	600	550	612	334	300
Pruning	194	258	236	263	144	130
Year 1 total	3930	5061	4698	5207	3014	2725
Year 2 - Weeding *	160	160	160	160	160	160
Manuring	678	900	825	919	501	450
P&D *	160	160	160	160	160	160
Pruning	243	323	296	329	180	161
Year 2 total	1241	1543	1441	1568	1001	931
Year 1 + Year 2	5171	6604	6139	6775	4015	3656
(% Conventional)	(141)	(181)	(168)	(185)	(110)	

* Tractor mounted mechanised spraying

Assumption : Land preparation cost at constant for all systems

Planting system
1 – Plant at 1620 points/ha., permanent
2 – Plant at 2150 points/ha., thin to 1075/ha)
3 – Plant at 1970 points/ha., thin to 1075/ha) after 3 years
4 – Plant at 2195 points/ha., thin to 1197/ha) yielding
5 – Plant at 1197 points/ha., permanent
Conventional – plant at 1075 points/ha., permanent.

TABLE 5.2: ECONOMIC ANALYSIS OF HIGH DENSITY PLANTING (HDP) VS CONVENTIONAL PLANTING OF CLONAL COCOA OVER 6-YEAR TRIAL PERIOD (1988-1993) - TRIAL 4

	High Density Planting (trees/ha)					Conventional
	1,620	2,150	1,970	2,195	1,197	1,075
Cum. 3 year yield (kg dry bean/ha):	3,043	2,900	3,031	3,186	2,500	2,625
Total Revenue(RM) @ RM 3,500/metric tonne:	10,651	10,150	10,609	11,151	8,950	9,188
Total costs (RM/ha) of establishment & upkeep + indirect costs over 6-year priod (1988-1993):	15,942	18,025	17,397	18,534	13,612	13,238
Nett revenue (RM/ha):	- 5,290	- 7,874	- 6,788	- 7,382	- 4,861	- 4,049
NPV (10 %)	- 4,863	- 6,704	- 5,938	- 6,383	- 4,308	- 3,761

NPV = Nett Present value

returns over the conventional 1075 trees/ha planting. Infact, the higher densities viz. 1970, 2150 and 2195/ha were relatively worst off.

Generally, the same conclusions also applied to the hedgerow and other conventional HDP systems beyond 2000 trees/ha. As even at the respective agronomic optimum densities, the increased yields obtained were not sufficiently high to offset the higher establishment and upkeep costs at high densities. The exception being PBC159 at hedgerow density of 3000 trees/ha and PBC 123 at conventional density of 3500 trees/ha. The option that appeared to be viable is to fully exploit cocoa clones that are precocious and less vigorous but with high yield efficiency eg. PBC 123 and 159 for planting at around 2500 trees/ha with conventional planting system.

The hedgerow HDP system is not favoured as the potential of the system can be fully realised only with drip irrigation input which, at installation and annual running costs of RM5700 and RM700/ha respectively, is considered prohibitive to be economically viable, especially with the prevailing depressive cocoa prices.