DETERMINING YIELD POTENTIAL DURING EARLY MATURE PHASE OF *HEVEA* CLONES

M.J. Reju and T. Meenakumari

Rubber Research Institute of India, Rubber Board, Kottayam-686 009, Kerala, India

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Yield data from eight clone evaluation trials, both small-scale and large-scale,were used for yield correlations in the early years with the overall yield. Irrespective of the trial, clones, years of planting and varying duration of yield recording, significant association was noticed between yield in the initial and later years. Yield of clones as early as in the third year in some trials and in the fourth year in all the trials showed strong association with the overall yield. Yield over the first four years of tapping and the BO-1 panel yield were significantly correlated with the overall yield. Yield in the third and the fourth years, entire BO-1 panel yield and the overall yield showed similar pattern in yield variations. Hence it is assumed that yield of clones in the fourth year of tapping is an indication of the overall yield performance of a clone. Thus it is possible that in a regularly tapped clone trial, even if the yield data recording is skipped or missed in the first couple of years, yield recorded in the third and the fourth years may be sufficient to identify clones for yield performance. Moving averages of the annual yields showed that the high yielding clones in the trials were top performing clones in the earlier years also, although there were annual variations. The study showed that promising high yielding clones can be identified from the fourth year of tapping.

Keywords: BO-1 panel, Clones, Correlations, Early yield, Yield pattern

INTRODUCTION

Hevea brasiliensis, a perennial deciduous tree crop with a laticiferous system is the major source of natural rubber (NR). NR extracted from the bark of rubber tree in the form of latex contains rubber particles. Coagulated and dried latex represent commercial yield of rubber. Yield of rubber varies from clone to clone and also from tree to tree due to intrinsic (clone-specific) and environmental (prevailing weather conditions) reasons. Genotype-environment interactions are also major source of yield variations in *Hevea* (Tan, 1995; Costa *et al.*, 2000; Goncalves *et al.*, 2003; Meenakumari *et al.*, 2011). Yield in *Hevea* shows annual, monthly, and even daily variations. Factors such as the planting material, the environment and their interactions determine quantum of yield in rubber (Mildford *et al.*, 1969; Shangpu, 1986; Paardekoopar, 1989; Ortolani *et al.*, 1998; Reju *et al.*, 2001). Clonal yield variation on account of environmental reasons (annual yield of clones and trials) is the focus of the present study. In order to determine yield potential of a clone, data of many years are needed because of variations in the yield pattern. Hence, identifying early years' yield, especially in the BO-1 panel, corresponding very close to the overall yield of a clone would be beneficial

Correspondence: Reju M.J. (Email: reju@rubberboard.org.in)

for early determination of yield potential of a clone.

MATERIALS AND METHODS

Yield data recorded from eight clone evaluation trials were utilized for the study (Table 1). Four of the clone evaluation trials were Small-Scale Trials (SSTs) and four were Large-Scale Trials (LSTs) planted in different years. All the trials were laid out in Randomized Block Design with three replications. A total of 119 clones were planted across the trials. Six of the trials were planted at the Central Experiment Station (CES), Chethackal, and one trial each in Kanyakumari and Padiyoor. Tapping was initiated in all the trials when the trees attained 50 cm girth at 150 cm height from the bud-union following S/2 d3 6d/7 tapping system. Dry rubber yield (g t^{-1} t^{-1}) recorded from the clones in each trial was analyzed for the study. Correlations (r) between

Table 1. **Details of the clone evaluation trials**

Trial No	Trial	Location	Year of planting	Clones	Yield recording period (years)
1	SST	Chethackal	1995	90/55, 90/277, RRII 105, 90/72, 90/104, 90/107, 90/109, RO 87, 90/129, 90/130, 90/132, 90/136, RO 24, 90/102, 90/140, 90/274, MT 196, 90/92, 90/94, 90/97	12
2	SST	Chethackal	1995	RRII 203, RRII 105, RRIM 600, O 49, O 77, O 74, O 73, O 75, O 76, O 21, O 72, O 36, O 81, O 79, O 80, O 78, O 66	10
3	SST	Chethackal	1999	94/19, 94/84, 94/23, 94/12, 94/44, PB 260, RRII 208, 94/8, 94/101, 94/90, AVT 73, RRII 105, 94/25	8
4	SST	Chethackal	1999	95/118, 95/579, 95/129, 95/124, 95/95, 95/106, 95/7, 95/62, 95/184, 95/242, 95/131, 95/292, 95/552, 95/243, 95/575,95/4, 95/104, PB 242, RRIM 600, RRII 203, PB 235, PB 28/59, PB 217, Mil 3/2, RRI 105	9
5	LST	Chethackal	1994	RRII 50, RRIM 712, RRII 105, RRIM 722, 86/120, RRII 51, 86/44, RRIM 722, O 65, RRIM 600, O 70, 55/180	11
6	LST	Padiyur	1995	RRIM 600, RRII 429, RRII 203, PB 217, RRII 51, RRII 414, RRII 430, RRIC 100, RRII 422, RRII 105, RRII 417, RRII 176	13
7	LST	Kanyakumari	1995	RRIM 600, RRII 429, RRII 203, PB 217, RRII 51, RRII 414,RRII 430, RRIC 100, RRII 422, RRII 105, RRII 417, RRII 176	10
8	LST	Chethackal	1999	BPM 24, Clone 4, Clone 12, RRII 105, RRIM 600, Clone 11, Clone 22, Clone 26, Clone 46	8

annual rubber yield (starting from the opening year), BO-1 panel yield, and yield over the first four years with overall yield of clones were worked out. Corresponding values of coefficient of determination (R^2) was also worked out with overall yield as the dependent variable. Moving averages of the annual yields of clones were plotted to identify consistent top performers and yield pattern. Annual yield of clones in the third or fourth year (depending on the magnitudes of correlation and R^2 values with overall yield), average of BO-1 panel, and overall yields were plotted and the pattern in yield variations was recorded.

RESULTS AND DISCUSSION

Correlation between yield of clones in the BO-1 panel and the overall yield, and their corresponding R^2 values (overall yield as dependent variable) were calculated (Fig.1).

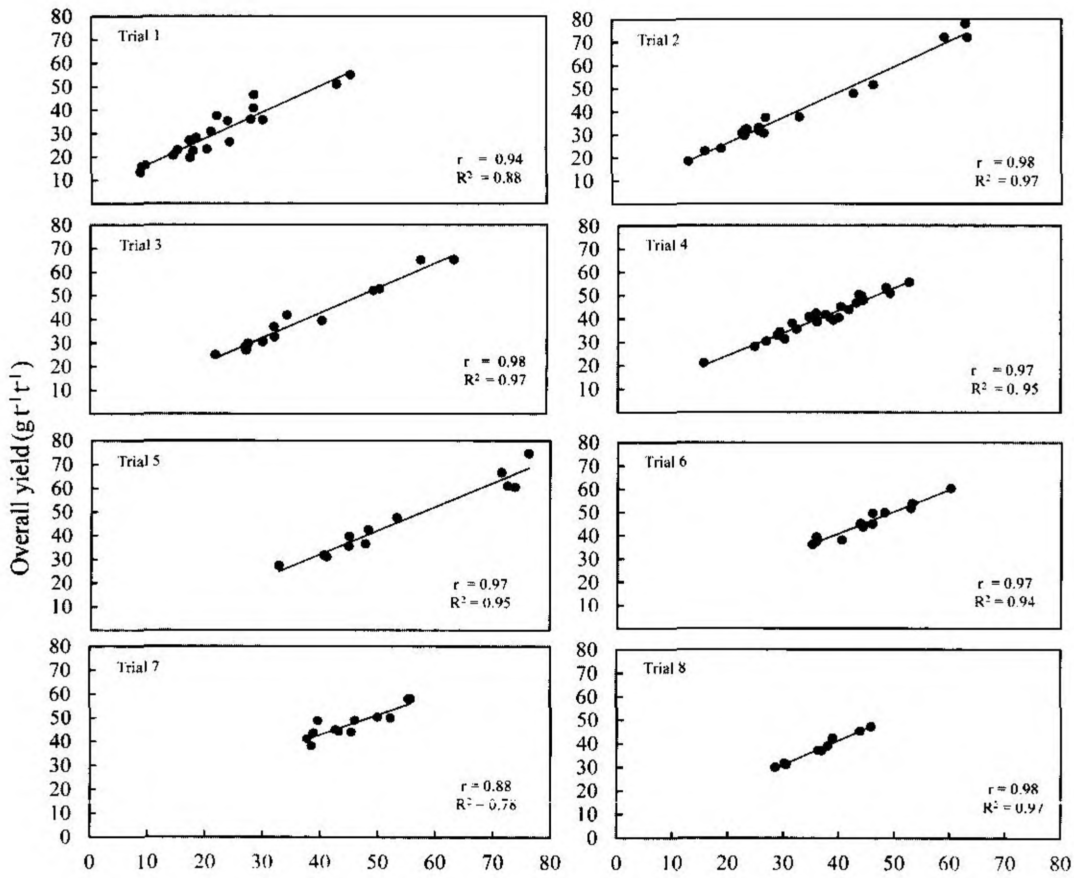

Fig. 1. Correlation (r) and Coefficient of determination (R^2) between overall yield and yield of BO-1 panel in eight clone trials

Table 2. **Association between annual yield and overall yield - Correlation (r) and Coefficient of determination (R^2) in eight clone trials**

Annual yield in different years	Overall yield															
	Trial 1		Trial 2		Trial 3		Trial 4		Trial 5		Trial 6		Trial 7		Trial 8	
	r	R^2	r	R^2	r	R^2	r	R^2	r	R^2	r	R^2	r	R^2	r	R^2
1st	0.802	0.644	0.820	0.673	0.732	0.537	0.704	0.495	0.852	0.726	0.725	0.530	0.748	0.559	0.871	0.759
2nd	0.860	0.740	0.742	0.550	0.705	0.496	0.856	0.734	0.904	0.818	0.901	0.810	0.672	0.451	0.75	0.563
3rd	0.909	0.827	0.909	0.826	0.896	0.804	0.896	0.802	0.980	0.960	0.935	0.870	0.817	0.667	0.765	0.585
4th	0.949	0.900	0.937	0.877	0.973	0.947	0.935	0.873	0.943	0.889	0.917	0.840	0.904	0.818	0.932	0.869
5th	0.591	0.349	0.979	0.958	0.970	0.940	0.906	0.821	0.990	0.981	0.836	0.700	0.603	0.364	0.889	0.790
6th	0.920	0.847	0.963	0.926	0.930	0.865	0.887	0.787	0.973	0.948	0.909	0.830	0.334	0.112	0.927	0.859
7th	0.791	0.625	0.928	0.861	0.919	0.844	0.806	0.650	0.977	0.955	0.861	0.740	0.845	0.714	0.933	0.870
8th	0.926	0.857	0.967	0.935	0.274	0.075	0.631	0.398	0.918	0.843	0.896	0.800	0.919	0.845	0.882	0.778
9th	0.960	0.922	0.935	0.874			0.685	0.470	0.950	0.903	0.921	0.850	0.584	0.340		
10th	0.906	0.820	0.948	0.899					0.918	0.842	0.793	0.630	0.206	0.042		
11th	0.773	0.598							0.840	0.705	0.899	0.810				
12th	0.845	0.715									0.924	0.850				
13th											0.892	0.800				

Correlation values are significant at 5 per cent level

Significant correlations were obtained between the BO-1 panel yield and the overall yield. Overall yield showed dependence on the BO-1 panel yield in terms of R^2 values with high magnitudes. High association and closeness between the overall yield and the BO-1 panel yield was recorded in all the eight trials. Such significant association between the BO-1 panel yield and the overall yield was reported earlier (Mydin *et al.*, 2011). Since the BO-1 panel yield of clones was significantly associated with the overall yield performance of clones, identification and selection of clones for yield from the BO-1 panel without having to wait for data from the subsequent panels may be reliable.

Association between yield within the BO-1 panel was also examined. Correlation between annual yield of the clones and the overall yield were calculated and their corresponding R^2 values were worked out (Table 2). Significant association between yield in the early years and the overall yield was obtained in all the trials. Magnitude of

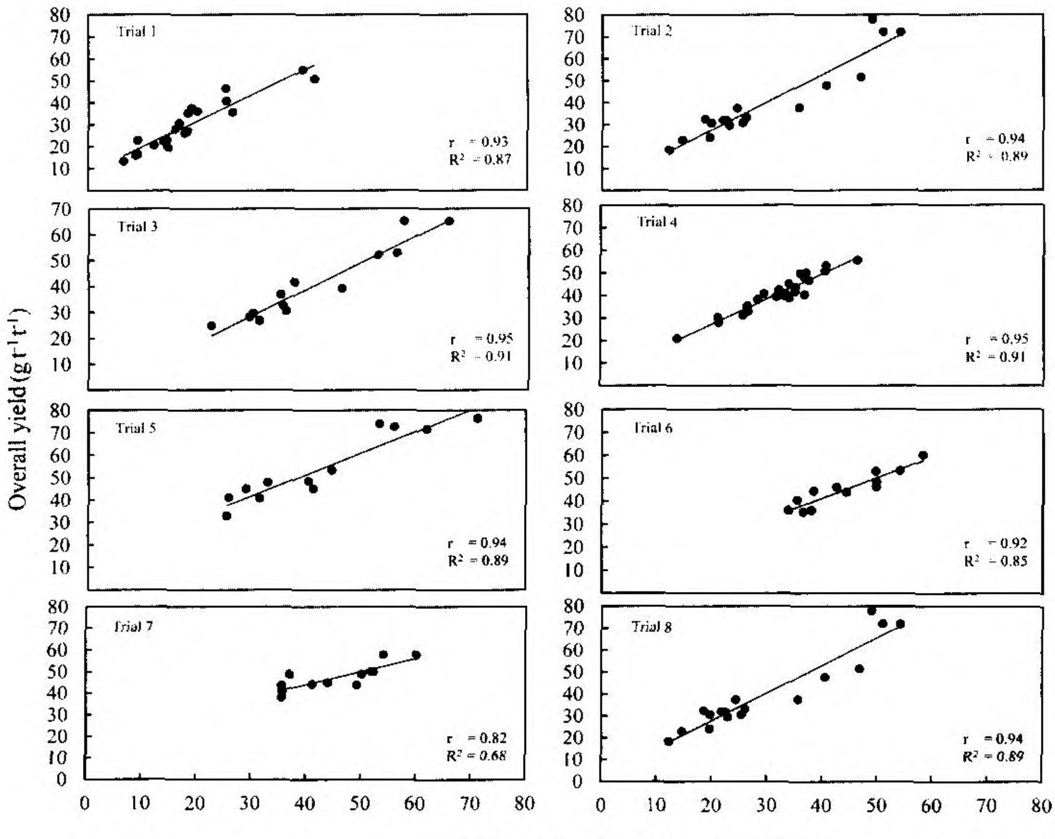

Fig. 2. Correlation (r) and Coefficient of determination (R^2) between overall yield and yield over the first four years in eight clone trials

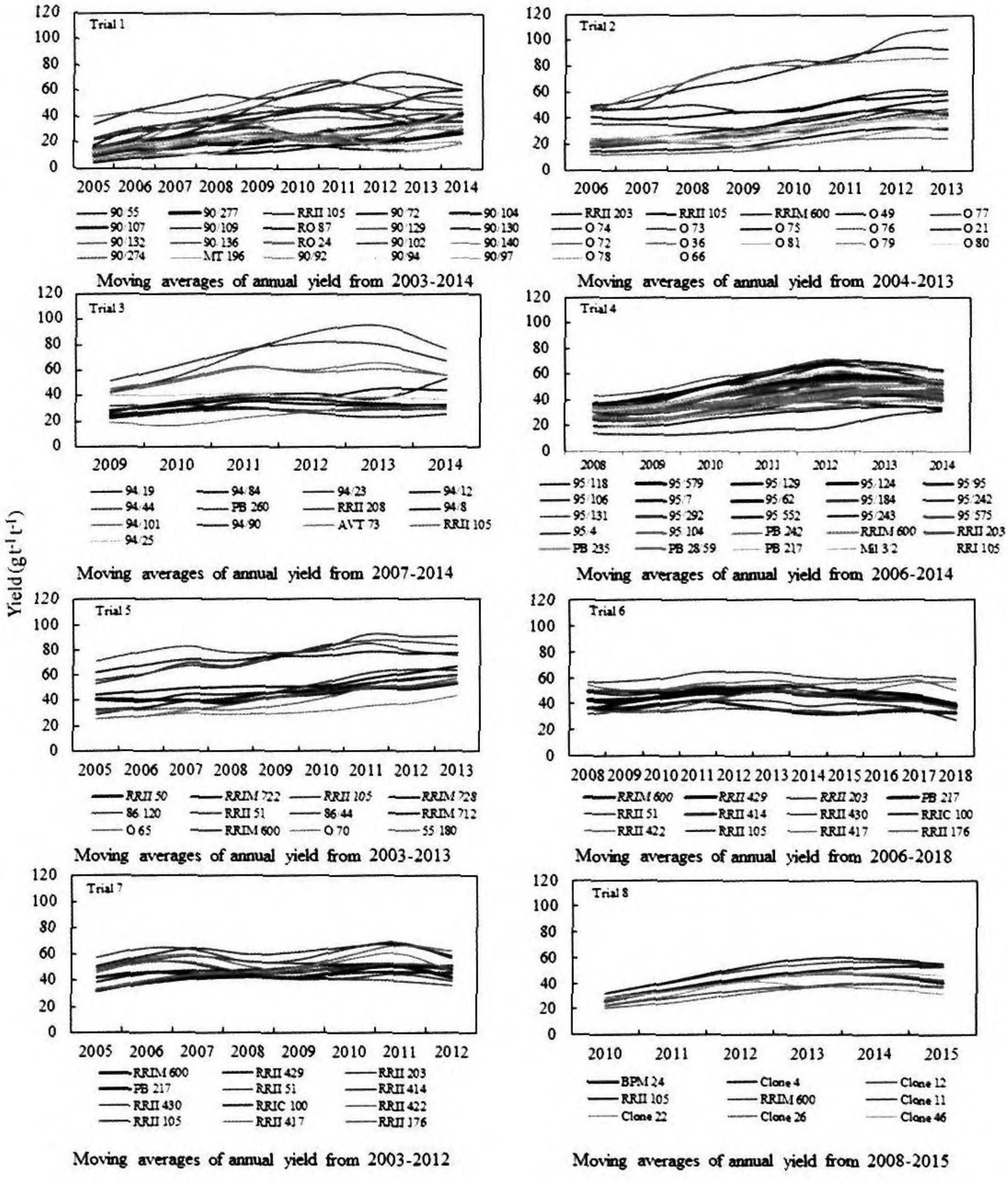

Fig. 3. Moving averages of annual yield of clones in eight clone evaluation trials

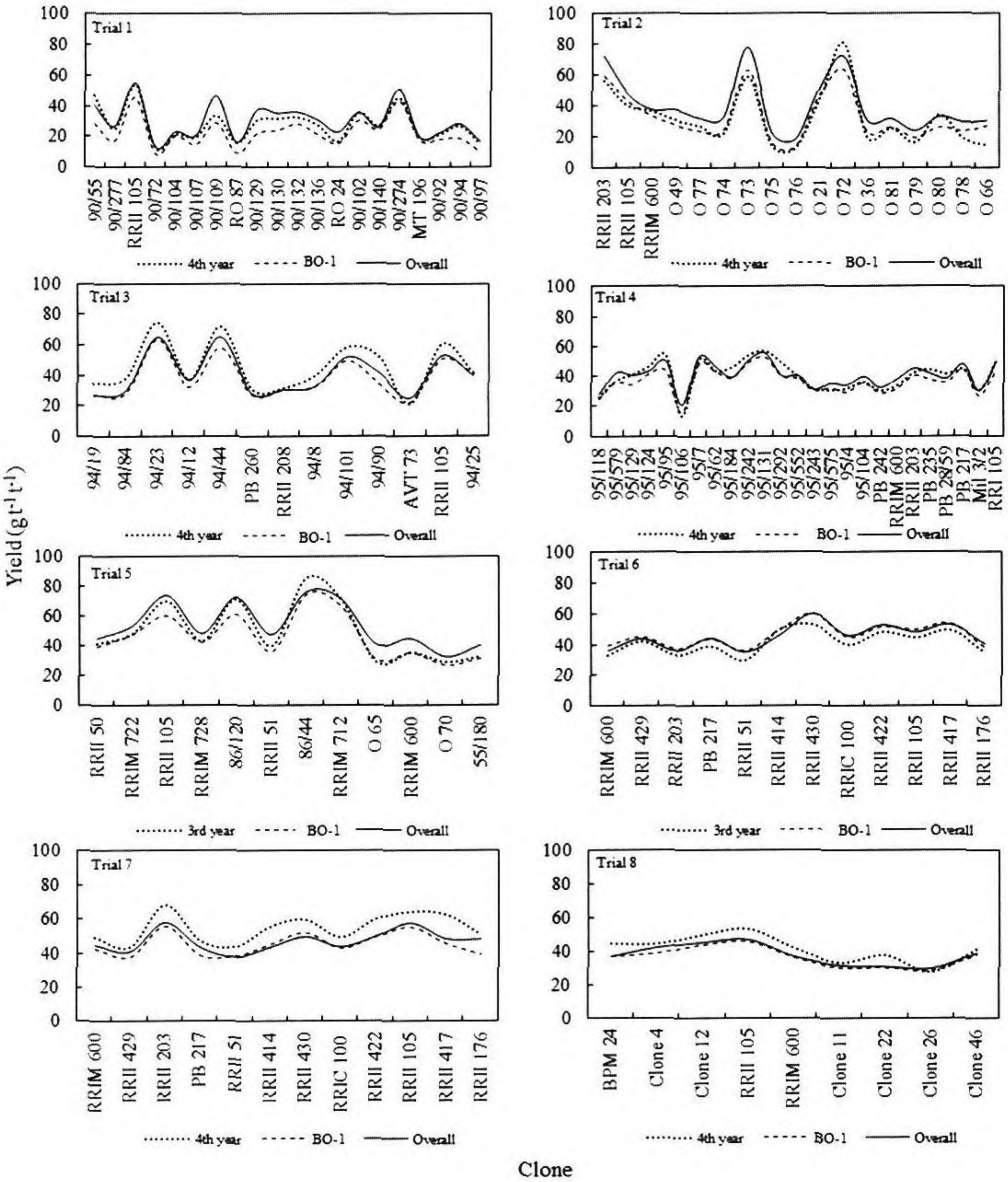

Fig. 4. Pattern of yield in the 3rd or 4th year, BO-1 panel yield and the overall yield in eight clone trials

the values was higher in the third and the fourth years compared to the first two years. Among the trials in the first year, the magnitude of correlations and the R^2 values varied from 0.704 in trial 4 to 0.871 in trial 8, and R^2 from 0.495 to 0.759 respectively; whereas in the fourth year r and R^2 values varied from 0.904 in trial 7 to 0.973 in trial 3, and R^2 from 0.818 to 0.947, respectively. Similar results showing significant association between yield in the third and fourth years with the overall yields were reported earlier (Mydin *et al.*, 2011; Meenakumari *et al.*, 2015). In another experiment, clones opened for tapping in four and a half year old trees showed significant association with the mature phase yield (Licy *et al.*, 1998). In the present study, significant correlations with higher magnitudes were obtained between rubber yield during the first four years and the overall yield (Fig. 2). This indicated that rubber yield during the first four years of tapping in the BO-1 panel may be sufficient to identify future high yielders with respect to the overall yield performance. Hence it is assumed from analysis of the data that if regular tapping was carried out in a clone trial right from the opening year, and data recording was skipped or missed in the initial two years due to various reasons, data recorded in the third and the fourth years would be sufficient to identify clones for yield from the trial. In one of the earlier studies it has been reported that rubber yields showed stabilization in the sixth year and forward and hence early selections were possible in the sixth year in large scale trials (Chandrasekhar *et al.*, 2007). Hence, yield recorded in the first four years of tapping may be enough and reliable for selection of clones from clone trials.

Rubber yield is a polygenic clonal trait significantly influenced by the environment (Simmonds, 1989; Clement-Demange *et al.*, 2007). A major impact of the environmental influence is the monthly, seasonal and annual yield variations. In the present study, clones showed year to year yield variation without a specific pattern. In order to minimize the annual variations, moving annual averages of yield were worked out and values were plotted (Fig. 3). Moving averages showed that the top yielders in the trials were high yielders in the initial years also. Hence it is assumed that the outstanding high yielders in the early years would retain its yielding superiority in terms of the overall yield performance of the clones in a trial. In earlier studies, RRII 105 in the RRII 100 series as well as other top high yielding clones, both from the traditional and the North-East India, showed high yielding trend in the early years as well as in the long term which indicated that outstanding performers in the early years may continue to perform well in the later years as well (Nazeer *et al.*, 1986; Priyadarshan *et al.*, 2005; Mydin *et al.*, 2011; Meenakumari *et al.*, 2015).

Yield of clones in the third or the fourth year, yield of clones in the BO-1 panel and the overall yield showed similar pattern of variation (Fig. 4). Since the early years' yield pattern (3^{rd} or the 4^{th} year) is similar to the BO-1 panel yield and the overall yield pattern across clones in all the trials, it may be reliable to assess future yield performance of clones from the early years' yield.

CONCLUSION

The data analysis carried out from eight clone evaluation trials showed strong association between yield in the early years of tapping with that of the later years. Overall yield of the clones in the trials was largely determined by the yield in the BO-1 panel. Within the BO-1 panel, yield recorded in the fourth year and in some cases in the third year showed strong association with the overall yield. Moving annual averages of yield showed that outstanding performers in the trials were high yielding in the early years as well. Yield of clones in the early years showed a similar pattern with that in the BO-1 panel and the overall yield. Hence it may be concluded that clones for yield performance can be identified by the fourth year from the BO-1 panel.

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