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HEVEA DISEASE RESISTANCE BREEDING-1. JUVENILE GROWTH AND YIELD PERFORMANCE OF SEGREGATING POPULATIONS

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Breeding for natural disease resistance is a viable eco-friendly and long-term strategy for sustainable integrated disease management in *Hevea*. Many clones and germplasm accessions show variable levels of resistance. Being a repository of resistance genes acquired from its parents *viz. Hevea benthamiana* and AVROS 363, clone Fx 516 was used for hybridization with high-yielding but susceptible RRII clones to recover high-yielding recombinants with enhanced resistance. In addition, open pollinated half-sibs of Fx 516 were also collected and evaluated to rapidly recover high-yielders with disease tolerance. Another high-yielding Wickham x Amazonian hybrid (HP 90/21) was also used in the breeding programme. In the first phase, the above segregating population comprising of hybrids and half-sibs were evaluated for juvenile growth and yield. Wide range of growth and yield performance among the hybrids and half-sibs was recorded. Highest range in yield was exhibited by progenies from RRII 414 x Fx 516 (6-212 g $t^{-1}15t^{-1}$). Specifically, cross combination of RRII 414 x Fx 516 yielded a selection with very high juvenile yield (212 g $t^{-1}15t^{-1}$) followed by those of RRII 430 x Fx 516 (158 g $t^{-1}15t^{-1}$), RRII 414 x HP 90/21 (152 g $t^{-1}15t^{-1}$) and RRII 429 x Fx 516 (111 g $t^{-1}15t^{-1}$). Similarly, the top selection from half-sib family of disease resistant clone Fx 516 possessed very high-yield (172 g $t^{-1}15t^{-1}$). A large number of selections which are vigorous and very high-yielding has been identified offering wide scope for further screening for disease-resistance and large-scale evaluation for high-yield with potential for commercial deployment to enable sustainable rubber cultivation.

Key words: *Hevea*, Disease resistance breeding, Juvenile growth , Juvenile yield

INTRODUCTION

Hevea brasiliensis (the Para rubber tree; family, Euphorbiaceae; 2n=36) is native to the Amazon forests of Brazil and is the major global source of natural rubber. Abnormal leaf fall (ALF) and shoot rot caused by *Phytophthora* spp., pink disease by *Corticium salmonicolor*, leaf infection by *Corynespora cassiicola*, and powdery-mildew by *Oidium* sp. are the major devastating fungal diseases capable of significantly reducing yield of rubber leading to severe economic losses up to 40 per cent (Jacob, 1997; Narayanan and Mydin, 2012). In severe cases, pink and shoot rot lead to complete drying of young plants considerably reducing stand density. South American Leaf Blight (SALB) caused by Pseudocercospora ulei (=*Microcyclus ulei)* is a devastating fungal disease which almost wiped out rubber plantations in Brazil

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epidemic outbreaks (Hora Júnior *et al.*, 2014). SALB is a looming threat to the global rubber cultivation (Chee, 1990).

Every year, thousands of tonnes of fungicides are being used for prophylactic spraying in plantations not only for prevention of major disease outbreaks but also to ensure good crop. However, long-term applications of fungicides have several environmental and socio-economic issues besides the huge costs. Breeding for disease resistance and use of disease resistant clones is the only viable long-term strategy for integrated disease management to prevent severe economic losses due to outbreak of pathogens in rubber plantations. Use of disease resistant clones will also help to considerably reduce use of fungicides for disease management and ultimately the aim is to avoid use of fungicides.

Increased cost of chemical fungicides, coupled with acute scarcity in labour warrants breeding for disease resistance as a high-priority area of research in *Hevea*. Many *Hevea* clones show variable levels of resistance to fungal pathogens; none of the clones are completely resistant / tolerant. In view of the above, Fx 516 and HP 90/21 were used for hybridization with high-yielding clones RRII 414, RRII 430 and RRII 105, to recover high-yielding recombinants with enhanced levels of resistance. Clone HP 90/21 is a high-yielding Wickham x Amazonian hybrid which was developed through hybridization between the popular clone RRII 105 and RO 142, a wild Amazonian accession from Rondônia, South America (Sankariammal *et al.*, 2011). Clone Fx 516 was earlier used in breeding programme in Sri Lanka for resistance to SALB (South American Leaf Blight) and other major fungal diseases (Senanayake and Wijewantha, 1968; Fernando and Liyanage, 1975, 1980). Since SALB testing is prohibited in India due to quarantine reasons, it is anticipated that inclusion of Fx 516 in disease resistance breeding would possibly generate a few genotypes possessing genes for tolerance to SALB. In the present study, open-pollinated half-sib progenies of Fx 516 were also collected and evaluated in nursery trials to recover progenies with high-yield and tolerance to diseases. The hybridization programme was carried out during 2014-17 and the population was established in the main campus of Rubber Research Institute of India, Kottayam (Kerala, India). In the first phase, hybrids as well as half-sibs from the above programme were evaluated for growth and yield. This paper reports the results using first set of segregating population under first phase of the evaluation programme in the long-term breeding programme initiated in the year 2014.

MATERIALS AND METHODS

The details of parental clones used in hybridization are given in Table 1. Hybridization was carried out using the parental clones located in a large scale clonal trial, planted in 1993 at the Central Experimental Station of Rubber Research Institute of India located in Chethackal (Pathanamthitta Dt., Kerala, India). For hybridization using various parental clones standard procedure was followed (Mydin and Saraswathyamma, 2005). Since the parental clones were tall (more than 15-20 m) for ground-level pollination, hybridization was carried out by erecting temporary scaffolds using poles of *Casuarina equisetifolia* for support. Since flowering in clone Fx 516 was asynchronous with few selected parental clones, some of the combinations could not be carried out using fresh pollen. Hence, in such cases, fresh pollen was collected and stored under low temperature

Table 1. **Details of parents used in resistance breeding**

Clone	Pedigree
RRII 105	Tjir 1[1] x Gl 1[2]
RRII 414	RRII 105 x RRIC 100 (RRIC 52 x PB 83)
RRII 417	RRII 105 x RRIC 100
RRII 429	RRII 105 x RRIC 100
RRII 430	RRII 105 x RRIC 100
Fx 516	F 4542[3] x AVROS 363[4]
HP 90/21	RRII 105 x RO 142[5]

[1]Primary clone of *H. brasiliensis* from Indonesia; [2]Primary clone of *H. brasiliensis* from Malaysia; [3]Primary clone of *H. benthamiana* from Brazil; [4]AVROS, Al-gemene Verneiging Rubber planters Oostkust Sumatra, Indonesia; [5] Rondônia accession from Brazil

in the laboratory as per the standard method (Hamzah and Leene, 1996). The stored pollen, was also tested for their germination capacity before use in hand pollination in the field (Fig. 1). After hand pollination and maturation of fruits, hybrids were collected and germinated in laboratory trays and subsequently planted in seedling nursery beds with a spacing of 50 x 50 cm, for further evaluation. Progenies were evaluated for growth and yield after 36 months of growth as per the method described by Mydin and Saraswathyamma (2005). For collection of

Table 2. **Details of hand-pollinations made using Fx 516 and hybrid 90/21**

Pedigree	No. of hand-pollinations	No. of progenies
RRII 430 x Fx 516	721	78
RRII 414 x Fx 516	934	38
RRII 417 x Fx 516	198	11
RRII 429 x Fx 516	172	32
Fx 516 x RRII 105	173	13
Fx 516 x RRII 414	214	12
RRII 105 x Fx 516	167	19
RRII 414 x 90/21	148	8
Total	2727	211

half-sibs from Fx 516, individual fruits were bagged using nylon net bags. Subsequently, the half-sib population was planted and evaluated as per method described above for hybrids.

RESULTS AND DISCUSSION

Under hybridization programme during Phase-I, a total of 2727 crosses were carried out under various cross combinations (Table 2). Several high-yielding selections could be recovered from various cross combinations. Details of growth and test-tap yield of hybrids are given in Table 3. Four hundred

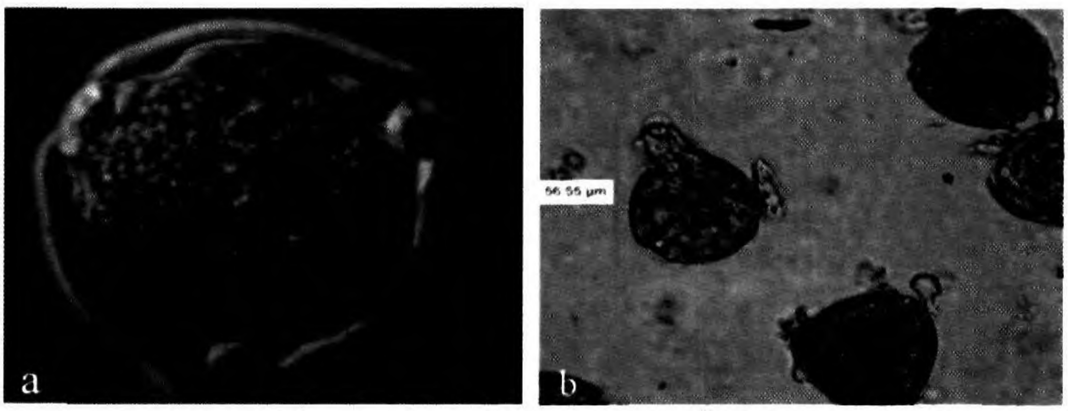

Fig. 1. Pollen of Fx 516 a. stored under low temperature at 80^{0}C, b. showing germination

Table 3. **Girth and yield in hybrids and half-sibs**

Pedigree	Girth (cm)		Rubber yield (g $t^{-1}15t^{-1}$)	
	Range	Mean (S.E.)	Range	Mean (S.E.)
Hybrids				
RRII 430 x Fx 516	12.0-47.0	27.0 (0.8)	2.7-158.8	35.5 (3.2)
RRII 414 x Fx 516	18.5-50.0	31.4 (5.1)	6.0-212.1	81.8 (34.8)
RRII 417 x Fx 516	13.0-39.0	24.9 (0.9)	1.4-111.6	20.1 (3.3)
RRII 429 x Fx 516	11.0-44.0	25.1 (1.0)	1.0-139.1	24.6 (3.4)
Fx 516 x RRII 105	21.0-21.5	21.3 (0.3)	5.0-17.9	11.47 (6.5)
Fx 516 x RRII 414	24.0-28.0	26.0 (2.0)	5.8-63.4	34.6 (28.8)
RRII 105 x Fx 516	19.0-39.0	26.1 (1.7)	2.11-55.4	16.7 (4.4)
RRII 414 x HP 90/21	9.0-41.0	37.3 (2.7)	22.8-152.1	77.4 (38.7)
Half-sibs (Fx 516)	2.0-46.0	23.7 (0.3)	0.56-172.0	21.1 (1.2)

and twelve half-sibs of clone Fx 516 were established under Phase I of the resistance breeding programme. Based on preliminary observation in the field, the hybrids were free from major fungal diseases.

There was wide range of growth and yield performance (Table 3) among the hybrids. Highest range in yield was exhibited by progenies from RRII 414 x Fx 516 (6.0-212.1 g $t^{-1}15t^{-1}$). Lowest range in growth and yield was exhibited in cross combination of Fx 516 x RRII 105. Based on mean girth of progenies, highest girth was attained by hybrids under cross combination RRII 414 x HP 90/21 (37.3 cm), followed by progenies of RRII 414 x Fx 516 (31.4 cm) (Table 3). It is worthwhile to note that RRII 414 is a vigorous clone among the RRII 400 series clones as demonstrated by its innate capability to reach early tapping (Mydin, 2014). Highest girth (50.0 cm) was also attained by one of the hybrids of RRII 414 x Fx 516 followed by those of RRII 430 x Fx 516 (47 cm) and RRII 429 x Fx 516 (44 cm). Regarding half-sibs of Fx 516 also, there was wide variation for girth as well as yield (Table 3). The half-sibs attained high girth and also showed good yield performance comparable with top-yielding hybrids. In terms of yield performance, top yielding half-sib with very high yield (172 g $t^{-1}15t^{-1}$) also closely followed the top yielding selection from RRII 414 x Fx 516 (212.1 g $t^{-1}15t^{-1}$).

Very large range in yield was exhibited by progenies of cross combination RRII 414 x Fx 516 (Table 3). Highest individual yield was also achieved from this cross combination (212.1 g $t^{-1}15t^{-1}$) followed by those of RRII 430 x Fx 516 (158.8 g $t^{-1}15t^{-1}$), RRII 414 x HP 90/21 (152 g $t^{-1}15t^{-1}$) and RRII 429 x Fx 516 (111.6 g $t^{-1}15t^{-1}$). Among various cross combinations, lowest mean yield was achieved by combination of RRII 414 x Fx 516 (81.8 g $t^{-1}15t^{-1}$) followed by RRII 414 x HP 90/21 (77.4 g $t^{-1}15t^{-1}$).

From the above population, individual selections could be made based on mean of population from each cross combination. The selections were further classified into three classes as Class I (> population mean), Class II (> 50 g $t^{-1}15t^{-1}$) and Class III (> 100 g $t^{-1}15t^{-1}$) based on their intra-class performance (Table 4). From among hybrids, maximum selections (37) could be recovered from cross

Table 4. **Number of selections from hybrids and half-sibs based on test-tap yield**

Pedigree	Class-III* ($>n$)	Class-II (>50 g $t^{-1}15t^{-1}$)	Class-I (>100 g $t^{-1}15t^{-1}$)
Hybrids			
RRII 430 x Fx 516	37	29	3
RRII 414 x Fx 516	20	4	2
RRII 417 x Fx 516	5	1	-
RRII 429 x Fx 516	18	6	2
Fx 516 x RRII 105	1	-	-
Fx 516 x RRII 414	1	1	-
RRII 105 x Fx 516	6	1	-
RRII 414 x HP 90/21	3	1	1
Half-sibs (Fx 516)	255	40	7
Total	346	83	15

*classification based on yield potential (for details please see text); n, population mean

combination of RRII 430 x Fx 516 under Class III which is based on mean of the population. This was followed by RRII 414 x Fx 516 (20) and RRII 429 x Fx 516 (18). This showed that RRII 430 could possibly be a good choice as a pre-potent parental clone for recovering more high-yielding progenies through hybridization as demonstrated by pre-potency in many *Hevea* clones (Mydin, 2014). The cross combination of RRII 430 x Fx 516 also yielded maximum progenies in Class-II with more than 50 g $t^{-1}t^{-1}$ and under Class-I with more than 100 g $t^{-1}15t^{-1}$ (Table 4). With reference to half-sibs, 255 selections performed well above population mean. While forty selections yielded more than 50 g $t^{-1}15t^{-1}$, seven selections showed yielded more than 100 g $t^{-1}15t^{-1}$. Thus it was possible to recover comparatively more number of progenies with very high growth and yield from the above population of half-sibs.

In the present study we could identify many selections with good growth and yield. In the next phase, it will be important to evaluate the selections from the present disease resistance breeding programme for tolerance to major fungal diseases. Since clone Fx 516 has been used in the breeding programme, it is possible that its progenies would harbour genes for tolerance to diseases. However, this needs further detailed investigations.

CONCLUSION

The breeding programme using selected parental clones could successfully generate several outstanding high-yielding genotypes through hybridization as well as selection from half-sibs of Fx 516. The above outstanding selections offer wide scope as a valuable genetic base for further field-screening and validation of their other traits including disease tolerance. Although testing for SALB is not possible within the country due to quarantine reasons, inclusion of Fx 516 in the present disease resistance breeding could have possibly resulted in a few genotypes possessing genes for SALB tolerance and this is under detailed investigations.

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