EVOLVING HIGH YIELDING *HEVEA* CLONES THROUGH TRANSGRESSIVE INTROGRESSION HYBRIDIZATION OF AMAZONIAN HYBRIDS AND WICKHAM CLONES

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Secondary gene pool available in the wild relatives of a cultivated variety can be employed when the variation within the primary gene pool is exhausted to develop improved varieties through introgression hybridization. The time-consuming breeding cycle makes introgressive hybridization through repeated backcrossing a highly challenging strategy in *Hevea*. Three promising Wickham (W) x Amazonian (A) hybrids identified earlier *viz*. 90/10 and 90/34 (RRII 105 x RO 142) and 90/274 (RRII 105 x MT 196) were selected as the paternal parents. The maternal parents used in the back cross included RRII 105, along with RRII 414, RRII 430 and RRII 429 which are the hybrids of RRII 105 x RRIC 100. A total of 353 hybrid seedlings derived from 13,859 hand pollinations were planted in the nursery for evaluation. The hybrids were screened for yield and girth under seedling nursery evaluation. Sixty three promising hybrids were identified and the per cent recovery of high yielding hybrids from a cross combination varied between 0 to 33 per cent. Cross combinations involving RRII 430 as maternal parent resulted in maximum number of selections. Number of selections from crosses involving 90/10 as paternal parent was the highest with an average of 26.2 per cent. The average test tap yield of hybrids of RRII 430 as maternal parent was the highest. The promising hybrids identified in the present study were forwarded to the next level of evaluation to develop improved clones.

Keywords : *Hevea*, Introgression, Nursery evaluation, Wickham (W) x Amazonian (A) hybrids

INTRODUCTION

Scope for developing improved varieties through breeding by exploiting variation within the species primary gene pool is limited. The supply of novel variants and narrow genetic base are always a limiting factor in crossing the yield threshold beyond a certain level (Jacob *et al*., 2021). In order to overcome this limitation, supply of usable genetic variation can be widened by accessing the secondary gene pool, as represented by its wild relatives (Rieseberg and Wendel, 1993). Introgressive hybridization (introgression) is a method in which the genetic modification of one species is achieved through hybridization and repeated backcrossing by another species (Anderson, 1949). It is important in plant breeding where a desirable trait can be transferred from wild to cultivated crops.

Being a perennial tree crop, conventional breeding and selection in *Hevea* is a long term

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process extending up to 24 years (Mydin and Saraswathyamma, 2005). The long breeding cycle makes introgressive hybridization through repeated backcrossing a highly challenging strategy in *Hevea*.

The wild accessions collected under the 1981 IRRDB wild *Hevea* germplasm collection from three provenances in Brazil *viz*. Acre (AC), Rondonia (RO) and Mato Grosso (MT) are a potential source for introgression of genes required for complementing the cultivated clones, popularly called Wickham clones. Systematic characterization for yield and yield contributing factors like laticifer rows was successful in identifying promising wild accessions which were eventually utilized in breeding programmes by crossing with cultivated Wickham (W) clones. In 1990, Wickham (W) x Amazonian (A) hybrids were developed from the crosses between RRII 105, a popular Wickham (W) clone and different Amazonian wild germplasm accessions. Mydin *et al*. (2012) reported that even though most of the progeny of such W x A crosses are expected to be poor yielders, recombination between such diverse parents could result in new genotypes with high yield as well as possessing the desired secondary traits. Nursery level screening and selection of the hybrid seedlings were followed by small scale evaluations in the field. Through the evaluation of hybrids for yield and other secondary characters for 22 years, a few promising W x A hybrid clones were identified (Sankariammal and Mydin 2010, 2011; Sankariammal *et al*., 2010, 2011; Mydin *et al*., 2011, 2012). Among the promising W x A hybrids, two promising clones, 90/10 and 90/34 (RRII 105 x RO 142) and one clone, 90/274 (RRII 105 x MT 196) were selected as the paternal parents for back crossing under the present study. The maternal parents used in the back cross included RRII 105, along with RRII 414, RRII 430 and RRII 429, the hybrids of RRII 105 x RRIC 100. Hence, the introgression hybridization employed in the present study is termed 'transgressive' as only one generation of backcrossing was done and the back crosses were not confined to RRII 105, the original maternal parent but also with its second generation hybrids as well. The schematic representation of the entire breeding program employed in developing the progeny population is given in Figure 1.

The main objective of the experiment was to evolve high yielding *Hevea* clones through introgression hybridization of Amazonian hybrids and Wickham clones. The hybrid clones developed under the experiment will potentially widen the genetic base of the breeding populations which may enable breeders to overcome the yield threshold observed in conventional *Hevea* breeding programmes.

MATERIALS AND METHODS

Hybridization and development of progenies

The trees of hybrid clones 90/10, 90/34 and 90/274 along with RRII 105, RRII 430, RRII 414 and RRII 429 were dusted with sulphur at fortnightly interval commencing from refoliation up to completion of the crossing programme to protect the flowers from powdery mildew disease. Hand pollination was carried out as per the standard procedure (Mydin and Saraswathyamma, 2005). Later the hybrid fruits developed were given prophylactic treatment against *Phytophthora* infection with fungicide spray of one per cent Bordeaux mixture at fortnightly interval during the monsoon season. The hybrid fruits were enclosed in net bags to prevent loss of seeds when they dehisce on maturation. Mature fruits were harvested and sown in trays filled with sand

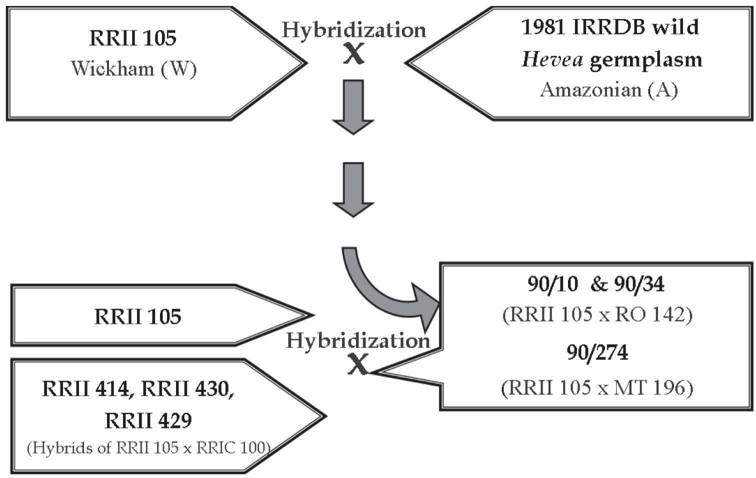

Fig. 1. Breeding programme to develop progeny population

for germination. The germinated seedlings were transplanted to seedling nursery. The identity of each cross combination was maintained at every stage from hand pollination to planting of seedlings in the nursery.

Evaluation of the progenies

The seedlings were planted in nursery beds in 1 x 1 m spacing. Evaluation of seedlings was done as per standard procedure based on two important juvenile parameters *viz*. yield on test tap in gram per tree per 10 tap (g t^{-1} 10 tap^{-1}) and girth (cm) (Mydin and Saraswathyamma, 2005). Girth was recorded annually by measuring the stem diameter at 15 cm from the ground level in the second and third year of planting in the field. Yield on test tapping was recorded in the second and third year after planting by tapping the plants only during the peak yield season (November-December) at a height of 20 cm from the base under S/2 d3 6d/7 system of tapping. After discarding the latex from the first five tappings, latex collected in the cup was coagulated from ten consecutive tappings. The coagulated cup lumps were dried and weighed to record the test tap yield (g t^{-1} 10 tap^{-1}). The best 20 per cent of the population in the nursery was selected based on test tap yield and girth.

RESULTS AND DISCUSSION

Development of progeny population

A progeny population was developed through introgression hybridization from the cross between Wickham (high yielding popular clones) with Amazonian hybrids (WxA) (high yielding clones having genes from wild Amazonian parent) during 2012-14. The cross combinations attempted in the present study is listed in Table 1. Hand pollinations were not carried out in the cross combination RRII 429 x 90/274 due to asynchrony in flowering. A total of 13,859 hand pollinations were carried out as detailed in Table 2. The number of pollinations attempted in each cross combination varied depending on the availability of flowers. Maximum number of pollinations were performed in the cross combination in which maximum synchrony

Table 1. **List of cross combinations attempted**

Sl. No.	Cross combination
1.	RRII 414 x 90/10
2.	RRII 414 x 90/34
3.	RRII 414 x 90/274
4.	RRII 429 x 90/10
5.	RRII 429 x 90/34
6.	RRII 430 x 90/10
7.	RRII 430 x 90/34
8.	RRII 430 x 90/274
9.	RRII 105 x 90/10
10.	RRII 105 x 90/34
11.	RRII 105 x 90/274

in flowering was obtained between the parents. Cross combinations RRII 414 x 90/10 and RRII 105 x 90/34 showed maximum synchrony in flowering and hence maximum number of pollinations were performed with 4016 and 3150, respectively. Flowering in RRII 414 and 90/10 was earlier compared to RRII 105 and 90/34. An overlap in flowering was observed making it possible to perform other cross combinations also, even though the number of pollinations in such cases was comparatively low.

A total of 353 hybrid seedlings were successfully planted in the nursery for evaluation. The overall success in obtaining hybrid seedlings with respect to the number of flowers pollinated was 2.5 per cent. The number of hybrid seedlings in each cross combination is given in Table 2 and 3. Number of seedlings obtained in the cross RRII 105 x 90/34 was the highest with a total of 99 seedlings from 3150 hand pollinations. Maximum success in obtaining hybrid seedlings with respect to the number of flowers pollinated was in the cross combination of RRII 430 x 90/10 with 7.1 per cent. Hybrid seedlings were not obtained in the cross combinations RRII 429 x 90/10, RRII 414 x 90/274 and RRII 105 x 90/274.

Evaluation of the progenies

The hybrids were screened for test tap yield and girth under seedling nursery evaluation. Frequency distribution of girth of the seedling in the hybrid population showed a normal distribution (Fig. 2). But, the frequency distribution of test tap yield of the seedling in the hybrid population was observed to be negatively skewed with majority of the seedlings falling in the lower yield classes (Fig. 3). The population mean girth and yield were 15.9 cm and 9.1 g t^{-1} 10 tap^{-1} respectively. Population mean test tap yield observed in the present study was higher compared to the earlier reports involving different cross combinations (Mydin *et al.*, 2012; Reju *et al.*, 2017). Mean girth of hybrid population of RRII 414 as

Table 2. **Details of hand pollinations performed and hybrids obtained**

Maternal parents	Paternal parents (W x A)					
	Clone 90/10		Clone 90/34		Clone 90/274	
	No. of hand pollinations	No. of hybrid seedlings obtained	No. of hand pollinations	No. of hybrid seedlings obtained	No. of hand pollinations	No. of hybrid seedlings obtained
RRII 414	4016	62	1566	81	240	-
RRII 429	362	-	699	6	-	-
RRII 430	883	63	260	6	420	23
RRII 105	1736	13	3150	99	527	-

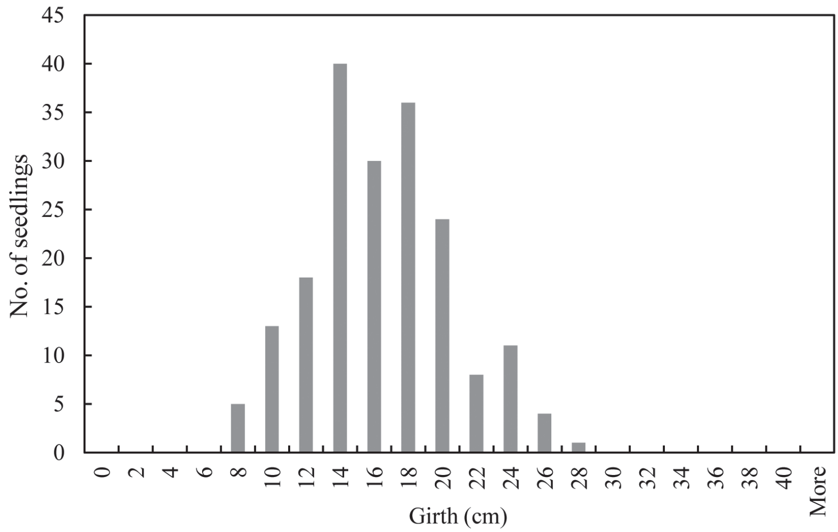

Fig. 2. Frequency distribution of seedling girth in the hybrid population

maternal parent was the highest with 16.6 cm followed by RRII 105 and RRII 430 with 15.7 and 14.3 cm respectively (Table 4). However, the average test tap yield of hybrid population of RRII 430 as maternal parent was the highest with 11.1 g t^{-1} 10 tap^{-1} followed by RRII 414 and RRII 105 with 8.4 and 6.6 g t^{-1} 10 tap^{-1} respectively (Table 4).

From the hybrid population, 63 hybrids were identified and selected for further evaluation based on test tap yield and girth (Table 3). Mean girth of selected hybrids of

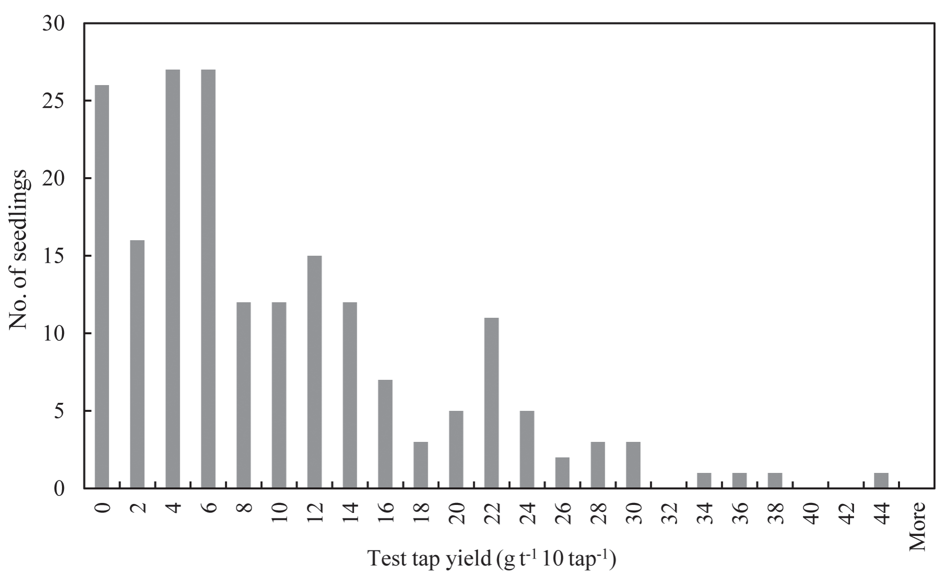

Fig. 3. Frequency distribution of test tap yield in the hybrid population

Table 3. **No. of pollinations, hybrids obtained and selections**

Cross combination	No. of hybrid seedlings obtained	No. of selections	Selection percentage (%)
RRII 414 x 90/10	62	12	19.4
RRII 414 x 90/34	81	14	17.3
RRII 429 x 90/34	6	0	0
RRII 430 x 90/10	63	18	28.6
RRII 430 x 90/34	6	2	33.3
RRII 430 x 90/274	23	3	13.0
RRII 105 x 90/10	13	4	30.8
RRII 105 x 90/34	99	10	10.1
Total	353	63	17.8

RRII 414 as maternal parent was the highest with 20.9 cm followed by RRII 105 and RRII 430 with 19.4 and 16.9 cm respectively (Table 4). The average test tap yield of selected promising hybrids of RRII 430 as maternal parent was the highest with 22.3 g t^{-1} 10 tap^{-1} followed by RRII 414 and RRII 105 with 18.5 and 18.3 g t^{-1} 10 tap^{-1} respectively (Table 4). It was observed that out of the 63 hybrids selected, 55 were having a girth more than the population average. The present study showed 87.3 per cent selections from above population mean girth compared to 99 per cent selections as reported by Reju *et al*. (2017). Reason for the selection coming even from the lower girth group might be because of the fact that the population in the present study is a hybrid population involving selected parents, contrary to polycross population reported earlier (Reju *et al*., 2017).

The per cent recovery of high yielding hybrids ranged from 0 to 33 per cent with no selections in the cross combination RRII 429 x 90/34 and two selections out of six hybrid seedlings under evaluation in the cross combination RRII 430 x 90/34. Earlier report showed that the per cent recovery of high yielding seedlings vary depending upon the cross combinations. Mydin *et al*. (2012) reported 46.15 per cent recovery of high yielding seedlings in the family of the cross RRIM 600 x AC 498 as the highest from a study involving different W x A cross combinations. In the present study, cross combinations involving RRII 430 as maternal parent resulted in maximum number of selections ranging from 13 to 33 per cent. Number of selections from cross combinations involving 90/10 as paternal parent was the highest with an average of 26.2 per cent. The advantage of using W x A hybrid clone 90/10 as paternal parent is evident from the results as observed in the case of RRII 105 when used as maternal parent, 90/10 gave 30.8 per cent selection in comparison to 10.1 per cent selection in the case of 90/34,

Table 4. **Girth and test tap yield of hybrid populations and selections**

Maternal parent	Mean girth (cm)		Average test tap yield (g t^{-1} 10 tap^{-1})	
	Population	Selection	Population	Selection
RRII 105	15.7	19.4	6.6	18.3
RRII 414	16.6	20.9	8.4	18.5
RRII 430	14.3	16.9	11.1	22.3

although the parents of both hybrids were the same (RRII 105 x RO 142). Selections from cross combinations involving 90/34 and 90/274 as paternal parents were 15.2 and 13 per cent respectively. The population generated in this study will be employed to widen the genetic base of *Hevea* so as to develop improved high yielding clones.

CONCLUSION

In the first ever introgression hybridization done in *Hevea* using Amazonian hybrids and Wickham clones for evolving high yielding clones, cross combinations involving 90/10 (a hybrid of RRII 105 x RO 142) as paternal parent gave maximum number of high yielding selections with an average of 26.2 per cent. Average test tap yield of hybrids of RRII 430 as maternal parent was the highest both in the hybrid population and selections. Promising hybrids identified under the present study will be evaluated further to develop improved clones with high yield potential.

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