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Evolving cashew F_1 hybrids suitable for high density planting system

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ABSTRACT

Hybridization and selection experiment was carried out in cashew to evolve a compact or dwarf F_1 hybrid suitable for high density planting system, which is the utmost need to improve the productivity of cashew nuts in the country. Eight promising hybrids with tall, semi-tall or dwarf stature were selected from the crosses and evaluated for morphological parameters and stomatal density. The results revealed that the hybrids HC 6 was dwarf with 3.0 m height, reduced number of primary and secondary branches, number of leaves per current season's shoot (5.3), reduced internodal length (0.25 cm) and number of internodes (5.3). HC 6 also recorded a higher number of stomata (57.2 per mm^2). The highest cumulative yield for three years was recorded in HC 1 (3.5 kg nuts per tree) followed by HC 6 (2.65 kg nuts per tree). HC 1 was semi-tall and compact. Correlation studies revealed that there is strong positive correlation between plant height and length of current season's shoot, number of internodes per shoot, intermodal length and number of branches. This study resulted in a hybrid with reduction in height, number and length of internodes, spur formation on shoots, reduced leaf size, number of shoots with moderate yield. However, the genetic nature of dwarfness is to be confirmed by further evaluation through conventional breeding and molecular approaches.

Key words: Cashew, F_1 hybrid, dwarf, semi-dwarf genotype.

INTRODUCTION

India has been the prime producer and exporter of cashew in the world, earning a forex of Rs. 2,700 crores every year. A stiff competition is felt from several SE countries like Vietnam, hence there is an urgent need to boost the indigenous production to sustain its position in the world cashew trade (Korikanthimath,10). Extensive cultivation of high yielding varieties/ hybrids under high density planting system is the best option to double the cashew production. On the other side, the existing cashew varieties are mostly of spreading types and necessarily needs annual maintenance pruning, which is time and labour consuming. A smaller, more compact tree is more efficient at intercepting the sun's energy (Green *et al*., 9). Development of dwarf hybrids or genotypes with compact canopy can suit to the high density planting system to enhance the yield of nuts per unit area. In India, dwarf / compact canopy hybrids are yet to be developed or released (Bhat *et al*., 3). Reduced stem elongation, decreased leaf size and dark green foliage in GA-deficient dwarf hybrid poplar mutants were reported by Busov *et al*. (7). They observed four-fold reduction in height in these mutants. Rajendra *et al*. (14) reported correlation of plant height on stomatal frequency and size in *Hordeum vulgare.* A smaller apple tree tends to intercept more of incoming PPF energy compared to large trees due to adequate distribution of light within the tree canopy (Green *et al*., 9). These dwarf varieties allows the plant to put more energy into the useful organs instead of stalks or trunk and reduces toppling damage by wind and rain (Moffat, 12). With this perception, the present investigation was carried out to evolve dwarf hybrids with reduced height, compact canopy and intensive branching habit combined with moderate or high nut yield to suit the requirement of high density planting system.

MATERIALS AND METHODS

The present investigation was carried out in the Experimental Orchard of the Regional Research Station, TNAU, Vridhachalam during 2005 to 2010. Hybridization was carried out following Line x Tester method of crossing using VRI 2, VRI3, TK1, VSK2, KGN1, SL1, VSK 1, PKP 1 and PKP 2 as parents (Table 1). Totally 64 cross combinations were carried out in both the ways with 200 flowers in each cross. The individual F_1 seeds were collected and raised in polybags. The F_1 hybrid seedlings of 60 days age were planted out and regular cultural operations were carried out. The number of seedlings recovered varied between hybrids and it ranged from 15-25. The hybrids were evaluated based on the standard descriptor for characterization of cashew trees. Based on this, single seedling selection was carried out and only eight promising F_1 hybrid plants were selected for further evaluation on morphological parameters namely plant height (m), trunk height (m), canopy height (m),

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Table 1. Parentage of the cashew F_1 hybrids under evaluation.

Hybrid	Female parent	Male parent
HC 1	VRI 2	VRI 3
HC 2	VRI 3	VSK 2
HC 3	VRI 3	TK 1
HC 4	VRI 3	SL 1
HC 6	VRI 3	KGN 1
HC 7	VRI 3	VSK 1
HC 8	VRI 3	PKP 1
HC 9	VRI 3	PKP 2

canopy spread east-west and north-south (m), trunk girth (cm), number of primary branches, number of secondary branches, tertiary branches, branching pattern, length of the current season's shoot (cm), number of internodes per shoot, length of the internode (cm), leaf shape, colour of mature leaves, odour of the leaves, leaf margin, leaf apex shape, brittleness of the leaves, angle of leaf petiole to stem, shape of leaf cross-section, number of flower clusters, number of nuts per m^2, yield (kg per tree). Stomatal density was estimated on the adaxial surface of leaves midway between the third and fourth veins by means of a quick-fix film (Beakbane *et al*., 1). Pooled data of three years were statistically analysed. Statistical analysis for un-replicated data and correlation coefficient was worked out using SPSS software package.

RESULTS AND DISCUSSION

The eight hybrid trees identified were five-year-old and showed considerable variations in growth parameters, yield and yield attributing parameters and stomatal density. The tallest plant (4.6 m) was in HC 9 and the shortest in 3.0 m in HC 6 (Fig. 1; Table 2). Canopy spread showed a range of 3.2 to 3.9 m on east-west and north-south direction, the least recorded in HC 6 (3.2 m) and the highest HC 4 (5.6 m). Trunk girth also showed variation among the hybrids evaluated. The plants with shorter height recorded smaller trunk girth, which was shown by the positive correlation coefficient value between these two characters (Table 3). The hybrid HC 9 recorded the highest number of primary branches and HC 6 the lowest number. The hybrid HC 6 with shorter plant height among the hybrids recorded lower number of secondary branches. In contrast, Perez and Colin (13) recorded a high significant negative correlation between height and number of branches in avocado. However, HC 6 had higher number of tertiary branches which is required for the production of more current season's shoot for bearing flower clusters. Hybrid HC 9 was the tallest among the hybrids and used to compare the other dwarf hybrids.

In the present investigation also, with regard to growth of shoots, the highest value for length of current season's shoot, number of leaves per current season's shoot, number of internodes, internode length and leaf size was recorded in HC 9 showing high heterotic vigour of the plant. In contrast, HC 6 hybrid showed the lowest values for all the above parameters (Figs. 2, 3 & 4). The leaf area in HC 6 was nearly half (36.8 cm^2) of that of HC 9 (77.5 cm^2). There was 55.20% reduction in number of internodes and 68.75% reduction in internode length in HC 6 hybrid compared to HC 9, the tallest hybrid. The decrease in internode length might be due to the inhibition of mitotic activity in developing internodes leading to decrease in cell number or cell length and is characteristic of genetic dwarfness (Brown *et al*., 6). Leaf size and internode length variations were shown in Fig. 2, which shows the largest leaves and longest internodes in HC 9 and the smallest leaves and shortest internodes in HC 6. Internode number and length showed a high positive correlation with plant height (Table 4). Plants with reduced height recorded lower internode number and length and the same might be the reason for their reduced height. As reduced height is an important criteria for developing varieties for high density planting system, this hybrid could be used in future breeding programme. The stomatal density is an indication of the genetic dwarfness of the plant. Rajendra *et al*. (14) reported correlation of plant height on stomatal frequency and size in *Hordeum vulgare.* The present study also revealed lower stomatal density in taller genotypes (Table 2). This was justified by the correlation coefficient analysis, which showed high negative correlation between plant height and density of stomata. This is in accordance with Perez and Colin (13) who reported negative relationship between stomatal density and height of avocado trees.

From this interpretation it is very clear that the hybrids showed high variation for plant height and could be used for breeding programmes to evolve

new dwarf hybrids. Bezerra *et al*. (2) reported two types of cashew trees namely tall and dwarf trees. The dwarf trees were reported to have a compact, homogenous crown, smaller leaves and smaller stem diameter. This is in accordance with the present study that shows HC 6 to be a dwarf hybrid with a smaller round compact canopy, 3.0 m tall, less spreading, intensive branching, smaller trunk girth, smaller leaves, lower number of internodes, reduced internodal length and higher stomatal density. The dwarfing genes might have decreased the plant height by morphological or cytological changes directly such as internode reduction (Maungprom and Osborn, 11) and cell number decrease or through modulation in endogenous hormone level (Bin-mei *et al*., 4). Faust and Zagaja (8) reported that a compact type of trees should have a combination of small size, short internodes and compact spur. The genetic dwarfness of the dwarf HC 6 has to be explored.

The cumulative nut yield for three years in hybrid HC 6 was 2.65 kg per tree, which was the second highest yield among the hybrids evaluated, HC 1 being the highest (3.50 kg per tree). Hybrid HC 1 was also better as it was comparatively compact, semi-tall (3.65 m) with higher stomatal density of 41.2 per mm^2 combined with high yield. The increased nut yield in dwarf statured plant might be genetically inherited from their parents or might be due to better light interception due to its compact canopy. Green *et al*. (9) reported that a smaller more compact fruit tree is more efficient at intercepting solar energy and it also allows adequate light distribution within the tree canopy. Correlation analysis showed a negative correlation between plant height and nut yield. Earlier breeders believed that the taller cultivars have higher yield potential as compared to short statured ones as they possess higher biomass and have a larger source to contribute to the final sink or grain yield (Briggle and Vogel, 5). However, with the induction of semi-dwarfing genes into the wheat varieties, the theories have been changed by modifying the cell size and number, root weight, coleoptiles length, leaf size, harvest index, grain yield, disease reaction etc. (Sial *et al*., 15). This indicates the suitability of the small statured or dwarf tree hybrids for inclusion in the breeding programmes for evolving dwarf hybrid with high or moderate yield suited for high density planting system in the country. The F_1 hybrids evolved through hybridization and selection in this study namely HC 6 and HC 1 might be used further to study the physiological mechanisms associated with the genetic expressions of the morphological differences. Identification of molecular markers for dwarfness and yield to identify and isolate the dwarf plant in the early stages of plant breeding programmes (Venkatachalam *et al*., 16) need to be explored using these small, compact, dwarf /semi-tall cashew hybrids.

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REFERENCES

1. Beakbane, A.B. and Majumder, P.K. 1975. A relationship between stomatal density and growth potential in apple rootstocks. *J. Hort. Sci*. **50**: 285-89.

2. Bezerrra, M.A., de Lacerda, C.F., Filho, E.G., de Abreu, C.E.B. and Prisco, J.T. 2007. Review: Physiology of cashew plants grown under adverse conditions. *Brazilian J. Plant Physiol*. **19**: 449-61.

3. Bhat, M.G., Yadukumar, N. and Gangadhara Nayak, M. 2007. Cashew research achievements, technologies developed and research and development strategies. **In**: *Souvenir on National Seminar on Research, Development and Marketing of Cashew*, Nov. 20-21, 2007, ICAR Research Complex for Goa, Ela, Old Goa, India.

4. Bin-mei, L., Can, C., Yue-jin, W., Ji-ping, T., Ying, Z. and Qin, Y. 2006. Effect of dominant semi-dwarf gene on plant height and its related traits and sensitivity to gibberellic acid in rice. *Rice Sci.* **13**: 179-84.

5. Briggle, L.W. and Vogel, O.A. 1968. Breeding short-statured, disease resistant wheat in the United States. *Euphytica*, **17**: 107-30.

6. Brown, C.L., Sommer, H.E. and Wetzstein, H. 1994. Morphological and histological differences in the development of dwarf mutants of sexual and somatic origin in diverse woody taxa. *Trees Structure Func.* **9**: 61-66.

7. Busov, B.V., Meilan, R. and Strauss, S.H. 2003. A short route to gene discovery in trees: Control of stature through gibberellin catabolism. *ISB New Report*. **Sept**. pp.1-4. (http://www.isb.vt.edu)

8. Faust, M. and Zagaja, S.W. 1984. Prospects for developing low vigour fruit tree cultivars. *Int. Workshop on Controlling Vigour in Fruit Trees. Acta Hort.* **146**: **1**: pp. 1.

9. Green, S., McNaughton, K., Wunschem, J.N. and Clothier, B. 2003. Modelling light interception and

transpiration of apple tree canopies. *Agron. J.* **95**: 1380-87.

10. Korikanthimath, V.S. 2007. Preface. **In**: *Souvenir on National Seminar on Research, Development and Marketing of Cashew, Nov. 20-21, 2007,* ICAR Research Complex for Goa, Ela, Old Goa, India.

11. Maungprom, A. and Osbourn, T.C. 2004. Characterization of a dwarf gene in *Brassica rapa*, including the identification of a candidate gene. *Theor. Appl. Genet.* **108**: 1378-84.

12. Moffat, A.S. 2000. Can genetically modified crops go 'Greener' ? *Science*, **290**: 253.

13. Perez, F.B. and Colin, S.S. 1982. Height variability obtained from a new dwarf new avocado tree population. *California Avocado Soc. Yearbook*, **66**: 155-60.

14. Rajendra, B.R., Mujeeb, K.A. and Bates, L.S. 1978. On the correlation of height on stomatal frequency and size of two lines of *Hordeum vulgare* L. *Env. Exp. Bot.* **18**: 117-19.

15. Sial, M.A., Arain, M.A., Javed, M.A. and Jamali, K.D. 2002. Genetic impact of dwarfing genes (Rht_1 and Rht_2) for improving grain yield in wheat. *Asian J. Plant Sci.***1**: 254-56.

16. Venkatachalam, P., Priya, P., Saraswathyamma, C.K. and Thulaseedharan, A. 2004. Identification, cloning and sequence analysis of a dwarf genome specific RAPD marker in rubber tree. *Plant Cell Rep.* **23**: 327-32.

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