Performance of cashew (*Anacardium occidentale*) varieties under different planting density for growth and yield traits

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ABSTRACT

Cashew (*Anacardium occidentale* L) is an important tropical tree crop revered for its economic and nutritional needs. The demand for cashew is increasing significantly in both domestic and international markets. Planting density and tree canopy influence the yield performances of tree crops. Planting of trees at higher densities in orchards offers high yield potential. In the current study, a field experiment was conducted to study the effect of planting density on growth and yield of different varieties of cashew during 2013-14 to 2017-18. The three varieties, *viz.* H-130, NRCC Sel. 2 and Bhaskara were planted at three different planting systems, *viz.* ultra density $(2.5 \times 2.5 \text{ m})$, high density $(5.0 \times 5.0 \text{ m})$ and normal density $(7.5 \times 7.5 \text{ m})$ and evaluated for growth and yield traits. The heading back was carried out in ultra density planting during the last week of May in all the years. The results revealed significant differences for yield and related traits among cashew varieties under different plant densities. The maximum yield was recorded in variety H-130 planted at $2.5 \times 2.5 \text{ m}$ spacing during second year (1248 kg/ha), third year (2234 kg/ha) and fourth (2432 kg/ha) year of planting and minimum (154 kg/ha) was observed in variety Bhaskara at $2.5 \times 2.5 \text{ m}$ spacing. The variety H-130 performed well in all the three different planting systems compare to NRCC Sel. 2 and Bhaskara due to positive response of pruning.

Key words: Cashew, H-130, Planting densities, Yield

Cashew (Anacardium occidentale L.), is one of the most important plantation crops of India earning significant foreign exchange through exports. Presently, commercial cultivation of cashew is being done in more than 33 countries in the world and Vietnam, Nigeria, Ivory Coast, Benin, Ghana, Tanzania, India, Brazil and Indonesia are the top cashew producers. The cashew occupies 10.35 lakh hain India with 7.79 lakh MT of production (Anonymous 2017). The major cashew growing states are Maharashtra, Andhra Pradesh, Odisha, Karnataka, Kerala, Goa, Tamil Nadu and West Bengal. In India, the established processing capacity of raw nuts is around 15-20 lakh tonnes, where the domestic contribution is around 7-8 lakh tonnes. In the recent years, there is an increase in the domestic demand for cashew. Thus, India has been importing nearly half of the raw cashew nuts processed in the country mainly from the African countries at the cost of ₹ 8839 crores annually (Anonymous 2017). Of late, the import possibility from many of these African countries is dwindling, as these countries have setup their own processing facilities and also the competition for import of nuts from these countries by

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the major cashew processing and exporting countries like Vietnam is increasing.

The major problem for deficit of raw nuts for processing by Indian cashew industries is the low productivity (800 kg/ ha). It is mainly due to large area of old senile orchards, low plant population per unit area, poor canopy management and non-adoption of improved package of practices. In recent times, demand for cashew in both domestic and international market is growing every year. In India, cashew consumption has increased by about 5.5 times in the last decade and is expected, grow further in the future. It has been estimated that the domestic demand for raw cashew nut is about 50 million MT or more by 2050 (Saroj and Nayak 2016). Hence, to meet this huge demand for cashew there is urgent need for increasing the productivity per unit area. This can be achieved easily by the adoption of ultra and high density planting systems. In recent times, there is a shift in farmers' perception from production to productivity and profitability which can be achieved through accommodating more number of plants per unit area. Studies on high density planting systems in fruit crops such as guava, mango and cashew have been shown to be more economical compared to the traditional planting system Yadukumar et al. 2001, Bal and Dhaliwal 2003, Sousa et al. 2012, Gaikwad et al. (2017). Efforts have been made to standardize the high density planting in cashew (Rejani et al. 2013), and mango (Gunjate et al. 2009) and some pruning techniques for improving

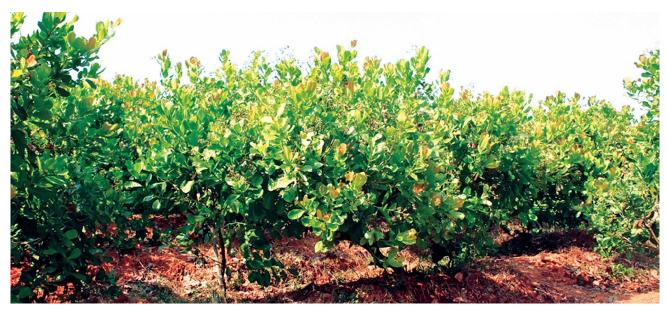


Fig 1 General view of ultra density planting system in cashew.

nut yield in cashew (Mohan and Singh 1988, Rani *et al.* 2011, Kumar *et al.* 2015, Murali *et al.* 2015). The results of these studies have revealed that closer planting will help in increasing the productivity. However, the responses of the varieties to the pruning varied. Therefore, it is very much essential to identify varieties suitable for ultra and high-density planting which respond to pruning. Hence, present investigation was undertaken to know the performance of different cashew varieties under different planting densities for growth and yield traits.

MATERIALS AND METHODS

Present study was conducted at ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur. Experimental site is located at 12.45° N 75.15° E and has an average elevation of 90 m above the MSL. The climatic condition of the region is hot and humid for most period of the year with distinct dry season from January to April. The average annual rainfall is 3500 mm and it is distributed from May to November. The soil type of experimental field was sandy clay loam with pH of 5.25, medium nitrogen content and low in phosphorus and potassium contents.

The experiment was laid out in factorial randomized block design consisting of three varieties and three planting densities. The three varieties of cashew namely, H-130 (V1), NRCC Sel. 2 (V2) and Bhaskara (V3) were planted during 2103-14 at three different spacings, i.e. 2.5×2.5 m (S1), 5.0×5.0 m (S2) and 7.5×7.5 m (S3) and evaluated for morphological and yield traits. Similar cultural practices were followed for all the treatments as per standard package of practices. But severe pruning (heading back) was done in ultra density planting system to restrict the plant height and light pruning (criss-cross and overcrowded branches were removed) was practised in high and normal density planting at the end of May month.

The observations were recorded for growth traits such

as plant height (m), collar girth (cm), canopy spread (m), number of panicles per plant, panicle length (cm), panicle width (cm), panicle girth (cm) and yield traits like nuts per panicle, cashew apple weight (g), cashew apple length (cm), cashew apple width (cm), nut weight (g), nut length (cm), nut width (cm), yield per plant (kg/plant) and yield per ha (kg/ha). The yield per plant and yield per ha was recorded for three years and growth observations were recorded during fourth year after planting.

Statistical analysis

The experimental values were analyzed statistically by using factorial randomized block design (FRBD) with two factors and three replications. The data was analyzed statistically by using SPSS 16.0 version.

RESULTS AND DISCUSSION

Determining effect of variations due to genotypic, spacing and genotype by spacing interaction variations especially that of genotype by environment (spacing) interaction is very important to develop and release cultivars suitable to different planting systems in tree crops (Fox et al. 1997). In the current study, analysis of these three sources of variation on different vegetative and reproductive traits of cashew was studied in three varieties under three different spacings to identify suitable cultivars for ultra density planting. In ultra or high density planting, canopy management is an important aspect, which can be achieved by pruning as the tree grows (Singh et al. 2013). However, removal of plants is cost intensive and laborious which increases the cost of cultivation. On the other hand, pruning can lead to plant stress in less responsive cultivars leading to reduced productivity (Martin et al. 2015).

Plant height

Interaction effect of variety by spacing on plant height

Table 1 Performance of different varieties under different planting densities in cashew for growth traits and number of panicles per plant

		Plant l			Collar girth (cm)			Plant spread (m) Average of E-W and N-S				Number of panicles per plant				
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
V1	2.20	3.43	3.58	3.07	27.00	37.33	42.33	35.56	2.43	2.77	3.07	3.38	27.33	60.00	94.00	60.44
V2	2.42	3.68	3.82	3.31	33.33	37.00	46.00	38.78	3.68	4.00	4.87	3.93	40.33	103.00	212.33	118.56
V3	4.00	4.93	5.17	4.70	32.33	50.00	55.00	45.78	3.72	5.34	5.83	4.59	7.00	66.00	110.00	61.00
Mean	2.87	4.02	4.19		30.89	41.44	47.78						24.89	76.33	138.78	
	V	S	V*S		V	S	V*S		V	S	V*S		V	S	V*S	
CD (P=0.05)	0.379	0.379	NS		2.85	2.585	4.478		0.345	0.345	0.591		10.02	10.02	17.36	
CV %		10.	17			6.4	40			8.	67			12	2.43	

V1- H-130, V2- NRCC Sel. 2, V3 - Bhaskara, S1- 2.5×2.5 m, S2- 5×5 m, S3- 7.5×7.5 m

was studied in three cashew varieties at three spacings (2.5 \times 2.5 m, 5 \times 5 m and 7.5 \times 7.5 m). The results suggest that variety by spacing interaction on plant height was insignificant in the studied cashew genotypes under different spacing. However, the spacing had significant effect on plant height of cashew varieties at P=0.05 (Table 1). Additionally, significant differences were also observed for plant height among the three cashew genotypes in all the three spacing suggesting a genotypic effect on the plant height. Among the three varieties, Bhaskara recorded maximum mean plant height (4.70 m), it was followed by 3.31 m in NRCC Sel-2 (3.31 m) and 3.07 m in H-130 (Table 1). Similar results have been reported for plant height in the previous studies in cashew (Tripathy et al. 2015). The genotypic effect of variety on plant height was more pronounced in the plants under ultra density due to the heavy pruning suggesting that the pruning response of a cultivar is genetically determined. The genotypes which are less responsive to pruning produce excessive vegetative growth and poor reproductive traits and thus, yield poor.

Canopy spread

Effect of variety by spacing interaction on canopy spread was studied in three cashew varieties at three spacings (2.5 \times 2.5 m, 5 \times 5 m and 7.5 \times 7.5 m). The results suggest that genotype by spacing interaction on plant height was significant in the studied cashew genotypes under different spacing. Further, spacing and varieties also had significant effect on the canopy spread of the cashew varieties at P=0.05 (Table 1). The canopy spread increased with increasing spacing, i.e. the mean canopy spread of the three cashew varieties was 2.74 m in 2.5×2.5 m, 4.29 m in 5 \times 5 m and 4.83 m in 7.5 \times 7.5 m spacing. The very low canopy spread in ultra density planting compared to other two spacing can be attributed mainly to the pruning carried out to avoid overlapping of branches. The canopy spread determines the photosynthetic area which determines the photosynthetic capacity of a plant. Plants with larger canopies have higher photosynthetic capacity which allows better growth and yielding potential. These results suggest that canopy spread among the three cashew genotypes is influenced by genotype, spacing and genotype by spacing interaction effects.

Collar girth

Analysis of effect of variety by spacing interaction on collar girth of plants in three cashew varieties at three spacing $(2.5 \times 2.5 \text{ m}, 5 \times 5 \text{ m} \text{ and } 7.5 \times 7.5 \text{ m})$ suggest that genotype by spacing interaction on collar girth was significant. Further, both genotype and spacing also had significant effect on the collar girth of the cashew varieties at P=0.05 (Table 1). The collar girth increased with wider spacing, i.e. 30.89 cm in 2.5×2.5 m, 41.44 cm in 5×5 m and 47.78 cm in 7.5×7.5 m which can be attributed to the less competition between plants for moisture and nutrients under wider spacing and the reduced photosynthetic area in the ultra density due to pruning of canopy. In addition, significant differences were also observed in cashew varieties for collar girth at each of the spacing. Maximum mean collar girth of three spacing was observed in Bhaskara (45.78 cm) followed by 38.78 cm in NRCC Sel-2 and 35.56 cm in H-130. These results are in agreement with the earlier observations on spacing studies of other fruit tree crops such as mango (Gaikwad et al. 2017), guava (Brar et al. 2012; Bal and Dhaliwal 2003) and apricot (Kumar et al. 2013).

Number of panicles per plant

Number of panicles per plant is an important yield contributing trait in cashew. Analysis of genotype by spacing interaction on number panicles per plant in three cashew genotypes at three spacing ($2.5 \times 2.5 \text{ m}$, $5 \times 5 \text{ m}$ and $7.5 \times 7.5 \text{ m}$) suggests that genotype by spacing interaction has significant effect on number of panicles per plant. Further, analysis of both genotype and spacing also had a significant effect on the number of panicles per plant in the three cashew cultivars grown (Table 1). The number of panicles per plant increased with increasing plant spacing, *i.e.* the mean of panicles per plant of three cultivars was 24.89, 76.33 and 138.78 under 2.5 m \times 2.5 m, 5 m \times 5 m and 7.5 m \times 7.5 m spacing, respectively, suggesting that

Table 2 Performance of different cashew varieties for panicle traits under different planting densitie

	Panicle length (cm)			Pa	Panicle width (cm)			Panicle girth (cm)				Number of rachis per panicle				
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
V1	30.67	32.00	32.33	31.67	35.33	39.67	31.33	35.44	2.33	2.13	2.13	2.20	8.67	9.00	8.33	8.67
V2	21.00	24.00	25.50	23.50	29.00	28.33	29.67	29.00	1.60	1.27	1.43	1.43	4.67	5.33	5.00	5.00
V3	17.67	17.33	17.00	17.33	22.33	20.00	19.33	20.56	1.63	1.80	1.57	1.67	5.67	5.67	6.33	5.89
Mean	23.11	24.44	24.94		28.89	29.33	26.78		1.86	1.73	1.71		6.33	6.67	6.56	
	V	S	V*S		V	S	V*S		V	S	V*S		V	S	V*S	
CD (P= 0.05)	3.38	NS	NS		2.94	NS	NS		0.23	NS	NS		1.01	NS	NS	
CV %	13.86				10.28			12.84				15.30				

V1- H-130, V2- NRCC Sel. 2, V3 - Bhaskara, S1- 2.5 × 2.5 m, S2- 5 × 5 m, S3- 7.5 × 7.5 m

the increasing canopy size and number of shoots which provide enhanced availability of natural resources, *i.e.* space, light, moisture and nutrient thereby carbohydrates reserves in plants planted at larger spacing. Moreover, the number of panicles per plant also varied among the three genotypes in each of the spacing suggesting genetic effect on the number of panicles per plant. Similar results were observed in spacing studies of other fruit tree crops such as mango (Gaikwad *et al.* 2017), guava (Brar *et al.* 2012, Bal and Dhaliwal 2003) and apricot (Kumar *et al.* 2013).

Panicle morphology

Analysis of genotype by spacing interaction on morphology of panicle, i.e panicle length, panicle width, panicle girth and number of rachis per panicles in three cashew genotypes at three spacing $(2.5 \times 2.5 \text{ m}, 5 \times 5 \text{ m})$ and 7.5×7.5 m) suggest that genotype by spacing interaction has no significant effect on panicle morphology. Further, spacing also did not have a significant effect on the panicle morphology. However, the panicle morphology varied among the three varieties (Table 2). Suggesting that the differences in the panicle morphology are mainly due to the genetic effect rather than the spacing or genotype by spacing interaction. These results are similar to the observations in studies on spacing performance of different fruit crops such as mango (Gaikwad et al. 2017) and apricot (Dinesh et al. 2013). Among the three varieties, H-130 produces large size and sturdy panicles compared to other two varieties.

Cashew apple characters

The apple characters such as cashew apple weight (g), cashew apple length (cm) and cashew apple width (cm) was influenced by variety by spacing interactions. The significant differences were observed in different varieties of cashew which are grown under different spacing (Table 3). The maximum apple weight (117.1 g), apple length (6.53 cm) and apple width (5.27 cm) were found in variety H-130 which were planted at 5×5 m spacing and the minimum apple weight (72.14 g), apple length (5.30 cm) and apple width (4.43 cm) were noticed in H-130 is planted at $2.5 \times$ 2.5 m (Table 3). The least values of apple characters were noticed in ultra density planting system compared to other wider space planting. It is mainly because of more number of panicles per unit canopy area which leads to competition for nutrients among fruits within the panicle (Tripathy et al. 2015). Among the different varieties, H-130 recorded highest apple weight (102.12 g), apple length (6.03 cm) and apple width (4.94 cm) while lowest apple weight (80.53 g) and apple width (4.48 cm) was noticed in variety Bhaskara. It is mainly due to the genotypic character of the variety. With respect to spacing, the plants spaced at 5×5 m were recorded highest fruit weight (94.85 g), fruit length (6.16 cm) and fruit width (4.87 cm) and least values were observed in 2.5×2.5 m for apple weight (78.80 g) and apple length (5.61 cm). Similar observations were recorded in cashew (Tripathy et al. 2015) and other fruit crops like mango (Sousa et al. 2012, Gaikwad et al. 2017).

Table 3 Performance of different cashew varieties for cashew apple traits under different planting densities

		Apple w	veight (g)			Apple le	ngth (cm))	Apple width (cm)				
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	
V1	72.14	117.11	117.11	102.12	5.40	6.53	6.17	6.03	4.43	5.27	5.13	4.94	
V2	86.45	86.67	83.67	85.59	5.67	5.87	5.63	5.72	4.93	4.97	4.50	4.80	
V3	77.83	80.78	82.97	80.53	5.77	6.07	5.73	5.86	4.77	4.37	4.30	4.48	
Mean	78.80	94.85	94.58		5.61	6.16	5.84		4.71	4.87	4.64		
	V	S	V*S		V	S	V*S		V	S	V*S		
CD (P=0.05)	10.43	10.43	18.06		0.22	0.22	0.38		0.25	NS	0.44		
CV %	11.57					3.	.73		5.30				

Table 4 Performance of different cashew varieties for nut characters under different planting densities

	Nuts per panicle				Nut weight (g)				Nut length (cm)				Nut width (cm)			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
V1	8.67	9.33	9.67	9.22	10.82	13.02	13.32	12.39	3.43	3.50	3.63	3.52	2.13	2.43	2.55	2.37
V2	5.00	4.67	4.33	4.67	8.84	8.50	8.80	8.71	3.17	3.10	3.21	3.16	2.33	2.40	2.47	2.40
V3	10.00	8.33	8.33	8.89	8.54	8.42	8.20	8.39	3.47	3.17	3.13	3.26	2.33	2.57	2.53	2.48
Mean	7.89	7.44	7.44		9.40	9.98	10.11		3.36	3.26	3.32		2.27	2.47	2.52	
	V	S	V*S		V	S	V*S		V	S	V*S		V	S	V*S	
CD (P=0.05)	1.16	NS	NS		0.86	NS	1.48		0.16	NS	NS		NS	0.18	NS	
CV%	15.10				8.63			4.70				7.49				

V1- H-130, V2- NRCC Sel. 2, V3 - Bhaskara, S1- 2.5 × 2.5 m, S2- 5 × 5 m, S3- 7.5 × 7.5 m

Table 5 Yield performance of different varieties of cashew under different planting densities

		Yield per plant (kg)												
	_		2 nd	year			3 rd ye	ear		4 th year				
		S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean	
V1		0.78	2.12	2.82	1.91	1.40	2.67	3.75	2.61	1.52	3.03	4.09	2.88	
V2		0.15	1.05	2.73	1.31	0.39	1.50	3.22	1.70	0.46	1.81	3.51	1.93	
V3		0.01	1.38	2.82	1.41	0.04	1.84	3.58	1.82	0.10	2.05	3.84	2.00	
Mean		0.32	1.52	2.79		0.61	2.00	3.52		0.69	2.30	3.81		
		V	S	V*S		V	S	V*S		V	S	V*S		
C D (0.05)	(P =	0.09	0.09	0.16		0.10	0.10	0.18		0.12	0.12	0.20		
CV%			6.	.13			4.88	8		5.15				

V1- H-130, V2- NRCC Sel. 2, V3 - Bhaskara, S1- 2.5 × 2.5 m, S2- 5 × 5 m, S3- 7.5 × 7.5 m

Nut characters

Nuts is the economical part of cashew; the quality of nuts were mainly influenced by the genotype of the plant. There were no significant differences noticed among interaction effect of variety and spacing (Table 4). But the varieties showed significant differences for the nut characters. The number of nuts per panicle were maximum in variety H-130 (9.22), followed by variety Bhaskara (8.89) and minimum was noticed in NRCC Sel. 2 (4.67). There were no significant differences among different spacing and variety into spacing interactions. The results clearly indicate that the number of nuts per panicle was not influenced by the spacing which are genetic character of the variety. Similar observations were recorded in the earlier studies on density planting systems in cashew (Rejani et al. 2013, Tripathy et al. 2015). The maximum nut weight (12.39 g) and nut length (3.52 cm) was recorded in H-130 while minimum nut weight (8.39 g) was noticed in variety Bhaskara. The influence of spacing on nut weight and nut length for different varieties was not significant. However, in H-130, the nut weight increased with increasing plant spacing which could be attributed to competition for the nutrients, lesser penetration of sun light in ultra and high density planting compared to normal spaced plants. Similar results were observed by Mahesh et al. (2017) in guava. The increase in nut weight in normal planting which could be due to the lesser competition for the nutrients and other

growth resources. Similar findings were reported by Kumar *et al.* (2010) in apricots.

Nut yield per plant

The significant differences were observed for nut yield per plant with respect to variety, spacing and variety by spacing interactions under different planting densities (Table 5). In variety by spacing interaction, the variety H-130 planted at 7.5×7.5 m spacing recorded highest yield during 2^{nd} (2.82 kg), 3^{rd} (3.75 kg) and 4^{th} (4.09 kg) year of planting and minimum was noticed in variety Bhaskara planted at 2.5 × 2.5 m. The variety H-130 recorded highest mean yield per plant during 2nd (1.91 kg), 3rd (2.61 kg) and 4th (2.88 kg) year of planting, whereas minimum was noticed in variety NRCC Sel. 2. With respect to spacing, the plants planted at 7.5×7.5 m recorded maximum yield during 2nd (2.79 kg), 3rd (3.52 kg) and 4th (3.81 kg) year of planting and minimum was observed in 2.5×2.5 m spacing. The lower yields were noticed in variety Bhaskara and NRCC Sel.-2 in ultra density planting system suggesting that these varieties are not responding well for severe pruning required for ultra density planting. Similar results were reported by Brar et al. (2012) in guava and Rejani et al. (2013) in cashew.

Nut yield per ha

Production of cashew nuts per unit area is the main



Fig 2 Fruiting in H-130

objective of cashew growing farmers. The significant differences were noticed for yield per ha in variety by spacing interactions as well as in the varieties and different spacing (Table 6). The variety by spacing interaction analysis of yield per ha showed highest nut yield per ha in H-130, whereas as lowest nut yield per ha was noticed in Bhaskara planted under 2.5 × 2.5 m spacing. This could be attributed to its luxuriant vegetative growth with very low panicle bearing shoots suggesting its poor response to pruning in Bhaskara. The maximum yield per ha was recorded in H-130 during 2nd (865.29 kg), 3rd (1322.39 kg) and 4th (1455.98 kg) years of planting compared to other varieties which is mainly due to its ability to respond well to the severe pruning practiced under ultra density planting. Among different spacing, H-130 yielded maximum under 2.5 x 2.5 m spacing compared to

wider spacing in all the three years this could be mainly attributed to the more number of plants per unit area and the ability of H-130 to convert all newly emerging shoots into panicles. Similar findings were reported by Kumar *et al.* (2013) in apricot.

In conclusion, the study revealed that interaction effect of varieties by spacing was observed for most of the growth and yield related characters except plant height and nut traits. Among the three varieties, H-130 performs better under ultra high density conditions compared to the other two popular cultivars with respect to nut yield per ha suggesting H-130 is highly suitable for ultra density planting among the tested varieties. However, in the long run, development of dwarf varieties should facilitate highly efficient ultra density planting in cashew.

Table 6	Yield performanc	e of different v	varieties of cashew	under different	planting densities
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							Yield	per ha (k	g)						
			2 nd y	ear			3 rd	year		4 th year					
		S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean		
V1		1,248.00	849.33	498.55	865.29	2,234.67	1,069.33	663.16	1,322.39	2,432.00	1,212.00	723.93	1,455.98		
V2		245.33	418.67	483.21	382.4	624	600	570.53	598.18	736	724	620.68	693.56		
V3		21.33	552	499.73	357.69	64	734.67	633.07	477.25	154.67	820	679.68	551.45		
Mean		504.89	606.67	493.83		974.22	801.33	622.25		1,107.56	918.67	674.76			
		V	S	V*S		V	S	V*S		V	S	V*S			
C D 0.05)	(P =	26.80	26.80	46.42		109.15	109.15	189.05		79.93	79.93	138.44			
CV%			4.9	06			4.	88		8.80					

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REFERENCES

- Aneesa Rani M S, Jeeva S and Vaidyanathan R. 2011. Effect of pruning and foliar spray on growth and yield of cashew variety VRI 3. (In) *Ist International symposium on cashew nut, held at AC & RI, TNAU*, Madurai.
- Anonymous. 2017. Directorate of cashew nut and cocoa development board. http://www.dccd.gov.in.
- Anonymous. 2017. Indian Horticulture Database. http://www.nhb.gov.in.
- Bal J S and Dhaliwal G S 2003. High density planting studies in guava. *Haryana Journal of Horticultural Sciences* **32**: 19-22.
- Brar J S, Dhaliwal H S, Bal J S, Dhillon W S and Singh S P. 2012. Effect of spacing on canopy microclimate, vegetative growth and yield attributes in guava (*Psidium guajava L.*). *Journal of Horticultural Sciences* 7 (1): 41–45.
- Fox P N, Crossa J and Ramagosa I. 1997. Multi environment testing and genotype × environment interaction. (In) Kempton R A and Fox P N. (Eds.), *Statistical Methods for Plant Variety Evaluatio*, pp 117-138. London: Chapman & Hall.
- Gaikwad S P, Chalak S U and Kamble A B. 2017. Effect of spacing on growth, yield and quality of mango. *Journal of Krishi Vigyan* **5** (2): 50–53.
- Gunjate R T, Kumbhar A R, Thimaiah I M and Amin S M. 2009. Growth and fruiting of some mango cultivars under high density plantation in arid conditions of Gujarat. *Acta Horticulturae* **820**: 463–468.
- Kumar D, Ahmed N, Srivastava K K and Dar T A. 2010. Effect of planting density and varieties on growth, yield and quality of apricot. 4th Indian Horticulture Congress, New Delhi, p 298.
- Kumar D, Ahmed N, Verma M K and Dar T A. 2013. Growth, yield, quality and leaf nutrient status as influenced by planting densities and varieties of apricot. *Indian Journal of Horticulture*

- 70(2): 126-130.
- Kumar P B, Hari Babu K and Srihari D. 2015. Effect of time and level of pruning on flowering, fruit and yield of cashew (*Anacardium occidentale* L.). *Acta Horticulturae* **1080**: 245–262.
- Mahesh P, Shant L, Pankaj N and Prabhakar J. 2017. Response of high density spacing on physico-chemical quality and yield of guava (*Psidium guajava* L.) cv. Pant Prabhat. *International Journal of Agriculture Sciences* 9(9): 3962–3965.
- Martin M and Montes J M. 2015. Quantitative genetic parameters of agronomic and quality traits in a global germplasm collection reveal excellent breeding perspectives for *Jatropha curcas* L. *GCB Bioenergy* 7: 1335–1343.
- Mohan E and Singh R. 1988. Effect of time and severity of pruning in cashew. *Proc. of VIII Symposium on Plantation Crops*, pp 7-10.
- Murali K, Prasanna Kumar P and Aneesha Rani M S. 2015. Effect of tertiary shoot pruning and foliar spray of nutrients on flowering and yield of cashew under high density planting system. *Bioscan* **10**(1): 411–415.
- Rejani R, Adiga J D and Yadukumar N. 2013. Performance of different varieties of cashew under high density planting system. *Journal of Plantation Crops* **41**(1): 28–33.
- Saroj P L and Nayak M G. 2016. High density orcharding in cashew. *Cashew Week* 16: 13–14.
- Singh B, Singh K, Rejeshwar Rao G, Chikara J, Kumar D, Mishra D K, Saikia S P, Pathre U V, Raghuvanshi N and Rahi T S. 2013. Agro-technology of *Jatropha curcas* for diverse environmental conditions in India. *Biomass Bioenergy* **48**: 191–202.
- Sousa C A F D, Cavalcanti M I L G, Vasconcelos L F L, Sousa H U D, Ribeiro V Qand Silva J A L D. 2012. 'Tommy Atkins' mango trees subjected to high density planting in subhumid tropical climate in northeastern Brazil. *Pesquisa Agropecuária Brasileira* 47(1): 36–43.
- Tripathy P, Sethi K, Patnaik A K and Mukherjee S K. 2015. Nutrient management in high density cashew plantation under coastal zones of Odisha. *International Journal of Bio-resource and Stress Management* 6 (1): 93–97.
- Yadukumar N, Rao E V V B and Mohan E. 2001. High density planting of cashew. *Tropical Agriculture* **78**: 19–28.