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## Studies on effect of rootstocks on root distribution pattern of cashew

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**Abstract**

The present investigation on the root distribution pattern of cashew rootstocks was carried out at ICAR-Directorate of Cashew Research (DCR), Experimental Station, Santhigodu, Karnataka. The study aimed to understand the root distribution of two dwarfing rootstocks (NRC 492, Taliparamba- 1) and one vigorous rootstock (Vengurla-4) of eight-years-old cashew tree, as determined by the root excavation method. The root samples were collected vertically from different depths (0-200 cm) and laterally at different distances (0-300 cm) from the tree trunk. Results indicated that the root distribution pattern showed significant genotypic variation. Regarding the vertical distribution of roots, 95 percent of the roots were distributed in 0-100 cm horizons, while very few roots were in the 100-200 cm horizons. In the lateral distribution, 97 percent of root density was in the 0-200 cm area from the tree trunk. Vengurla-4 (vigorous rootstock) had a higher root length, root volume and two-fold increases in total root production compared to dwarf rootstocks. PCA study revealed that the selection of rootstocks based on tree height, TCSA, canopy spread, lateral and vertical distribution of roots represent the main morphological indices for evaluating the effect of cashew rootstocks.

**Keywords:** Cashew, rootstocks, vertical distribution, lateral distribution, PCA

**Introduction**

Cashew (*Anacardium occidentale* L.), an evergreen tropical tree is adapted to the coastal areas of the western and eastern peninsular India. Presently, the cashew is grown in the country in an area of 10.62 lakh ha with the annual production of 8.17 lakh MT of raw nut and its average productivity of 753 kg ha<sup>-1</sup>. To meet the requirements of the processing industry, India imported 5.92 lakh MT of raw nuts valued at Rs 1811 Crores from African and Asian countries (Anon, 2019) [1]. Therefore, to ensure the steady supply of raw cashew nut domestically, it is important to increase the local production in India by adopting some important strategies such as quality planting material of improved/ high yielding varieties, high-density planting, integrated nutrient, pest and disease management to achieve the same. High Density Planting (HDP) is one of the improved productions technologies; it refers to the maximum utilization of available space by accommodating a greater number of trees per unit area for maximum production and productivity. Dwarf rootstocks are considered useful, economical and eco-friendly practices to control the vigour of tree in HDP system. Positive effect of rootstocks on scion-vigour management and productivity of HDP orchard was reported in several deciduous (apple, peach) and evergreen trees (mango, cashew, lemon, and pomegranate) (Webster, 1995) [16]. Root distribution patterns are considered essential to aid in the selection of rootstocks (Black *et al.*, 2010) [3]. The root distribution pattern of trees varies from region to region and it is influenced by species, age of the tree, season, soil properties and other cultural practices (Singh *et al.*, 2012) [12]. The structural relationship between the rootstock and scion shows the relationship between vigour reduction of rootstocks and dry matter content of the root (Bithell *et al.*, 2016) [2]. Several previous reports are available to determine the cashew rooting pattern (Tsakiris and Northwood, 1967; Vidyadharan and Peethambaran, 1979; Harishu Kumar and Khader, 1985; Khader, 1986; Wahid *et al.*, 1989, Salam *et al.*, 1995 and Yadhukumar, 2001) [13, 14, 5, 6, 15, 10, 17] but not to compare rootstocks. Earlier studies have shown that the root distribution pattern of cashew depends on the climate, planting material, tree age, type of soil and fertility, irrigation *etc.* (Kumar and Khader, 1985, Tsakiris and Northwood 1967,

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Vidyadharan and Peethambarm, 1979 and Yadhukumar, 2001) [8, 13, 14, 17]. Precise information on root distribution in the rootstock decides the plant density, irrigation as well as to explore the possibility of using the subsoil resources of the soil and intercultural operations. However, root distribution pattern in cashew rootstocks is not well known under rain fed conditions. In this study, we examined the differences in root distribution patterns of cashew rootstocks and the relationships between scion vigour and yield.

### Materials and methods

The present investigation was undertaken during the year 2016 in Experimental Station of Directorate of Cashew Research (DCR), Puttur, Dakshina Kannada District, Karnataka, India (latitude 12° 46'36"N, longitude 75° 16'08" and altitude 72 m above MSL) in the soft wood grafted plants which were field planted in 2008 at a closer spacing of 6m x 6m (278 trees/ha). Root excavation studies were carried out on eight year old cashew plants softwood grafted on rootstocks which comprised of dwarf types like NRC 492 and Taliparamba-1 along with vigorous rootstock Vengurla-4.

### Root sampling

Uniform and healthy trees were selected for excavation of roots on July-August, 2016; 3m away from the trunk and all surface debris were removed. A hand-driven auger was used to collect the soil samples containing roots. The lateral distribution of roots was collected at 3m from the trunk, using the excavation method. Lateral distribution was made up of intervals of 100 cm, providing three sample portions of R<sub>1</sub>: 0-100 cm, R<sub>2</sub>: 100-200 cm, and R<sub>3</sub>: 200-300 cm. Each portion was excavated for four depths viz., D<sub>1</sub>: 0-50 cm, D<sub>2</sub>: 50-100 cm, D<sub>3</sub>: 100-150 cm, and D<sub>4</sub>: 150-200 cm. Three trunk distances and four sampling depths and four directions provided forty-eight samples per tree (Fig.1). The roots from each block of soil were washed and dried in an oven at 70°C for 48 hours. Based on root diameter, the roots were classified into four size categories, such as feeder (>0.2cm), thin (0.2-0.5 cm), medium (0.5-1.5 cm) and thick (< 1.5cm). The density of roots spread laterally and vertically were determined in terms of dry weight per soil volume and the same was calculated for the total root spread and depth of the tree. The mean root distributions between the rootstocks were compared by the chi-square test. The principal component analysis (PCA) was done using the SAS statistical program (version 9.3) to determine the relationship between rootstock root distribution vs. vigour and yield of different stionic combinations.

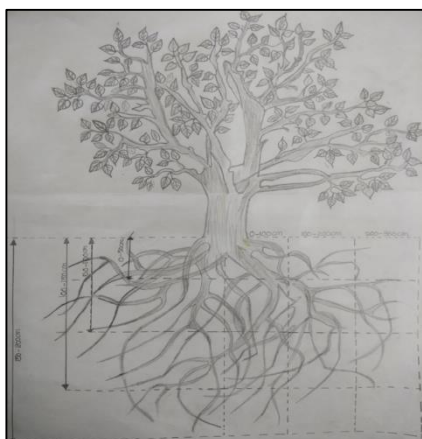


Fig 1: Root distribution Patten of cashew rootstocks

## Results and Discussion

### Root distribution

Root distribution at different distances from the tree trunk viz., 0-100cm, 100-200 cm and 200-300 cm and soil depth is viz., 0-50cm, 50-100 cm; 100-150 cm and 150-200 cm revealed that 8 eight year old field planted cashew rootstocks had an extensive root system, spread over an area of 300 cm in lateral and 200 cm vertically from the soil surface (Fig 2 and Fig.3). The dry weight of roots of rootstocks ranged from 3.48 kg to 6.90 kg/ trees.

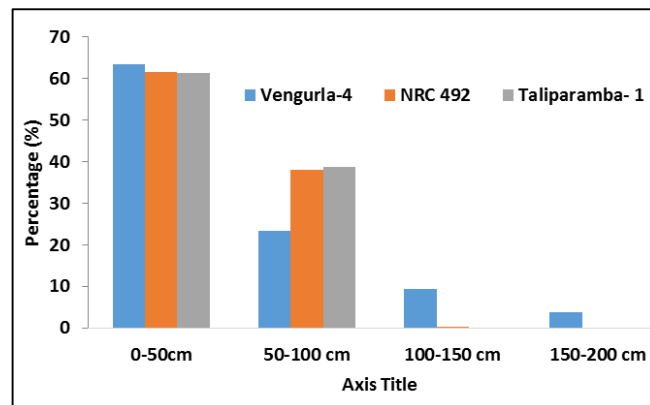


Fig 2: Effect of rootstocks on vertical distribution of roots

### Vertical distribution of roots

Cashew rootstocks varied for the root penetration and distributions of the roots at different horizons of the soil profile. The roots of Vengurla-4 rootstock showed a uniform distribution of the root between the four horizons, 86.39 percent of roots found within horizons of 0-100 cm (D<sub>1</sub> and D<sub>2</sub>), while 13.31 per cent of roots in 100 to 200 cm horizons (D<sub>3</sub> and D<sub>4</sub>), indicating a deep root architecture than NRC 492 and Taliparamba-1 (Fig. 2). Although Taliparamba-1 and NRC 492 were classified as dwarfing rootstocks, they had lower root penetration in the lower horizons (100-200 cm), with 99 per cent of roots in the 0-100 cm horizons (D<sub>1</sub> and D<sub>2</sub>). The present study indicated that the maximum amount of root was found in the surface soil layer (D<sub>1</sub>: 0-50 cm depth). This is in accordance with the findings of Salam *et al.* (1995) [10], who reported about 89.3 per cent of roots of cashew in the surface horizon of 100 cm. Tsakiris and Northwood (1967) [13] reported that the 3 ½ years old cashew trees tap root extend to a depth of 2.3m from ground surface. Khader (1986) [6] studied the root distribution pattern of 10-year cashew trees by soil excavation method and reported that 90 percent of cashew roots are found within 1m depth and the maximum depth of roots extended was 9.5m. Apart from the (dwarf) nature of root stock, the soil texture also may play an important role in vertical distribution of roots (Vidyadharan and Peethambaran, 1979 and Harishukumar and Khader, 1985) [14, 5].

### Lateral distribution of roots:

Overall, approximately 97% of lateral roots spread were recorded at 0-200cm from the tree trunk. Vengurla-4 rootstock recorded a lateral spread of 200-300cm (R<sub>3</sub>) from the trunk, but beyond this distance no roots were available. Whereas, Thalibaramba-1 recorded 94.25 per cent of the total roots within 100 cm radius (R<sub>1</sub>) from the tree trunk and the remaining 5.75 per cent was occurred within a radius of 100-300cm (R<sub>2</sub> and R<sub>3</sub>) around the trunk. In NRC-492, 85 per cent of the total roots occurred at a distance of 0-100cm (R<sub>1</sub>) from

the trunk and the remaining 15 percent occurred in a radius of 100-200cm ( $R_2$ ) around the trunk (Fig.3). The present study indicated that the maximum of roots was found in 100cm ( $R_1$ ) radius from the tree trunk. Similar observations have been reported by Singh and Chandra (2009) [11] in acid lime. Salam *et al.* (1995) [10] reported a maximum root activity of 89.3 per cent at a depth of 100 cm vertically with a radius of 300 cm in 19-year-old cashew plantations raised from seedling. The lateral spread of the cashew roots varied with age of the tree (Tsakiris and Northwood, 1967) [13], who found that the lateral spread of roots was up to 1.2m in an 18-month tree, 4.6 m in a 2 ½ years old tree and 5.6m in 6-year-old cashew trees.

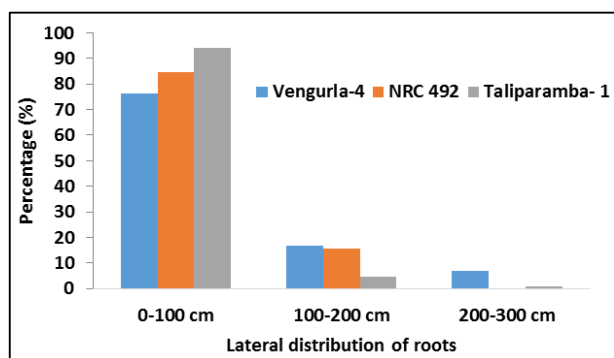


Fig 3: Effect of rootstocks on lateral distribution of roots

### Dry weight percentage of roots

The vertical, lateral spread of roots was determined on dry weight basis and the results revealed that rootstock had a pronounced effect on the total dry weight of root (data not shown). The effect of rootstocks on dry root weight percentage is shown in Fig.4. The increases in depth of the roots between the rootstocks have been associated with concomitant increases in many feeder roots. However, the highest total dry root weight (6.90 kg) was associated with a deeper and more vigorous rootstock (Vengurla-4). The root systems of dwarf rootstocks were intermediate, but in most cases, they had some characteristics more similar to one or the other. The dwarf rootstock (NRC 492) had a deep but dense root system compared to Thalibaramba-1. The maximum dry weight of thick roots was observed between 0-100 cm from the trunk. Similar results were earlier reported in cashew by Tsakiris and Northwood (1967) [13]. The percentage of the total dry weight of the roots were found in the following order; thick roots (54.10 %) > thin roots (15.66%) > medium roots (14.81%) > feeder roots (13.29 %). Yadhukumar (2001) [17] reported 80 per cent of root activity in a radius of 1.2m from the trunk with maximum fine roots (active roots-16.78%) in a radius of 60-120cm laterally under irrigated conditions in cashew. The root spread study conducted in the present trial indicated that vigorous rootstock (Vengurla-4) recorded higher root length, root volume and two-fold increases in the total root production compared to dwarf rootstocks. The study indicated that dwarf rootstocks can be utilized for propagating vigorous cultivars which are intended to be used for high density planting as dwarf rootstocks can reduce the spread of roots avoiding root completion under

high density planting system. Further vigorous rootstocks should not be utilized when the intention is to go for high density planting.

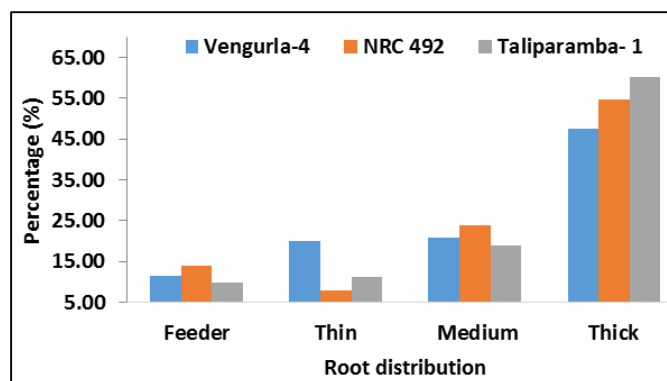


Fig 4: Effect of rootstocks on dry weight percentage of fibrous, thin, medium and thick roots

### Principal Component Analysis

In the present investigation, various quantitative characteristics of cashew rootstocks were studied using PCA tool to find out the correlation coefficients of growth, yield, and root distribution characteristics. The results revealed that the canopy spread had a significant and positive correlation with scion growth (TCSA, tree height) and yield. At the same time, the vertical and lateral root distribution of rootstocks were negatively correlated to the canopy spread (Table 1) which means that the increase in yield is directly influenced by the increase in canopy spread, TCSA, tree height. TCSA and tree height had a positive correlation with the growth, root distribution, and yield of rootstocks, indicating a strong association of two characters. A similar positive correlation between TCSA for growth and yield was reported by Black *et al.* (2010) [3] in cherry, Kumar *et al.* (2014) [7] in apricot. Depth of rootstocks correlated to tree height; the taller tree has deep root system. Similar results were reported in citrus rootstock by Castle and Krezdron (1975) [4]. The cashew nut yield ( $t\ ha^{-1}$ ) was significantly and positively correlated with canopy spread, TCSA, tree height, lateral distribution of roots (200-300cm), vertical distribution of roots (100 -200cm). In contrast, it was negatively correlated with the later distribution upto 0-200 cm and vertical distribution of roots upto 0-100 cm. This indicates that these parameters did not contribute significantly to the yield. Therefore, the results showed that the selection of rootstock based on these traits can lead to higher yield per tree. These findings are close agreement with the findings of Salam *et al.* (1995) [10] in cashew, Kumar *et al.* (2014) [7] in apricot. Salam *et al.* (1995) [10] found that the cashew tree develops an extensive root system and 89.3 percent of the roots occur 300cm laterally and 100 cm vertically. The root density reduction concerning the lateral distance suggests that the fertilizer application should be done 300 cm laterally around the tree. However, Harishukumar and Khader (1985) [5] reported that the development of the cashew roots system mainly depends on soil texture.

**Table 1:** Principal compound analysis (PCA) for the relationship between the cashew rootstocks on growth, yield and root distribution pattern

	CS	LH	LTH	LTW	TCSA	TRHT	VF	VH	VOF	VTWH	YLD
CS	1.0000	-0.0816	-0.0840	-0.0744	<b>0.8837</b>	<b>0.8869</b>	-0.0824	-0.0110	-0.0851	-0.0847	0.4598
LH		1.0000	0.8925	0.9768	0.0863	0.1555	0.9994	0.4123	0.9315	0.9158	-0.1234
LTH			1.0000	0.7751	0.0671	0.1244	0.9077	-0.0428	0.9954	0.9985	0.0725
LTW				1.0000	0.0890	0.1587	0.9687	0.5980	0.8319	0.8085	-0.2074
TCSA					1.0000	0.8879	0.0855	0.0556	0.0724	0.0702	0.3328
TRHT						1.0000	0.1543	0.0931	0.1332	0.1296	0.3153
VF							1.0000	0.3803	0.9436	0.9293	-0.1093
VH								1.0000	0.0526	0.0118	-0.4199
VOF									1.0000	0.9992	0.0324
VTWH										1.0000	0.0496
YLD											1.0000

Canopy spread, Lateral spread (100cm), Lateral spread (300cm), Lateral spread (200cm), Trunk Cross-Sectional Area, Tree height, Vertical spread (0-50cm), Vertical spread (50-100cm), Vertical spread (100-150cm), Vertical spread (150-200cm), Yield ( $t\ ha^{-1}$ )

## Conclusions

The root distribution pattern of vigorous/ dwarfing rootstocks of cashew examined in eight-year-old cashew plantation. The results indicated the potential benefits of dwarf rootstocks in view of reduced lateral spread and volume which could prevent the root competition under high-density planting systems. This would make the high-density planting system a sustainable option. The principal compound analysis revealed that the selection of rootstocks based on tree height, TCSA, canopy spread, lateral and vertical distribution of roots represents the main morphological indices to evaluate the effect of cashew rootstocks.

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