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Determination of root distribution in *ber* (*Ziziphus mauritiana*) by root excavation*

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A powerful root system, its wide and deep distribution in the soil and a persistent and adequate annual growth of absorbing roots are the principal prerequisites of abundant fruit bearing. The knowledge of root distribution pattern is very helpful in allocating inputs like fertilizers, irrigation and to determine intercultural operations in the orchards. It has been experimentally proven that root distribution pattern varies from region to region and is influenced by such factors as age of plant, season of the year, plant species, fluctuation in water-table and properties of soil. Although time consuming and labour intensive, root excavation methods are widely used for the study of root distribution patterns in fruit trees. Root excavation methods are mechanically simpler and require instruments which are ordinarily available at the site of the experiments. Jujuve or *ber* (*Zizyphus mauritiana* Lamk.) is a perennial fruit crop cultivated in arid and semi-arid regions of India. It is mainly cultivated in northern India due to its rich nutritive value and hardiness to adverse climatic conditions. *Ber* cv. 'Gola' is finding great favour with fruit growers in Sikar district of Rajasthan because of its good quality fruits particularly its taste, mellowness and attractive appearance of the fruit and also it can be successfully grown in hot arid climate. To date, however, there is scanty and preliminary information available on its root distribution pattern in the arid irrigated parts of Rajasthan.

Experiments were carried out on nine-year old trees of 'Gola' during post rainy (October 2007) and spring season (March 2008) at farmer's orchard in Purohit Ka Bas village in Sikar district of Rajasthan. Three uniform trees were selected for excavation. In each experimental tree of *ber*, a circle with a radius of 2.40 m from the tree trunk was marked and soil was excavated from 1/4th portion of the area of circle. The 2.40 m radius was further sub-divided into 0–80 cm (R_1), 80–160 cm (R_2) and 160–240 cm (R_3) portions. Each portion was excavated for three depths, viz 0–25 cm (D_1), 25–50 cm (D_2) and 50–75 cm (D_3). The average plant height of experimental trees was recorded 391 cm and spread of tree from north to south and east to west were 599 cm and 557 cm, respectively. Roots were collected from each combination of depth and radial distance separately and washed. After washing, roots were graded in four categories on the basis of their diameter. Its diameter was measured by Vernier calipers and then divided into four categories, (i) less than 0.2 cm diameter (t_1), (ii) more than 0.2 cm to 0.5 cm diameter (t_2), (iii) more than 0.5 cm to 1.5 cm diameter (t_3), and (iv) more than 1.5 cm diameter (t_4). These categories were designated as feeder, thin, medium and thick, respectively.

Roots were kept in an oven at 70°C for 72 hr for drying and were then weighed. The density of roots on dry weight basis was calculated in terms of per cubic meter volume of soil. It was obtained by multiplying the amount of dried roots (g) obtained at 0–80 cm, 80–160 cm and 160–240 cm radial distances with 7.9617, 2.6539 and 1.5923, respectively. In case of types of roots, it was obtained by multiplying the quantity of roots obtained (g) at 0–80 cm, 80–160 cm and 160–240 cm radial distances with 2.6539, 0.8846 and 0.4423, respectively. The distribution of roots on weight basis at different radial distances and soil depths was tested in factorial RBD experiment. Meteorological data of temperature and relative humidity during the experiments were collected from the meteorological observatory at Agricultural Research Station, Fatehpur Shekhawati, district Sikar (Rajasthan).

During spring season significantly higher quantity of roots were found at R_1 as compared to other distances from tree trunk (Table 1). Quantity of roots at R_1 was 86.72%, followed by 11.22% at R_2 and 2.06% at R_3. During post-rainy season also, distribution of roots was in the same trend and 71.20% of total roots were found at R_1 (Table 1). Similar observations

*Short note

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have been reported by Chandra and Singh (1979) in Eureka lemon, Chandra and Yamdagni (1997) in Kinnow Mandarin. Mishra *et.al*. (2003) in grapefruit, Bhatnagar and Chandra (2001) and Hiwale (2002) in *ber* where root density was much higher at the nearest distance from tree trunk taken in excavation studies. Rohitash (2007) also reported in aonla that distribution of feeder roots was observed 71.54% at nearest radial distance from tree trunk (0–70 cm).

Data presented in Table 1 revealed that during spring season 54.57% of total roots was found at D_3 soil depth, followed by D_2 (34.70%) and D_1 (10.73%). During post-rainy season also, significantly higher quantity of roots was observed at D_2 (36.07%), followed by D_1 (32.91%) and D_3 (31.02%) as shown in Table 1. The present studies also indicate that maximum quantity of roots was found at deeper soil depths, viz 25–50 cm to 50–75 cm soil depths. Similar findings have been reported by Chandra and Yamdagni (1997) in kinnow mandarin, Bhatnagar and Chandra (2001) in 'Gola' *ber* and Rohitash (2007) in aonla.

On dry root weight basis, medium and thick types of roots comprised 94.01 and 84.44% of total roots during spring and post rainy season, respectively. Thin roots were also maximum at the nearest distance from tree trunk and it decreased as distance from tree trunk increased during both the seasons. Similar trend was also observed for feeder roots distribution at different distance from tree trunk.

The interaction between radial distance and types of roots indicates that maximum quantity of roots at R_1 was of t_4 type of roots (> 1.5 cm diameter), ie 77.95 and 39.45% (Table 2) which were significantly higher than the other three types of

Table 1 Distribution of roots in *ber* at different radial distances from tree trunk and at varying soil depths during spring and post-rainy season (g/m^3 of soil volume)

Distance from tree trunk (cm)	Soil depth (cm)			
	0–25 (D_1)	25–50 (D_2)	50–75 (D_3)	Mean
Spring season				
0–80 (R_1)	1 921.42 (9.70%)	5 995.15 (30.26%)	9 264.76 (46.76%)	5 727.11 (86.72%)
80–160 (R_2)	141.54 (0.71%)	797.05 (4.02%)	1 284.48 (6.48%)	741.02 (11.22%)
160–240 (R_3)	63.15 (0.32%)	82.79 (0.42%)	262.19 (1.32%)	136.05 (2.06%)
Mean	708.70 (10.73%)	2 291.67 (34.70%)	3 603.81 (54.57%)	
CD (*P*=0.05): Depth (D)= 189.68; distance (R) =189.68; interaction (R×D) = 328.54				
Post-rainy season				
0–80 (R_1)	3 585.41 (24.08%)	3 503.14 (23.53%)	3 513.76 (23.60%)	3 534.10 (71.20%)
80–160 (R_2)	1 189.83 (7.99%)	1 535.72 (10.31%)	667.89 (4.49%)	1 131.15 (22.79%)
160–240 (R_3)	125.25 (0.84%)	332.26 (2.23%)	437.88 (2.94%)	298.46 (6.01%)
Mean	1 633.50 (32.91%)	1 790.37 (36.07%)	1 539.84 (31.02%)	
CD (*P*=0.05): Depth (D)= 109.81; distance (R) = 109.81; interaction (R×D) =190.20				

Table 2 Distribution of different types of roots at different radial distances from tree trunk in *ber* trees on the basis of dry weight of roots during spring and post-rainy season (g/m^3 of soil volume)

Root diameter (cm)	Distance from tree trunk (cm)			
	0 – 80 (R_1)	80 – 160 (R_2)	160 – 240 (R_3)	Mean
Spring season				
<0.2 (t_1)	111.46 (1.61%)	34.49 (0.50%)	18.72 (0.27%)	54.89 (2.38%)
>0.2 – 0.5 (t_2)	163.65 (2.37%)	54.25 (0.78%)	31.25 (0.45%)	83.05 (3.60%)
>0.5 – 1.5 (t_3)	353.85 (5.12%)	43.63 (0.63%)	0.00 (0.00%)	132.49 (5.75%)
>1.5 (t_4)	5 388.30 (77.95%)	603.29 (8.73%)	109.69 (1.59%)	2033.76 (88.26%)
Mean	1 504.32 (87.05%)	183.92 (10.64%)	39.91 (2.31%)	
CD (*P*=0.05): = Distance (R) = 39.02; Types of roots (t)= 33.79; Interaction (R×t) =67.58				
Post-rainy season				
<0.2 (t_1)	190.19 (3.76%)	72.83 (1.44%)	44.67 (0.88%)	102.56 (6.08%)
>0.2 – 0.5 (t_2)	268.92 (5.31%)	148.61 (2.93%)	62.36 (1.23%)	159.96 (9.48%)
>0.5 – 1.5 (t_3)	1 066.86 (21.07%)	213.77 (4.22%)	93.76 (1.85%)	458.13 (27.14%)
>1.5 (t_4)	1 997.50 (39.45%)	711.80 (14.06%)	192.40 (3.80%)	967.23 (57.30%)
Mean	880.87 (69.58%)	286.75 (22.65%)	98.30 (7.76%)	
CD (*P*=0.05): = Distance (R) = 25.78; types of roots (t)= 22.33; interaction (R×t) =44.66				

roots, ie t_3, t_2 and t_1 in spring and post-rainy season, respectively. At R_2 radial distance, also maximum quantity of roots was of t_4 types which were also significantly higher than the t_3, t_2 and t_1 types of roots in both seasons. At R_3 radial distance, there were no statistically significant differences observed in feeder (<0.2 cm diameter) and thin (0.2–0.5 cm diameter) types of roots. The t_3 type of roots were completely absent at R_3 radial distance.

It may be inferred from the data that on dry root basis, quantity of thick type of roots comprised 88.26 and 57.30% of total roots found during spring and post-rainy season, respectively. Quantity of thick and medium type of roots at R_1 was 77.95, 5.12% and 39.45 and 21.07%, respectively of total roots found during spring and post-rainy season.

The mean value of feeder roots of *ber* found during post rainy season was 102.56 g/m^3 of soil volume (6.08%) which was higher than mean value of feeder roots during spring season 54.89 g/m^3 of soil volume (2.38%). The greater quantity of feeder roots during post-rainy season might be due to congenial conditions for better top and root growth under north Indian conditions which coincides with active growth period of leaf, flower and fruit development from July to November in *ber* and good moisture availability. The greater amount of thick roots during spring season might be due to poor soil moisture availability and destruction of the feeder root system at higher temperature. Bhatnagar and Chandra (2001) in 'Gola' *ber* reported the similar findings.

SUMMARY

The rooting pattern studies on nine years old trees of 'Gola' *ber* were carried out during post-rainy season (October 2007) and spring season (March 2008). It was observed that root density was found maximum at nearest radial distance from tree trunk, ie 0–80 cm (71.20 and 86.72% during post-rainy and spring season, respectively) and an increase in distance from the tree trunk resulted in reduction of root density considerably. It was also observed that maximum root density was found at deeper soil layers ie at 25 – 50 cm soil depth during post rainy and at 50 – 75 cm soil depth during spring season. Thick (> 1.5 cm in diameter) and medium (> 0.5–1.5 cm in diameter) comprised major amount of roots during both seasons. The amount of thick type of roots was more during spring season as compared to post rainy season. Distribution of feeder roots (< 0.2 cm in diameter) revealed that these were maximum at 0–80 cm distance from tree trunk during post rainy and spring season. Thus, it emphasizes the need to maintain adequate moisture in *ber* orchard during spring and summer months. The fertilizer application should be done during post-rainy season for efficient use of nutrients.

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