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Root length, root mass, and distribution of dry matter in different parts of Thompson Seedless grapevine grafted on different rootstocks in heavy soil of Maharashtra

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Abstract: The root distribution pattern of 3 grape rootstocks, Dog Ridge, Salt Creek, and St. George, grafted with Thompson Seedless grapevine was studied at the National Research Centre for Grapes in Pune, India. The soil is heavy black cotton soil (vertisol) with a pH of >8.0. Roots of different thicknesses (<2 mm, 2-5 mm, 5.01-10 mm, and >10 mm) were examined at horizontal distances of 0-30 cm, 31-60 cm, 61-90 cm, 91-120 cm, and 121-150 cm away from the trunk and also to depths of 0-30 cm, 31-60 cm, and 61-90 cm from the surface. Among the different categories of roots, Dog Ridge put forth the maximum root length in the <2 mm category at a distance of 0-30 cm from the trunk, while at a distance of 31-60 cm, Salt Creek had the maximum root length in the <2 mm category. The total root length at 2-5 mm was at its maximum at 31-60 cm of distance in both Dog Ridge and St. George. The total root length at 5.01-10 mm was highest in Dog Ridge, followed by Salt Creek and St. George, at distances of 31-60 cm and 61-90 cm from the trunk. We could observe the spread of thicker roots (>10 mm) up to a 60-cm distance, beyond which there was no spread in any of the rootstocks. At a depth of 0-30 cm, Dog Ridge put forth the greatest root mass, followed by Salt Creek and St. George. However, the highest root mass was recorded in all of the rootstocks at depths of 31-60 cm. Dry matter accumulation was highest in Thompson Seedless grafted on Dog Ridge, and Salt Creek was next. Dog Ridge rootstock grafted vines had more dry matter in the roots, trunk, primary arms, and canes while St. George had the least dry matter in roots.

Key words: Dry matter, grape rootstocks, root length, root mass, saline soil

Introduction

The functions of grapevine roots include anchorage, storage of reserves, uptake and translocation of water and minerals, and supply of growth substances (Richard 1983). Most grapevine roots occur in the top 100 cm of the soil, although individual roots might penetrate to a depth of 600 cm or even more. The anatomy, morphology, development, and distribution of root systems, which largely depend on genetic properties, may be different in different rootstock species.

With continuous drought prevailing in the grape-growing region and a build-up of salinity in the soil, the use of rootstocks in grape cultivation is becoming essential. The root system has an important physiological and biological function and it has been shown that both grape yield and quality are dependent upon the health status of the roots (Morlat and Jaquet 1993). Soil management factors such as aeration, texture, water and nutrient availability, mulching, and organic matter content affect the root distribution of grapevines (Richards 1983).

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Roots provide the vine with the water and nutrient requirements for healthy growth, and the uptake of both depends on the intensity with which the roots explore the soil (Stevens and Nicholas 1994). In addition, the functioning of these roots also depends upon the grapevine cultivars or rootstocks (Perry et al. 1983; Nagarajah 1987; Morano and Kliewer 1994). Studies of the different grapevine cultivars have shown that the soil environments can influence the root distribution (Nagarajah 1987; Van Huyssteen 1988; Southey 1992). The different genotypes of rootstock may behave differently in the homogeneous condition of soils (Perry et al. 1983). It has been pointed out that edaphic conditions determine the root distribution in soil profiles while genetic factors determine root density (Southey and Archer 1988; Williams and Smith 1991), and hence different rootstocks may have different patterns of root distribution. Although research on root distribution of grape rootstocks is considerably meagre, it has received a little attention in the past century. The study of different rootstocks and the dry matter in different parts of the vine helps in understanding the vine requirements of water and nutrients and the supply of root-synthesised hormones. Considering this, the present investigation was carried out to study the root parameters and dry matter distribution in Thompson Seedless grafted on different rootstocks.

Materials and methods

The study was conducted at the farm of the National Research Centre for Grapes, Pune, India, during the years 2004 and 2005. Six-year-old Thompson Seedless grapevines grafted on 3 rootstocks (Dog Ridge, Salt Creek, and St. George) were selected for the study. The vines are pruned twice in a year. The first, called back pruning, is done in April after harvest to develop canes on which fruit bud differentiation takes place. The other pruning is done in September or October on the canes that developed in the previous season. This pruning is called fruit pruning or forward pruning. The experiment site is situated in mid-western Maharashtra at 18.32°N, 73.51°E. The soil of the experimental vineyard is black (Vertisol), with a pH of 7.75 and an electrical conductivity (EC) of 0.46 ds m^{-1} (Sharma and Upadhyay 2005).

The vines were trained onto extended Y trellises having double cordons placed horizontally. The shoots in this training system were placed vertically on the cordon. The spacing between rows was maintained at 3.05 m, with 1.83 m between vines. The vines were irrigated using a drip system, with 2 drippers placed 45 cm away from the trunks on both sides along the row. Irrigation and fertigation were given as per a schedule developed for heavy black cotton soil according to the growth stage of the vine. The vineyard was kept weed-free by spraying herbicides between the rows and by hand-weeding along the rows using garden hand tools without much disturbance to the root system. About 10-15 days before each pruning, shallow trenches of 0.60 m × 1.20 m were dug to a depth of 7.5-10.0 cm on either side of the trunks along the row to apply a mixture of green manure, compost, and oil cakes. The trial was laid out in factorial randomised block design with rootstocks and different depths as 2 factors with a single vine plot.

Root distribution studies

Just before the fruit pruning, the root excavation was started and the root distribution study was carried out both horizontally and vertically. For the horizontal distribution studies, the soil excavation was done from the trunk region up to 150 cm away in all 4 directions. The horizontal distance of 0-150 cm was divided into 5 blocks of 0-30 cm, 31-60 cm, 61-90 cm, 91-120 cm, and 121-150 cm, and the soil was removed carefully using hand implements from each block to a depth of 30 cm. The roots separated from the soil were thoroughly washed under running water to remove adhered soil particles. These roots were characterised into different groups based on thickness, in categories of <2 mm, 2-5 mm, 5.01-10 mm, and >10 mm. The same procedure was followed for all horizontal blocks. The lengths of the roots in each category were recorded using a measuring scale and the total length of the roots in each category was determined. For the vertical distribution studies, the soil was excavated to a 90-cm depth in all 4 directions by making 3 vertical blocks of depths of 0-30 cm, 31-60 cm, and 61-90 cm. The soil was dug out from each block and measurement of root length was done as explained above.

Root mass studies

The fresh roots from each soil section, vertical and horizontal, were collected in a plastic tray. All of the weeds and soil particles were then removed from the fresh roots. The roots were then separated based on root diameter category. The roots in each root diameter category and soil depth were weighed for fresh weight. The mean data were collected for each replication and are presented in the Tables.

Dry matter studies

The vines excavated for root distribution studies were also used to study dry matter accumulation in different parts of the vine. The different vine parts (trunk, primary arms, secondary arms, and canes) were separated using secateurs and a saw. The fresh weight was recorded for each vine part separately and the material was dried in an oven at 70 °C until a constant dry weight was recorded. The dry matter percentage was calculated using the fresh and dry weights.

Statistical analysis

The data collected on different parameters were arranged replication-wise and a statistical analysis was carried out as per the procedures of Panse and Sukhatme (1985).

Results

Horizontal distribution of root system

The observations recorded on the horizontal distribution of roots are presented in Tables 1-4. A significant difference was recorded for roots of different thickness in all of the horizontal blocks among the rootstocks. The rootstocks Dog Ridge and Salt Creek put forth the maximum root length in the category of <2 mm thickness in the 0-30 cm and 31-60 cm horizontal blocks, while St. George produced the least (Table 1). The same trend was observed for roots of a thickness of 2-5 mm, wherein at the distances of 0-60 and 61-150 cm, Salt Creek had the maximum total root length and was followed by Dog Ridge (Table 2). At the distance of 0-30 cm, it was observed that for the root diameter category of 5.01-10 mm, the rootstock Salt Creek had the greatest root length (Table 3), followed by Dog Ridge and St. George, respectively, whereas Dog Ridge had a greater root length at distances of 31-60 cm than Salt Creek. The St. George rootstock produced more roots at distances of 31-60 cm. At a farther distance of 91-120 cm, the maximum root length in the category of anchor roots 5.01-10 mm in thickness was highest in Dog Ridge and Salt Creek, while at distances of 121-150 cm, it was highest only in Salt Creek. A significant difference was observed in the interaction between horizontal blocks and rootstocks for all root thickness categories.

Table 1. Horizontal distribution of roots <2 mm thick in different rootstocks.

Rootstock (A)	Horizontal distance (B) (cm)				
	0-30	31-60	61-90	91-120	121-150
Dog Ridge	139.02	125.76	109.69	96.64	85.25
Salt Creek	119.53	146.87	123.82	86.26	88.79
St. George	116.43	111.66	103.57	85.61	71.44
	SE m ±*	P = 0.05**			
Rootstock (A)	0.67	1.88			
Horizontal distance (B)	0.86	2.43			
Interaction (A × B)	1.49	4.22			

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

Table 2. Horizontal distribution of roots 2-5 mm thick in different rootstocks.

Rootstock (A)	Horizontal distance (B) (cm)				
	0-30	**31-60**	**61-90**	**91-120**	**121-150**
Dog Ridge	141.52	178.55	143.19	130.57	109.92
Salt Creek	106.22	151.73	154.16	133.37	118.21
St. George	112.73	125.99	113.62	99.80	92.90
	SE m ±*	P = 0.05**			
Rootstock (A)	0.66	1.87			
Horizontal distance (B)	0.85	2.41			
Interaction (A × B)	1.48	4.18			

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

Table 3. Horizontal distribution of roots 5.01-10 mm thick in different rootstocks.

Rootstock (A)	Horizontal distance (B) (cm)				
	0-30	**31-60**	**61-90**	**91-120**	**121-150**
Dog Ridge	131.58	231.37	159.26	132.31	33.21
Salt Creek	172.87	156.53	212.50	77.69	47.94
St. George	97.04	144.44	0.00	6.19	16.86
	SE m ±*	P = 0.05**			
Rootstock (A)	0.76	2.15			
Horizontal distance (B)	0.98	2.77			
Interaction (A × B)	1.70	4.80			

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

For roots of <2 mm in diameter, the rootstock Dog Ridge had its greatest root length at 0-30 cm, Salt Creek at 31-60 cm, and St. George at 0-30 cm. At distances of 31-60 cm, Dog Ridge and St. George produced the maximum root length in the category of 2-5 mm, whereas in Salt Creek, the greatest root length was recorded at distances of 61-90 cm. The same trend was recorded for root diameters of 5.01-10 mm (Table 3). In the present study, we could observe roots of >10 mm diameter at a distance of 0-60 cm from the trunk in all the rootstocks, but beyond this distance there were no roots of this diameter available.

A feeder root plays an important role in absorbing nutrients and water from soil. Finer roots, also known as feeder roots, are more important for rapid uptake of nutrients and water for better growth and development of vines. A greater density of this type of root helps the vine achieve maximum absorption of nutrients. Rootstocks Dog Ridge and Salt Creek put forth more, finer roots in all of the blocks and, hence, these rootstocks are popular for their better water and nutrient uptake ability in this grape-growing region. Here we also observed greater root length in Salt Creek and Dog Ridge than in St. George. This clearly suggests that the Dog Ridge and Salt Creek

Table 4. Horizontal distribution of roots >10 mm thick in different rootstocks.

Rootstock (A)	**Horizontal distance (B) (cm)**				
	0-30	**31-60**	**61-90**	**91-120**	**121-150**
Dog Ridge	28.94	140.71	0.00	0.00	0.00
Salt Creek	203.84	40.20	0.00	0.00	0.00
St. George	74.16	0.00	0.00	0.00	0.00
	SE m ±*	P = 0.05**			
Rootstock (A)	0.41	1.16			
Horizontal distance (B)	0.53	1.50			
Interaction (A × B)	0.92	2.60			

rootstocks, which belong to *Vitis champinii*, put forth prolific root systems of thicknesses of <2 mm and 2-5 mm in the top depths of 0-30 cm up to 60 cm away from the trunk, and later thicker roots of >5 mm beyond 60 cm from the trunk. However, St. George, which belongs to *Vitis rupestris*, has less root length in all categories at all blocks excavated horizontally up to a 150-cm distance from the trunk.

Vertical root distribution

The data collected on vertical root distribution in different depths of all rootstocks are presented in Tables 5-8. Vertical excavation of the roots revealed significant differences among the rootstocks, soil depth, and their interactions among different categories of roots.

Salt Creek showed the greatest root length in the category of <2 mm at a depth of 0-30 cm, while Dog Ridge and St. George were at par for root length. However, at depths of 31-60 cm and 61-90 cm, Dog Ridge produced the greatest root length, followed by Salt Creek and St. George, respectively (Table 5). Similarly, in the category of roots of 2-5 mm, the maximum root length was recorded in Dog Ridge at 0-30 cm, followed by Salt Creek. However, at depths of 31-60 cm, the Salt Creek rootstock produced a greater root length than the Dog Ridge rootstock (Table 6). In the deeper layer of 61-90 cm, Salt Creek had a greater root length than both of the other rootstocks. High quantities of thicker roots of 5.01-10 mm in diameter could be observed in the soil depth of 61-90 cm for Dog Ridge and Salt Creek, but this was lowest in St. George (Table 7).

Table 5. Vertical distribution of roots <2 mm thick in different rootstocks.

Rootstocks (A)	**Soil depth (B) (cm)**		
	0-30	**31-60**	**61-90**
Dog Ridge	118.47	166.42	160.42
Salt Creek	132.97	152.58	143.00
St. George	118.79	140.71	124.20
	SE m ±*	P = 0.05**	
Rootstock (A)	0.95	2.72	
Horizontal distance (B)	0.95	2.72	
Interaction (A × B)	1.65	4.71	

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

Table 6. Vertical distribution of roots 2-5 mm thick in different rootstocks.

Rootstocks (A)	**Soil depth (B) (cm)**		
	0-30	**31-60**	**61-90**
Dog Ridge	166.84	191.47	184.47
Salt Creek	125.93	206.65	164.36
St. George	78.91	163.85	159.81
	SE m ±*	P = 0.05**	
Rootstock (A)	1.14	3.25	
Horizontal distance (B)	1.14	3.25	
Interaction (A × B)	1.98	5.64	

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

Table 7. Vertical distribution of roots 5.01-10 mm thick in different rootstocks.

Rootstocks (A)	**Soil depth (B) (cm)**		
	0-30	**31-60**	**61-90**
Dog Ridge	184.47	99.07	246.77
Salt Creek	164.36	61.65	283.13
St. George	57.64	110.69	27.49
	SE m ±*	P = 0.05**	
Rootstock (A)	1.16	3.31	
Horizontal distance (B)	1.16	3.31	
Interaction (A × B)	2.01	5.74	

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

The poor availability of roots in St. George at deeper depths indicates that its root distribution goes to a depth of 60 cm only. Thicker roots of >10 mm could be observed only in Salt Creek at all of the soil depths studied. At the depth of 0-30 cm, Salt Creek had greater root length than St. George and Dog Ridge, whereas at the depth of 31-60 cm, the same trend was observed for Salt Creek, but Dog Ridge had greater root length than St. George. However, beyond the 60-cm depth, the Dog Ridge and St. George rootstocks did not produce any roots of >10 mm in diameter. This indicates that thicker anchor roots of >10 mm in diameter are only put forth by Salt Creek at a soil depth beyond 90 cm (Table 8).

The interactions between soil depth and rootstock differed significantly in all categories of roots. The results revealed that all 3 rootstocks had root distributions of <2 and 2-5 mm in diameter at depths of 31-60 cm depth than at increased soil depths. The Dog Ridge and Salt Creek rootstocks were more efficient at producing maximum root lengths of 5.01-10 mm in diameter at 61-90 cm of depth, whereas St. George was found at depths of 31-60 cm. The root production of >10 mm in diameter was higher

Table 8. Vertical distribution of roots >10 mm thick in different rootstocks.

Rootstocks (A)	**Soil depth (B) (cm)**		
	0-30	**31–60**	**61-90**
Dog Ridge	10.19	35.02	0.00
Salt Creek	33.49	123.64	58.64
St. George	29.98	24.82	0.00
	SE m ±*	P = 0.05**	
Rootstock (A)	0.70	2.01	
Horizontal distance (B)	0.70	2.01	
Interaction (A × B)	1.22	3.49	

*Standard error of mean for means averaged over all treatments.
**Least significant difference at P = 0.05 for comparison of means.

in Dog Ridge and Salt Creek at depths of 31-60 cm, whereas St. George had more roots of this diameter at depths of 0-30 cm.

Root mass studies

Apart from the total root length of different categories, root mass distribution was also measured at different soil depths (Table 9). The average root mass differed significantly among the rootstocks in all 3 depths studied. All rootstocks produced higher root mass at depths of 31-60 cm than at 0-30 cm or 61-90 cm. The Salt Creek rootstock produced a higher root mass at depths of 31-60 cm and 61-90 cm. In Dog Ridge, maximum root mass was recorded at depths of 31-60 cm with a moderate root mass at lower depths, indicating its ability for maximum absorption of nutrients and available water at 31-60 cm and better anchorage roots at lower depths, similar to the Salt Creek rootstocks. However, the lower root mass of St. George in all 3 layers of soil reveals its poor root system, which is not an ideal character for rootstock used in a water-scarce region like western Maharashtra. For better root mass, the Salt Creek and Dog Ridge rootstocks were found to be more efficient.

Distribution of dry matter

The observations recorded on dry matter content from different vine parts grafted on different rootstocks are presented in the Figure. The dry matter content differed significantly among rootstocks in all of the vine parts analysed. It is evident that

Table 9. Average root mass (fresh weight kg m^{-3}) of different rootstocks at different soil depths.

Rootstocks	**0-30 cm**	**31-60 cm**	**61-90 cm**
Dog Ridge	2.296^{a*}	2.896^{b}	1.301^{b}
Salt Creek	2.049^{ab}	3.510^{a}	2.440^{a}
St. George	1.691^{b}	2.192^{c}	1.528^{b}
P = 0.05	0.037	0.005	<0.001

* Letters indicate the depth-wise significant difference among average root masses. Root mass followed by the same letter is not significantly different according to Duncan's multiple range tests at P ≥ 0.05

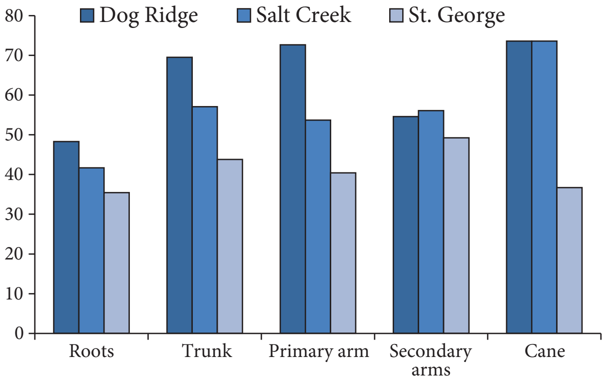

Figure. Dry matter percentage in different parts of Thompson Seedless vines grafted onto 3 rootstocks.

different rootstocks differed in their ability to accumulate dry matter in different parts. Maximum dry matter content was recorded in canes, followed by trunks, primary arms, secondary arms, and roots, respectively. It is thought that the dry matter content accumulated in canes becomes available to buds for their sprouting immediately after pruning and further growth of the new sprouts, until the leaves become photosynthetically active. When enough dry matter is not available in the canes for bud sprouting and subsequent shoot growth, vines rely on food reserves accumulated in other vine parts in the order of the secondary arms, primary arms, trunks, and, finally, the root system. Thus, it is clear from the data presented in the Figure that Dog Ridge and Salt Creek rootstocks accumulate maximum dry matter content in either canes or primary arms, which can thus be available for developing sprouts immediately after pruning. However, in the vines grafted on St. George rootstock, the dry matter content in the canes and primary arms is less than that of the secondary arms, trunks, and roots.

Discussion

The roots of any plant play an important role in its life. The grape rootstock has a deep root system that helps in the uptake of water and nutrients from deeper soil layers. Understanding the root distribution pattern of different rootstocks in grapes helps to know the nutrient uptake pattern. Different rootstocks have a different capacity for absorption of various nutrients. The differences in nutrient uptake of rootstocks may be due to differences in absorption capacity or the tendency towards specific minerals, differences in translocation and distribution of nutrients, differences in hormone synthesis, or the fact that some nutrients assimilate mostly by roots, thus reducing the amount translocated to the shoots.

Maximum horizontal root spread in the category of diameters of <2 mm was found at a distance of 31-60 cm from the trunk. The roots having diameters of <2 mm were consolidated at a maximum up to 0-60 cm, beyond which the proportion of availability was found to be reduced. This might be due to the application of irrigation water and spread in the soil that resulted in consolidation in that particular area. Among the diameters of 2-5 mm, the root spread was greatest in Dog Ridge at a distance of 31-60 cm, while that of Salt Creek was greatest at a 61-90 cm and St. George's was greatest at 31-60 cm. Dog Ridge had its maximum root length in roots of 5.01-10 mm in diameter at a distance of 31-60 cm from the trunk. Salt Creek was next in order of root spread at 61-90 cm from the trunk. The root spread was observed to reduce beyond a 90-cm distance from the trunk. Even the Dog Ridge rootstock had very little root spread at 121-150 cm from the trunk. The horizontal root spread of all of the rootstocks in the category of diameters of >10 mm was up to 60 cm from the trunk. Salt Creek produced more roots in distances of 0-30 cm and was followed by Dog Ridge at 31-60 cm. The St. George rootstock did not have >10-mm-thick roots further than 30 cm from the trunk. From this study, it can be observed that the maximum horizontal root spread in the different rootstocks was found at 31-60 cm from the trunk. These results are in conformity with the results obtained by Nagarajah (1987), who reported that root density in the soil profile at 30 cm from the vine trunk was generally higher than root densities at 90- and 120-cm positions. In Salt Creek, the maximum root spread in the category of roots of 2-5 mm was recorded at 61-90 cm from trunk, which confirms the results obtained by Perry et al. (1983). Uptake of water and nutrients by roots is a function of root length rather than mass (Gardener 1964; Nye and Tinker 1969). The earlier studies of Perold (1927) indicated that the main roots of *V. rupestris* form narrow angles with the vertical axis and can penetrate deeply, while those of *V. riparia* form wide angles and remain relatively shallow.

The differences for root length in the vertical direction were significant among all of the depths studied. Maximum root length was recorded at a depth of 31-60 cm, followed by depths of 61-90 cm. This is mainly because of the ability of rootstocks with deep roots to absorb nutrients and water from lower depths. These results confirm the results obtained by Nagarajah (1987), who reported a concentration of roots in the top 40-60 cm and a sharp reduction in root growth at greater depths. In our study, the maximum total root length in the roots with diameters of <2 mm at all depths was recorded for Dog Ridge, followed by Salt Creek, and the minimum was recorded for St. George. The same trend was also observed for the other root diameter categories. At the first depth of 0-30 cm, Dog Ridge produced the most roots in the category of 2-5 mm. However, at subsequent depths, from 31 cm to 60 cm, Salt Creek produced more root length than Dog Ridge. The feeder roots are mainly consolidated in the first layer of the root zone. Penetration of roots in deeper layers of the soil may enable the rootstock plant to absorb water and nutrients more effectively from the deeper layers of the soil (Nagarajah 1987). These findings are in confirmation with other research findings, where rootstocks were used to increase the water use efficiency of Tas-A-Ganesh grapes grafted onto Dog Ridge and 110 R rootstocks, thus saving irrigation to the extent of 20%-30% (National Research Centre for Grapes 2003). Stevens and Nicholas (1994) could retrieve 90% of roots at soil depths of 0-70 cm. However, the results of Wakabayashi et al. (1974) showed that the rooting depth of grapevine went up to 200 cm, while Seguin (1972) showed that grapevines have the potential to grow at much greater soil depths (600 cm) than reported in this study. Morano and Kliewer (1994), in their study on root distribution, found significant differences among rootstocks for total root number and class of smallest root size. In that study, St. George had a higher root distribution pattern than either 110 R or A × R # 1. The St. George rootstock also had the largest root number and there was a significant difference among the rootstock and soil depth interactions for the roots with diameter classes of 2-5 mm and 5-12 mm, indicating the influence of soil characteristics on root distribution.

The fresh root mass at different soil depths was studied for the 3 rootstocks. Among all the soil depths, the largest root mass of 7.984 kg m^{-3} was recorded in Salt Creek, followed by Dog Ridge (6.492 kg m^{-3}) and St. George (5.410 kg m^{-3}), whereas the maximum root mass of 8.597 kg m^{-3} was recorded at a depth of 31-60 cm, followed by 0-30 cm (6.035 kg m^{-3}) and 61-90 cm (5.268 kg m^{-3}). Randall and Coombe (1978) reported 1.77 kg m^{-2} in the 1-m-deep root zone of Shiraz, and McKenry (1984) reported 1.62 kg m^{-2} in the 1.2-m-deep root zone of Sultana.

In addition to the effect of rootstock on root development, partitioning of dry matter might also be affected by rootstock. Williams and Smith (1991) found no differences in dry matter partitioning on Cabernet Sauvignon grafted to A × R # 1, St. George, and Teleki-5C. In contrast, Tardaguila et al. (1995) observed significant differences in the partitioning of dry matter in Cabernet Sauvignon grafted onto different rootstocks. The rootstock 101-14 favoured dry weight accumulation in the canes while 41B favoured accumulation in the clusters. Similarly, in the present study, the dry matter partitioning of Thompson Seedless also varied among the rootstocks with the maximum dry matter found in the primary arms of Dog Ridge and in the canes of Salt Creek and St. George.

The research done on the percentage of dry matter distribution in the different parts of Thompson Seedless on this rootstock could be the first of its kind in India in which all vine parts have been evaluated for this parameter. Williams and Smith (1991) reported the distribution of more dry matter in the stems of St. George followed by A × R # 1 and Teleki-5C rootstocks. In this study, the greatest effect of the percentage of dry matter among the different parts was recorded in the canes followed by the primary arms, with Salt Creek showing the least and St. George the most. Among the rootstocks, dry matter distribution was greatest in Dog Ridge and least in Salt Creek. The differences in the distribution of the dry matter might be due to the genetics of the rootstocks altered with Thompson Seedless scions.

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