Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 850-853
Received: 13-01-2019
Accepted: 16-02-2019

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Effect of rootstocks on graft success, growth and photosynthetic activity in grape varieties (*Vitis vinifera* L.)

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Abstract
The field experiment was conducted to study the effect of different rootstocks (Dogridge, 110R and 140Ru) on graft success, growth parameters and photosynthetic activity in Thompson Seedless, Manjari Medika and Manjari Kishmish grape varieties. Growth parameters such as trunk girth, number of canes/vine and leaf area varied significantly on different rootstocks. The stock: scion ratio varied significantly in Thompson Seedless while in Manjari Medika and Manjari Kishmish, the differences were non-significant. Graft success showed non-significant differences in Thompson Seedless and Manjari Kishmish while significant difference in Manjari Medika grafted on different rootstocks. Physiological parameters such as transpiration rate and stomatal conductance showed significant effect on different rootstocks while assimilation rate showed significant effect in Manjari Kishmish.

Keywords: Rootstocks, graft success, growth parameters, photosynthetic activity

Introduction
Grape (*Vitis vinifera* L.) is an important commercial fruit crop and widely cultivated in different regions. Though the grape is originated from temperate regions, it performed well under tropical climate in the country, where it grows as an evergreen vine without undergoing dormancy. The major grape growing states are Maharashtra, Karnataka, Punjab, Tamil Nadu and Telangana amounting to nearly 90 per cent of the total production (Anonymous, 2016) [1]. The area under grapes during 2016-17 was 1.37 lakh hectares (Anonymous, 2017) [2]. In the traditional viticulture in India, commercial varieties of grapes were grown on their own roots (Satisha *et al.,* 2010) [11]. The decline in yield due to the problems associated with soil and water salinity, chlorides in irrigation water and excess levels of sodium in soil and shortage of irrigation water in Maharashtra state alerted the situation. The use of rootstock to maintain the productivity of grapes under adverse situation is gaining popularity. The choice of proper rootstock is becoming difficult due to availability of large number of rootstocks (Loreti and Massai, 2006) [8]. Performance of rootstock is different under different condition; hence it is necessary to evaluate rootstock best suited to particular environment (Shaffer, 2002) [12].
Rootstock affects vine growth by interacting with environmental factors (Zhiyuan, 2003) [18]. The effect of rootstock on growth parameters significantly varies from cultivar to cultivar (Kose *et al*., 2014) [7]. Rootstock influences vegetative growth thereby increasing the photosynthesis of vine (Somkuwar *et al.,* 2015) [13]. The differences in vegetative growth patterns affect gas exchange by altering source/sink relations (Ezzahouani and Williams, 1995). The effect of rootstocks on photosynthetic activity is scion specific (During, 1994). Keeping in view, the present investigation was carried out to study the effect of different rootstocks on graft success, growth and photosynthetic activity in Thompson Seedless, Manjari Medika and Manjari Kishmish grape varieties.

Materials and methods
The trial was conducted at the farm of ICAR-National Research Centre for Grapes, Pune during 2018-19. The experimental site is situated in Mid-West Maharashtra at an altitude of 559 m above mean sea level (18.32°N and 73.51°E). The rootstocks i.e. Dogridge, 110R and 140Ru were planted in January 2017 at a spacing of 9 x 5 feet. The rootstocks were maintained in the field following standard recommended cultural practices. The grape varieties i.e., Thompson Seedless, Manjari Medika and Manjari Kishmish were grafted in August 2017 and trained to extended Y- Trellis. The observations recorded were as below.

Stock: scion ratio: The girth of rootstock was measured one cm below the graft union while the scion girth was measured one cm above the graft union with the help of digital Vernier calliper.

Trunk girth (mm): The trunk girth was measured at a point where two arms were separated with the help of digital Vernier calliper.

Number of canes: The number of canes per vine was counted at cane maturity and mean was recorded.

Graft success (%): The percent graft success was calculated by using the formula given below.

$$\text{Graft success (\%)} \frac{\text{No. of successful grafts}}{\text{Total no. of rootstocks grafted}} \times 100$$

Leaf area: Leaf area was measured by linear method (LBK method) expressed in cm^2. The mathematical relationship for calculation was given as follows

Leaf area (A) = L x B x K (0.810)

Physiological parameters: A fully opened fifth leaf from apex was selected to measure gas exchange parameters with the help of an infra-red gas analyser (Li 6400, LI-COR Biosciences, Linacoln, Nebraska, USA).

Statistical Analysis

The experiment was conducted in Randomized Block Design (RBD) consisting of three treatments as rootstocks which were replicated seven times. Statistical analysis of data collected during the course of studies was carried out by standard method of analysis of variance as described by Panse and Sukhatme (1995) [9]. The standard error of mean (S. Em±) was worked out and the critical difference at 5 per cent and 1 per cent level of significance was calculated wherever the results were found significant.

Results and discussion

Growth parameters

The data recorded on various growth parameters are presented in Table 1. In Thompson Seedless, maximum stock: scion ratio was recorded on 110R grafted vines while minimum in 140Ru grafted vines. In Manjari Medika and Manjari Kishmish variety the stock: scion ratio was higher in 140Ru and Dogridge respectively while minimum in 110R rootstock. Among the different varieties, maximum stock: scion ratio was recorded in Manjari Medika grafted on 140Ru rootstocks while minimum in Thompson Seedless grafted on 140Ru rootstock. The stock scion ratio nearing 1.00 will have uniform girth of both stock and scion (Somkuwar *et al*., 2015) [13]. The variation in stock: scion ratio of same cultivar grafted on different rootstocks might be due to differences in genetic constituent of the rootstock. Somkuwar *et al*., (2006) [13] reported higher stock: scion ratio in Flame Seedless grafted on different rootstocks while Satisha *et al.,* (2010) [11] found that there is no adverse effects of different rootstocks on stock: scion ratio in Thompson Seedless grapes in initial years of vineyard and also long duration evaluations.

It was observed that rootstocks had significant influence on trunk girth. In Thompson Seedless and Manjari Medika maximum trunk girth was recorded in 140Ru while minimum in 110R rootstock. However, in Manjari Kishmish maximum trunk girth was observed in 110R grafted vines and minimum in Dogridge grafted vines. Among the different varieties, highest trunk girth was recorded in Thompson Seedless grafted on 140Ru while lowest in Manjari Kishmish grafted on Dogridge rootstock. It might be due to the difference in interaction of different rootstocks on scion cultivars and differences in storage of vines. Reddy (1987) [10] found maximum trunk girth in Anab-E-Shahi grafted on Dogridge and on Gulabi rootstocks.

Number of canes/vine showed significant difference among the varieties. In Thompson Seedless and Manjari Medika, highest number of canes was recorded in 140Ru grafted vines while minimum in 110R and Dogridge rootstocks grafted vines respectively. The Manjari Kishmish vines grafted on 110R rootstock produced maximum number of canes/vine while 140Ru grafted vines were found to be poor in cane producing. Among the varieties, Manjari Medika grafted on 140Ru recorded maximum number of canes/vine while lowest in Manjari Kishmish grafted on 140Ru rootstock. The production of more number of canes/vine might be due to the vigour imparted by rootstock that was converted into number of canes/vine. Tambe (1999) [16] recorded greater number of canes in Thompson Seedless grafted on Dogridge rootstock. Further, Tambe and Gawade (2004) [17] reported greater number of canes in Tas-A-Ganesh grafted on rootstocks as compared with own rooted vines.

In Thompson Seedless, maximum graft success was recorded in Dogridge grafted vines while minimum in 140Ru rootstock grafted vines. In Manjari Medika, maximum graft success was noted in 110R while lowest in 140Ru rootstock grafted vines. In Manjari Kishmish, highest graft success was obtained in Dogridge while lowest in 110R grafted vines. Among different varieties, maximum graft success was recorded in Thompson Seedless and Manjari Kishmish grafted on Dogridge rootstock while minimum in Manjari Medika and Manjari Kishmish grafted on 140Ru and 110R rootstock respectively. Higher percentage of graft survival in the present study might be due to active growing meristematic stage exhibited by both the rootstock and scion, which facilitates callus formation and thereby enhances grafting success (Stino *et al*., 2011) [15], however, Somkuwar *et al*., (2015) [13] reported the differences in graft success due to the use of rootstocks.

The rootstock showed significant effect in leaf area among the varieties studied. In Thompson Seedless, maximum leaf area was recorded in 140Ru grafted vines while Dogridge rootstock grafted vines recorded minimum leaf area. Manjari Medika and Manjari Kishmish recorded maximum leaf area on 110R grated while minimum in 140Ru and Dogridge grafted vines respectively. Among the different varieties, maximum leaf area was recorded in Thompson Seedless grafted on 140Ru rootstock and minimum in Manjari Kishmish grafted on Dogridge rootstock. The variation in leaf area obtained in different varieties might be due to the changes in root anatomy and physiology of scion which results in vigorous growth leads to more photosynthesis which attributed to the large sized leaves. De Souza *et al.,* (2015) [4] reported that leaf area of Cabernet Sauvignon is affected by the different rootstocks.

Physiological parameters

The data on photosynthetic activity in different grape varieties are presented in Table 2. In Thompson Seedless and Manjari Medika, maximum transpiration rate was recorded in 110R and 140Ru grafted vines while minimum in Dogridge and 110R grafted vines respectively. In Manjari Kishmish, higher transpiration rate was obtained in Dogridge and minimum in

110R rootstock. Among different varieties, maximum transpiration rate was recorded in Manjari Medika grafted on 140Ru and minimum in Thompson Seedless grafted on Dogridge rootstock. In Thompson Seedless, Manjari Medika and Manjari Kishmish variety maximum assimilation rate was recorded in 110R, Dogridge and 140Ru rootstock respectively whereas minimum in 140Ru and 110R rootstock. Among all three varieties, highest assimilation rate was recorded in Manjari Medika grafted on Dogridge and lowest Manjari Kishmish grafted on 110R rootstock. Rootstocks showed significant effect on stomatal conductance. In Thompson Seedless, highest stomatal conductance was recorded in 110R while minimum in Dogridge rootstock grafted vines. In Manjari Medika, highest stomatal conductance was recorded in 140Ru and lowest in Dogridge rootstock. In Manjari Kishmish highest stomatal conductance was recorded in Dogridge and lowest in 110R rootstock. Among different varieties, highest stomatal conductance was recorded in Manjari Kishmish grafted on Dogridge rootstock and lowest in Thomson seedless grafted on Dogridge rootstock. The rate of transpiration, stomatal conductance and assimilation rate might be influenced by rootstock genotype, root system, vine vigour and scion characteristics (Somkuwar *et al*., 2015) [13]. Bica *et al*. (2000) [13] reported that scion foliar biomass and leaf area might be responsible for alteration in the gas exchange parameters. They found significant effect of rootstock on leaf area, transpiration rate, stomatal conductance and assimilation rate.

Conclusion

It is concluded that Thompson Seedless showed good performance on 110R rootstock for stock: scion ratio, graft success and physiological parameters while 140Ru for trunk girth, number of canes and leaf area. Manjari Medika grafted on 140Ru performed better for stock: scion ratio, trunk girth, number of canes and physiological parameters while 110R for graft success and leaf area. However, Manjari Kishmish grafted on Dogridge rootstock showed good performance for stock: scion ratio, graft success and physiological parameters while 110R for trunk girth, number of canes and leaf area. In overall, rootstocks 110R and 140Ru were better for these varieties.

Table 1: Effect of different rootstocks on graft success and growth parameters in different grape varieties

Treatment	Thompson Seedless					Manjari Medika					Manjari Kishmish				
	Stock: scion ratio	Trunk girth (mm)	No. of canes/ vine	Graft success (%)	Leaf area (cm^2)	Stock: scion ratio	Trunk girth (mm)	No. of canes/vine	Graft success (%)	Leaf area (cm^2)	Stock: scion ratio	Trunk girth (mm)	No. of canes/vine	Graft success (%)	Leaf area (cm^2)
Dogridge	0.98	28.13	12.14	100.00	139.92	1.02	25.60	17.89	92.86	139.48	1.01	21.56	11.12	100.00	133.89
110R	1.00	26.11	11.06	98.57	145.00	0.99	25.37	18.20	100.00	151.71	0.97	25.34	12.85	92.50	148.77
140Ru	0.84	31.67	14.47	94.64	154.78	1.08	28.17	21.80	92.50	145.07	1.00	23.10	10.11	94.64	142.09
SEm±	0.02	0.60	0.54	3.27	3.82	0.02	0.71	0.95	1.94	3.06	0.02	0.78	0.52	2.60	2.34
C.D. at 5 %	0.05	1.84	1.66	10.07	11.76	0.07	2.18	2.92	5.98	9.44	0.07	2.41	1.61	8.00	7.22
Sig	**	**	**	NS	*	NS	*	*	*	*	NS	*	**	NS	**

*= significant at 0.05 level, **= significant at 0.01 level

Table 2: Effect of different rootstocks on photosynthetic activity in different grape varieties

Treatment	Thompson Seedless			Manjari Medika			Manjari Kishmish		
	Transpiration Rate (mmol m-2 s-1)	Assimilation Rate (µmol m-2 s-1)	Stomatal Conductance	Transpiration Rate (mmol m-2 s-1)	Assimilation Rate (µmol m-2 s-1)	Stomatal Conductance	Transpiration Rate (mmol m-2 s-1)	Assimilation Rate (µmol m-2 s-1)	Stomatal Conductance
Dogridge	1.35	9.68	50.69	1.79	9.98	59.55	2.11	9.59	82.22
110R	1.77	9.94	78.70	1.65	9.60	64.05	1.64	9.18	74.24
140Ru	1.58	9.49	58.74	2.44	9.72	67.11	1.71	9.64	76.05
SEm±	0.07	0.14	2.77	0.13	0.11	1.37	0.10	0.11	2.08
C.D. at 5 %	0.21	0.44	8.53	0.41	0.34	4.22	0.32	0.33	6.39
Sig	**	NS	**	**	NS	**	*	*	*

*= significant at 0.05 level, **= significant at 0.01 level

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