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Grapevine Rootstock Influences Growth, Yield, and Quality of Fantasy Seedless Grapevines (*Vitis vinifera L.*) Grown Under Semi-Arid Condition

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Abstract

The experiment was conducted during three years (2017-2020) to study the effect of rootstocks (140Ru, Dogridge, 110R and own rooted vines) on growth, yield, quality, and nutrient contents of Fantasy Seedless. The growth parameters such as minimum days to bud sprout was recorded in own rooted vines. Maximum stock: scion ratio was recorded in vines grafted on 140Ru rootstock. Average bunch weight, 50 berry weight and yield per vine were maximum in vines grafted on 140Ru rootstock. The maximum berry diameter and minimum physiological loss in weight was recorded in vines grafted on 140Ru rootstock. Whereas, maximum TSS and acidity was recorded in own rooted vines. As regards nutrient content viz., maximum phosphorous was recorded in vines grafted on Dogridge rootstock while, maximum calcium content was recorded in vines grafted on 140Ru rootstock.

Keywords: Rootstocks; Growth; Yield; Quality; Nutrient Content

Introduction

Grape (*Vitis vinifera* L.) is an important commercial fruit crop widely cultivated in different regions. Through the grape is originated from temperate regions, it is performing well under tropical climate in the country, where it grows as an evergreen vine without undergoing dormancy. The production of fresh grapes in India is about 31.25 lakh MT with the cultivation on an area of 1,62,000 ha area with production of 34.45 lakh MT and productivity of 21.00 MT/ha [1]. The major grape growing states are Maharashtra, Karnataka, Mizoram, Tamil Nadu, Andhra Pradesh, and Madhya Pradesh amounting to nearly 99 per cent of the total production. Rootstocks have recently gained importance in consistently effective and successful strategy in major grape growing countries worldwide [2]. Traditionally grapes were grown in India on its own roots. However, subsequent deterioration in soil and water, and use of rootstock has become important in semi-arid tropical climate to sustain production and fruit quality. Choice of specific rootstock for establishment of vineyard is difficult due to wider options. *Vitis* species, such as *V. champinii, V. rupestris, V. berlandierii, V. longii, V. parviflora,* etc. has capacity to synthesize biochemical constituent modulating scion physiology, root morphology, development, and distribution [3]. The decline in yield started due to the build-up of soil salinity, sodium available in irrigation water and calcium carbonate the in the soil and thus alerted the grape growing. Performance of rootstock is different under different condition; hence it is necessary to evaluate rootstock best suited to environment [4].

Most secondary effects of rootstocks are mediated through their influence on vine size and internal canopy shading. For sustainable viticulture, it is important to know the interactions among rootstocks, different soil characters and scion productivity [5]. The same rootstock may have different effects on the macronutrient content of scion varieties. A rootstock found to be suitable for one cultivar may not be uniformly advantageous for others, as the interaction of stock and scion effects vine performance more than the stock or scion alone [6]. With increased awareness about the use of rootstocks in overcoming the adverse effects of drought and salinity, growers started using Dogridge rootstock for the cultivation of Fantasy Seedless grapes. However, in the tropical and subtropical climate, Dogridge rootstock induces more vegetative vigour in the scions, which may reduce the bud fruitfulness of Fantasy Seedless in the long run. Keeping in view, the present investigation was carried out to study the influence of three different rootstocks on growth, yield, quality, shelf life and nutrient content on 'Fantasy Seedless' grapevine.

Materials and Methods

The study was conducted at ICAR-NRC for Grapes, Pune, during the year 2017-18, 2018-19 and 2019-2020. Five-year-old vineyard of Fantasy Seedless grapevine grafted on different rootstocks (Dogridge, 110R, 140Ru) and compared with own rooted Fantasy Seedless. The vines were trained to 'extended Y' trellis with four cordons (H shape – Height = 1.20 m from ground, cross arm width = 0.60 m) developed horizontally with vertical shoot orientation on each cordon. A distance of 0.60 m was maintained from the fruiting wire to the top of foliage support wire. The soil in the region is heavy black with pH 7.75 and EC 0.46 dS m^{-1}. The region falls under a tropical belt, where double pruning and single cropping is being practiced. The foundation pruning was carried out in the month of April while fruit pruning during October. Five vines were selected and tagged under each replication and means of five vines was calculated for each parameter which includes growth parameters like pruned weight, days to bud sprout, fruitful canes, and stock: scion ratio, yield, and quality parameters like numbers of bunches/vine, average bunch weight, 50 berry weight and yield (kg/vine), berry diameter, berry length, TSS, acidity and physiological loss in weight, nutrient content parameters like nitrogen, phosphorous and calcium. The experiment was laid out in Randomized Block Design (RBD) with five replications. Data were subjected to statistical analysis as per method given by Panse V, et al. [7].

Results and Discussion

Growth Parameters

The data on effect of different rootstocks on growth of Fantasy Seedless grapevines is presented in Table 1. The rootstocks showed non-significant effect on pruned weight (kg) during all the year of study as well as their pooled data. In 2017-18, the bud sprouting was early in own rooted vines (8.50) followed by 110R rootstock (9.50), while the rootstock Dogridge was late to sprout (11.00 days). The same trend was recorded in the coming years of study. The pooled data also showed significant effect for days to bud sprout. Own rooted vines were early to sprout (8.63) while vines grafted on Dogridge rootstock were late to sprout (11.19 days). The variation in time taken for bud sprout might be due to the availability of storage material in scion that has helped to supply for early bud sprout. These results confirm the results obtained by Errea [8] who reported insufficient callus growth, phloem differentiation, lignification, and metabolic interaction. Stino, et al. [9] emphasized variation in percentage success and survival of grape grafting due to the use of rootstocks.

The results over three years elucidated that the fruitful canes % significantly influenced by use of rootstocks. In first year of study, the maximum fruitful canes were recorded in 110R rootstock (90.0%) which was at par with own rooted vines (88.0%) while Dogridge grafted vines recorded minimum fruitful canes (83.8%). The same trend was followed for pooled analysis. The vines grafted on 110R rootstock recorded maximum fruitful canes (90.2 %) which was significantly superior over the rootstocks and was at par with own rooted vines (88.2 %) while minimum fruitful canes were recorded in Dogridge rootstock (84.0 %). A variation of 25 per cent in fruitfulness among the rootstocks was reported by Larry [10]. Since the yearly variation in fruitfulness was independent of rootstock (fruitfulness for all rootstock were high one year and low during the next year), climatic factors can be considered as probable causes for variation. During, 2018-19, significantly highest mean petiole P and K content was also recorded which indicated that high petiole P and K content may have had a major role to play in fruitfulness.

The highest stock: scion ratio was recorded in vines grafted on 140Ru rootstock (1.02, 1.03, 1.04 and 1.03, respectively) which was followed by Dogridge (1.01, 1.02, 1.03 and 1.02, respectively) rootstock while lowest stock: scion ratio was recorded in vines grafted on 110R rootstock (0.96, 0.97, 0.98 and 0.97) respectively. This is an important parameter about longevity of any composite plant combinations. An extreme stock-scion ratio can cause delayed incompatibility. The variation in stock: scion ratio of same cultivar grafted on different rootstocks must be due to the differences in genetic makeup of the rootstock. Somkuwar, et al. [11] reported higher stock to scion ratio in Thompson Seedless grafted on different rootstocks. In contrast Satisha, et al. [12] found that there was no adverse effect of different rootstocks on stock: scion ratio in Thompson Seedless grapes in initial years of vineyard and long duration evaluations.

The results over three years elucidated that the days to harvest significantly influenced by use of rootstocks. In third year of study and pooled data, the minimum days to harvest were taken in own rooted vines (144.00 and 143.20 respectively) which was followed by 140Ru grafted vines. The maximum days to harvest was recorded on vines grafted on Dogridge rootstock (149.00 and 148.08), respectively. In The early harvest is an important parameter in grapes. In the present study, minimum days taken for harvest was recorded in own rooted vines, in terms of quality and yield the vines grafted on rootstocks performed better. Similar studies were previously reported by Somkuwar, et al. [13] in Manjari Naveen grapevines grafted on Dogridge Stock root.

	Pruned weight (kg)				Days to bud sprout				Fruitful canes (%)				Stock: scion ratio			
Root stocks	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean
140Ru	0.9	1	1.2	1.06	10	10.1	10.36	10.15	84.6	84.7	85	84.8	1.02	1.03	1.04	1.03
Dogridge	1	1.1	1.3	1.13	11	11.2	11.37	11.19	83.8	83.9	84.2	84	1.01	1.02	1.03	1.02
110R	0.94	1.04	1.24	1.07	9.5	9.6	9.73	9.61	90	90.2	90.4	90.2	0.96	0.97	0.98	0.97
Own roots	0.8	0.9	1.08	0.93	8.5	8.6	8.78	8.63	88	88.2	88.5	88.2	NR	NR	NR	NR
S.Em±	0.06	0.07	0.07	0.07	0.38	0.39	0.38	0.38	0.83	0.84	0.84	0.84	-	-	-	-
C.D at 5 %	0.21	0.21	0.23	0.21	1.19	1.19	1.18	1.19	2.57	2.59	2.58	2.58	-	-	-	-
Sig	NS	NS	NS	NS	**	**	**	**	**	**	**	**	-	-	-	-

	Days to Harvest			
Rootstocks	2017-2018	2018-2019	2019-2020	Pooled Mean
140Ru	144	145.2	145.8	145
Dogridge	147	148.26	149	148.08
110R	146.5	147.87	148.15	147.5
Own roots	142.2	143.4	144	143.2
S.Em±	0.36	0.46	0.54	0.41
C.D at 5 %	1.13	1.43	1.68	1.26
Sig	**	**	**	**

Table 1: Effect of different rootstocks on growth of Fantasy Seedless grapevines.
*= Significant at P < 0.05
**= Significant at P < 0.01
NS=Non significant
NR=Not Recorded

Yield Parameters

The number of bunches/vines significantly influenced by use of rootstocks for same scion cultivar. The pooled analysis revealed that higher number of bunches per vine were recorded on 110R rootstock (44.46) which was at par with 140Ru (44.13) rootstock while lowest number of bunches per vine was noted in own rooted vines (38.94). The vines grafted on rootstock recorded significantly higher number of bunches than own rooted vines. In a present study, higher number of bunches were recorded in vines grafted on 110R rootstock (Table 2). It might be due to higher petiole P content in 110R grafted vines during fruit bud differentiation stage which results into more fruitful canes [14].

The higher bunch weight was recorded in 140Ru rootstock (277.52 g) followed by Dogridge rootstock (256.20 g) while minimum average bunch weight was observed in own rooted vines (225.36 g) during 2017-18. The same trend was continued during the next years of study. The average bunch weight in Fantasy Seedless grapevines was significantly influenced by different rootstocks. It is a prime important parameter and directly related to quality grape production [15]. In the present investigation, the higher photosynthetic

rate, cane carbohydrate and protein content, petiole K content were recorded in vines grafted on 140Ru rootstock which might results in higher bunch weight on 140Ru rootstock. The similar results were reported by Rizk-Alla, et al. [16] who reported higher bunch weight in Red Globe grapevines grafted on Dogridge rootstock.

During all the years of study, the highest 50 berry weight was recorded in Fantasy Seedless grapevines grafted on 140Ru rootstock which was followed by Dogridge rootstock while lowest 50 berry weight was observed in own rooted vines. Pooled analysis over three years also showed that highest 50-berry weight was recorded in 140Ru rootstock (169.23 g) which was significantly superior over all other rootstocks. The lowest 50-berry weight was recorded in own rooted vines (149.20 g). This might be due the environmental conditions at the time of maturity and different genetic constitution of rootstocks recorded higher bunch weight which might also be due to the reduced competition between source-sink and utilization of more stored carbohydrates for available berries [13].

The yield/vine was significantly influenced by use of different rootstocks. During the first year of study, the higher yield was recorded in Fantasy Seedless grapevines grafted on 140 Ru rootstock (11.99 kg/vine) followed by vines grafted on 110R (10.88 kg/vine) while lower yield was recorded in own rooted vines (8.56 kg/vine). The same trend was continued during the next years of study. In the present study, the use of different rootstocks significantly affected the yield/vine. The higher yield/vine in Fantasy Seedless grapevines was recorded on 140Ru rootstock followed by 110R rootstock. The available food reserve was significantly utilized by vines grafted on 140Ru rootstock resulted into higher average bunch weight and berry diameter and produced maximum yield per vine as compared to vines grafted on other rootstocks as well as own rooted vines. A review on pruning severity on yield and quality attributes in grapes had also described the positive correlation of photosynthetic rate with yield [17]. The lower yield on own rooted Fantasy Seedless vines might be due to the low vigour, less storage in vines and low photosynthetic activity. According to Venu Gopal [18] and Menora [19] also reported that Thompson Seedless grafted on Dogridge rootstock had the highest yield compared to own rooted vines.

	Number of bunches/vines				Average bunch weight (g)				50 berry weight (g)				Yield (kg/vine)			
Root stocks	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean
140Ru	43.2	44.4	44.8	44.13	277.5	278.4	279.1	278.3	168	169.4	170.1	169.2	12	12.4	12.5	12.28
Dogridge	41	42.2	42.4	41.87	256.2	257.2	258	257.1	159	159.9	160.3	159.7	10.5	10.9	10.9	10.77
110R	43.6	44.8	45	44.46	249.6	250.8	251	250.5	151	152.6	153.1	152.4	10.9	11.2	11.3	11.14
Own roots	38	39.2	39.6	38.94	225.4	226.5	227	226.3	148	149.4	150	149.2	8.56	8.88	8.99	8.81
S.Em±	0.8	0.65	0.84	0.82	1.57	1.77	1.57	1.67	0.87	0.94	0.91	0.9	0.19	0.2	0.2	0.2
C.D at 5 %	2.49	1.98	2.59	2.52	4.84	5.45	4.84	5.16	2.7	2.9	2.81	2.76	0.59	0.61	0.62	0.6
Sig	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Table 2: Effect of different rootstocks on yield of Fantasy Seedless grapevines.
*: Significant at P < 0.05
**: Significant at P < 0.01
NS: Non significant

Quality Parameters

The rootstock showed non-significant effect for berry length during all years. The berry diameter significantly influenced using different rootstock. In pooled data, higher berry diameter was recorded on 140Ru rootstock (18.65 mm) which was at par with vines grafted on Dogridge (18.51 mm) and 110R (18.37 mm) rootstocks as compared to the lowest in own rooted vines (17.84 mm). The berry diameter is an important parameter for quality grape production [20]. The higher photosynthetic rate, cane carbohydrate and protein storage which leads to higher accumulation of food material towards developing berries and results into higher berry diameter.

The total soluble solid significantly influenced by use of rootstocks. The results obtained from pooled analysis showed higher TSS on 140 Ru grafted vines as compared to other rootstock. The own rooted vines recorded higher total soluble solid (20.83^0B) followed by Dogridge (19.49^0B) and

110R (19.33^{0}B) rootstocks while lowest total soluble solid was recorded in vines grafted on 140Ru rootstock (18.59^{0}B). TSS content of berries was influenced by the duration i.e., time taken from pruning to harvest and yield per vine [19]. The own rooted vines were early in harvest which might have resulted into production of secondary metabolites and proper utilization of potassium for accumulation of more sugar into the berries. These findings are in accordance with the results obtained by Somkuwar, et al. [21,13] in Sharad Seedless and Manjari Naveen grapevines grafted on Dogridge rootstock, respectively.

Higher acidity content was recorded in own rooted vines (5.85 g/L) while lowest acidity in 140Ru (0.56 g/L %) rootstock. The total soluble solids and acidity were negatively correlated to each other. As the TSS increased, the acidity was decreased. The acidity content of berries appears to be influenced by the prevailing temperature at the time of development and ripening of berries. Cool and mild temperature increases the production of acids particularly malic and tartaric acids, while hot condition lowers the acid level in grapes [22]. Various workers reported different ranges of acidity [23]. Acidity of juice has negative correlation with the TSS of juice [24]. Similar results were reported by Venu gopal [18] who reported that, Thompson Seedless own rooted vines recorded lowest acidity.

	Berry diameter (mm)				Berry length (mm)				TSS (0B)				Acidity (g/L)			
Root stocks	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean	2017-2018	2018-2019	2019-2020	Pooled Mean
140 Ru	18.64	18.6	18.71	18.65	21.38	21.78	22.18	21.78	18.46	18.52	18.8	18.59	5.45	5.55	5.67	5.56
Dogridge	18.46	18.45	18.63	18.51	21.58	21.98	22.02	21.86	19.34	19.42	19.7	19.49	5.57	5.67	5.78	5.67
110 R	18.24	18.34	18.54	18.37	20.84	21.28	21.52	21.21	19.16	19.3	19.52	19.33	5.49	5.59	5.7	5.59
Own roots	17.78	17.82	17.93	17.84	20.6	20.98	21.14	20.91	20.72	20.83	20.96	20.83	5.75	5.85	5.96	5.85
S.Em±	0.17	0.13	0.14	0.14	0.31	0.29	0.36	0.32	0.18	18	0.2	0.16	0.01	0.01	0.02	0.01
C.D at 5 %	0.53	0.41	0.45	0.42	0.97	0.92	1.11	0.98	0.56	0.53	0.6	0.5	0.03	0.04	0.05	0.04
Sig	*	**	**	**	NS	NS	NS	NS	**	**	**	**	**	**	**	**

Table 3: Effect of different rootstocks on quality of Fantasy Seedless grapevines.
*: Significant at P < 0.05
**: Significant at P < 0.01
NS: Not significant

Shelf Life Studies

In all the rootstocks, the PLW (%) increased with the advancement in storage duration (Figure 1). In pooled data, the minimum physiological loss in weight (%) were recorded in 140Ru rootstock within 5th day (5.14 %) followed by 110R rootstock (5.51 %) while increased physiological loss in weight was recorded in own rooted vines (7.22 %). This might be due to the reduction in water diffusion over the cuticle, which ultimately strengthened the walls of epidermal cells. These results also support the results obtained by Yun, et al. [25] who reported better shelf life by controlling berry abscission with calcium treatments in Sheridan and Muscat Bailey grapes.

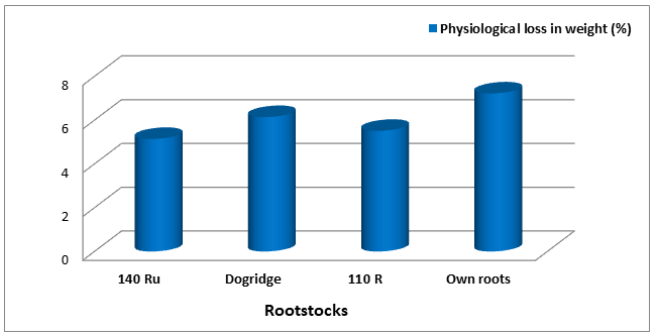

Figure 1: Effect of rootstocks on physiological loss in weight (%) in Fantasy Seedless grapes at 5th Days after storage.

Petiole Nutrient Content (At Flowering Stage)

The data on effect of different rootstocks on petiole nitrogen content in Fantasy Seedless grapevines during flowering stage during 2017-18, 2018-19 and for pooled are presented in Figure 2A. The petiole nitrogen content recorded during flowering stage elucidated that in 2017-18 rootstocks showed significant effect for petiole nitrogen content while in second year (2018-19) and in pooled analysis data it showed non-significant effect. In 2017-18 the highest petiole nitrogen content was noted in own rooted vines (1.100 %) which was followed by 110R (1.020 %) rootstock. The lowest petiole nitrogen content was noted in 140Ru rootstock (0.962 %).

The mean as well as pooled data of the year 2017-18, 2018-19 and pooled data pertaining to the effect of different rootstocks on petiole phosphorous content in Fantasy Seedless grapevines during flowering stage are presented in Figure 2B. The pooled data showed that, maximum petiole phosphorous content was found in Dogridge rootstock (0.354 %) followed by own rooted vines (0.319 %). The minimum petiole phosphorous content was recorded in 140Ru rootstock (0.276 %). The petiole phosphorus content is an important element in securing more fruitfulness in vines. The higher value of petiole P might be due to the more absorption of P at fruit bud differentiation stage among all the rootstocks. The vines grafted onto Dogridge had higher contents of the element than vines grafted on other rootstocks. The difference may be related to its V. berlandieri parentage, the metabolism of this American native species is better adapted for P absorption. The different rootstocks might have different ability to absorb Phosphorus [26].

The petiole calcium content significantly influenced by different rootstocks during both years and pooled data (Figure 2C). In 2017-18, the higher petiole calcium content was recorded in Dogridge grafted vines (1.246 %) which was at par with vines grafted on 140Ru rootstock (1.218 %) while lower petiole calcium content was recorded in own rooted vines (1.001 %). The same trend was also recorded in coming years of study. Calcium is an important element for growth and development of berries. It helps in proper berry setting, attaining required berry size and avoids the berry cracking. In the present investigation all rootstock showed optimum level of calcium, which significantly affected by use of different rootstocks. This might be due the genetic differences and capacity of absorption of nutrients by rootstocks. The rootstock showed the variation for preferential nutrient absorption which might result in variation of nutrients [27]. Venu gopal [18] also reported that Thompson Seedless vines grafted on Dogridge rootstock recorded higher petiole Ca content.

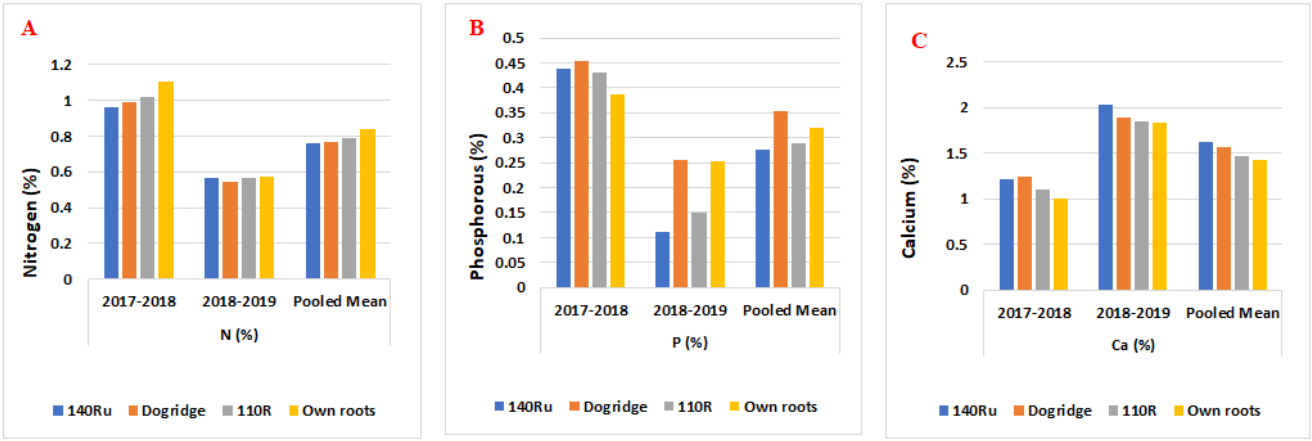

Figure 2: Effect of different rootstocks on Petiole A. Nitrogen (%), B. Phosphorous (%), C. Calcium (%) content in Fantasy Seedless grapevines during flowering stage.
Mean with different letters in the same column were significantly different (P<0.05)

Conclusion

Based on the results obtained in present experiment, it can be concluded that there was significant difference among the rootstock with respect to growth, yield, quality and nutrient content parameters as compared to own rooted vines. Among the three rootstocks evaluated, Fantasy Seedless performed well on 140Ru with respect to growth, yield, quality and shelf life components such a stock: scion ratio, number of bunches, bunch weight, 50 berry weight, berry diameter, yield per vine and physiological loss in weight was followed by vines grafted on 110R and Dogridge rootstock. Considering overall

parameters, Fantasy Seedless grapevines grafted on 140Ru rootstock was found better than other rootstock.

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