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COMPARATIVE ANALYSIS OF GROWTH AND YIELD PARAMETERS OF GRAPE VAR. 'MUSCAT HAMBURG' GRAFTED ON 'DOG RIDGE' ROOTSTOCK AND SELF-ROOTED CUTTINGS

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ABSTRACT

India ranks seventh in grape production at the global level. Tamil Nadu is one of the leading states in grape cultivation in India. The utilization of rootstock has become a priority aspect in grapes cultivation worldwide, especially in the current climatic conditions. The utilization of grape root stocks has not been completely explored yet in Tamil Nadu. In this regard, we compared the growth and yield parameters of grape (*Vitis vinifera*) var. ''Muscat Hamburg'' grafted on 'Dog Ridge' (*Vitis champini*) and self-rooted cuttings(of ''Muscat Hamburg'') under Cumbum valley condition, Theni district, Tamil Nadu, India. Randomly, fifty vines were chosen, each in grafted and self-rooted cutting category. 'Muscat Hamburg' is a wide variety in Cumbum valley of Theni district. The growth and yield characters were recorded. The petiole nutrient content for major elements during the flowering phase was analyzed. The growth characters *viz*., trunk diameter (42.46 mm), cane diameter (5.70 mm), number of fruitful shoots per cane (1.37), shoot length after pruning (42.52 cm), and leaf area (108.16 cm^2) were recorded maximum in 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock. The grafted 'Muscat Hamburg'on 'Dog Ridge' showed the highest berry weight (3.67 g),and the number of clusters per shoot (1.46).The yield characters, *viz*., the fruitfulness characters, such as the number of fruitful shoots per cane (1.37) was recorded better in 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock. The total number of berries per bunch (87.00), and yield per vine (21.87 kg/vine) were recorded as the highest in grafted vines. Obviously, when berry weight was the highest in grafted type, it reflected in bunch weight (276.74 g) with a maximum amount than self-rooted. The petiole nutrient contents were also found to be higher in grafted ones than in self-rooted cuttings. Overall, the use of 'Dog Ridge' as rootstock for grape variety 'Muscat Hamburg' was found promising to set enhanced vegetative growth, berry characters, and yield of the bunch than self-rooted cutting.

***Keywords*:** Muscat Hamburg, growth, bunch weight, rootstocks, graft

Introduction

Grape is a temperate fruit crop, adapted to tropical and subtropical climate conditions of the world. China is the world's leading grape production country, followed by Italy, U.S.A., Spain, and France. India ranks seventh in grape production at the global level. According to National Horticulture Board (NHB, 2022), Gurgaon, India, grapes production is 2.958 million tonnes from an area of 0.139 million hectares. During 2020-2021, India exported 0.246 million tonnes of grapes worldwide. The area under grapes in Tamil Nadu state is 2800 ha, out of which, Cumbum valley of Theni district, alone accounts for 2184 ha(APEDA, 2022). In Cumbum valley, grapes cultivation is increasing daily due to its salubrious climate. ''Muscat Hamburg'' is the leading grape variety in the Cumbum valley of Tamil Nadu. It is known for its Muscat flavour and shiny appearance. It is suitable for double pruning and double cropping. The vigour of the vine, fruitfulness, yield, berry quality, the longevity of the vineyard, *etc*., is greatly determined by rootstock. Rootstocks are used to surmount root aphid, nematodes, diseases (Blank *et al*., 2009), salt, water and temperature stresses ((Fisarakis *et al*., 2001 and Walker *et al*., 2002). Various investigations emphasized that rootstocks can influence growth, yield, and quality in grapes (Clark and Watson, 1998; Dry, 2007). The rootstocks control vegetative growth, precocity, and fruit quality. 'Dog Ridge' (*Vitis* × *champini*) is identified for its abiotic stress tolerance in principal grape producing tracts of India. It also has much compatibility with most commercial varieties of grapes (Satisha *et al*., 2010 and Pongraz, 1983).

Tamil Nadu positioned second in standard productivity at 27.27 tonnes per hectare (APEDA, 2022). The grapes cultivated under Cumbum valley have not fetched the market quality. Due to the non-availability of rootstocks, farmers have traditionally followed the planting of self-rooted plants for several decades. Currently, most vineyards in Cumbum valley are from rooted cuttings. Vineyards of self-rooted plants generally have lower yields with fewer small berries. Grafts are endurable to drought conditions, nematode infestation, and salinity compared to self-rooted vines. The

usefulness of 'Dog Ridge' rootstock is seldom knownto the growers of the Cumbum valley of Tamil Nadu. Hence, an attempt was made with the critical objective of comparative analysis of growth and yield parameters of grapes variety ''Muscat Hamburg'' grafted on 'Dog Ridge' rootstock and self-rooted cuttings.

Materials and Methods

The research was conducted in four years old *in-situ* grafted grape variety 'Muscat Hamburg' on 'Dog Ridge' rootstock and four years old self-rooted ''Muscat Hamburg'' cuttings with spacing 3.6×3.6m. The training system followed in the experimental site was the bower/ pandal system. Two treatments wereconsidered as T_1:'Muscat Hamburg' grafted on 'Dog Ridge' rootstock and T_2:self-rooted'Muscat Hamburg'. The parameters were recorded from fifty tagged vines of both 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock and self-rooted 'Muscat Hamburg'. Fifty vines were divided into 10 vine clusters, each comprising 5 vines. The vine cluster was denoted as V_1 to V_{10}.

Growth Parameters

Various growth characteristics recorded during the experiment in both seasons were trunk diameter, cane diameter, the number of shoots per cane, shoot-length after pruning, and leaf area. The trunk diameter was measured in each vine using Vernier-calliper and expressed in millimeters (mm). Mean cane diameter was observed at 3rd nodal position in a bunch bearing shoot by selecting two canes randomly in each vine cluster and expressed in millimeters (mm).The number of fruitful shoots was counted in the canes of ten selected vine clusters, and the mean value is expressed in numbers. The shoot length after pruning was measured in the shoot arising from the seasonal buds after reaching the terminal growth (i.e., before tipping). Leaf area was recorded on the 60th day after pruning when the leaves were functionally matured. The leaf area was arrived at using the following equation and expressed in cm^2 (Jayalakshmi *et al*., 2019).

$$\text{Leaf area} = (L \times B) \times K$$

Where,

L: Leaf length at longest leaf lamina (cm)

B: Leaf breadth at widest leaf lamina (cm)

The K factor value for 'Muscat Hamburg' variety is 0.79.

Yield Parameters

The number of clusters per shoot was observed at the time of flowering in the tagged vine clusters, and the mean value is expressed in numbers. The total number of berries per bunch was recorded by counting the berries at the time of harvest randomly in two bunches in each tagged vine cluster and repeated for all the vine clusters. The mean value was calculated and expressed in numbers. The individual berry weight was measured by weighing five randomly selected berries in each bunch, and the average was worked out and expressed in grams (g). The individual berry diameter was measured at harvest from five randomly selected berries per bunch per vine cluster and measured by using a Vernier caliper. The mean value was expressed in millimeter (mm). Bunch weight was quantified at the harvesting stage from five randomly selected bunches per vine cluster. The average was worked out and was expressed in grams (g).Fruit yield per vine was calculated by weighing the individual bunch borne on the vine in each treatment, and the combined weight of these bunches was considered as the total yield and expressed in kg vine^{-1}.

Petiole Nutrient Analysis

The petiole samples were digested by adhering to the procedure suggested by Muthuvel *et al*. (1985). The petioles opposite to the inflorescence were collected during the flowering period. The collected petioles were dried evenly at 65˚C for 48 hours in a hot air oven. The dried samples were powdered and used for analysis. The total nitrogen content of the sample was estimated by Micro Kjeldhal method (Humphries, 1956) and expressed in percentage. The total phosphorus content was analyzed in triple acid digest by adopting Vanado-molybdate phosphoric yellow colour method and expressed in percentage. The potassium content was estimated by reading the flame photometer values of triple acid digest and expressed in percentage (Jackson, 1958).The calcium and magnesium contents were analyzed by EDTA titration. The sulphur content was analysed by reading the spectrophotometer by turbidometry method (Piper, 1996).

Statistics

The statistical design followed was an 'independent t-test'. Statistical scrutiny of the experimental data was subjected to analysis by using Microsoft Excel version 2007. The mean separations were done on the self-rooted 'Muscat Hamburg', and 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock for growth and yield parameters using an independent t-test at 0.05 level of significance (Heeren and D'agostino, 1987).

Results and Discussion

Growth Parameters

The various growth characters observed at the field level are furnished in table 1. The rootstock, '''Dog Ridge''', had significantly influenced growth parameters such as trunk diameter, cane diameter, number of shoots per cane, shoot length after pruning, and leaf area. The mean trunk diameter was higher in the grafted vines (42.46 mm) than in self-rooted vines (38.65 mm). The p-value (0.001) for the mean of self-rooted and grafted is lesser than the significance level (0.05). Thus, it differed significantly in respect of trunk diameter. This might be due to the vigorous nature of the vine. Increased nutrient uptake by the vine might also be the reason for having a greater trunk diameter (Figure. 1). This is in agreement with the findings of Jogaiah *et al*. (2013).A high level of cane diameter is much more helpful in producing more shoots by utilizing its reserved food materials for berry development. The data on cane diameter recorded is presented in table 1. The p-value (0.0008) showed that the cane diameter had a significant difference between self-rooted 'Muscat Hamburg' and 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock, as the p-value (0.0008) was lesser than the level of significance (0.05). Therefore, a significant difference between self-rooted and grafted typeswas observed regarding cane diameter. The grafted (5.70 mm) had a better cane diameter than the self-rooted (5.14 mm).

The vigorousness of the vine also judges cane diameter and the number of cane production. According to Sommer *et al*. (1993) and Jogaiah *et al*. (2013), 'Dog Ridge' has a maximum cane diameter, which might be due to vigour and affinity to develop a dense canopy. This follows the results obtained in the current study, as the grafted 'Muscat Hamburg' on 'Dog Ridge' rootstock had a greater cane diameter (5.70 mm) than self-rooted (5.14 mm). The cane diameter got reduced when the number of shoots increased. It is due to paucity for nutrients and water among the shoots (Somkuwar *et al*., 2012).The number of fruitful shoots per cane is the critical growth parameter that decides the yield per vine in grapes. If the number of fruitful shoots increases, the vine yield will also increase. The mean of self-rooted and grafted vines were 1.14 and 1.37, respectively. According to Mullins (1967), the cytokinins /gibberellins ratio should be favorable for fruit bud formation. In the present study, the higher number of fruitful shoots may be due to the enhanced synthesis of cytokinins in the root system and transportation efficiency by the rootstock to the shoot system. Satyanarayana and Shikhamany (1986) opined that fruitfulness is the transformation of vegetative primordial into reproductive primordial. Tukey *et al*. (1962) reported that rootstocks influence the vigour and fruitfulness of the scions through enhanced nutrient uptake.

Table 1: Comparison of different growth characters of 'Muscat Hamburg' grape grafted on 'Dog Ridge' rootstock and self-rooted

Vine cluster Number	Trunk diameter (mm)		Cane diameter (mm)		Number of fruitful shoots per cane		Shoot length after pruning (cm)		Leaf area (cm^2)	
	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock
V_1	38.07	41.69	4.83	5.48	1.20	1.40	26.74	45.70	85.59	114.72
V_2	37.76	44.45	5.43	5.93	1.10	1.33	30.90	43.73	75.74	128.2
V_3	39.39	45.94	5.22	5.63	1.00	1.53	27.35	39.27	100.12	129.25
V_4	36.85	42.63	5.30	5.95	1.08	1.23	33.98	44.57	110.53	107.86
V_5	42.52	40.87	4.74	5.74	0.98	1.33	31.73	41.20	72.81	83.23
V_6	37.61	43.78	5.26	5.76	1.21	1.40	30.14	42.38	99.57	102.23
V_7	41.06	38.41	4.85	5.51	1.20	1.33	30.00	47.72	88.77	103.83
V_8	40.80	40.00	4.30	6.23	1.23	1.45	29.43	43.05	82.25	117.85
V_9	35.43	43.22	5.70	5.80	1.33	1.35	35.69	39.28	72.93	91.25
V_{10}	37.06	43.80	5.76	5.74	1.13	1.35	30.37	38.35	93.13	98.06
Mean	38.65	42.46	5.14	5.70	1.14	1.37	30.63	42.52	89.17	108.12
Variance	4.92	5.09	0.21	0.05	0.01	0.01	7.35	9.25	181.92	229.36
T statistic	-3.82		-3.97		5.23		9.23		3.06	
***p*-value**	**0.001***		**0.0008***		**<0.001***		**<0.001***		**0.008***	

* Represents significant difference at p@0.05 level of significance

The mean of shoot length after pruning in self-rooted and grafted was 30.63 cm and 42.52 cm, respectively. The highest shoot length in 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock may be due to increased vigour of *Vitis champini.* Hartman *et al*. (2002) reported a constructive association between shoot length, inter-node length, and leaf numbers, indicating that vigorous rootstock influence on the scion shoot growth. A significant difference was observed in mean data with the p-value of the test statistic (<0.001), revealing that shoot length after pruning had an effect on the vigorous growth of the vine. It is attributed to vigour inducing capacity of the species *Vitis champini*in 'Muscat Hamburg'. In grapevine, leaf area playsa vital role in biomass production through photosynthesis activity. Leaf area directly influences the grapevine yield by synthesizing maximum carbohydrates and transporting them to all the vine parts for better growth. It differed significantly among self-rooted and grafted types in respect of leaf area. The grafted vines (108.12 cm^2) have better leaf area than self-rooted (89.17 cm^2). Rootstocks of vigorous nature significantly impact the scion length and leaf area in grafts (Hartman *et al*. 2002). The leaves store the photosynthates in the vine's cane, cordon, and trunk. The higher leaf area provides the maximum room for photosynthesis and results in vigorous growth of the vine. It could be due to vigour inducing capacity of the species, *Vitis champini* in ''Muscat Hamburg'' grafted on 'Dog Ridge'. Leaves are the primary source for the growth and development of sinks namely bunch (Somkuwar and Ramteke, 2004).

Yield Parameters

The number of clusters data indicated a significant difference between the grafted and self-rooted 'Muscat Hamburg'(table 2). The influence of rootstock on scion significantly increased the number of clusters per shoot. The grafted vines (1.46) had a better number of clusters per shoot than self-rooted (1.32). High phosphorus content might have helped to form more fruitful canes,which helped the vigorous vines to produce more bunches (Fig. 1). The significant difference was observed between self-rooted and grafted types in respect of the total number of berries per bunch. The grafted (87.00) had a greater total number of berries per bunch than the self-rooted (61.25). The grafted (3.67g) had better berry weight than the self-rooted (2.94g). It may be due to the vigorousness of rootstock, which helps increase the berries in the bunch. The highest potassium content uptake by the rootstock also favours berry development (Fig. 1).

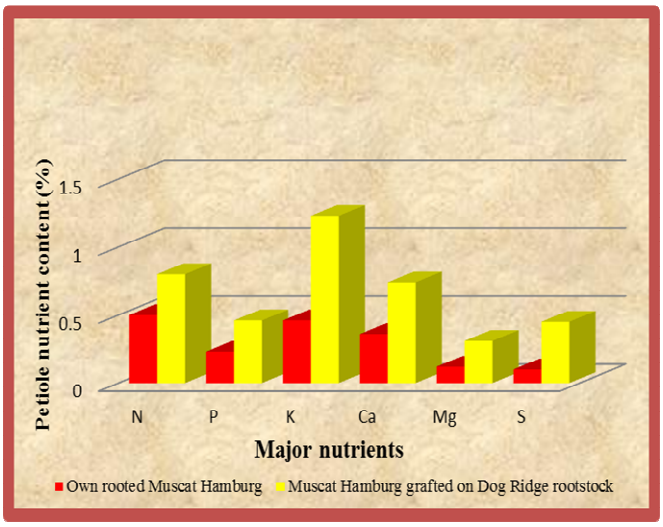

Fig. 1 : Effect of 'Muscat Hamburg' grafted on 'Dog Ridge' rootstock and self-rooted on petiole nutrient content

A significant difference between self-rooted and grafted types was observed in respect of bunch weight. The grafted (276.74 g) has a greater bunch weight than the self-rooted (194.56 g). The highest petiole potassium content might also increase the bunch weight in 'Dog Ridge' grafted varieties (Manjuvani *et al*., 2015). Higher potassium content increased the bunch size and weight (Hassan, 1968). When Thompson seedless grafted on 'Dog Ridge' rootstock in Maharashtra, it produced higher bunch weight than self-rooted vines (Tambe, 1999). Purohit *et al*. (1979) reported the higher leaf area was responsible for the massive bunch weight. In the present study, the grafted vines (21.87 kg/vine) yielded higher than the self-rooted vines (13.07 kg/vine). The primary vital processes between self-rooted and grafted vines were water and nutrient uptake (Serra *et al*., 2013). The reason for the rootstock effect on plant yield was reported by Aloni *et al*. (2010) that grafted vines had the highest ability to produce and translocate cytokinins and gibberellins in the roots, which helped in enhanced uptake of nutrients, thus reflected in yield. *Vitis champinii* rootstocks were the best to have higher relative water content and water use efficiency, thus making more vigorous than other rootstocks and self-rooted vines, and it reflected in high yield as the outcome (Satisha *et al*., 2008).

Table 2: Comparison of different yield parameters of 'Muscat Hamburg' grape grafted on 'Dog Ridge' rootstock andself-rooted

Vine cluster Number	Number of clusters per shoot		Total number of berries per bunch		Berry weight (g)		Bunch weight (g)		Yield per vine (kg)	
	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock	Self-rooted 'Muscat Hamburg'	'Muscat Hamburg' grafted on 'Dog Ridge' rootstock
V_1	1.30	1.50	69.00	93.25	3.64	3.75	191.55	282.43	12.40	22.80
V_2	1.30	1.50	59.25	82.25	3.73	3.50	204.41	377.98	13.63	23.05
V_3	1.40	1.50	56.50	80.25	2.73	3.73	200.75	265.75	14.00	21.66
V_4	1.40	1.70	67.25	100.5	2.53	3.38	161.43	266.64	11.90	22.42
V_5	1.40	1.30	63.50	84.75	2.76	3.36	210.63	299.32	13.55	20.99
V_6	1.30	1.50	66.50	97.75	2.66	3.81	200.63	240.18	12.77	22.22
V_7	1.20	1.40	54.00	76.00	2.79	3.46	225.13	285.33	14.00	21.51
V_8	1.10	1.40	57.25	82.25	2.75	3.18	170.43	232.58	14.10	21.47
V_9	1.50	1.20	50.00	98.25	2.60	3.96	175.65	235.28	12.51	21.29
V_{10}	1.30	1.60	69.25	74.75	3.10	4.55	205.00	281.90	11.89	21.34
Mean	**1.32**	**1.46**	**61.25**	**87.00**	**2.93**	**3.67**	**194.56**	**276.74**	**13.07**	**21.87**
Variance	0.01	0.02	46.04	92.25	0.18	0.15	391.17	1791.15	0.77	0.49
T statistic	-2.42		6.92		-4.03		-5.56		-24.77	
***p*-value**	**0.03***		**<0.001***		**0.0007***		**<0.001***		**<0.001***	

* Represents significant difference at *p*@0.05 level of significance

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