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Impact of Fertilizer and Micronutrients Levels on Growth, Yield and Quality of Grape cv. Sahebi

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Authors' contributions

This work was carried out in collaboration between all authors. Author AK designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors MKS, NN, RB and ASS managed the analyses of the study. Authors SB and KJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A study was carried out in model grapevine orchard of department of Horticulture at Kralbagh, Tehsil Lar, district Ganderbal (J&K) for two consecutive years. The treatment consisted of 3 levels of fertilizer doses, F_1(FYM50 kg/vine + recommended dose of NPK: 555, 227, 470 g/vine), F_2(FYM 50 kg/vine+ 2 times recommended dose of NPK: 1110, 454, 940 g/vine), F_3(FYM 50 kg/vine+ 3 times recommended dose of NPK: 1665, 681, 1410 g/vine), 3 micronutrients viz. M_1(Solubor 0.1%), M_2($ZnSO_4$ 0.4%) and M_3(Solubor 0.1% + $ZnSO_4$ 0.4%) applied two weeks before bloom and their combinations replicated thrice with a double plot size in a completely randomized block design. Fertilizer level F_2 recorded maximum percentage of fruitful shoots per, number of bunches per vine, fruit yield, berry TSS, berry total sugars, berry anthocyanin contents and lowest berry titrable acidity and shot berries during both the years. Among micronutrients, M_1 resulted in highest percentage of

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fruitful shoots per vine, number of bunches per vine, fruit yield, bunch weight, bunch diameter, berry weight, berry length, berry diameter, berry juice, berry TSS, berry total sugars, berry anthocyanin content and lowest berry titrable acidity and shot berries during both the years of study. Combination of fertilizer level F_2 and micronutrient M_1 resulted in highest percentage of fruitful shoots per vine, number of bunches per vine, fruit yield, berry TSS, berry total sugars, berry anthocyanin content and lowest berry titrable acidity and shot berries during both the years under study. Thus it could be concluded that fertilizer dose F_2(FYM-50 kg/vine + 2 times recommended dose-NPK: 1110, 454, 940 g/vine), micronutrient M_1(Solubor 0.1%) and their combination was most effective for improving growth, yield, quality and lowering shot berry incidence of grape cv. Sahebi.

Keywords: Fertilizer doses; micronutrients; grapes; growth; yield; quality.

1. INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most important fruit crops of temperate zone, which has acclimatized to sub tropical and tropical agro climatic conditions prevailing in the Indian sub-continent. It is a refreshing fruit, rich in sugars, acids, minerals, vitamins and tannins. It can be eaten raw or can be used for making jam, juice, jelly, vinegar, wine, grape seed extracts, raisins, molasses and grape seed oil. In India, the major grape growing states are Maharashtra, Karnataka, Andhra Pradesh, Punjab and Tamil Nadu and the bulk of the production is used for table purpose followed by raisin. In Jammu and Kashmir, grapes are grown in an area of 321 hectares with a production of 648 MT [1] but the productivity of grape vines had been declining and has come down to a very low level. Further quality of grape is also poor when compared to other grape growing states of India. The possible reason is non-adoption of proper management practices particularly pruning and fertilizer application. The productivity and quality of grapes is dependent mainly on perfect pruning and proper fertilization. Proper pruning plays an important role in sustaining the productivity for longer period of time. The purpose of pruning is to regulate or encourage good yield and to improve size and quality of fruit. Grape is a heavy feeder of nutrients. Three of the major elements i.e. N, P, K are removed from the soil in large amounts. Micro-nutrients e.g. B and Zn are those essential nutrient elements which are required in very small quantity but they have specific structural physiological and metabolic roles in the plant system. Boron is an important micro-nutrient governing many physiological and biochemical plant processes. It plays a significant role in flowering, fruit set, nitrogen metabolism, hormone movement and its action, sugar transport, cell wall synthesis and lignifications. Besides regulating K/Ca ratio in plants, it is associated with Ca uptake and also increases permeability of the membrane. Foliar application of boron act as a signal capable of interacting with cellular transcription factors to regulate various physiological processes affected by boron deficiency. Zinc is an important nutrient element for growth, flowering and quality of fruits. It is involved in the biosynthesis of the plant hormone, indole acetic acid and it is a component of variety of enzymes such as carbonic anhydrase, alcohol dehydrogenase. Zinc also plays a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen. If major macro and micro-nutrients are not replenished regularly, they start depleting in the soil and reach a threshold where they become deficient and result in reduced plant growth, yield and fruit quality. For a successful commercial cultivation of fruits, it is essential to ensure vigorous vegetative growth and development during the entire productive life of the tree. Therefore, it is necessary to apply the nutrients through manures and fertilizers to meet the growth and reproductive needs of the grapevine.Further the optimum combination of the pruning severity and the fertilizer rate play an important role in regulating the tree performance. District Ganderbal is the main grape growing area of Kashmir valley where Sahebi is grown as the predominating variety but itsnot being maintained on the scientific lines with respect to budload, application of nutrients and other cultural techniques thus resulting in low yields of poor quality berries. During the last 10-11 years, the cultivar Sahebi is suffering from a physiological disorder, shot berry. This disorder is characterized by a number of small seeded berries (chicken) among large fully developed seeded berries (hen) and is caused due to the boron deficiency and inadequate or excess use of fertilizers. Hence the present investigations were carried out to standardize the fertilizer dose and micronutrients for enhancing growth, yield and quality of grape cv. Sahebi.

2. MATERIALS AND METHODS

These investigations were carried out to assess the influence of bud load, fertilizer levels and their combinations on growth, yield and quality of grape cv. 'Sahebi' in model grapevine orchard of department of Horticulture at Kralbagh, Tehsil Lar district Ganderbal (J&K) for two consecutive years.

2.1 Treatments

The treatment consisted of 3 levels of fertilizer doses,F_1=FYM (50 kg/vine) + Recommended dose (NPK: 555, 227, 470 g/vine), F_2=FYM (50 kg/vine)+ 2 times recommended dose (NPK: 1110, 454, 940 g/vine), F_3=FYM (50 kg/vine)+ 3 times recommended dose (NPK: 1665, 681, 1410 g/vine) 3 levels of micronutrients viz. M_1(Solubor 0.1%), M_2 ($ZnSO_4$ 0.4%) and M_3 (Solubor 0.1% + $ZnSO_4$ 0.4%) and their combinations replicated thrice with a double plot size in a completely randomized block design. Micronutrients were applied two weeks before bloom.

2.2 Vegetative Characteristics

Data on percentage of fruitful shoots/vinewas calculated by dividing the number of fruitful shoots with total number of shoots emerged and multiplying by 100. Percentage of vegetative shoots per vinewas calculated by dividing the number of vegetative shoots with total number of shoots emerged and multiplying by 100. Leaf area was calculated withthe help of leaf area meter (Licor model 3100) and expressed in centimeter square (cm^2). Number of leaves in the randomly selected four canes in different directions were counted and then mean number of leaves per shoot was worked out.

2.3 Fruit yield and Physical Characteristics

Fruit yield per vine was calculated based on the number of bunches and the mean weight of bunches at harvest [2]. The weight of five bunches from each replication was observed on laboratory balance and the mean weight per bunch was recorded in grams. Five bunches were randomly selected replication wise and the mean bunch length was recorded in centimeters. Each bunch length was measured from the apex to the base. Five bunches from each replication were randomly selected and their mean diameter was recorded in centimeters. Each bunch diameter was recorded at the place of maximum spread. Fifty berries were separated from five randomly selected bunches per replication (10 berries per bunch) and weighed on laboratory balance. The mean weight per berry was calculated in grams. Ten berries were taken randomly from each bunch and the berry length was noted in centimeters with a verniercaliper and from this the average berry length was calculated. Ten berries were randomly taken from each bunch and the berry diameter was recorded in centimeters with a verniercaliper and from this the average berry diameter was noted. Fruit juice percentage was measured as per the method described by Mazumdar and Majumder [3].

2.4 Fruit Chemical Characteristics and Incidence of Shot Berries

Freshly extracted juice of fifty randomly selected berries was strained through muslin cloth. It was thoroughly stirred and a drop of it was placed on the hand refractometer and the TSS reading was recorded in ^{o}Brix. The readings were corrected at 20°C with the help of temperature correction chart [4]. Titrable acidity was estimated by titrating a known quantity of homogenised juice against 0.1N NaOH solution using phenolphthalein as indicator [4] and was expressed in terms of tartaric acid. Total sugars were estimated by Lane and Eynon method [5]. Anthocyanin contentwasextracted with ethanolic hydrochloride and the intensity of the colour appeared was measured colorimetrically [6]. The count of normal and shot berries per bunch was taken separately. The berries of the size of black pepper or small were considered as shot berries. The sum of the normal berries and shot berries gave the total number of berries per bunch. The percentage of shot berries was calculated as under, according to the procedure suggested by Nangia and Bakhshi [7] and Dhillon [8].

The data generated were subjected to statistical analysis as per the procedures described by Gomez and Gomez [9].

3. RESULTS AND DISCUSSION

3.1 Vegetative Characteristics

Fertilizer doses, micronutrients and their interactions significantly influenced percentage of fruitful shoots per vine, vegetative shoots per vine and leaf area,however interaction effect of fertilizer levels and micronutrients on number of leaves per shoot was non-significant during both the years of study (Table 1). Significantly highest percentage of fruitful shoots per vine was recorded with F_2 (44.10 and 44.99%) and M_1 (43.57 and 44.40%) in comparison to other fertilizer levels and micronutrients. Among the fertilizer level and micronutrient combination, highest percentage of fruitful shoots per vine was recorded with F_2M_1 (44.36 and 45.26%). This is because the medium dose of nitrogen, phosphorus and potassium produced more fertile buds. Optimum nitrogen is required for the proper fruitset in vines which results in maximum fruitful shoots/vine. Phosphorus helps to promote fruitfulness through synthesis of higher rates of ribonucleic acids in the buds. Potassium promotes fruitfulness through activation of enzymes involved in the conversion of carbohydrates to ribose sugar which is a component of RNA. This is in accordonce with the findings of Abd El-Razek. [10] and Maatouk et al. [11]. Further boron helps in the metabolism of nitrogen biosynthesis, translocation of carbohydrates and fruiting process.These results are in conformity with the findings of Ahmad and Abd El-Hameed [12], Ali [13], and Mostafa et al. [14].

Significantly higher percentage of vegetative shoots per vine (57.49 and 56.76%) was reported when vines were pruned to F_3 level during both the years. Micronutrient M_2resulted in maximum percentage of vegetative shoots per vine (56.91 and 56.04%) during both the years, respectively. Significantly maximum percentage of vegetative shoots per vine was recorded in F_3M_2(57.81 and 57.03%) during both the years, respectively. Maximum percentage of vegetative shoots/vine was registered in B_3 (160 buds/vine), F_3 (FYM-50 kg/vine+ 3 times recommended dose NPK-1665, 681, 1410 g/vine) and M_2 ($ZnSO_4$-0.4%) because of less percentage of fruitful shoots/vine recorded in these treatments.This is in line with the findings of Abd El-Razeket al. [10], Mostafa et al. [14] and Salem et al. [15].

Maximum leaf area (188.74 and 195.54 cm^2) was recorded with fertilizer level $F_3$and micronutrients M_3 (184.48 and 190.08 cm^2). Combination of F_3M_3 registered maximum leaf area (191.08 and 198.10 cm^2) in comparison to other fertilizer levels and micronutrients during both the years, respectively. Highest number of leaves per shoot was recorded with fertilizer level F_1 (54.42 and 61.65) and micronutrient M_1 (52.45 and 60.21). The combined influence of fertilizer level and micronutrient had shown non-significant influence on number of leaves per shoot. These results indicate that there was a direct effect on leaf expansion of each nutrient. The role of nitrogen as a constituent of amino acids and protein, as well as important role of phosphorus and potassium in encouraging cell division and development of meristimatic tissues (Tisdale et al. [16]) provides an explanation for their effect on leaf area. These findings are in agreement with Maatouk [11], Salem et al., [15], Delgado et al.[17] and Khan [18]. Boron has a direct effect on plant tissue growth via cell wall development (toughness and firmness) and protein synthesis. Zinc also increases the source of energy used in producing chlorophyll and preparing the joined enzymes in the active operation especially in generating chlorophyll and increasing surface area of leaves. The results are in agreement with the reports of Ahmad and Abd El Hamid [12] Mostafa et al*.,* [14], Al Imam and Al Saidi [19], and Zhang [20].

Highest number of leaves/shoot was obtained in fertilizer dose F_1 (FYM-50 kg/vine +Recommended dose, NPK-555, 227, 470 g/vine) which was statistically at par with F_2 (FYM-50 Kg/vine + 2 times recommended dose, NPK-1110, 454, 940 g/vine). This is because of the fact that shoots under the low and medium fertilizer dose grow less rapidly with shorter internodes which in turn affected the number of leaves per shoot. Similar results were found by Salem et al. [15] and Khan [18]. Maximum number of leaves/shoot was obtained in micronutrient M_1 (Solubor-0.1%).This is due to the favourable effect of boron on metabolism of nitrogen which in turn increased the number of leaves/shoot. This is in agreement with the findings of Ahmad and Abd El-Hameed [12] and Zhang [20].

3.2 Fruit Yield and Physical Characteristics

Effect of fertilizer level, micronutrients and their interaction on fruit yield, bunch weight, length and diameter and berry weight, length and diameter is given in Table 2. Highest fruit yield per vine (20.08 and 23.10 kg/vine) was recorded with fertilizer level F_2 and micronutrient M_1(19.78 and 22.81 kg/vine). Combination of F_2M_1 registered maximum fruit yield (20.42 and 23.80 kg/vine) in comparison to other fertilizer level andmicronutrient doses during both the years, respectively. This may be due to increase in both number of clusters per vine and cluster weight and better flower set, improved pollen viability, germination and fertilization, reduced fruit drop and increase in the berry size. These results are in agreement with the findings of Salem et al. [15], Ganai [21] and Prabu and Singaram [22].

Among fertilizer levels, highest bunch weight (412.61 and 436.98 g), bunch length (23.06 and 23.47 cm) and bunch diameter (13.87 and 13.68 cm) was recorded with fertilizer level F_3. Among micronutrients, highest bunch weight (402.81 and 427.54 g) and diameter (13.55 and 13.31 cm) was recorded with M_1 however bunch length was highest (22.65 and 23.85 cm) with M_2. Combination of F_3M_1 resulted in highest bunch weight (419.22 and 442.44 g) and bunch diameter (14.05 and 13.90 cm) however bunch length was highest (23.29 and 24.67 cm) with F_3M_2during both the years under study. This is probably because of the role of N, P and K in photosynthetic activity of the vine that results in more accumulation of assimilates for higher bunch weight. Similar findings were reported by Dhillon [8], Abd El-Razeket al. [10] and Terra etal [23].The highest bunch weight observed with micronutrient M_1 (Solubor-0.1%) was because of more fruitset due to boron. These results are in agreement with the findings of Ali [13], Mostafa et al. [14] and Ganai [21].

Highest berry weight (8.98 and 9.41 g), berry length (2.99 and 3.15 cm) and berry diameter (1.76 and 1.81 cm) was recorded with fertilizer level F_3. Among micronutrients, highest berry weight (8.66 and 9.03 g), berry length (2.92 and 3.08 cm) and berry diameter (1.72 and 1.76 cm) was recorded with M_1. Combination of F_3M_1 resulted in highest berry weight (9.12 and 9.54 g), berry length (3.02 and 3.18 cm) and berry diameter (1.79 and 1.86 cm) during both the years of study. This is due to the role of nitrogen, phosphorus, and potassium in increasing the cell division and cell elongation that might have contributed in increasing the berry weight, length and diameter. Also the highest berry weight, length and diameter may be due to enhanced supply of food material by way of increased leaf area due to boron. These results are in agreement with the findings of and Abd El-Razek et al. [10], Mostafa et al. [14] and Delgado et al. [17].

3.3 Fruit Chemical Characteristics and Incidence of Shot Berries

Data on response of fertilizer levels, micronutrients and their interaction on berry TSS, titrable acidity, total sugars, anthocyanin content and shot berry and is presented in Table 3.

Maximum TSS (16.78 and 17.95^{o}Brix), total sugars (13.33 and 13.84%) and lowest titrable acidity (0.480 and 0.498%) was recorded with fertilizer level F_2. Among micronutrients, highest TSS (16.48 and 17.48^{o}Brix), total sugars (12.92 and 13.30%) and lowest titrable acidity (0.488 and 0.505%) was recorded with M_1. Combination of F_2M_1 interaction resulted in highest TSS (16.97 and 18.12^{o}Brix), total sugars (13.55 and 14.03%) and lowest titrable acidity (0.470 and 0.490%) in comparison to other treatments during both the years of study. This might be due to the fact that nitrogen increases the availability of the assimilates and higher dose causes excess vegetative growth which requires most of the metabolites while little was left for storage in the berries. Increasing the applied phosphorus improves sugar accumulation in the berries which in turn induces high TSS. Potassium fertilization also helps in sugar transport into the berries. This increased TSS is also due to enhanced hydrolysis of polysaccharides into monosaccharides. These findings are in parallel with those of Abd-EL Razek et al. [10] and Martin et al. [24]. The highest improvement in TSS due to the application of micronutrient M_1 (Solubor-0.1%) is because of the impact of boron on the enzyme system of vines resulting in better nucleic acid synthesis, better nutrient uptake due to adequate root growth, increase in the sugar content and better translocation of sugars and nutrients from leaves to fruit. These results are in agreement with the findings of Prabu and Singaram [22]. The lowest acidity recorded in these treatments is because the increased sugar content might have decreased the acidity. This may also be due to conversion of acids into sugars. Similar results were investigated by Dhillon et al.[8] and Salem et al. [15],

Fertilizer level F_2 resulted in significantly higher anthocyanin content in berries (61.23 and 63.15 mg/100 g) and lowest percentage of shot berries (13.20 and 12.46%) during both the years. Among micronutrients, M_1 resulted in more anthocyanin accumulation (59.36 and 61.20 mg/100 g) and lowest proportion of shot berries (14.14 and 13.33%) in comparison to other micronutrients. Combination of F_2M_1 resulted in highest anthocyanin accumulation (62.32 and 64.56 mg/100 g) and lowest shot berry percentage (12.97 and 12.10%) in comparison to other fertilizer levels and micronutrient

Table 1. Effect of fertilizer level, micronutrients and their combinations on vegetative characteristics of grape

Treatments	Fruitful shoots per vine (%)		Vegetative shoots per vine (%)		Leaf area (cm^2)		Number of leaves per shoot	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
F_1	43.36	44.25	56.64	55.75	174.73	179.31	54.42	61.65
F_2	44.10	44.99	55.90	55.01	182.33	187.35	51.23	59.11
F_3	42.51	43.24	57.49	56.76	188.74	195.54	48.06	56.45
$CD_{(0.05)}$	**0.13**	**0.12**	**0.17**	**0.19**	**2.76**	**2.84**	**2.20**	**2.55**
M_1	43.57	44.40	56.43	55.60	181.97	187.50	52.45	60.21
M_2	43.09	43.96	56.91	56.04	179.35	184.61	50.96	59.02
M_3	43.31	44.14	56.69	55.86	184.48	190.08	50.30	57.98
$CD_{(0.05)}$	**0.13**	**0.11**	**0.10**	**0.12**	**1.43**	**1.57**	**0.20**	**0.23**
F_1M_1	43.50	44.43	56.50	55.57	175.32	179.79	55.77	63.19
F_1M_2	43.27	44.16	56.73	55.84	171.11	175.79	54.03	61.48
F_1M_3	43.30	44.17	56.70	55.83	177.76	182.35	53.46	60.28
F_2M_1	44.36	45.26	55.64	54.74	182.13	187.26	52.43	60.00
F_2M_2	43.82	44.75	56.18	55.25	180.26	184.98	50.96	59.04
F_2M_3	44.11	44.98	55.89	55.02	184.59	189.80	50.31	58.29
F_3M_1	42.84	43.50	57.16	56.50	188.47	195.46	49.14	57.43
F_3M_2	42.19	42.47	57.81	57.03	186.68	193.06	47.90	56.54
F_3M_3	42.51	43.27	57.49	56.73	191.08	198.10	47.13	55.37
$CD_{(0.05)}$	**0.16**	**0.15**	**0.19**	**0.22**	**2.79**	**2.87**	**NS**	**NS**

Table 2. Effect of fertilizer level, micronutrients and their combinations on fruit yield and physical characteristics of grape

Treatments	Fruit yield (Kg/vine)		Bunch weight (g)		Bunch length (cm)		Bunch diameter (cm)		Berry weight (g)		Berry length (cm)		Berry diameter (cm)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
F_1	18.64	21.50	385.01	407.92	21.70	22.75	12.91	12.57	8.01	8.36	2.76	2.96	1.61	1.66
F_2	20.08	23.10	396.41	421.14	22.41	23.61	13.41	13.13	8.51	8.86	2.89	3.04	1.70	1.73
F_3	19.02	22.00	412.61	436.98	23.06	24.37	13.87	13.68	8.98	9.41	2.99	3.15	1.76	1.81
$CD_{(0.05)}$	**0.73**	**0.81**	**4.31**	**4.58**	**0.67**	**0.78**	**0.48**	**0.55**	**0.48**	**0.55**	**0.12**	**0.13**	**0.07**	**0.09**
M_1	19.78	22.81	402.81	427.54	22.37	23.59	13.55	13.31	8.66	9.03	2.92	3.08	1.72	1.76
M_2	18.73	21.60	393.64	417.20	22.65	23.85	13.40	13.12	8.51	8.86	2.88	3.05	1.68	1.73
M_3	19.23	22.14	397.59	421.30	22.14	23.30	13.24	12.95	8.33	8.73	2.84	3.02	1.66	1.70
$CD_{(0.05)}$	**0.15**	**0.17**	**3.22**	**4.12**	**0.14**	**0.13**	**0.06**	**0.08**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	**0.02**

Treatments	Fruit yield (Kg/vine)		Bunch weight (g)		Bunch length (cm)		Bunch diameter (cm)		Berry weight (g)		Berry length (cm)		Berry diameter (cm)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
F_1M_1	19.29	21.96	389.01	411.97	21.66	22.75	13.06	12.73	8.21	8.47	2.81	2.99	1.64	1.68
F_1M_2	18.05	21.12	381.15	404.34	22.05	23.01	12.93	12.57	7.97	8.36	2.76	2.96	1.61	1.66
F_1M_3	18.57	21.48	384.87	407.46	21.39	22.50	12.74	12.73	7.86	8.24	2.72	2.93	1.58	1.63
F_2M_1	20.42	23.80	400.19	428.22	22.39	23.63	13.54	13.30	8.64	9.08	2.93	3.07	1.72	1.75
F_2M_2	19.70	22.47	392.66	414.95	22.62	23.86	13.42	13.14	8.55	8.84	2.89	3.05	1.69	1.73
F_2M_3	20.11	22.93	396.39	420.27	22.21	23.34	13.26	12.94	8.33	8.67	2.85	3.01	1.67	1.70
F_3M_1	19.62	22.66	419.22	442.44	23.06	24.39	14.05	13.90	9.12	9.54	3.02	3.18	1.79	1.86
F_3M_2	18.44	21.21	407.10	432.32	23.29	24.67	13.86	13.65	9.01	9.39	2.99	3.15	1.75	1.81
F_3M_3	19.01	22.00	411.52	436.17	22.82	24.05	13.71	13.49	8.81	9.29	2.96	3.12	1.72	1.77
CD$_{(0.05)}$	**0.79**	**0.85**	**4.35**	**4.89**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3. Effect of fertilizer level, micronutrients and their combinations on fruitchemical characteristics and incidence of shot berry

Treatments	TSS (^{o}Brix)		Titrable acidity (%)		Total sugars (%)		Anthocyanin (mg/100 g)		Shot berry (%)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
F_1	16.32	17.30	0.495	0.511	12.71	13.08	58.60	59.76	14.36	13.67
F_2	16.78	17.95	0.480	0.498	13.33	13.84	61.23	63.15	13.20	12.46
F_3	15.83	16.67	0.514	0.526	12.10	12.37	55.20	57.41	16.22	15.14
CD$_{(0.05)}$	**0.13**	**0.13**	**0.01**	**0.01**	**0.58**	**0.73**	**1.18**	**1.20**	**1.14**	**1.20**
M_1	16.48	17.48	0.488	0.505	12.92	13.30	59.36	61.20	14.14	13.33
M_2	16.13	17.12	0.503	0.524	12.51	12.87	57.36	59.24	15.05	14.18
M_3	16.32	17.31	0.497	0.506	12.71	13.13	58.30	59.87	14.58	13.76
CD$_{(0.05)}$	**0.10**	**0.12**	**NS**	**NS**	**0.31**	**0.28**	**1.04**	**1.26**	**0.19**	**0.13**
F_1M_1	16.48	17.50	0.490	0.506	12.94	13.29	59.62	60.91	13.73	13.29
F_1M_2	16.16	17.10	0.496	0.520	12.51	12.88	57.58	58.95	14.87	14.05
F_1M_3	16.32	17.29	0.500	0.506	12.68	13.08	58.61	59.40	14.49	13.67
F_2M_1	16.97	18.12	0.470	0.490	13.55	14.03	62.32	64.56	12.97	12.10
F_2M_2	16.62	17.76	0.493	0.513	13.10	13.59	60.05	61.78	13.48	12.85
F_2M_3	16.77	17.95	0.476	0.493	13.33	13.91	61.32	63.13	13.14	12.43
F_3M_1	15.98	16.83	0.506	0.523	12.28	12.57	56.16	58.14	15.73	14.61
F_3M_2	15.62	16.50	0.520	0.540	11.92	12.15	54.46	57.00	16.81	15.64
F_3M_3	15.87	16.69	0.516	0.516	12.10	12.40	54.98	57.08	16.11	15.19
CD$_{(0.05)}$	**0.16**	**0.15**	**NS**	**NS**	**NS**	**NS**	**1.21**	**1.29**	**NS**	**NS**

interactions during both the years. The increase in anthocyanin content with these treatments may be due to the presence of more sugars in these treatments which act as a trigger for anthocyanin synthesis. Moderate application of nitrogen stimulates the activity of phenylalanine ammonia lyase enzyme which is involved in anthocyanin synthesis. Potassium fertilization increases carbohydrate accumulation which in turn improves colour. Also boron plays an important role in metabolism of phenolic compounds resulting into the promotion of red colour in the fruits These results are in agreement with the findings of Abd-EL Razek et al. [10], Ganai [21], Martin et al. [24] and Bhat et al. [25] and Vine nutrition has an impact on bud fruitfulness developed during the previous season as well as floral differentiation in the current season prior to bloom. Nitrogen status of vines has been implicated as a potential cause of poor fruitset and incidence of shot berry. Too high or too low nitrogen can lead to poor fruitset. Poor nutrient uptake can also lead to poor fruitset and high percentage of shot berry. This indicates that fertilizer dose F_2 maintains proper C/N ratio in vines thereby minimizing the incidence of shot berry. The decrease of shot berries due to boron may be due to better pollination, germination and fertilization of ovules.

4. CONCLUSION

From the present study, it could be summarized that fertilizer dose F_2 (FYM-50 kg/vine + 2 times recommended dose-NPK: 1110, 454, 940 g/vine) micronutrient M_1(Solubor 0.1%)and their combination proved to be the best for improving growth, yield quality as well as reducing the incidence of shot berry in grape cv. Sahebi.

DISCLAIMER

Some parts of this manuscript presented in the following conference:
Conference name: - National Conference on Innovative Technological Interventions for Doubling Farmers Income
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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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