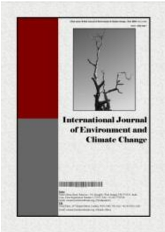

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Evaluation on the Effect of Silica (DE) for Growth and Quality of Mango Kesar

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted during 2012-2014 at Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak (Karnataka), India to study the effect of silicon on yield and quality of mango cv. Kesar. The experiment was laid out in a randomized complete block design with nine treatments replicated five times. The results revealed that, the highest yield per tree (140.93 kg/tree) was recorded in the treatment supplemented in (T_5) Half of RDF + DE 600 kg/ha which significantly more than the compared to control during 2012-2013, 2013-2014 and pooled data. It was noticed that the (T_7) RDF + DE 300 kg per hectareas RDF + DE 300 kg/ha was best on the basis of physical characteristics like increased in length, diameter and volume of the fruit, and the treatment was significantly higher than the untreated control mango fruits. The treatment also helped in better chemical characteristics like increased TSS, total sugars, and reducing sugars and optimum physiological loss in weight, resulting in improved keeping quality at ambient conditions (25-35^{0}C, 50-60% RH). The T_7 treatment was judged as the most effective soil application for the mango cv. Kesar that helped in increasing the quality of the mango fruits during storage even after 18 days of storage. The same treatment was also found to be more effective and significantly more than the compared to control during 2012-2013, 2013-2014 and pooled data with respect to organoleptic parameters for the mango cv. Kesar.

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Keywords: Mango; silica (DE); yield; physical parameters; TSS; shelf life; PLW etc,.

1. INTRODUCTION

Mango (*Mangiferaindica* L.) is one of the most popular fruit crops in the tropical and sub-tropical regions of the world, and belongs to the family Anacardiaceae. It has been under cultivation in the sub-continent from the past 4000 years [1], and is said to have originated in the Indo-Burma region [2]. It is named as the 'King of the fruits' owing to its wide range of adaptability, captivating flavour, delicious taste and an excellent source of Vitamins A and C. The fruit is not only eaten fresh, but also utilised for processing into various products like nectar, pulp, squash, juice, flakes, pickles and other delicacies.

Mango is grown in more than 87 countries of the world, and India ranks first both in area (25.00 million hectares) and production (18.003 million metric tonnes) (Ref). India contributes to more than 70 per cent of the total world mango production and it is largely grown in Uttar Pradesh, Bihar and Andhra Pradesh in India [3]. In the state of Karnataka, the leading fruit crop is mango occupying an area of 178.80 thousand hectares with a total production of 1.80 million metric tonnes of fruit [3]. The export of mango pulp from India in 2012-2013 amounted to 147815.69 MT to the World for the worth of Rs. 608 million [3].

In India, nearly 1000 varieties of mango are under cultivation, but only around 20 of them are grown under commercial scale. In Karnataka, mango varieties like Alphonso, Pairi, Banganpalli, Totapuri, Neelum etc., are the popular ones. Mango variety Kesar a popular one cultivated in Gujarat and Maharashtra is also gaining importance in Karnataka. In the recent past numerous investigations have showed that Kesar mango is successfully competing with Alphonso in domestic and export markets in respect of price, keeping quality, processability and overall marketability [4,5].

Mango being a highly heterozygous and cross pollinated crop, has resulted in enormous variations in the yield, quality and physico-chemical characteristics in mango which has resulted to lesser productivity (6.6 t/ha). Even though the area under mango is expanding rapidly, the pace of development is not appreciable.

Silica is considered as an important beneficial element as it helps in growth and development of plant. Silicon (Si) improves the cell wall due to deposition of silicon in the form of silica and phytoliths, and thus increases the thickness and erectness of plant. Silicon is one of the elements in the lithosphere, and it is the most abundant element in soil next to oxygen and comprises 28% of its weight and 3-17% in soil solution [6]. It is most commonly found in soils in the form of solution as silicic acid (H_4SiO_4), and plants takeup directly as silicic acid [7]. Being a dominant component of soil minerals, it has many important functions in environment, although sillicon is not considered as an essential plant nutrient. Because of its ubiquitous presence in the biosphere, most plants can be grown from seed to seed without its presence. Many plants can accumulate sillicon concentrations higher than essential macro nutrients [6].Therefore a detailed study on this aspect was undertaken to study theyield and quality attributes of mango variety Kesar.

2. MATERIALS AND METHODS

A field experiment was carried out at the farmer's field located in the Nellanatti village which is 05 km away from Arabhavi in mango cv. Kesar orchard with nine treatments which were imposed as soil applications.

2.1 Climate

Arabhavi is considered to have the benefit of both South-West and North-East monsoons. The mean annual rainfall of this area is about 530 mm distributed over a period of five to six months (June-November) with prominent peaks during July to October. The mean maximum temperature during the period (2012) of experimentation was 30.45^0 C, and the minimum temperature was 18.86^0 C with relative humidity ranged from 63.39 to 87.16%. The annual rainfall during the experimentation (2012) was 350.7 mm. The mean maximum and minimum temperature during 2013 was 29.83^0C, and 19.77^0C, respectively with the relative humidity ranged from 52.00 to 86.30%. The annual rainfall during the experimentation period was 110.88 mm.

2.2 Experimental Details

A field experiment was carried out at the farmer's field located in the Nellanatti village which is 05 km away from Arabhavi in mango cv. Kesar orchard with nine treatments which were imposed as soil applications.

Diatomaceous earth (DE) used as a source of silica was applied as a basal dose to the respective treatment in this experiment. The recommended dose of fertilizers was applied as per the package of practice of UHS, Bagalkot. Fertilizer dose of 750 g of Nitrogen, 200 g of Phosphorous and 700 g of Potassium was applied in the form of Urea, Diammonium phosphate and Muriate of potash, respectively in addition to 50 kg of farm yard manure. The fertilizers were applied in two splits. It was grown in irrigated conditions. Regular cultural operations like irrigation, weeding, etc. were carried out. No severe pest and diseases were recorded during research period (2012-2013 and 2013-2014).

2.3 Observations Recorded

The following observations on yield and quality attributes were recorded on each treatment.

2.4 Yield and Quality Parameters

Raw weight of fruit (g)

Immediately after the harvest of the fruit, the stalk was removed and the weight of raw fruit was recorded and expressed in grams.

Fruit yield–number of fruits per tree

The number of fruits harvested from each treated tree was counted at the time of harvest, and the data expressed as the number of fruits per tree.

Fruit yield (kg/tree)

The fruits harvested from each tree were weighed and expressed in kilograms of fruit per tree.

Fruit yield (t/ha)

The fruits harvested from each tree were weighed and converted to hectare basis based on number of trees per hectare (100) and expressed in tones per hectare.

2.5 Physical Parameters of Mango Fruit

Length of fruit (cm)

The length of the fruit from stalk end to the apex of fruit was determined at harvest, with the help of digital vernier callipers, and expressed in centimetres.

Breadth of fruit (cm)

The breadth of fruit was determined as the maximum linear distance between two shoulders of the fruit with the help of digital vernier callipers, and expressed in centimetres.

Volume of fruit (ml)

Fruit volume was determined by the conventional water displacement method, and the mean was computed, and expressed as millilitre.

Specific gravity of the fruit (g/ml)

This was computed as the ratio of fresh weight of fruit to its volume, and expressed as gram/millilitre.

Ripe weight of the fruit (g)

The fruits were ripened at room temperature, and their ripe weight was recorded in grams.

List 1. Treatment details

Treatments
T1 : Control
T2 : Recommended dose of fertilizer-RDF (750:200:700 g/tree/year of N, P and K)
T3 : Half of RDF
T4 : Half of RDF + DE 300 kg/ha
T5 : Half of RDF + DE 600 kg/ha
T6 : Half of RDF + DE 900 kg/ha
T7 : RDF + DE 300 kg/ha
T8 : RDF + DE 600 kg/ha
T9 : RDF + DE 900 kg/ha

DE: Diatomaceous Earth; Number of treatments: 9; Replications: 3; Variety: Kesar; Number of trees: 81 (3 trees/treatment); Age of the tree: 24; Design of the experiment: RBD

Pulp weight of the fruit (g)

Mango pulp, after separation from the peel and stone was weighed, and the weight expressed in grams.

Peel weight of fruit (g)

The peel of 10 fruits from each treatment was separated, recorded weight in grams, and the mean weight was computed.

Stone weight of fruit (g)

The stones of 10 fruits of each treatment were separated from the pulp, worked out their mean weight, and expressed in grams.

Pulp recovery (per cent)

The pulp recovery from the ripe fruits was determined by the following formula:

$$\text{Pulp percentage} = \frac{\text{Weight of pulp (g)}}{\text{Weight of the ripe fruit (g)}} \text{ x } 100$$

2.6 Post-harvest Behaviour of Fruit

Number of days taken for ripening

Fully mature mango fruits were harvested and the date of harvest was recorded. The difference between the date of harvest and date of ripening gives the number of days taken for ripening.

Physiological loss in weight (per cent)

At harvest, the raw mango fruits were weighed, and the fruits were kept for ripening. The fruits were then ripened at room temperature and the weight of the fruit was recorded again at the proper stage of ripeness. The physiological loss in weight was then calculated as:

$$\text{Loss in weight} = \frac{\text{Physiological} \quad \text{Raw weight of fruit (g)} \quad \text{Ripe weight of fruit (g)}}{\text{Raw weight of the fruit (g)}} \text{ x } 100$$

Shelf life (days)

The shelf life of fruits was determined by counting the number of days from harvesting to till the fruits remained in good condition without spoilage.

2.7 Bio-chemical Parameters of Fruits

Total soluble solids (^{0}B)

The juice extracted by crushing the ripe pulp from the two halves of each fruit, separately was strained through muslin cloth and used for measuring total soluble solids. TSS was determined by Voisny Erma hand refractometer (0^0 to 32^0 range) and expressed in ^{0} Brix.

Titratable acidity (%)

A composite sample of one gram was blended using the blender, and the volume was made upto 10 ml with distilled water. It was then titrated against 0.1N sodium hydroxide to the phenolphthalein end point, and expressed as per cent maleic acid.

Volume of x Normality of x Molecular x 100

$$\text{Per cent maleic acid} = \frac{\text{Sample (ml)} \quad \text{the alkali} \quad \text{weight of acid}}{\text{Aliquot taken (ml) x Weight of sample (g) x 1000}}$$

Sugar-acid ratio

Sugar-acid ratio of fruit pulp was computed as the ratio of total sugars to the titratable acid.

Total sugars (%)

The content of total sugar per cent in the ripe fruit pulp was estimated by the phenol-sulphuric acid method as described by Dubios et al. (1951).

Reducing sugar (%)

The reducing sugar content of the ripe fruit pulp was estimated by the dinitrosalicylic acid method as developed by Miller [8].

Non-reducing sugar (%)

The non-reducing sugar content was computed by the following formula :

Non-reducing sugar (%) = Total sugar (%) – Reducing sugar (%)

3. RESULTS AND DISCUSSION

3.1 Effect of Silica (DE) on Yield of Mango cv. Kesar

The yield parameters are measured in terms of number of fruits per tree, yield per tree and yield per hectare. Fruit characteristics like the fruit weight, fruit length, diameter of fruit and volume of fruit were recorded. The quality parameters like the shelf life, total soluble solids and physiological loss in weight were recorded to know the influence of application of silicon on the yield and quality of mango cv. Kesar.

The significant differences were observed in the yield per tree with soil application of silica (DE) and RDF on mango. The highest yield per tree (140.93 kg/tree) was recorded in the treatment supplemented of Half of RDF + DE 600 kg/ha (T_5) which significantly more than the treatment supplemented with (T_7) RDF + DE 300 kg/ha (132.77 kg/tree) compared to control during 2012-2013. In 2013-2014, the highest yield (145.04 kg/tree) was recorded in the treatment T_7 which was on par with T_5 (Half of RDF + DE 600 kg/ha) of 137.37 kg/tree, while the lowest (120.75 kg/tree) was recorded under control condition. Similarly, in the pooled data, the highest yield (139.15 kg/tree) was recorded in the treatment with T_5 which was on par with T_7 (138.91 kg/tree), and the lowest (125.13 kg/tree) was in control treatment (Table 1). Similarly, the highest yield (14.09 t/ha) was recorded in the treatment T_5 which was at par (13.27 t/ha) with the treatment T_7, and the lowest (12.97 t/ha) was found in control treatment during (2012-2013). In 2013-2014 highest yield (14.50 t/ha) was recorded in the treatment with (T_7) RDF+ DE 300 kg per hectare followed by T_5(13.37 t/ha) compared to control (12.07 t/ha). For the pooled data highest yield (13.89 t/ha) was recorded in T_7 and lowest was recorded (10.67 t/ha) in T_6 (Table 1). Silica (DE) had positive effect on the yield characteristics and yield, and the maximum values were recorded in soil applied with silica treatments than in control treatment. Previous studies emphasized the beneficial effects of salicylic acid in reducing abiotic stress activity in plants and it was also showed that Si influence a number of physiological processes including flowering, mineral uptake, transport and photosynthesis rate [6]. The essential role of silica on stimulating of antioxidant system in plants as well as immobilization of toxic metals and uptake of essential nutrients effectively encouraged cell division and the biosynthesis of organic foods could explain Silicon had many positive effects on the growth and yield as well physiology and metabolism of different crops. Increased yield might have attributed to more canopy spread which facilitated better harvest of sunlight leading to higher photosynthetic activity of plant, more formation of carbohydrates and more uptakes of other nutrients. Similar results were also noticed by Ahmed et al. [9] in mango, Miyake and Eiichi [10,11] in strawberry, Miyake and Eiichi (1983) in cucumber, Cai and Rian [12] in pecan nut, Reaple and Laane [13] in papaya, Bhavya [14] in Bangalore Blue grapes, and Adatia and Besford [15] in cucumber.

The maximum fruit weight (306.17 g) was recorded with treatment (T_7) RDF + DE 300 kg/ha, and the minimum fruit weight (248.53 g) was recorded in T_9 during 2012-13. In 2013-2014 maximum fruit weight (315.73 g) was recorded with DE application of RDF + DE 300 kg/ha (T_7) and the minimum fruit weight was recorded in T_5 (170.50 g). The pooled data had maximum fruit weight (310.95 g) with treatment of RDF + DE 300 kg/ha (T_7) and the minimum fruit weight was recorded in T_5 (225.22 g) (Table 1). Previous studies emphasized the beneficial effects of salicylic acid in reducing abiotic stress activity in plants, it was also shown Si influence a number of physiological processes including flowering, mineral uptake and transport, photosynthesis rate [6]. The essential role of silicon on stimulating of antioxidant system in plants as well as immobilization of toxic metals and uptake of essential nutrients effectively encouraged cell division and the biosynthesis of organic foods could explain Silicon had many positive effects on the growth and yield as well physiology and metabolism of different crops. Increased yield might have attributed to leaf erectness which facilitated better penetration of sunlight leading to higher photosynthetic activity of plant, more formation of carbohydrates and more uptakes of other nutrients. Similar results were also noticed by Miyake and Eiichi [10,11] in strawberry, Miyake and Eiichi (1983) in cucumber, Cai and Rian [12] in pecan nut, Reaple and Laane [13] in papaya, Bhavya [14] in Bangalore Blue grapes, Adatia and Besford [15] in cucumber, and Ahmed et al. [9] in mango.

3.2 Fruit Character

The maximum fruit length (14.53 and 14.07 and 14.30 cm) was recorded with soil application of RDF + DE 300 kg/ha (T_7) and the minimum (10.58, 11.85 and 10.83 cm) was observed in T_2 during 2012-2013, 2013-2014 and pooled data, respectively (Table 2). The diameter of fruit was significantly influenced by soil application of silicon. However, the maximum fruit diameter (8.98 cm) was recorded in T_8 in 2012-2013 followed by the treatment T_7 (8.79 cm) and the pooled data (8.84 cm) during 2013-2014, and the minimum (6.30, 6.68 and 6.49 cm) was recorded in the control during 2012-2013, 2013-2014 and pooled data, respectively (Table 2). It was reported that phytoliths deposited on the cell wall leads to lesser respiration. As a result, cell swelled and helped in cell division and cell elongation. The increase in weight was mainly due to cell division in the initial stages and later due to cell expansion associated with movement of water and other metabolites into the cell causing increase in overall weight of the fruit. Similar results were noticed by Ahmed et al. [16], Nam et al. [17] and Bhavya [14] in grapes and Nessreen et al. [18] in beans.

The maximum weight of the pulp (266.60, 218.33 and 242.47 g) was recorded with soil application of RDF + DE 300 kg/ha (T_7) and the minimum (171.25, 153.00 and 162.13 g) was observed in control during 2012-2013, 2013-2014 and pooled data, respectively (Table 3).

The maximum weight of the fruit peel (59.30 g) recorded from T_9 during 2012-2013 and 54.33 g and 56.17 g was recorded with soil application of RDF + DE 600 kg per hectare (T_8) during 2013-2014 and pooled data. Minimum (41.0 g, 38.33 g and 39.67 g) peel weight was observed in control during 2012-2013, 2013-2014 and Pooled data respectively (Table 3). As silicon restricts the stomata conductance, decreases the plasticity of the cell wall and thus, cell elongation and cell division might have occurred and helped in expansion of tissue and in obtaining maximum fruit pulp and peel weight. The results are in accordance with Nessreen et al. [18] in beans, Bhavya [14] in grapes and Bertling et al. [19] in avocado.

3.3 Quality Parameters

The shelf life was found significant due to application of DE, and the treatment RDF + DE 300 kg/ha (T_7) extended its shelf life up to maximum of 18, 17.75 and 17.87 days during 2012-2013, 2013-2014 and pooled data, respectively (Table 4). The data on physiological loss in weight as indicate that PLW increased slowly along with increased storage period in fruits treated with soil application of silica in 2012-2013, 2013-2014 and pooled data. However, physiological loss in weight was comparatively more in control mango samples throughout the storage period (Table 5a, b and c). Babak and Majid [20] reported that the use of silicon increased vase life of carnation as it lowered the ethylene production and silicon formed complexes with organic compounds in the cell wall of epidermal cells therefore increased their resistance to degrading enzymes. Silica sources might help in improving fruit quality due to suppression of respiration and reduction in ethylene evolution. The results are in conformity with Kaluwa et al. [21] in avocado and Stamatakis et al. [22] in tomato.

The significant difference was noticed in the total soluble solids, with soil application of silica on mango. Silica gave significant difference in the total soluble solids with maximum content (22.20 ^{0}B, 21.00^{0}B and 21.60^{0}B) were found in RDF + DE 300 kg/ha when compared to control. Silica helped in the synthesis of more sugars in the fruit and thus helped in increasing total soluble solids (Table 6). Significant difference was noticed with respect to acidity content of the fruits for soil application of silica. The minimum acidity was noticed in Half of RDF + DE 600 kg/ha treatment during 2012-2013, 2013-2014 and pooled data (0.31, 0.32 and 0.31%, respectively). On the contrary, the maximum acidity (0.36 %, 0.41 % and 0.35 %) was noticed in the control treatment during 2012-2013, 2013-2014 and pooled data, respectively (Table 6). The decrease in acidity might be due to increase in the total soluble solids and also due to the role of silicon which might have either involved in fast conversion of metabolites into sugar and their derivatives. Similar observations were made by Ahmed et al. [9] in mango, Su et al. [23] in apple and Stamatakis et al. [22] in tomato.

There were significant differences noticed with respect to total sugar content of the fruit for soil application of silicon. The maximum total sugar content was noticed in (T_7) RDF + DE 300 kg/ha treatment (16.11, 15.80 and 15.96%) when compared with the control treatment during 2012-2013, 2013-2014 and pooled data, respectively (Table 7). Silica helped in synthesis of more sugars in the fruit and thus helped in increasing total sugar content. Similar observation was made by Su *eta*l. [23] in apple.

The maximum reducing sugars (8.20, 7.33 and 7.77%) were noticed in T_7 treatment during 2012-2013, 2013-2014 and pooled data, respectively, and the minimum was noticed in control (Table 7). This might be due to the role of silicon which might have either involved in fast conversion of starch. Similar finding was observed by Bertling et al. [19] in avocado, who stated the beneficial effects of nutrients which led to faster conversion of starch to sugars and their derivatives. Ahmed et al. [9] in mangoes and Bhavya [14] in Banglore blue grapes, Stamatakis et al. [22] in tomato and Su et al. [23]) in apple also reported same.

3.4 Organoleptic Parameters

The results with respect to organoleptic parameters indicate that there was a significant difference among the treatments with respect to colour of fruit, colour of pulp, Taste of the fruit, aroma of the fruit and overall acceptability.

Significantly maximum score for colour of the fruit, pulp colour, aroma of the fruit and for the overall acceptability was recorded in T_7 (RDF + DE 300kg/ha) which recorded the maximum score for the pulp (8.63, 8.83 and 8.73), and aroma (9.00, 8.85 and 8.90) as shown in Table 8a and Table 8b during 2012-2013, 2013-2014 and pooled data, respectively. This might be due to the essential role of silicon on stimulating of antioxidant systems in plants as well as immobilization of toxic metals and uptake of essential nutrients effectively increased biosynthesis of organic foods and antioxidant capacity under stress conditions could explain the present results [24]. Similar results were reported by Tesfay et al. [25] in avocado.

Table 1. Effect of silica (DE) on the fruit yield of mango cv. Kesar

Treatments	Fruit Yield								
	Raw fruit weight (g)			Fruit yield (kg/tree)			Fruit yield (t/ha)		
	2012-2013	2013-2014	Pooled Data	2012-2013	2013-2014	Pooled data	2012-2013	2013-2014	Pooled data
T_1	305.30	246.00	275.65	129.35	120.75	125.05	12.93	12.07	12.50
T_2	256.17	224.30	240.24	111.09	127.45	119.27	11.10	12.74	11.92
T_3	292.17	192.60	242.39	106.13	135.19	120.66	10.61	13.51	12.06
T_4	293.00	201.60	247.30	112.39	129.66	121.03	11.23	12.96	12.10
T_5	279.93	170.50	225.22	140.93	137.37	139.15	14.09	13.37	13.91
T_6	258.80	205.75	232.28	91.93	122.18	106.74	9.19	12.21	10.67
T_7	306.17	315.73	310.95	132.77	145.04	138.91	13.27	14.50	13.89
T_8	290.83	216.65	253.74	122.05	133.33	127.69	12.20	13.33	12.76
T_9	248.53	228.35	238.44	132.00	129.85	130.93	13.20	12.98	13.09
SEm±	15.47	11.48	13.47	7.26	4.74	6.02	0.68	0.40	0.65
CD@5%	46.37	34.42	40.38	21.76	14.21	18.07	2.05	1.21	1.86

T_1: Control, T_2: RDF (750:200:700 g/tree/year), T_3: Half of RDF, T_4: Half of RDF + DE 300kg/ha T_5: Half of RDF + DE 600 kg/ha, T_6: Half of RDF + DE 900 kg/ha, T_7: RDF + DE 300 kg/ha, T_8: RDF + DE 600 kg/ha, and T_9: RDF + DE 900 kg/ha

Table 2. Effect of silica (DE) on the length and breadth of mango cv. Kesar

Treatments	Length (cm)			Breadth(cm)		
	2012-2013	2013-2014	Pooled Data	2012-2013	2013-2014	Pooled Data
T_1	12.73	11.85	12.29	6.30	6.68	6.49
T_2	10.58	11.07	10.83	7.59	7.68	7.64
T_3	13.55	11.55	12.55	8.59	8.13	8.14
T_4	13.33	11.42	12.38	7.27	6.71	6.97
T_5	12.83	11.58	12.21	7.80	7.48	7.65
T_6	13.03	12.93	12.98	6.77	7.52	7.14
T_7	14.53	14.07	14.30	8.88	8.79	8.84
T_8	12.42	12.85	12.64	8.98	8.67	8.83
T_9	12.56	12.75	12.66	8.23	8.06	8.15
S.Em±	0.23	0.58	0.40	0.16	0.18	0.17
CD@5%	0.68	1.75	1.21	0.48	0.54	0.51

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

Table 3. Effect of silica (DE) on ripe fruit, pulp and peel weight of cv. Kesar

Treatments	Ripe fruit weight (g)			Pulp weight (g)			Peel weight (g)		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	228.60	170.05	199.33	171.25	153.00	162.13	41.0	38.33	39.67
T_2	270.00	190.00	230.00	208.30	174.00	191.15	55.0	42.67	48.84
T_3	206.60	183.35	194.98	206.00	183.32	194.66	51.0	50.00	52.05
T_4	244.33	165.45	204.89	225.00	180.22	202.61	59.0	51.67	55.34
T_5	264.33	161.65	212.94	230.00	186.76	208.38	42.0	50.01	46.01
T_6	273.67	162.65	218.16	210.65	188.67	199.66	52.0	51.00	51.50
T_7	280.00	188.35	234.18	266.60	218.33	242.47	57.0	45.67	51.34
T_8	231.65	196.65	214.15	243.30	203.33	223.34	58.0	54.33	56.17
T_9	284.50	193.32	238.91	255.00	217.00	236.00	59.3	52.65	56.04
S.Em±	6.52	8.22	7.37	7.11	6.08	6.59	3.04	2.43	2.18
CD @5%	19.54	24.65	22.09	21.3	18.23	19.76	9.12	7.28	6.55

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

Table 4. Effect of silica (DE) on post harvest characters of mango cv. Kesar

Treatments	Number of days					
	For ripening			Shelf life		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	5.83	6.35	6.09	15.00	14.75	14.88
T_2	7.50	8.00	7.75	15.67	14.67	15.17
T_3	6.17	8.75	7.46	13.35	14.33	13.84
T_4	7.17	7.67	7.42	16.33	15.07	15.70
T_5	7.67	8.17	7.92	17.35	17.00	17.17
T_6	6.98	7.32	7.15	16.67	15.17	15.92
T_7	7.92	8.08	8.00	18.00	17.75	17.87
T_8	11.00	11.25	11.13	17.33	15.31	16.32
T_9	10.00	11.00	10.50	16.00	15.00	15.50
S.Em±	0.28	0.29	0.28	0.53	0.58	0.55
CD@5%	0.85	0.87	0.86	1.58	1.73	1.65

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

Table 5a. Effect of silicon on physiological loss in weight of mango cv. Kesar at ambient temperature

Treatments	Physiological loss in weight (%) at different storage days								
	4 Days			6 Days			8 Days		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	7.56	7.21	7.39	11.40	9.25	10.33	18.30	17.37	17.84
T_2	8.70	7.91	8.31	12.33	9.73	11.03	17.70	17.68	17.69
T_3	8.10	6.93	7.52	12.25	10.67	11.46	17.40	17.19	17.30
T_4	6.94	6.52	6.73	10.33	8.33	9.33	17.10	16.90	17.00
T_5	9.27	6.89	8.08	13.35	8.35	10.85	18.90	17.04	17.97
T_6	8.92	7.82	8.37	14.50	12.13	13.32	19.49	18.00	18.75
T_7	9.00	8.40	8.70	14.48	12.25	13.37	18.50	19.07	18.79
T_8	9.80	6.89	8.35	15.54	12.11	13.83	19.01	19.31	19.16
T_9	9.50	7.77	8.64	13.26	12.07	12.67	18.06	19.00	18.53
S.Em±	0.27	0.26	0.26	1.67	0.36	1.01	0.35	0.27	0.31
CD @5%	0.81	0.79	0.80	5.01	1.08	3.04	1.05	0.81	0.93

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

Table 5b. Effect of silica on physiological loss in weight of mango cv. Kesar at ambient temperature

Treatments	Physiological loss in weight (%) at different days of storage								
	10 Days			12 Days			14 Days		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	20.34	17.37	18.86	25.73	20.22	22.98	28.58	23.42	26.00
T_2	21.11	17.68	19.40	27.53	22.07	24.80	30.59	24.51	27.51
T_3	21.90	17.04	19.47	27.51	23.45	25.48	34.10	25.76	29.93
T_4	22.20	17.19	19.70	26.77	22.12	24.45	32.10	24.98	28.54
T_5	19.07	16.90	17.98	23.63	19.33	21.48	26.63	22.59	24.61
T_6	21.55	18.00	19.78	28.70	22.48	25.59	29.37	25.35	27.36
T_7	23.70	19.07	21.39	28.40	23.52	25.96	33.96	25.71	29.84
T_8	24.20	19.31	21.76	26.40	23.23	24.82	32.11	26.07	29.09
T_9	23.70	19.00	21.35	25.08	23.52	24.30	34.10	26.37	30.24
S.Em±	0.51	0.27	0.39	0.56	0.97	0.76	0.87	0.67	0.77
CD @5%	1.52	0.81	1.16	1.68	2.91	2.29	2.61	2.01	2.33

T_1- Control T_4- Half of RDF + DE 300kg/ha T_7- RDF + DE 300 kg/ha DE: Diatomaceous earth
T_2- RDF (750:200:700 g/tree/year) T_5- Half of RDF + DE 600 kg/ha T_8- RDF + DE 600 kg/ha
T_3- Half of RDF T_6- Half of RDF + DE 900 kg/ha T_9- RDF + DE 900 kg/ha

Table 5c. Effect of silica on physiological loss in weight of mango cv. Kesar at ambient temperature

Treatments	Physiological loss in weight (%) at different days of storage					
	16 Days			18 Days		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	37.35	30.48	33.86	32.10	30.55	31.33
T_2	37.39	33.92	35.66	41.33	38.68	40.01
T_3	40.33	32.00	36.17	40.95	36.41	38.68
T_4	38.48	33.05	35.77	40.17	35.13	37.65
T_5	32.90	28.92	30.91	38.91	32.13	35.52
T_6	40.48	33.70	37.09	39.29	36.26	37.78
T_7	40.17	37.60	38.89	40.84	36.76	38.80
T_8	39.03	39.58	39.31	40.02	37.22	36.62
T_9	38.93	38.58	38.76	41.72	38.18	39.95
S.Em±	1.12	1.01	1.06	1.29	0.92	1.10
CD@5%	3.37	3.04	3.20	3.88	2.76	3.32

T_1- Control T_4- Half of RDF + DE 300kg/ha T_7- RDF + DE 300 kg/ha DE: Diatomaceous earth
T_2- RDF (750:200:700 g/tree/year) T_5- Half of RDF + DE 600 kg/ha T_8- RDF + DE 600 kg/haT_3- Half of RDF
T_6- Half of RDF + DE 900 kg/ha T_9- RDF + DE 900 kg/ha

Table 6. Effect of silica (DE) on TSS, Titratable acidity and Sugar-Acid ratio of mango cv. Kesar

Treatments	TSS (^oB)			Titratable Acidity (%)			Sugar-Acid Ratio		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	19.17	19.33	19.25	0.36	0.41	0.39	48.52	42.67	45.60
T_2	17.92	17.83	17.88	0.35	0.37	0.36	42.58	43.30	42.94
T_3	16.95	17.15	17.05	0.30	0.32	0.30	42.53	41.00	41.77
T_4	20.92	19.00	19.96	0.36	0.33	0.35	50.67	45.00	47.84
T_5	21.73	20.58	21.16	0.31	0.32	0.32	42.58	41.20	41.89
T_6	21.15	19.45	20.30	0.37	0.35	0.36	43.00	40.58	41.79
T_7	22.20	21.00	21.60	0.35	0.33	0.34	45.81	43.71	44.76
T_8	21.00	20.18	20.59	0.33	0.31	0.32	43.20	41.03	42.12
T_9	20.00	19.88	19.94	0.37	0.34	0.36	41.17	39.12	40.15
S.Em±	0.54	0.46	0.50	0.01	0.02	0.01	0.30	1.13	0.71
CD @5%	1.61	1.38	1.49	0.03	0.06	0.04	0.91	3.40	2.15

T_1- Control T_4- Half of RDF + DE 300kg/ha T_7- RDF + DE 300 kg/ha DE: Diatomaceous earth
T_2- RDF (750:200:700 g/tree/year) T_5- Half of RDF + DE 600 kg/ha T_8- RDF + DE 600 kg/ha
T_3- Half of RDF T_6- Half of RDF + DE 900 kg/ha T_9- RDF + DE 900 kg/h

Table 7. Effect of silicaon total sugars, reducing and non-reducing sugars on mango cv. Kesar

Treatments	Total Sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	15.20	15.38	15.29	7.22	5.45	6.34	8.00	9.93	8.95
T_2	14.26	13.76	14.01	6.51	5.68	6.10	7.75	8.08	7.91
T_3	15.26	14.16	14.71	7.04	6.10	6.57	8.22	8.06	8.14
T_4	13.03	12.62	12.83	6.32	6.17	6.25	6.71	6.42	6.58
T_5	13.59	12.90	13.25	6.86	6.58	6.72	6.73	6.32	7.53
T_6	14.27	13.23	13.75	6.63	6.98	6.81	7.64	6.25	6.94
T_7	16.11	15.80	15.96	8.20	7.33	7.77	7.91	8.47	8.19
T_8	16.00	15.23	15.62	8.03	7.20	7.62	7.97	8.03	8.00
T_9	15.87	15.40	15.64	7.83	7.18	7.51	8.04	8.22	8.13
S.Em±	0.28	0.29	0.29	0.21	0.24	0.21	0.15	0.24	0.19
CD @5%	0.84	0.86	0.86	0.63	0.71	0.64	0.45	0.71	0.58

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha*
DE: Diatomaceous earth
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

Table 8a. Effect of silica (DE) on Organoleptic characters of mango cv. Kesar

Treatments	Colour of the Peel			Colour of the Pulp		
	2012-2013	2013-2014	Pooled	2012-2013	2013-2014	Pooled
T_1	7.42	7.17	7.30	6.92	8.33	7.63
T_2	7.75	7.82	7.79	7.50	7.50	7.50
T_3	6.75	6.00	6.38	6.33	6.92	6.63
T_4	7.05	7.42	7.24	7.58	7.92	7.75
T_5	7.25	7.30	7.28	7.00	7.42	7.21
T_6	7.46	7.08	7.26	7.75	7.92	7.84
T_7	8.63	8.83	8.73	8.75	8.83	8.79
T_8	8.08	7.25	7.67	8.17	8.17	8.17
T_9	8.50	7.92	8.21	9.13	7.83	8.48
S.Em±	0.18	0.21	0.18	0.18	0.30	0.17
CD@5%	0.55	0.62	0.53	0.53	0.89	0.52

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha* *Cont...*

Table 8b. Effect of silica(DE) on Organoleptic parameter of mango cv. Kesar

Treatments	Taste			Aroma			Overall Acceptability		
	2012-2013	2013-2014	Pooled Data	2012-2013	2013-2014	Pooled Data	2012-2013	2013-2014	Pooled
T_1	8.17	8.42	8.30	7.88	8.42	8.15	8.42	8.00	8.21
T_2	7.67	7.93	7.80	6.83	7.58	7.21	6.92	7.75	7.34
T_3	7.17	6.83	7.00	6.33	6.58	6.46	6.25	7.02	6.64
T_4	8.08	7.92	8.00	7.75	8.42	8.09	7.55	7.50	7.53
T_5	8.17	7.50	7.84	8.00	8.68	8.34	8.17	7.75	7.96
T_6	7.32	8.15	7.74	8.42	7.90	8.16	7.42	8.25	7.84
T_7	8.70	9.00	8.85	9.00	8.80	8.90	8.17	8.83	8.50
T_8	8.13	8.50	8.34	6.92	8.85	7.89	8.00	7.92	7.96
T_9	8.50	8.68	8.59	7.92	8.12	8.02	8.50	8.67	8.59
S.Em±	0.26	0.24	0.18	0.26	0.23	0.18	0.21	0.27	0.25
CD @5%	0.77	0.70	0.53	0.79	0.66	0.53	0.62	0.79	0.73

T_1- Control *T_4- Half of RDF + DE 300kg/ha* *T_7- RDF + DE 300 kg/ha* *DE: Diatomaceous earth*
T_2- RDF (750:200:700 g/tree/year) *T_5- Half of RDF + DE 600 kg/ha* *T_8- RDF + DE 600 kg/ha*
T_3- Half of RDF *T_6- Half of RDF + DE 900 kg/ha* *T_9- RDF + DE 900 kg/ha*

4. CONCLUSION

The effect of silicon on yield and quality of mango cv. Kesar. The experiment was laid out in a randomized complete block design with nine treatments replicated five times. The results revealed that, the highest yield per tree (140.93 kg/tree) was recorded in the treatment supplemented in (T_5) Half of RDF + DE 600 kg/ha which significantly more than the compared to control during 2012-2013, 2013-2014 and pooled data. It was noticed that the (T_7) RDF + DE 300 kg per hectareas RDF + DE 300 kg/ha was best on the basis of physical characteristics like increased in length, diameter and volume of the fruit, and the treatment was significantly higher than the untreated control mango fruits. The treatment also helped in better chemical characteristics like increased TSS, total sugars, and reducing sugars and optimum physiological loss in weight, resulting in improved keeping quality at ambient conditions (25-35^{0}C, 50-60% RH). The T_7 treatment was judged as the most effective soil application for the mango cv. Kesar that helped in increasing the quality of the mango fruits during storage even after 18 days of storage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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