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Effect of Organic Manures on Yield and Quality Characteristics of Pomegranate (*Punica granatum* L.) Cv. Bhagwa

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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

The research work carried out during *Mrig bahar* (July to December) in 2019 and 2020 at Technology park, CTAE and laboratories of Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan). It was conducted to investigate the effect of organic manures on yield and quality characteristics of pomegranate (*Punica granatum* L.) cv. Bhagwa. For this purpose selected 6 years old 42 pomegranate plants consisted of 14 treatments with different organic manures which are tested with randomized block design with three replications. Results showed that among all the treatments, the organic combination T_{13} - *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1} has recorded significantly effect on fruit quality characteristics found

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maximum total soluble solids (13.54 ^{o}Brix), ascorbic acid (19.05 mg/100 ml juice) and reducing sugar (9.68 %), which was at par with treatment T_2- RDF recorded total soluble solids (13.45 ^{o}Brix), ascorbic acid (18.92 mg/100 ml juice) and reducing sugar (9.63%). But, fruit yield characteristics like fruit volume (191.67 cm^3) was found maximum in treatment T_2- RDF which was at par with treatment T_{13} - *Jeevamrut* 16.08 L $plant^{-1}$ + Vermicompost 24.79 kg $plant^{-1}$ (190.50 cm^3) on pooled data basis of both the year 2019 and 2020. It may be concluded that organic treatment is best for improving the quality as well similar yield as compare to inorganic treatment.

Keywords: Pomegranate; Organic; Quality; Vermicompost; Jeevamrut; Farmyard Manure (FYM).

1. INTRODUCTION

Pomegranate (*Punica granatum* L.) is an important commercial fruit crop grown in south-western part of Rajasthan. This fruit crop can tolerant drought, salinity, winter hardy and also thrives well under rainfed conditions. Its cultivation steadily increasing because of the high commercial value of this fruit. Consumer interest in its consumption due to the organoleptic characteristics of the arils (seeds) and to the beneficial effects on health [1]. In Rajasthan, it covering about area of 10,352 ha and with a production of 63,608 MT. Barmer, Jalore, Jaisalmer, Jodhpur, Sirohi, Chittorgarh, Bhilwara and Udaipur are the most important pomegranate growing districts [2].

Improvement in nutrient availability [3], soil physical conditions and enzymatic activity have been reported by vermicompost application in fruit crops. Vermicompost is rich in organic carbon, which plays a key role in soil fertility and contains all essential plant nutrients in appropriate proportion. Thus, it is a complete and balanced plant food. It also contains biochemical substances that promote plant growth and fight against plant diseases. The use of vermicompost not only increases the rate of water intake into the soil but also improves the soil's ability to hold water. Its use enhances colour, smell, taste, flavour and keeping quality of fruits.

FYM being a bulky organic manure improves soil aeration in addition to the supply of essential plant nutrients and organic matter thereby increasing the soils biological activities. FYM also provided room for better microbial establishment along with the accumulation of excess humus content [4].

Compost improves drainage and absorption of moisture in soils with structural deficiencies or lack of nutrients. They also make it possible to increase crop productivity, promote plant growth by incorporating essential nutrients, facilitate implementation in different types of soil, reduce runoff and obtain economic benefits for farmers. Adding organic composts to apple orchard soils has been shown to improve the blooming and growth of newly planted trees and fruit yields [5].

According to Boraiah et al*.* [6] the application of *Jeevamrit* promotes biological activity in the soil and makes the nutrients available to the crop. Higher microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients resulted in better growth and yield of crops. *Jeevamrit* contains an enormous amount of microbial load which multiplies in the soil and acts as a tonic to enhance microbial activity in soil.

Therefore, in view of above mention this study was conducted to out-come the better nutritional composition of organic manures which improve the yield and quality characteristics of pomegranate fruit crop.

2. MATERIALS AND METHODS

2.1 Experimental Site and Description

The research work carried out during *Mrig bahar* (July to December) in 2019 and 2020 at Technology park, CTAE and laboratories of Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) located at 582.17 m above mean sea level with coordinates of 24º 34´ N latitude and 73º 42´ E longitudes. The experimental site's soil has pH 8.5, with clay loam texture, medium organic carbon (0.644 %), low in available nitrogen (272.68 kg ha^{-1}), available phosphorus (23.90 kg ha^{-1}) and available potassium (292.82 kg ha^{-1}). The weekly meteorological parameters of the experimental site were recorded during the crop season of 2019 and 2020. The maximum temperature (42.90 & 40.80°C) and relative humidity (94.3 & 95.7%) was recorded in 2019 and 2020, respectively, the minimum

temperature (4.7 & 3.8°C), relative humidity (11.3 and 19.9 mm) and annual rainfall (1160.6 and 862.7 mm) were recorded during 2019 and 2020, respectively are presented in Fig. 1.

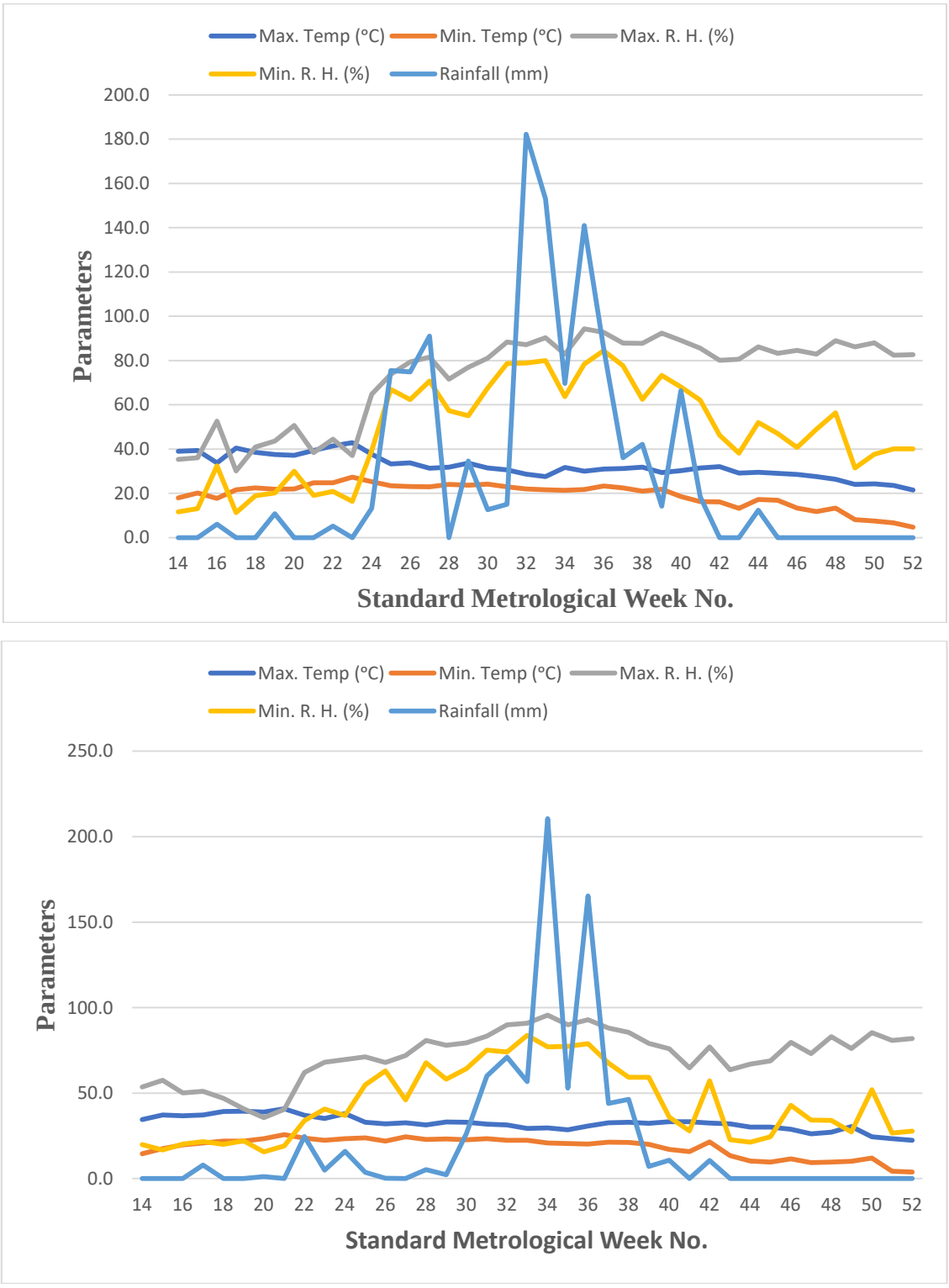

Fig. 1. Mean weekly weather parameters during cropping season 2019 and 2020

2.2 Experimental Design and Treatments

This experiment was laid out in Randomized Block Design. There were 14 treatment combinations [T_1-Control, T_2- RDF (600: 200: 200g NPK Plant^{-1} year^{-1}), T_3- FYM (120.72 kg plant^{-1}), T_4- Compost (54.10 kg plant^{-1}), T_5- Vermicompost (49.58 kg plant^{-1}), T_6- NADEP Compost (70.83 kg plant^{-1}), T_7- *Jeevamrut* (32.17 L plant^{-1}), T_8- FYM (60.36 kg plant^{-1}) + Compost (27.05 kg plant^{-1}), T_9- FYM (60.36 kg plant^{-1}) + Vermicompost (24.79 kg plant^{-1}), T_{10}- FYM (60.36 kg plant^{-1}) + NADEP compost (35.41 kg plant^{-1}), T_{11}- *Jeevamrut* (16.08 L plant^{-1}) + FYM (60.36 kg plant^{-1}), T_{12}- *Jeevamrut* (16.08 L plant^{-1}) + Compost (27.05 kg plant^{-1}), T_{13}- *Jeevamrut* (16.08 L plant^{-1}) + Vermicompost (24.79 kg plant^{-1}) and T_{14}- *Jeevamrut* (16.08 L plant^{-1}) + NADEP (35.41 kg plant^{-1})] with 3 replications and in each replication one tree served as a treatment unit. Thus 42 trees were marked for the experiment.

In pomegranate *bahar* treatment was done with water holding for one month prior to nutrient application. The inorganic nutrient was applied in month of May and organic manures were applied in June month. The yield characteristics like diameter and length of fruits (cm) were measured from randomly selected five fruits from every treatments and replication with the help of vernier calipers and then averaged the data. The fruit volume was calculated by water displacement method. The volume of five fruits in each and every treatment selected. After fruit were dipped in a full filled jar and water displaced by the fruit was collected and calculated by graduated glass jar the recorded reading was averaged.

Quality parameters like fruit colour in each treatment was observed by panel of four judges, who examined the fruit and the awarded score by them were averaged. The grading was done on the following pattern.

Category	Mark/range
9	Highly Yellowish Red
8	Yellowish Red
7	Yellowish
6	Light Yellowish
5	Yellowish Green
4	Light Yellowish Green
3	Light Greenish
2	Greenish
1	Dark Greenish

Ascorbic acid content of juice was determined by diluting the known volume of clean juice filtered through muslin cloth with 3% metaphosphoric acid to appropriate volume. 10 ml of aliquot was titrated against 2, 6 dichlorophenol indophenol dye solution till a stable light pink colour appeared. The result was expressed as mg ascorbic acid per 100 ml of juice (A.O.A.C., 1990).

Standardization:

Standardization of 2, 6-dichlorophenol indophenol dye was done by titrating against standard ascorbic acid solution. The standard ascorbic acid solution was prepared by dissolving 100 mg of L-ascorbic acid in 3% metaphosphoric acid and 1 ml was used for titration.

The ascorbic acid content of fruit was calculated using following formula:

$$\text{Ascorbic acid (mg/100ml juice)} = \frac{\text{Titre(ml) x Dye factor x Volume made up (ml) x100}}{\text{Aliquot taken for estimation (ml) x Weight of juice (ml)}}$$

The reducing sugar (%) was measured with take 5 ml of juice extract in a test tube and added with 5ml of potassium ferricyanide solution. After covering the tubes using byaluminium foil and kept for 15 minutes in boiling water bath. Then cooled the test tubes under tap water and 5 ml of potassium iodide solution followed by 3 ml of acetic acid solution were added in each test tube. Using starch as an indicator, the liberated iodine was titrated with 0.01N sodiumthiosulphate solution. The disappearance of blue colour and the appearance of milky white colour was the end point. A blank was also run simultaneously.

Total soluble solids of the fruits was determined by using a hand refractometer of 0-30 per cent range wherein one drop of fruit juice was put on the prism of the refractometer and the percent TSS was recorded directly. The values were corrected at 20^{o}C and expressed as percent total soluble solids of the fruits (A.O.A.C., 1990).

For Acidity (%) take fruit sample of five grams was macerated in pastel mortar with distilled water and the volume was made up to 10 ml. The extract was then filtered through a rough filter paper and aliquot of 2 ml was taken for titration against N/10 NaOH solution using two drops of 1.0 per cent phenolphthalein solution as an indicator. The endpoint of titration appeared as a light pink colour. The acidity was calculated using following formula based on NaOH used and results were expressed as gram citric acid per 100 g of sample.

$$\text{Acidity percent} = \frac{\text{Titre} \times \text{acid factor} \times 100}{10 \text{ ml juice}}$$

TSS: acid was calculated by dividing the value of total soluble solid content by acidity percentage.

Considering the medicinal importance of pomegranate fruits, more rational approach to organic cultivation including exploitation of various locally available organic manures such as FYM, vermicompost, compost, NADEP compost and *Jeevamrut* should be practically implemented to rejuvenate the depleted soil fertility and enrich the available pool of nutrients to the plants, which could benefit the having long maturity time.

3. RESULTS AND DISCUSSION

3.1 Yield Characteristics

The pomegranate yield is an ultimate objective of the growers to get maximum returns per unit area per unit time. The fruit yield characteristics of the crop significantly increased with the application of organic manures and inorganic fertilizer, except fruit diameter and fruit length recorded non-significant (Table 1). The application of recommended dose of fertilizer (RDF- 600: 200: 200 g NPK plant^{-1}) has recorded maximum the fruit volume (187.01, 196.33 and 191.67 cm^3), which was statistically at par with organic treatment combination *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1} with fruit volume of 185.34, 195.66 and 190.50 cm^3 during the experimental year 2019, 2020 and pooled data, respectively.

The result shows that the inorganic fertilizer had significantly promote the yield characteristics which were statistically at par with organic manures. The better results of inorganic fertilizer were due to increased supply of major plant nutrients, which are required in larger quantities for growth and development of plants. The application of nitrogen at optimum level attributed to acceleration in development of growth and reproductive phases. Ray et al. [7] found that the yield of pomegranate plant significantly increased with different levels of nitrogen.

Among the different organics, vermicompost proved best and the growth was superior, which could be attributed to the readily available and higher nutrient content in vermicompost. The improvement in growth may also be due to better moisture retention capacity and supply of nutrients due to favourable soil condition brought out by vermicompost application Marathe et al. [8] found that application of poultry manure recorded highest fruit yield in pomegranate. Similar result was observed by Pachuau et al. [9] in Assam lemon.

Supply of nutrients might have increased the production, translocation and accumulation of photosynthates into sink. This might have stimulated the plants to produce productive flowers ultimately resulting in increased fruit diameter, fruit length and fruits volume [10] in okra. Beura et al. [11] recorded that the increase in number of fruits owing to this treatment might be due to the greater availability of mineral nutrient from nitration of vermicompost.

The beneficial effects of *Jeevamrut* reported by Boraiah et al. [6] was attributed to higher microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in better growth and yield of capsicum. These research findings are in accordance with Chaudhari et al. [12], the liquid manures (*Panchgavya*, *Jeevamrut* and *Sanjeevak*) provide balanced nutrition to the crops and helped to improve the yield as it provides readily available nutrients, growth hormones and microbes to *Vigna radiata*. Gore and Sreenivasa [13] concluded that *Jeevamrut* contains enormous amount of microbial load which multiply and act as soil tonic. Its application enhances microbial activity in the soil and ultimately ensuring the availability and uptake of nutrients by the crops. *Jeevamrut* promotes immense biological activity in soil and enhance nutrient availability to crop. *Jeevamrut* is a low-cost improvised preparation that enriches the soil with indigenous microorganisms and helps for mineralization.

The increased fruit diameter, fruit length and fruit volume basis might be attributed due to the fact that, increasing levels of nutrients in assimilating area of crop due to which the yield characteristics was enhanced. Similarly, due to rational partitioning of economic sink, the quality attributes were improved. The above results are in conformity with the findings in sapota [14]. Increase in fruit volume and yield due to application of organic manures was might be responsible for synthesis of plant growth hormone, development of root system and therefore high nutrient utilization by crop plants [15] in cape gooseberry. Similar, findings have been reported by Singh and Singh [16] in tomato.

3.2 Quality Characteristics

The effect of organic manures upon fruit quality characteristics like TSS (^{o}Brix), ascorbic acid (mg/100 ml juice) and reducing sugar (%) were recorded significant but colour of fruit, acidity and TSS/acidity ratio has found non-significant with organic manures application during investigation (Tables 2 & 3). The highest total soluble solids (13.30, 13.78 and 13.54 ^{o}Brix), ascorbic acid (18.66, 19.44 and 19.05 mg/100 ml juice) and reducing sugar (9.54, 9.81 and 9.68 %) were recorded with organic combination T_{13}- *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1} which was at par with the treatment T_2- RDF (600: 200: 200g NPK Plant^{-1} year^{-1}) as compare to control T_1 (nothing applied) during the experimental year 2019, 2020 and pooled data, respectively.

The quality characteristics of pomegranate was significantly influence with the application of organic manures as compare to inorganic fertilizer. Because organic manures like Vermicompost which contains essential nutrients in accessible forms which escalates the plant growth by easily supplying to plant physiological activity. There was enhancement in the physico-chemical properties of soil, enzymatic activity and microbial population due to the imposition of vermicompost. The improvement in quality of fruits may be due to the proper supply of micronutrients and induction of hormones, which enhances cell division and elongation, improve fruit size and weight, root development, water uptake and deposition of nutrients. It may also be due to the increased N addition and catalytic activity of several enzymes [9].

Table 1. Effect of organic manures on fruit yield characteristics of pomegranate cv. 'Bhagwa'

Treatment	Fruit diameter (cm)			Fruit length (cm)			Fruit volume (cm^3)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	5.0	5.1	5.1	5.2	5.3	5.2	155.68	162.74	159.21
T_2	6.0	6.2	6.1	6.1	6.3	6.2	187.01	196.33	191.67
T_3	5.3	5.5	5.4	5.3	5.5	5.4	164.37	170.77	167.57
T_4	5.4	5.6	5.5	5.5	5.6	5.5	165.64	172.47	169.06
T_5	5.5	5.7	5.6	5.6	5.7	5.6	171.45	177.34	174.40
T_6	5.2	5.2	5.2	5.3	5.4	5.4	158.46	163.55	161.01
T_7	5.2	5.2	5.2	5.3	5.4	5.4	159.34	164.37	161.86
T_8	5.5	5.7	5.6	5.7	5.8	5.8	175.11	184.00	179.56
T_9	5.6	5.8	5.7	5.7	5.9	5.8	176.39	185.12	180.76
T_{10}	5.5	5.6	5.6	5.5	5.6	5.6	163.47	169.56	166.52
T_{11}	5.7	6.0	5.9	5.8	6.0	5.9	181.07	190.45	185.76
T_{12}	5.8	6.0	5.9	5.9	6.2	6.1	184.66	193.98	189.32
T_{13}	5.9	6.1	6.0	6.0	6.3	6.2	185.34	195.66	190.50
T_{14}	5.4	5.4	5.4	5.5	5.6	5.5	161.53	166.33	163.93
SEm ±	0.22	0.24	0.15	0.24	0.24	0.16	2.75	2.86	1.83
CD p=0.05 %	NS	NS	NS	NS	NS	NS	7.98	8.31	5.21

Table 2. Effect of organic manures on fruit quality characteristics of pomegranate cv. 'Bhagwa'

Treatment	Colour of fruit (%)			Ascorbic acid (mg/100 ml juice)			Reducing sugar (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	8.00	8.00	8.00	15.60	16.27	15.94	8.89	9.03	8.96
T_2	8.67	8.67	8.67	18.53	19.31	18.92	9.51	9.74	9.63
T_3	8.33	8.33	8.33	16.50	17.19	16.85	9.20	9.42	9.31
T_4	8.33	8.33	8.33	15.83	17.29	16.56	9.22	9.45	9.34
T_5	8.33	8.67	8.50	17.18	17.73	17.46	9.32	9.60	9.46
T_6	8.00	8.00	8.00	15.62	17.62	16.62	8.93	9.15	9.04
T_7	8.00	8.00	8.00	15.21	15.73	15.47	8.96	9.24	9.10
T_8	8.33	8.33	8.33	17.32	16.13	16.72	9.35	9.63	9.49
T_9	8.33	8.33	8.33	17.82	17.35	17.58	9.38	9.65	9.52
T_{10}	8.00	8.00	8.00	16.56	17.06	16.81	9.05	9.38	9.22
T_{11}	8.33	8.33	8.33	18.00	18.62	18.31	9.45	9.70	9.58
T_{12}	8.67	8.67	8.67	18.24	19.20	18.72	9.50	9.72	9.61
T_{13}	8.67	8.67	8.67	18.66	19.44	19.05	9.54	9.81	9.68
T_{14}	8.00	8.00	8.00	16.18	16.86	16.52	9.00	9.32	9.16
SEm±	0.45	0.44	0.29	0.51	0.66	0.39	0.15	0.16	0.10
CD p=0.05 %	NS	NS	NS	1.48	1.92	1.09	0.43	0.45	0.28

Table 3. Effect of organic manures on fruit quality characteristics of pomegranate cv. 'Bhagwa'

Treatment	TSS (°Brix)			Acidity (%)			TSS / acid ratio		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	12.10	12.18	12.14	0.51	0.51	0.51	24.09	23.88	23.99
T_2	13.25	13.64	13.45	0.42	0.40	0.41	31.55	34.92	33.23
T_3	12.33	12.75	12.54	0.46	0.45	0.45	26.81	28.54	27.68
T_4	12.70	12.97	12.84	0.45	0.44	0.45	28.27	29.48	28.87
T_5	12.81	13.06	12.94	0.44	0.44	0.44	29.11	30.49	29.80
T_6	12.00	12.33	12.16	0.48	0.47	0.48	25.09	26.46	25.78
T_7	12.23	12.50	12.37	0.47	0.47	0.47	26.39	26.90	26.64
T_8	12.97	13.25	13.11	0.44	0.43	0.44	29.49	30.81	30.15
T_9	13.02	13.30	13.16	0.43	0.42	0.43	30.28	31.67	30.97
T_{10}	12.50	12.65	12.58	0.46	0.46	0.46	27.17	28.21	27.69
T_{11}	13.09	13.30	13.20	0.42	0.42	0.42	31.17	31.67	31.42
T_{12}	13.15	13.50	13.33	0.42	0.41	0.41	31.31	33.20	32.25
T_{13}	13.30	13.78	13.54	0.41	0.39	0.40	32.45	35.70	34.08
T_{14}	12.35	12.62	12.48	0.47	0.46	0.46	26.55	27.73	27.14
SEm±	0.21	0.22	0.14	0.02	0.02	0.01	1.03	1.61	0.88
CD p=0.05 %	0.61	0.64	0.40	NS	NS	NS	NS	NS	NS

Application of organic sources improved the quality parameters. This may be due to improvement in soil physical properties like bulk density, hardness, porosity, soil pH, EC, hormone etc., and biological properties like bacteria, fungi, actinomycets and earth worm activity etc. Improvement in soil properties might have improved the root growth, nutrient uptake and quality of pomegranate. Among the organic sources, application of nutrients in the form of vermicompost and *Jeevamrut* combination improved the quality characteristics.

In general quality of the juice of the fruits produced with the application of organic manure was better as compared to inorganic fertilizer. Increased fruit quality of pomegranate with the increased leaf K levels was reported under south Indian conditions [8]. Increase in quality parameters in tomato might be due to increased availability of major as well as minor nutrients especially nitrogen and potassium, as they play vital role in enhancing the fruit quality and minimum might be due to lack of availability of sufficient nutrients [17].

The effect of potassium on fruit quality may be explained from the fact that potassium improved photosynthetic activity and also help in better

translocation of metabolites from leaves to fruit [18].

The addition of organic manures supplements ample of nutrients, moisture and growth promoting substances which enhances metabolic and hormonal activity of the plant and that promotes production of more photosynthates which was stored in fruits in the form of starch and carbohydrates. It is an established fact that the transformation of mature fruit into ripe form i.e., during the process of ripening the fruit undergoes physical, physiological and biochemical changes. The increase in TSS, Total sugar and ascorbic acid content of papaya fruits could be attributed to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars. The reduction of titratable acidity of papaya fruits through application of different organic manure with inorganic fertilizer might be due to the positive influence of boron and zinc in conversion of acids into sugar and their derivatives by the reaction involving glycolytic path way or be used in respiration both in fruit crops [19].

In guava Athani et al. [20] reported that the increased fruit quality parameters are due to the addition of different organic manures and amendments to the soil and in turn to plants, which might had enhanced the biosynthesis and translocation of carbohydrates in to fruits. Further, the availability of nitrogen from different sources might have increased leaf area with higher synthesis of assimilates which is due to enhanced rate of photosynthesis. Such effects have been attributed to increase rate of translocation of photosynthetic products from leaves to developing fruits and thereby increasing total sugars. Similar results have also been reported by Singh et al. [21] in strawberry.

4. CONCLUSION

The continuous use of inorganic fertilizer adversely affect to the fruit quality which impact on human health as well as soil health. According to this research findings it may be concluded that the application of inorganic treatment T_2 - recommended dose of fertilizer (RDF- 600: 200: 200 g NPK plant^{-1}) enhanced fruit yield characteristic like fruit volume (191.67 cm^3) which is at par with organic treatment T_{13} - *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1} has recorded fruit volume (190.50 cm^3) but fruit quality characteristics such as total soluble solids (13.54 ^{o}Brix), ascorbic acid (19.05 mg/100 ml juice) and reducing sugar (9.68 %) were recorded maximum with organic combination T_{13}- *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1}. Based on the above findings, it could be recommended that pomegranate growers should apply organic combination *Jeevamrut* 16.08 L plant^{-1} + Vermicompost 24.79 kg plant^{-1} to enhance yield and quality characteristics of pomegranate cv. Bhagwa fruits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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