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Effect of Biofertilizers and Bioinoculants on Yield and Quality of Mango cv. Mallika

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ABSTRACT: The present study aimed to evaluate the effect of biofertilizers and bioinoculants on yield and quality of mango using factorial CRD with sixteen treatment combinations comprising two factors *i.e.*, four biofertilizers *viz.*, D_1: Bio NPK Consortium (10 ml/tree), D_2: VAM (10 g/tree), D_3: Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree) and D_4: No biofertilizers which were given as drenching at pea stage and four bioinoculants *viz.*, S_1: Seaweed extract (0.2 %), S_2: Novel organic liquid nutrient (2 %), S_3: Jeevamrut (10 %) and S_4: No bioinoculants which were sprayed in two frequencies at 2nd week of April and 1st week of May. Treatments were repeated thrice. Among biofertilizers, D_3 recorded maximum fruit weight, fruit length, fruit diameter, number of fruits per tree, fruit yield, pulp weight, pulp: stone ratio, TSS, vitamin-A and total sugar during two years and pooled mean. Among bioinoculants, S_2 showed higher fruit weight, fruit length, fruit diameter, number of fruits per tree, fruit yield, pulp weight, pulp: stone ratio, TSS, vitamin-A and total sugar in two years and pooled analysis. However, biofertilizers and bioinoculants showed non-significant effect on stone weight. Combine application of biofertilizers and bioinoculants (D_3S_2) significantly increased fruit yield and total sugar.

Keywords: Biofertilizers, drenching, bioinoculants, foliar spray, mango.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most important commercial fruit crop of India. Mango is the national fruit of India and known as “King of Fruits”. It occupies the same position in India as it occupied by the apple in temperate climates and grapes in sub-tropical areas. Being a useful and delicious fruit, it is the part of culture and religion since the time immemorial. It is also good source of vitamin A and C. It is highly invigorative, laxative and diuretic (Bal, 2006). A single fruit can provide up to 40 % daily dietary fiber needs (Sing *et al.*, 2005). In raw stage, fruit is used for extraction of tannin as well as for preparation of curries, pickles and chutneys. Ripe fruits are used for a table purpose as well as for preparation of squashes, juices, nectars, syrups, jams and jellies. India ranks first among world's mango producing countries accounting for 50 per cent of world mango production, but has a poor representation in international market.

Use of biofertilizers and bioinoculants has assumed great importance for sustainable production and to improve the soil physical, chemical and biological properties. The increasing cost of the chemical fertilizers and their harmful effects on soil health became a major issue for the growers. Therefore, the cost effective, sustainable and alternative organic sources are required to fulfill the nutrient requirements. Biofertilizers are input containing microorganisms capable of mobilizing and solubilization of nutritive elements through biological processes. They are less expensive, ecofriendly and sustainable and do not require non-renewable source of energy during their production. They improve plant growth and fruit quality by producing plant hormones. The beneficial effect of biofertilizers are now well established in many fruit crops like mango (Ahmad *et al.*, 2004). Biofertilizers provide strength against soil borne diseases and also help in composting and effective recycling of solid waste which results in improved soil health. *Azotobacter* and *Azospirillum* have good nitrogen fixation ability. Bio NPK Consortium contains five strains of agriculturally beneficial microorganism (two nitrogen fixer, two

phosphate solubilizers and one potash mobilizer) is the one-time solution for all the macronutrients (N, P, K) requirement of crops. Anubhav Bio NPK Consortium contains *Azotobacter chroococcum* (ABA-1), *Azospirillum lipoferum* (ASA-1), *Bacillus coagulans* and two *Bacillus* spp. This formulation also provides additional benefits of protecting plant from phytopathogenic fungi and nematodes. According to Aal *et al*. (2020) in aonla and Patel (2020) in mango, application of Bio NPK Consortium improves growth, yield and quality attributes. VAM (*Vesicular Arbuscular mycorrhiza*) has been reported to increase the uptake of phosphorus. It increases the uptake of Zn, Cu, Mn and Fe. Scientific evidences have also suggested that VAM biofertilizer enhanced growth, yield and quality parameters of fruit crops (Singh *et al.* (2020) in guava and Raut *et al.* (2020) in custard apple).

Foliar application of bioinoculants has also become an alternative approach to minimize the chemical loads on crop. Several growth regulating bioinoculants like seaweed extract, novel organic liquid nutrient and jeevamrut have potential in increased growth and development of fruit crops. Seaweed extract had higher amounts of macro nutrients, trace elements, organic substances like amino acids, antioxidant, organic acid and plant growth regulators such as auxin, cytokine in and gibberellins are applied to improved nutritional status, vegetative growth, fruit quality and yield in plants (Crouch *et al.,* 1992). Novel organic liquid nutrient suitable for foliar and soil application. Sap obtained from banana pseudostem contains ample amount of essential nutrient and plant growth hormone (Cytokinin and GA_3) for growth and development of crops. Jeevamrut contains enormous amount of microbial load which multiply and act as soil tonic. It promotes immense biological activity in soil and enhance nutrient availability to crop (Gore and Sreenivasa 2011). Solanki *et al.* (2020) in peach and Sahana *et al.* (2020) in strawberry recorded increased yield and quality attributed with the application of Jeevamrut. The biofertilizers and bioinoculants have beneficial effect on yield and quality of fruit crops. Keeping all these in mind, a study on effect of biofertilizers and bioinoculants on yield and quality of mango cv. Mallika was conducted.

MATERIALS AND METHODS

Experimental site: An experiment was conducted during the year 2019-20 and 2020-21 on twenty-one years old uniform size mango trees planted 8.0 × 8.0 m at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India which is situated geographically at 22°35' North latitude and 72°56' East longitude with an altitude of about 45.1 m above the mean sea level. According to agro-climatic conditions of Gujarat state, Anand falls under 'Middle Gujarat Agroclimatic Zone-III'. The soil of the experimental site was loamy sand, locally known as *"Goradu"* having pH 7.14, EC 0.23 dSm^{-1} and 0.46 % organic C. The available N, P and K of the field soil were 320.00, 34.35 and 442.10 kg ha^{-1}, respectively.

Experimental design and treatments: The experimental design was CRD with factorial concept with three repetitions. The recommended dose of fertilizers *i.e.,* 100 kg FYM with 750:160:750 kg NPK ha^{-1} were applied. Full dose of FYM, phosphorus, potash and half dose of nitrogen were given after harvest of the crop *i.e.,* June. Remaining half dose of nitrogen was given at pea stage *i.e.,* March. One tree was selected per treatment and total sixteen treatment combinations were carried out.

Treatment details are as under:

Factor A. Drenching of biofertilizers (D)
D_1: Bio NPK Consortium (10 ml/tree)
D_2: VAM (10 g/tree)
D_3: Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree)
D_4: No biofertilizers
Factor B. Spraying of bioinoculants (S)
S_1: Seaweed extract (0.2 %)
S_2: Novel organic liquid nutrient (2 %)
S_3: Jeevamrut (10 %)
S_4: No bioinoculants

Biofertilizers was given in the ring 1.5 m apart from the tree trunk by drenching and incorporation with well decomposed FYM, then after the week half dose of nitrogen was given before pea stage *i.e.,* 1st week of March. Spraying of bioinoculants was applied to the trees as a preharvest spray in two frequencies in the month of 2nd week of April and 1st week of May as per treatments on trees by foot sprayer.

Mature uniform size fresh mango fruits were harvested and kept in the laboratory. The five mature fruits per treatment were randomly selected and all observations regarding physical and biochemical parameters of fruits were recorded under ambient storage condition. Total Soluble Solids (TSS) in °Brix of fruits was recorded by using hand refractometer. Sugar and Vitamin-A contents of the fruits were determined using method described by Ranganna (1979); Mishra and Gupta (1998), respectively. Data for individual years were analyzed and in order to study the average effect of different treatments over the years, the pooled analysis was also carried out as suggested by Gomez and Gomez (1976).

RESULTS AND DISCUSSION

Effect of biofertilizers on yield parameters of mango. The drenching of biofertilizers significantly influenced the yield parameters of mango (Table 1 and 2). The yield parameters in terms of maximum fruit weight (353.47, 337.15 and 345.31 g), fruit length (13.67, 13.32 and 13.50 cm), fruit diameter (8.33, 8.11 and 8.22 cm), number of fruits per tree (212.27, 197.63 and 204.95), fruit yield (88.04, 83.45 and 85.75 kg/tree & 13.73, 13.02 and 13.38 t/ha), pulp weight (237.38, 231.67 and 234.52 g) and pulp: stone ratio (5.77, 5.36 and 5.56) were noted with drenching of Bio NPK Consortium 10 ml/tree + VAM 10 g/tree during the year 2019-20, 2020-21 and in pooled data, respectively. The drenching of biofertilizers failed to influence any significant effect on stone weight of mango fruit.

It might be due to biofertilizers (Bio NPK Consortium + VAM) may supply optimum plant nutrients and growth hormones at desired amount during entire period of fruit growth, ultimately increases higher rate of photosynthesis resulted in more accumulation of dry matter responsible for more fruit weight and diameter of mango fruit. Biofertilizer is considered as a significant source of different micronutrients which play an important role in regulation of length of fruit by enhancing metabolic activities in plant cells (Sharma *et al*., 2013). Due to the supply of all the nutrients in adequate right from starting of the experiment to the harvesting of the crop, which induced more retention of fruits by supply of photosynthates at critical requirement stage and that resulted into the higher number of fruits per tree and increased fruit yield. Biofertilizers have direct relation in N fixation, solubilizing phosphorus, production of phytohormone which increased the uptake of nutrients that ultimately increases pulp: stone ratio of mango fruits. These observations are in agreement with the Aal *et al*. (2020) in aonla, Patel (2020) in mango, Patel *et al.* (2017) in sapota and Nurbhanej *et al.* (2016) in acid lime.

Effect of bioinoculants on yield parameters of mango. The spraying of bioinoculants significantly influenced on the yield parameters of mango (Table 1 and 2). Maximum fruit weight was recorded (335.56 g) in pooled data, fruit length (13.08, 12.79 and 12.93 cm), fruit diameter (7.99, 7.82 and 7.90 cm), number of fruits per tree (204.83, 192.33 and 198.58), fruit yield (84.94, 80.30 and 82.62 kg/tree & 13.25, 12.53 and 12.89 t/ha), pulp weight (224.45, 217.32 and 220.88 g) and pulp: stone ratio (5.49, 5.05 and 5.27) during the year 2019-20, 2020-21 and pooled mean, respectively with spraying of novel organic liquid nutrient 2 %. The spraying of bioinoculants failed to influence any significant effect on stone weight of mango.

Novel organic liquid nutrient provides higher carbohydrate accumulation in plant at early stage of growth as a resulted in better nutrient supply, which causes an increased in fruit size and there by increased the fruit diameter, length and fruit weight (Patel *et al*., 2018). Similar type of results was also reported by Anon. (2012) in mango. It has also a good amount of K and the role of K in reducing the fruit drop is expected due to its catalytic effect in biochemical reactions occurring in physiological processes of the plant (Baiea *et al*., 2015) and also responsible for enhancement of auxin in the plant which is known to reduce fruit drop and increase the fruit retention by delaying the formation of abscission layer (Nason and Mc Elroy, 1963). These results are in close conformity with the findings of Parmar *et al.* (2018) in papaya, Rathod *et al*. (2017) in pomegranate.

Table 1: Effect of biofertilizers and bioinoculants on fruit weight, fruit length, fruit diameter and number of fruits per tree of mango cv. Mallika.

Treatments	Fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)			Number of fruits per tree		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Biofertilizers as drenching (D)												
D_1	344.99	326.52	335.76	13.19	12.77	12.98	7.99	7.81	7.90	205.69	190.94	198.31
D_2	331.81	316.32	324.06	12.48	12.23	12.35	7.63	7.43	7.53	196.26	183.90	190.08
D_3	353.47	337.15	345.31	13.67	13.32	13.50	8.33	8.11	8.22	212.27	197.63	204.95
D_4	294.53	279.33	286.93	10.55	10.37	10.46	6.48	6.23	6.36	169.13	159.94	164.54
S.Em.±	9.10	8.23	6.13	0.24	0.33	0.20	0.21	0.17	0.21	4.61	5.83	3.72
CD at 5 %	26.22	23.73	17.34	0.68	0.95	0.57	0.61	0.50	0.61	13.28	16.80	10.50
Bioinoculants as spraying (S)												
S_1	336.95	320.09	328.52	12.80	12.42	12.61	7.79	7.55	7.67	199.88	186.67	193.28
S_2	344.06	327.05	335.56	13.08	12.79	12.93	7.99	7.82	7.90	204.83	192.33	198.58
S_3	332.55	316.53	324.54	12.58	12.29	12.43	7.66	7.48	7.57	197.69	184.48	191.08
S_4	311.25	295.65	303.45	11.44	11.19	11.31	6.98	6.75	6.86	180.95	168.92	174.94
S.Em.±	9.10	8.23	6.13	0.24	0.33	0.20	0.21	0.17	0.21	4.61	5.83	4.61
CD at 5 %	NS	NS	17.34	0.68	0.95	0.57	0.61	0.50	0.61	13.28	16.80	13.28
Interaction (D × S)												
S.Em.±	18.19	16.47	12.27	0.47	0.66	0.40	0.42	0.35	0.27	9.21	11.66	7.43
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of biofertilizers and bioinoculants on fruit yield (kg/tree), fruit yield (t/ha), pulp weight, stone weight and pulp: stone ratio of mango cv. Mallika.

Treatments	Fruit yield (kg/tree)			Fruit yield (t/ha)			Pulp weight (g)			Stone weight (g)			Pulp:stone ratio		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Biofertilizers as drenching (D)															
D_1	83.69	79.03	81.36	13.06	12.33	12.69	223.77	217.57	220.67	40.85	40.50	40.67	5.51	5.06	5.28
D_2	78.78	73.94	76.36	12.29	11.53	11.91	207.49	202.26	204.87	40.27	39.95	40.11	5.18	4.70	4.94
D_3	88.04	83.45	85.75	13.73	13.02	13.38	237.38	231.67	234.52	41.29	40.87	41.08	5.77	5.36	5.56
D_4	66.60	62.80	64.70	10.39	9.80	10.09	157.15	152.44	154.79	38.46	38.51	38.49	4.15	3.64	3.89
S.Em.±	1.38	1.77	1.12	0.22	0.28	0.18	5.99	4.36	3.70	1.11	0.95	0.73	0.23	0.15	0.14
CD at 5 %	3.98	5.10	3.10	0.62	0.80	0.49	17.26	12.56	10.47	NS	NS	NS	0.65	0.43	0.38
Bioinoculants as spraying (S)															
S_1	81.07	76.51	78.79	12.65	11.93	12.29	213.30	208.20	210.75	40.46	40.16	40.31	5.27	4.84	5.06
S_2	84.94	80.30	82.62	13.25	12.53	12.89	224.45	217.32	220.88	40.84	40.46	40.65	5.49	5.05	5.27
S_3	79.63	75.26	77.44	12.42	11.74	12.08	209.99	203.92	206.95	40.32	40.05	40.19	5.28	4.76	5.02
S_4	71.48	67.15	69.32	11.15	10.48	10.81	178.05	174.49	176.27	39.24	39.16	39.20	4.56	4.10	4.33
S.Em.±	1.38	1.77	1.12	0.22	0.28	0.18	5.99	4.36	3.70	1.11	0.95	0.73	0.23	0.15	0.14
CD at 5 %	3.98	5.10	3.17	0.62	0.80	0.49	17.26	12.56	10.47	NS	NS	NS	0.65	0.43	0.38
Interaction (D × S)															
S.Em.±	2.76	3.54	2.24	0.43	0.55	0.35	11.98	8.71	7.41	2.21	1.89	1.46	0.45	0.30	0.27
CD at 5 %	NS	NS	Sig.	NS	NS	Sig.	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interaction effect of biofertilizers and bioinoculants on yield parameters of mango. Maximum fruit yield (95.35 kg/tree & 14.87 t/ha) in pooled result (Fig. 1) was observed with combined application of drenching with biofertilizers like Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree) and spraying with bioinoculants *viz.*, Novel organic liquid nutrient (2 %). Increased fruit yield is might be due to the combine effect of drenching with biofertilizers (Bio NPK Consortium + VAM) at critical stage *viz.*, pea stage and spraying with bioinoculant (Novel organic liquid nutrient) that provides essential macro nutrient (N, P and K) in adequate quantity, VAM may increases uptake of phosphorus and other micronutrients (Zn, Cu, Mn, Fe) as well as spraying with novel organic liquid nutrient act as a growth stimulant which have regulatory role in more fruit retention upto harvest period ultimately increases fruit yield. This finding is supported by Yadav *et al.* (2011); Patel (2020) in mango.

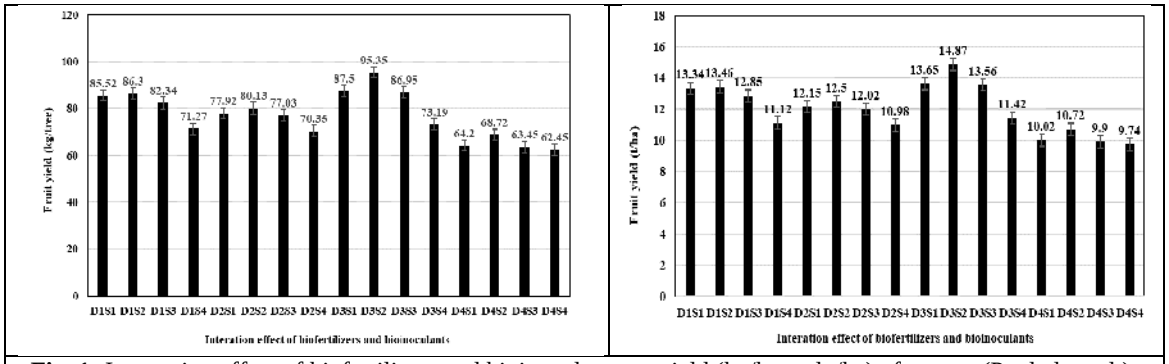

Fig. 1: Interaction effect of biofertilizers and bioinoculants on yield (kg/ha and t/ha) of mango (Pooled result).

Effect of biofertilizers on quality parameters of mango. Drenching with biofertilizers treatment significantly affected the quality parameters of mango (Table 3). Maximum total soluble solids (24.36, 23.42 and 23.89 °Brix), vitamin-A (1.37, 1.44 and 1.41 mg/100 g) and total sugar (19.47, 19.18 and 19.33 %) was noted in treatment of Bio NPK Consortium 10 ml/tree + VAM 10 g/tree during the year 2019-20, 2020-21 and in pooled data, respectively.

An increase in TSS contents with biofertilizers application may be attributed due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits, conversion of complex polysaccharides into simple sugars. Proper uptake may lead to increase in pigment synthesis, resulting higher carotenoids in mango fruits. Application of Bio NPK Consortium along with VAM might have performed regulatory role on absorption of nutrients and translocation of metabolites especially carbohydrates reserve in roots and stem which hydrolyzed into sugar during ripening which improve the sugar content of fruits. These findings are in agreement with the result of Dutta *et al.* (2016) in mango, Lodaya and Masu (2019) in guava, Sharma *et al.* (2016); Nehate and Jadav (2019) in mango.

Effect of bioinoculants on quality parameters of mango. Bioinoculants treatment showed significant result for quality parameters (Table 3). Among the different bioinoculants treatment maximum total soluble solids (23.48, 22.60 and 23.04 °Brix), vitamin-A (1.34, 1.41 and 1.38 mg/100 g) and total sugar (19.03, 18.75 and 18.89 %) was observed in spraying with novel organic liquid nutrient 2 % in the years 2019-20, 2020-21 and pooled, respectively.

Novel organic liquid nutrient contains macro, micro elements and plant growth regulators which might helped in improving the fruit quality of fruit (Modi *et al.* 2019). The fermented novel organic liquid nutrient contains higher amount of potassium (Mahalakshmi and Naveena 2016). The role of potassium in improvement of fruit quality is well documented (Asaduzzaman and Asao, 2018). Increased in TSS and sugar content might be due to respirational demand and adequate supply of nutrients, synthesis of invertase and starch splitting enzymes (Patel *et al*., 2018). Adequate availability of macro and micro nutrients that may increases the pigment synthesis which resulted in high vitamin-A content of mango fruits chemical compositions like TSS and total sugar were more in Novel organic liquid nutrient treatment. Similar results were obtained by Anon. (2012) in mango and Patel *et al.* (2018) also in mango.

Table 3: Effect of biofertilizers and bioinoculants on TSS, vitamin-A and total sugar of mango cv. Mallika.

Treatments	TSS (° Brix)			Vitamin-A (mg/100 g)			Total sugar (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Biofertilizers as drenching (D)									
D_1	23.57	22.68	23.13	1.35	1.41	1.38	18.98	18.63	18.81
D_2	22.54	21.73	22.13	1.31	1.38	1.34	18.36	18.11	18.23
D_3	24.36	23.42	23.89	1.37	1.44	1.41	19.47	19.18	19.33
D_4	19.36	18.97	19.16	1.22	1.27	1.25	16.58	16.49	16.53
S.Em.±	0.26	0.28	0.19	0.01	0.02	0.01	0.13	0.12	0.09
CD at 5 %	0.75	0.82	0.54	0.04	0.04	0.03	0.38	0.35	0.25
Bioinoculants as spraying (S)									
S_1	22.93	22.15	22.54	1.33	1.39	1.36	18.60	18.38	18.49
S_2	23.48	22.60	23.04	1.34	1.41	1.38	19.03	18.75	18.89
S_3	22.64	21.85	22.25	1.32	1.38	1.35	18.45	18.15	18.30
S_4	20.78	20.19	20.49	1.26	1.32	1.29	17.31	17.13	17.22
S.Em.±	0.26	0.28	0.19	0.01	0.02	0.01	0.13	0.12	0.09
CD at 5 %	0.75	0.82	0.54	0.04	0.04	0.03	0.38	0.35	0.25
Interaction (D x S)									
S.Em.±	0.52	0.57	0.39	0.03	0.03	0.02	0.27	0.24	0.18
CD at 5 %	NS	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.

Table 4: Interaction effect of biofertilizers and bioinoculants on total sugar of mango.

Code	Total sugar (%)		
	2019-20	2020-21	Pooled
D_1S_1	19.38	19.09	19.24
D_1S_2	19.55	19.15	19.35
D_1S_3	19.33	18.86	19.10
D_1S_4	17.65	17.44	17.55
D_2S_1	18.68	18.39	18.53
D_2S_2	18.83	18.56	18.70
D_2S_3	18.41	18.17	18.29
D_2S_4	17.52	17.30	17.41
D_3S_1	19.82	19.53	19.67
D_3S_2	20.60	20.28	20.44
D_3S_3	19.66	19.32	19.49
D_3S_4	17.81	17.60	17.71
D_4S_1	16.54	16.50	16.52
D_4S_2	17.14	17.02	17.08
D_4S_3	16.38	16.26	16.32
D_4S_4	16.24	16.18	16.21
S.Em.±	0.27	0.24	0.18
CD at 5 %	0.77	0.70	0.51

Interaction effect of biofertilizers and bioinoculants on quality parameters of mango. Combine treatment *i.e.,* drenching of biofertilizers like Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree) and spraying with Novel organic liquid nutrient 2 % (Table 4) resulted in maximum total sugar (20.60, 20.28 and 20.44 %) in both the years and pooled data, respectively. Combine application of biofertilizers and bioinoculants increases the metabolic activity and convert more sugar by synthesis of starch splitting enzymes which increased sugar content of fruits. These findings are in agreement with the result of Patel *et al.* (2018) in mango, Lodaya and Masu (2019) in guava and Aal *et al*. (2020) in aonla.

CONCLUSION

From the two years of field study, it can be concluded that drenching of biofertilizers like Bio NPK Consortium (10 ml/tree) + VAM (10 g/tree) at pea stage increased yield and quality of fruits. Similarly, spraying of novel organic liquid nutrient (2 %) twice at 2nd week of April and 1st week of May can enhanced yield and improved quality of fruits. Further, combined effect of biofertilizers like Bio NPK

Consortium (10 ml/tree) + VAM (10 g/tree) at pea stage with spraying of novel organic liquid nutrient (2 %) per tree twice at 2nd week of April and 1st week of May increased yield and quality.

FUTURE SCOPE

In order to increase yield and quality in mango, future studies have to be done further by employing the different biofertilizers and bioinoculants treatment in different locality.

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Conflict of Interest. None.

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