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Effect of biofertilizers and biostimulants on quality of mango Cv. Kesar

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Abstract
An experiment was conducted to study the effect of biofertilizers and biostimulants on quality of mango cv. kesar was conducted at Regional Horticultural Research Station, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat during the year 2022-23 and 2023-24. The experiment was conducted in completely randomized design with factorial concept (FCRD), which included sixteen treatment combinations comprising two factors like biofertilizers as drenching *viz.*, D_1: Bio NPK consortium, D_2: VAM, D_3: Bio NPK consortium + VAM, D_4: Control (Drenching with water) and biostimulants as foliar spray *viz.*, S_1: Seaweed extract (0.4%), S_2: Novel Plus Organic Liquid Nutrients (3%), S_3: *Panchagavya* (3%) and S_4: Control (Water spraying). Biofertilizers were applied as drenching at the rate of 20 ml/tree after a week of fertilizer application. The plant biostimulants were sprayed at flower initiation and one month after first spray. The individual effects of biofertilizers and biostimulants treatment as well as their interactions on quality of mango cv. Kesar were recorded. Drenching of Bio NPK consortium + VAM resulted in the maximum TSS (22.37 ºBrix), reducing sugars (5.58%), non-reducing sugars (10.00%), total sugars (15.58%), ascorbic acid (24.28 mg 100 g-1 pulp) and minimum acidity (0.28%). While, foliar application of Novel plus organic liquid nutrients @ 3% recorded the maximum TSS (21.90 ºBrix), reducing sugars (5.39%), non-reducing sugars (9.86%), total sugars (15.26%), ascorbic acid (22.84 mg 100 g^{-1} pulp) and minimum acidity (0.30%). Interaction effect between biofertilizers and biostimulants was found significant for TSS (23.97 ºBrix), reducing sugars (6.52%), non-reducing sugars (11.49%), total sugars (18.02%), ascorbic acid (25.66 mg 100 g^{-1} pulp), acidity (0.20%) in mango cv. Kesar.

Keywords: Mango, biofertilizers, biostimulants, quality parameters

Introduction
Mango (*Mangifera indica* L.) is a fruit that originated from Indo-Burma region and belongs to the Anacardiaceae family. Mango has been established itself as a global icon and one of the Asia's most important fruit crop. It is a part of Indian culture and religion since the dawn of time. It has been known in India from ancient times, as evidenced by the mention to it as *Amra* in early Sanskrit literature. It is noted for its flavour and high quality that's why it is also known as the "King of Fruit" and "The national fruit of India". The most popular commercial mango cultivar of Gujarat is Kesar.

After being given the Geographical Indication (GI) tag, the famed saffron-colored mango, which is mostly cultivated near the foothills of the *Girnar* mountains in Junagadh district of Gujarat has gained global reputation as the '*Gir Kesar*' mango.

Organic manures are the major source of nutrients under organic production but they slowly release nutrients to the soil. The beneficial soil micro-organisms further enhance this release rate and subsequent uptake of nutrients by plants. Microorganisms are also responsible for improved nutrient availability to the plant and enhancing the sink capacity. Biofertilizers are living microorganisms in the soil that contribute, preserve and mobilise plant nutrients (Yawalkar *et al*., 1996) [1]. Biofertilizers aid in the prevention of soil-borne illnesses as well as composting and effective recycling of solid waste. All of them which contribute to enhanced soil health. The Bio NPK consortium is a group of people that work together to deliver nutrients to the soil. Biostimulant application prior to harvest has also become a viable option for reducing the usage of chemical fertilizers. Organic liquid fertilizer is a rich source of plant nutrients as well as growth-promoting compounds like as cytokinin and GA_3.

Novel organic liquid nutrients is good source of plant nutrient along with growth promoting substances like cytokinin, GA_3, *etc*.

Materials and Methods

The present investigation was conducted to study the effect of biofertilizers and biostimulants on quality of mango cv. kesar was at Regional Horticultural Research Station, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat during the year 2022-23 and 2023-24. The experiment was conducted in completely randomized design with factorial concept (FCRD), which included sixteen treatment combinations comprising two factors like biofertilizers as drenching *viz.*, D_1: Bio NPK consortium, D_2: VAM, D_3: Bio NPK consortium + VAM, D_4: Control (Drenching with water) and biostimulants as foliar spray *viz.*, S_1: Seaweed extract (0.4%), S_2: Novel Plus Organic Liquid Nutrients (3%), S_3: *Panchagavya* (3%) and S_4: Control (Water spraying). Biofertilizers were applied as drenching at the rate of 20 ml/tree after a week of fertilizer application. The plant biostimulants were sprayed at flower initiation and one month after first spray. Biofertilizers was applied as drenching application at the rate of 20 ml/tree after a week of fertilizer application. Biostimulants was given as a foliar spray in two times (1st spray at the flower initiation and one month after first spray).

Results and Discussions

TSS

The interaction between different application of biofertilizers (D) and biostimulants (S) were found significant. The maximum TSS (22.37 °Brix) was recorded in D_3 treatment (Bio NPK consortium + VAM) While, the minimum TSS (18.06 °Brix) was observed in D_4 treatment (Drenching with water) In case of biostimulants, the maximum TSS (21.90 °Brix) was recorded in S_2 treatment (Novel plus organic liquid nutrients @ 3%). While, the minimum TSS (18.30 °Brix) was noted in S_4 treatment (Water spraying). The results showed that significantly the maximum TSS (23.97°Brix) was recorded in D_3S_2 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3%) While, the minimum TSS (17.61 °Brix) was noted in D_4S_4 treatment combination (Drenching with water + Water spraying). By increasing nutrient intake and photosynthetic efficiency, the Bio NPK collaboration, VAM and Novel plus organic liquid nutrients improve TSS. Mangoes with greater sugar content and increased TSS are the consequence of improved carbohydrate conversion and accumulation in the fruit. Similar result was reported by Rathod *et al.* (2022) [2] in mango.

Ascorbic acid (mg/100 g pulp)

The data presented in Table 1 indicated that there were significant differences due to different application of biofertilizers and biostimulants on ascorbic acid. The maximum ascorbic acid (24.28 mg/100 g) was observed in D_4 treatment (Bio NPK consortium + VAM) In contrast, the minimum ascorbic acid (17.87 mg/100 g) was noted in D_3 treatment (Drenching with water). In case of biostimulants, significantly the maximum ascorbic acid (22.84 mg/100 g) was recorded in S_4 treatment (Novel plus organic liquid nutrients @ 3%) Whereas, the minimum ascorbic acid (19.37 mg/100 g) was noted in S_2 treatment (Water spraying). The interaction between different application of biofertilizers (D) and biostimulants (S) were found significant (D × S). The results showed that significantly the maximum ascorbic acid (25.66 mg/100 g) was recorded in D_1S_1 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3%) Moreover, the minimum ascorbic acid (17.52 mg/100 g) was noted in D_3S_2 treatment combination (Drenching with water + Water spraying). By improved nutrient absorption and general plant health, the combination of the Bio NPK consortium, VAM and Novel plus organic liquid nutrients raises ascorbic acid levels. This synergy increases the availability of micronutrients and phosphorus, two important nutrients to produce ascorbic acid. As a result of improved root health and microbial activity, the fruit produces more ascorbic acid due to improved metabolic processes and stress tolerance. Similar findings were recorded by Kundu *et al.* (2011) [3] in mango, Zala *et al.* (2021) [5] and Patel *et al.* (2021b) [2] in Sapota.

Acidity (%)

A perusal of data of acidity indicated that there were significant differences due to different application of biofertilizers and biostimulants on acidity (%). Significantly the maximum acidity (0.40%) was observed in D_4 treatment (Bio NPK consortium + VAM) While, the minimum acidity (0.28%) was noted in D_3 treatment (Drenching with water). In case of biostimulants, the maximum acidity (0.38%) was recorded in S_4 treatment (Novel plus organic liquid nutrients @ 3%) Whereas, the minimum acidity (0.30%) was noted in S_2 treatment (Water spraying). The interaction between different application of biofertilizers (D) and biostimulants (S) were found significant (D × S). The results showed that significantly the maximum acidity (0.43%) was observed in D_4S_4 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3%) On other hand, the minimum acidity (0.20%) was recorded in D_3S_2 treatment combination (Drenching with water + Water spraying). The combination of Bio NPK consortium, VAM and Novel plus organic liquid nutrients reduces acidity by improving nutrient absorption and metabolic equilibrium in the plant. This increases the plant's general health and vigour, resulting in enhanced nutrient absorption and a balanced carbohydrate to acid ratio in the fruit. Improved microbial activity and root health also contribute to more effective conversion of organic acids into sugars, resulting in less acidity in the fruit. Similar findings were recorded by Zala *et al.* (2021) [5] and Patel *et al.* (2021) [2] in Sapota.

Reducing Sugars (%)

The data clearly indicated that there were significant differences due to different application of biofertilizers and biostimulants on reducing sugars. The maximum reducing sugar (5.58%) was observed in D_3 treatment (Bio NPK consortium + VAM) While, the minimum reducing sugar (4.53%) was recorded in D_4 treatment (Drenching with water). In case of biostimulants, the maximum reducing sugar (5.39%) was recorded in S_2 treatment (Novel plus organic liquid nutrients @ 3%). In contrast, the minimum reducing sugar (4.74%) was noted in S_4 treatment (Water spraying). The interaction between different application of biofertilizers (D) and biostimulants (S) were found

significant (D × S). The results showed that significantly the maximum reducing sugar (6.52%) was observed in D_3S_2 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3%) While, the minimum reducing sugar (4.45%) was recorded in D_4S_4 treatment combination (Drenching with water + Water spraying). It might be due to the reason that combining 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. This result is in consonance with the findings of Kundu *et al.* (2011) [3] in mango; Dutta *et al.* (2014) [6] in guava and Ghosh *et al.* (2017) [7] in lemon.

Non-reducing Sugars (%)

It is evident from the data presented, clearly indicated that there were significant differences due to different application of biofertilizers and biostimulants on non-reducing sugar**.** Significantly the maximum non-reducing sugar (10%) was observed in D_3 treatment (Bio NPK consortium + VAM) Whereas, the minimum non-reducing sugar (8.62%) was recorded in D_4 treatment (Drenching with water). In case of biostimulants, the maximum non-reducing sugar (9.86%) was recorded in S_2 treatment (Novel plus organic liquid nutrients @ 3%) In contrast, the minimum non-reducing sugar (8.74%) was noted in S_4 treatment (Water spraying). The interaction between different application of biofertilizers (D) and biostimulants (S) were found significant (D × S). The results showed that significantly the maximum non-reducing sugar (11.68, 11.32 and 11.49%) was observed in D_3S_2 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3%) during both the years and in pooled analysis, respectively which was at par with treatment D_3S_1 during second year respectively. While, the minimum non-reducing sugar (7.99, 8.47 and 8.23%) was recorded in D_4S_4 treatment combination (Drenching with water + Water spraying). It might be due to the reason that 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. This result is in consonance with the findings of Kundu *et al.* (2011) [3] in mango; Dutta *et al.* (2014) [6] in guava and Ghosh *et al.* (2017) [7] in lemon.

Total Sugars (%)

A perusal of data of total sugars clearly indicated that there were significant differences due to different application of biofertilizers and biostimulants on total sugar**.** Significantly the maximum total sugar (15.58%) was observed in D_3 treatment (Bio NPK consortium + VAM). Whereas, the minimum total sugar (13.16%) was recorded in D_4 treatment (Drenching with water). In case of biostimulants, maximum total sugar (15.26%) was recorded in S_2 treatment (Novel plus organic liquid nutrients @ 3%). In contrast, the minimum total sugar (13.49%) was noted in S_4 treatment (Water spraying). The interaction between different application of biofertilizers (D) and biostimulants (S) were found significant (D × S). The results showed that significantly the maximum total sugar (18.02%) was observed in D_3S_2 treatment combination (Bio NPK consortium + VAM + Novel plus organic liquid nutrients @ 3. Whereas, the minimum total sugar (12.68%) was recorded in D_4S_4 treatment combination (Drenching with water + Water spraying). It might be due to the reason that 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. Similar observation was reported by Zala *et al.* (2021) [5] and Rathod *et al.* (2022) [2] in mango.

Table 1: Effect of biofertilizers and biostimulants on quality parameters in mango cv. Kesar (mean of two years)

Treatments	TSS	Acidity (%)	Ascorbic acid (mg^{-1} 100 g pulp)
Biofertilizers (Drenching)			
D_1: Bio NPK consortium	20.38	0.34	21.51
D_2: VAM	21.57	0.30	22.72
D_3: Bio NPK consortium + VAM	22.37	0.28	24.28
D_4: Control (Drenching with water)	18.06	0.40	17.87
S.Em. ±	0.45	0.01	0.49
C.D. at 5%	1.28	0.02	1.40
Biostimulants (Spraying)			
S_1: Seaweed extract (0.4%)	21.12	0.34	22.30
S_2: Novel plus organic liquid nutrients (3%)	21.90	0.31	22.84
S_3: *Panchagavya* (3%)	21.06	0.32	21.87
S_4: Control (Water spraying)	18.30	0.40	19.37
S.Em. ±	0.45	0.01	0.49
C.D. at 5%	1.28	0.03	1.40
Interaction effect (D × S)			
S.Em. ±	0.90	0.02	0.99
C.D. at 5%	2.56	0.07	2.81

Table 2: Effect of biofertilizers and biostimulants on quality parameters in mango cv. Kesar (mean of two years)

Treatments	Total sugars	Reducing sugars	Non-reducing sugars
Biofertilizers (Drenching)			
D_1: Bio NPK consortium	14.55	5.06	9.49
D_2: VAM	14.97	5.30	9.67
D_3: Bio NPK consortium + VAM	15.58	5.58	10.00
D_4: Control (Drenching with water)	13.16	4.53	8.62
S.Em. ±	0.17	0.09	0.16
C.D. at 5%	0.48	0.26	0.46
Biostimulants (Spraying)			
S_1: Seaweed extract (0.4%)	14.87	5.22	9.64
S_2: Novel plus organic liquid nutrients (3%)	15.26	5.39	9.86
S_3: *Panchagavya* (3%)	14.68	5.10	9.53
S_4: Control (Water spraying)	13.49	4.74	8.74
S.Em. ±	0.17	0.09	0.16
C.D. at 5%	0.48	0.26	0.46
Interaction effect (D × S)			
S.Em. ±	0.34	0.18	0.32
C.D. at 5%	0.97	0.53	0.92

Table 3: Interaction of biofertilizers and biostimulants on quality parameters in mango cv. Kesar (mean of two years)

Treatment combinations	TSS	Acidity (%)	Ascorbic acid (mg^{-1} 100 g pulp)
$D_1 S_1$	20.83	0.32	22.22
$D_1 S_2$	20.42	0.34	22.65
$D_1 S_3$	20.66	0.34	21.98
$D_1 S_4$	19.61	0.36	19.21
$D_2 S_1$	23.36	0.23	23.86
$D_2 S_2$	22.36	0.26	24.55
$D_2 S_3$	22.77	0.28	22.90
$D_2 S_4$	17.80	0.39	19.57
$D_3 S_1$	22.27	0.24	25.38
$D_3 S_2$	23.97	0.20	25.66
$D_3 S_3$	22.06	0.30	24.90
$D_3 S_4$	18.17	0.38	21.19
$D_4 S_1$	18.02	0.40	17.76
$D_4 S_2$	17.87	0.39	18.51
$D_4 S_3$	18.75	0.40	17.70
$D_4 S_4$	17.61	0.43	17.52
S.Em. ±	0.90	0.01	0.99
C.D. at 5%	2.56	0.04	2.81
C.V.%	10.78	11.58	11.28

Table 4: Interaction of biofertilizers and biostimulants on quality parameters in mango cv. Kesar (mean of two years)

Treatment combinations	Total sugars	Reducing sugars	Non-reducing sugars
$D_1 S_1$	14.89	5.22	9.67
$D_1 S_2$	14.93	5.07	9.85
$D_1 S_3$	14.41	5.07	9.34
$D_1 S_4$	13.96	4.86	9.10
$D_2 S_1$	15.55	5.54	10.07
$D_2 S_2$	15.39	5.58	9.81
$D_2 S_3$	15.45	5.38	10.06
$D_2 S_4$	13.50	4.70	8.79
$D_3 S_1$	15.92	5.65	10.26
$D_3 S_2$	18.02	6.52	11.49
$D_3 S_3$	15.54	5.52	10.02
$D_3 S_4$	12.84	4.61	8.85
$D_4 S_1$	13.21	4.49	8.63
$D_4 S_2$	13.66	4.39	8.29
$D_4 S_3$	13.17	4.80	8.71
$D_4 S_4$	12.68	4.45	8.23
S.Em. ±	0.34	0.18	0.32
C.D. at 5%	0.97	0.53	0.92
C.V.%	5.78	9.00	8.47

Conclusion

The results of present study of two years inferred that application of Bio NPK consortium + VAM with foliar spray of Novel plus organic liquid nutrients @ 3% improve the all-quality parameters like TSS, ascorbic acid, acidity, total sugars, reducing sugars and non-reducing sugars in mango cv. Kesar.

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