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Effect of fertigation on biochemical parameters in mango cv. Baneshan under north-eastern transitional zone of Karnataka

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Abstract
The investigation on standardization of fertigation levels in mango cv. Baneshan under north-eastern transitional zone of Karnataka was conducted during 2018- 2020. The results of experiment revealed that among the different fertigation levels, treatment T_3 (75 per cent of recommended dose of fertilizers through fertigation) found better regarding yield with moderate biochemical parameters *viz*., TSS (22.92 ^oB), ascorbic acid content (31.55 mg/100 g of pulp), titratable acidity (0.32%), carotenoid content (1.84 mg/100 g pulp), reducing sugars (5.10%), non-reducing sugars (9.50%), total sugars (14.60%) and with better shelf life (12.15 days) when compared to other treatments. The results obtained from the present investigation regarding effect of fertigation on mango cv. Baneshan can utilize for post- harvest studies and processed products in future.

Keywords: Fertigation, biochemical, parameters, Baneshan, transitional

Introduction
Mango (*Mangifera indica* L.) the king of fruits and is one of the most important tropical fruit crops in India. It is the premier and choicest fruit and consumed by all in India as such aptly designated as "National Fruit" of the country. Mango belongs to anacardiaceae family is grown in tropical and subtropical regions distributed in almost 110 countries of the world. It is popular due to its high palatability, taste, aroma, nutritive and medicinal value. Presently, mango is mainly cultivated in Brazil, China, Egypt, India, Indonesia, Mexico, Pakistan, Philippines and Thailand. India is leading producer and exporter of mango in the world with bright future prospects. In India it is grown over an area of 2.25 million ha with annual production of 21.82 million MT and productivity of 9.7 MT ha^{-1}. Mango has a share of 38 per cent of area and 21.7 per cent of production of total fruit production in India. The major mango producing states are Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat, Tamil Nadu, Odisha, West Bengal. In Karnataka, mango is cultivated in an area of 1.83 lakh ha with a production of 1.76 million MT and a productivity of 9.61 MT/ha (Annon, 2018). There are several factors responsible for such low productivity per unit area such as poor and neglected orchards, imbalanced fertilization, wider tree spacing, poor orchard management practices particular for water and nutrient, senile orchards with dense canopies permitting poor sunlight interception and higher pest infestation due to shade and lack of proper ventilation and unscientific management practices. One of the major factor is nutrient and water management that significantly influences the productivity in terms of quality and yield. In general, the input use efficiency of various nutrients used for optimum growth and development is currently very low leading to problems of poor productivity. Increasing the efficiency of water and fertilizer use can itself go a long way in realizing the improvement in production in mango. The shrinking availability of land and water resources, increasing fertilizer prices, energy crisis, wide spread pollution and fast degradation of natural resources further emphasises the need for improving water and fertilizer use efficiency (Solaimalai *et al.*, 2005) [20]. In the present study on effect of different fertigation levels on biochemical parameters in mango cv. Baneshan will be helpful for preparation of different processed products in post-harvest industry.

Material and Methods

The experimental site is located at 13.69º N and 78.32º E with an elevation of 657 MSL with lateritic landscape and a slope gradient of 1-3%. The soils of the site are lateritic red having shallow depth of 0-25 cm of with sandy clay loam texture. The field experiment was conducted on 10 years old trees of mango cv. Baneshan planted at 5 m X 5 m spacing during the year 2018-2020 at Madaragi village of Bidar district. The experiment was laid out in randomized block design with nine treatments and three replications in each treatment. The details of the treatments are T_1 –100 per cent of RDF through soil application (control), T_2 – 100 per cent of RDF application through fertigation, T_3 – 75 per cent of RDF application through fertigation, T_4 – 50 per cent of RDF application through fertigation, T_5 – 100 per cent of RDF: N and K application through fertigation: P as soil application, T_6 – 75 per cent of RDF: N and K application through fertigation: P as soil application, T_7 – 50 per cent of RDF: N and K application through fertigation: P as soil application, T_8 – 100 per cent of RDF: N application through fertigation: P and K as soil application and T_9 – 100 per cent of RDF: K application through fertigation: P and N as soil application. The following parameters were studied in the experiment.

Total soluble solids (TSS) (ºBrix)

Total soluble solids were determined with the help of hand refractometer where in the juice from randomly selected fruit per replication was extracted and strained through muslin cloth. The strained juice was stirred properly and then the drop of this juice was places on the prism of hand refractometer and per cent of total soluble solids was obtained from direct reading. It was then expressed in ºBrix.

Ascorbic acid content (mg/100 g of pulp)

Pulp samples of the ripe fruits were analysed for their ascorbic acid content using 2, 6-dichlorophenol indophenol dye by visual titration method Ranganna (1986) [13]. 5 grams of sample was blended with 4 per cent oxalic acid and filtered through Whatman No.1 filter paper and by adding oxalic acid volume was made up to 100 ml. To an aliquot of the extract (5 ml) of the sample, 10 ml of 4% oxalic acid mixture was added and titrated against the standard dye; the end point was the appearance of pink colour (V_2). Similar procedure was followed against standard solution prepared with 4 per cent oxalic acid to get standard titre value (V_1). The ascorbic acid content was calculated using the following formula and expressed in mg/ 100 g of fruit.

$$\text{Ascorbic acid (mg/100 g)} = \frac{0.5 \text{ mg X } V_2 \text{ (ml)}}{V_1 \text{ (ml) X 5 ml X Wt. of sample}} \text{ X 100}$$

Titratable acidity (%)

The titratable acidity of mango was calculated by titration method. A known weight of pulp sample (5g) was taken, extracted it with distilled water, filtered and volume was made to 30 ml. A known volume of aliquot (10 ml) was taken in conical flask and titrated against standard 0.1N NaOH using phenolphthalein solution as an indicator. The end point of the titration was determined when the colour of the solution turned to pink which persisted for few seconds. The value was expressed in terms of per cent titratable acidity (Srivastava and Sanjeevkumar, 1998) [21].

$$\text{TA (\%)} = \frac{\text{Titre value X Normality of alkali X Vol. made up X Eq. wt. of acid X 100}}{\text{Vol. of sample taken for estimation X Wt. of sample taken X 1000}}$$

Reducing sugars (%)

The titrimetric method of Lane and Eynon as described by Ranganna (1986) [13] was adopted for the estimation of reducing sugars. Weighed amount of rehydrated pulp sample was taken in a volumetric flask and 2 ml of 45% basic lead acetate solution was added for clarification. After 10 min. the solution was diluted by adding 2 ml potassium oxalate solution and the volume was made up to a known level with distilled water and filtered through whatman No. 1 filter paper. Filtrate was taken in a burette and titrated with boiling standard Fehling's mixture (5 ml solutions of Fehling's 'A' and 'B' each) till the blue colour faded. Then, 1ml of methylene blue indicator (1%) was added and the titration was continued till content attained a brick red colour and the titre values were noted. Percentage of reducing sugars was calculated according to the following formula.

$$\text{Reducing sugars (\%)} = \frac{\text{mg of invert sugar X Dilution}}{\text{Titre X Wt. of the sample}} \text{ X 100}$$

Total sugars (%)

For the estimation of total sugars, the filtrate obtained in the estimation of reducing sugars was used. An aliquot from the filtrate was taken, 10 ml of 50 per cent HCl was added and the inversion was carried out at room temperature for 24 hours, contents were cooled and neutralized with 40 per cent sodium hydroxide solution using phenolphthalein as indicator and the final volume was made. The solution was filtered through Whatman No. 1 filter paper and titration was carried out using filtrate as detailed for reducing sugars. The total sugar content was expressed as percentage in terms of invert sugar according to the following formula (Ranganna, 1986) [13].

$$\text{Total sugars (\%)} = \frac{\text{mg of invert sugar X Dilution}}{\text{Titre X Wt. of the sample}} \text{ X 100}$$

Non-reducing sugars (%)

The non-reducing sugar was calculated by subtracting reducing sugar from total sugar and expressed in per cent.

Carotenoid content (mg/100 g of pulp)

5 g of fruit pulp as sample was taken and crushed in 10-15 ml of acetone with the help of pestle and mortar. Few crystals of anhydrous Na_2SO_4 was added to it. The extraction was continued till yellow coloured supernatant appeared. Supernatant was transferred into a beaker. The process was repeated twice, the supernatant was transferred to a separatory funnel. To this, 10-15 ml petroleum ether was added and mixed thoroughly. Two layers separate out on standing, the lower layer is discarded and upper layer is collected in a 100 ml volumetric flask. Finally, the volume was made to 100 ml using petroleum ether and optical density (O.D.) at 452 nm was recorded using spectrophotometer and the total carotenoid content was calculated by using following formula.

$$\text{Total carotenoids (mg/100 g)} = \frac{3.857 \text{ X O.D X Volume made up}}{\text{Weight of sample X 100}} \text{ X 100}$$

Shelf life (days)

The shelf life of fruit was determined by counting the number of days from harvesting till they remained in a good edible condition without spoilage under ambient condition which was judged through visual appearance.

Statistical analysis
Statistical analyses of experiments were done by using Web Agri. Stat. Package (WASP) Version 2 (Jangam and Thali, 2010). The level of significance used in 'F' and 't' test was *p*=0.05. Critical difference values were calculated whenever F-test was found significant.

Result and Discussion
Quality parameters
In any production system, the primary goal is to achieve maximum fruit yield per unit area without affecting the fruit quality. Investigation was carried out to study the bio-chemical parameter like TSS, ascorbic acid, titratable acidity, carotenoid content, total sugars, reducing sugars, non-reducing sugars and shelf life in mango cv. Baneshan as influenced by different fertigation levels. The observations were recorded at edible stage of fruits in different treatments.

Total soluble solids
The data pertaining to TSS has shown less variations among the treatments. With most of treatment were found statistically on par *viz.*, T_8 (24.37 ^oB), T_5 (24.17 ^oB), T_6 (23.38 ^oB), T_3 (22.92 ^oB), T_7 (22.57 ^oB) and T_4 (21.75 ^oB) indicating marginal influence of mode and dose of fertilizer application on T.S.S. of fruits. Similar results were also found by Devi (2018) [4, 5] in mango cv. Pant Sinduri, Prakash *et al*. (2015) [5, 12] in mango cv Alphonso, Panwar *et al*. (2007) [11] in mango cv. Dashehari and Sivakumar (2007) [19] in mango cv. Ratna.

Ascorbic acid
Significantly highest ascorbic acid content was recorded among the various fertigation levels. The pooled mean revealed that the highest ascorbic acid was recorded in fruits of T_2 (32.48 mg/100 g) followed by fruits of T_9 (31.69 mg/100 g) which was found statistically on par. Higher ascorbic acid content with the higher levels of nitrogen might be attributed to increase in synthesis and catalytic activity of several enzymes and co-enzymes which are instrumental in ascorbic acid synthesis (Boora and Singh, 2000) [3, 4, 9, 11, 22].
Apart from higher sugar content observed with higher level of K applied, increased ascorbic acid content was noticed in fruits. This might be due to the fact that K could have helped to slow down the enzyme system that encouraged the oxidation of ascorbic acid, thus helping the plants to accumulate more ascorbic acid content in fruits as reported by Ananthi, *et al.* (2004) [1]. These results are in accordance with the findings of Devi (2018) [4, 5] in mango cv. Pant Sinduri, Makhmale (2017) [5] in mango cv. Kesar, Prakash *et al*. (2015) [12] in mango cv. Alphonso Sivakumar (2007) [19] in mango cv. Ratna and Kumar *et al*. (2017) [19] in sweet orange cv. Mosambi who reported that fertigation increased ascorbic acid content as compared to control and

Titratable acidity
The data pertaining to titratable acidity has shown significant differences. The pooled mean revealed that the minimum titratable acidity was found in T_2 (0.38%) and T_8 (0.38%) which was found on par with T_7 (0.37%). The decrease in titratable acidity appears to be due to conversion of acids into sugar and their utilization as respiratory substrate during growth and development of fruit. Similar results were also reported by Devi (2018) [4, 5] in mango cv. Pant Sinduri, Makhmale (2017) [5] in mango cv. Kesar and Prakash *et al*. (2015) [12] in mango cv Amrapali.

Carotenoid content
The results pertaining to carotenoid content pointed out significant differences the pooled mean revealed that the maximum value was recorded in fruits under T_2 (1.93 mg/100 g pulp) followed by T_5 (1.87 mg/100 g pulp) and T_9 (1.87 mg/100 g pulp). Carotenoids are responsible for characteristics colour of mango skin and pulp and its development involves a progressive loss of chlorophyll. It is evident from above results that total carotenoids increased with increasing fertigation levels. It might be due to better and efficient uptake of nutrients under drip fertigation. Better availability of these nutrients helps to promote synthesis of antioxidants like carotenoids and degradation of chlorophyll pigment with ripening of fruits. The above results were in confirmation with Devi (2018) [4, 5] in mango cv. Pant Sinduri, Panwar *et al*. (2007) [5, 11] in mango cv. Dashehari, Sivakumar (2007) [19] in mango cv. Ratna and Ravichandrane *et al*. (2002) [19] in papaya cv. Co-2.

Reducing sugars
The data pertaining to reducing sugars has shown significant differences. The pooled mean revealed that the maximum reducing sugars was found in T_8 (5.26%) which was found statistically on par with T_2 (5.19%) and T_9 (5.17%). These findings followed a trend of increasing reducing sugar content with recommended doses of fertigation. This might be due to due to recommended dose of nitrogen and potassium through drip which promotes hydrolysis of starch into sugars. Thakur and Singh (2004) [9, 22], who also recorded highest reducing sugar with 100 per cent of recommended dose of NPK applied through fertigation in mango cv Amrapali. Ghosh *et al*. (2004) [6] also reported that the highest level of N and K resulted in maximum increase in total sugar in custard apple. Similar results were also found by Devi (2018) [4, 5] in mango cv. Pant Sinduri, Boora and Singh (2000) [4, 5] in Sapota, Sharmah and Bhattacharya (2014) [16] in banana cv. Barjahaji.

Non-reducing sugars
The data pertaining to non-reducing sugars has shown significant differences. The pooled mean revealed that the maximum non-reducing sugars was found in T_2 (9.91%) followed by T_8 (9.56%), T_5 (9.52%) and T_3 (9.50%) which were found statistically on par. This might be due to either speedily conversion of sugar into their derivatives by reactions involving reverse glycolytic pathways or might have been used in respiration. Similar result was also reported by Singh and Rajput (1977) [3, 4, 9, 11, 17, 22] in guava.

Total sugars
The data pertaining to total sugars has shown significant differences. The pooled mean revealed that the maximum total sugars was found in T_2 (15.10%) followed by T_8 (14.81%). Soluble sugars of mango pulp mainly encompass fructose and sucrose as main components. During ripening process, there is transformation of starch into simple sugar as carbohydrates are broken down due to amylase activity. In the present study, there was an increasing trend in total sugars with increasing fertigation levels. It might be attributed to the fact that at recommended fertigation doses, the efficient absorption and uptake of macro-nutrients (NPK) increases the availability of these nutrients to the plants. This might be due to action major nutrients on converting hydrolysis of complex carbohydrates (starch) substance in to simple ones, which enhances the metabolic activity in fruits and result in increasing total sugar in developing fruits. Similar results

were also reported by Kumar and Pandey (2008) [8, 18] in banana cv. Rasthali, Jeyakumar *et al.* (2010) [7, 14] in Co.7 papaya and Sadarunnisa *et al.* (2010) [15] in papaya.

Shelf life

The data pertaining to shelf life has shown significant differences. The pooled mean revealed that the maximum shelf life was recorded in T_2 (13.67 days) followed by T_9 (13.29 days) and T_5 (13.27 days) which were found statistically on par. This might be due to altered physiology and biochemistry of the fruit as influenced by optimum dose of macro nutrients. Singh *et al.*, (2017) [3, 4, 9, 11, 22] found that the increase in shelf life of mango fruits might be due to increase in concentration of boron of middle lamella of cell wall which provide physical strength to cell wall and improve fruit colour and development and appearance. These findings are in accordance with the findings of Bhatt *et al.* (2012) [3] in mango cv. Dashehari and Singh *et al.* (2012) [3, 4, 9, 11, 22] in mango.

The present study suggests that treatment T_3 (75 per cent recommended dose of fertilizers applied through fertigation) can be recommended for increased quality parameters with better shelf life of mango cv. Baneshan under north-eastern transitional zone of Karnataka.

Table 1: Effect of different fertigation levels on TSS (°Brix), ascorbic acid content (mg/100 g of pulp), titratable acidity (%) and carotenoid content (mg/100 g pulp) in mango cv. Baneshan

Treatments	TSS (°Brix)			Ascorbic acid content (mg/100 g of pulp)			Titratable acidity (%)			Carotenoid content (mg/100 g pulp)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
T_1	20.20^{f}	21.47^{e}	20.83^{e}	26.71^{c}	27.24^{c}	26.98^{c}	0.39^{a}	0.38^{a}	0.38^{a}	1.77^{d}	1.73^{d}	1.75^{d}
T_2	23.90^{ab}	24.33^{ab}	24.12^{ab}	32.14^{a}	32.81^{a}	32.48^{a}	0.33^{bcd}	0.32^{b}	0.32^{bcd}	1.92^{a}	1.94^{a}	1.93^{a}
T_3	22.67^{cd}	23.17^{cd}	22.92^{c}	31.22^{a}	31.88^{a}	31.55^{a}	0.32^{cd}	0.32^{b}	0.32^{cd}	1.85^{abcd}	1.82^{bc}	1.84^{bc}
T_4	21.27^{e}	22.23^{de}	21.75^{d}	28.48^{bc}	29.14^{bc}	28.81^{bc}	0.35^{b}	0.34^{b}	0.34^{b}	1.90^{ab}	1.81^{bcd}	1.85^{b}
T_5	24.03^{ab}	24.30^{ab}	24.17^{ab}	28.77^{bc}	29.75^{b}	29.26^{b}	0.35^{b}	0.34^{b}	0.34^{bc}	1.86^{abc}	1.88^{ab}	1.87^{ab}
T_6	23.30^{bcd}	23.47^{bc}	23.38^{bc}	28.19^{bc}	28.99^{bc}	28.59^{bc}	0.34^{bc}	0.34^{b}	0.34^{bcd}	1.82^{bcd}	1.83^{bc}	1.83^{bc}
T_7	22.57^{d}	22.57^{cd}	22.57^{cd}	27.57^{bc}	28.47^{bc}	28.02^{bc}	0.37^{a}	0.37^{a}	0.37^{a}	1.79^{cd}	1.78^{cd}	1.78^{cd}
T_8	24.27^{a}	24.4^{7a}	24.37^{a}	29.09^{b}	29.55^{b}	29.32^{b}	0.32^{d}	0.32^{b}	0.32^{d}	1.84a^{bcd}	1.85^{bc}	1.85^{bc}
T_9	23.57^{abc}	24.30^{ab}	23.93^{ab}	31.21^{a}	32.17^{a}	31.69^{a}	0.33^{bcd}	0.32^{b}	0.33^{bcd}	1.86^{abc}	1.89^{ab}	1.87^{ab}
S. Em±	0.312	0.326	0.275	0.702	0.666	0.679	0.007	0.007	0.007	0.028	0.027	0.024
C. D. at 5%	0.92	0.96	0.81	2.06	1.96	2.09	0.02	0.02	0.02	0.09	0.08	0.07
C. V. (%)	12.37	12.42	12.06	14.15	13.85	13.97	13.87	13.65	13.73	12.67	12.59	12.32

Treatment details

T_1 –100 per cent of RDF through soil application (control), T_2 – 100 per cent of RDF application through fertigation, T_3 – 75 per cent of RDF application through fertigation, T_4 – 50 per cent of RDF application through fertigation, T_5 – 100 per cent of RDF: N and K application through fertigation: P as soil application, T_6 – 75 per cent of RDF: N and K application through fertigation: P as soil application, T_7 – 50 per cent of RDF: N and K application through fertigation: P as soil application, T_8 – 100 per cent of RDF: N application through fertigation: P and K as soil application, T_9 – 100 per cent of RDF: K application through fertigation: P and N as soil application

Table 2: Effect of different fertigation levels on reducing (%), non-reducing (%), total sugars (%) and shelf life (days) in mango cv. Baneshan

Treatments	Reducing sugars (%)			Non-reducing sugars (%)			Total sugars (%)			Shelf life (days)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Pooled mean
T_1	4.77^{f}	4.73^{d}	4.75^{e}	8.74^{c}	8.80^{e}	8.81^{e}	13.52^{e}	13.61^{e}	13.57^{e}	10.25^{d}	10.92^{d}	10.59^{f}
T_2	5.31^{ab}	5.08^{abc}	5.19^{ab}	9.79^{a}	9.90^{a}	9.91^{a}	15.09^{a}	15.10^{a}	15.10^{a}	13.28^{a}	14.06^{a}	13.67^{a}
T_3	5.17^{bcd}	5.03^{abc}	5.10^{bc}	9.42^{b}	9.48^{bcd}	9.50^{bc}	14.59^{bc}	14.61^{bc}	14.60^{bc}	12.00^{bc}	12.30^{c}	12.15^{cd}
T_4	4.89^{ef}	4.94^{c}	4.92^{d}	9.27^{b}	9.38^{bcd}	9.36^{bcd}	14.16^{d}	14.40^{cd}	14.28^{d}	11.38^{cd}	11.76^{cd}	11.57^{de}
T_5	5.18^{abc}	5.16^{a}	5.17^{ab}	9.40^{b}	9.53^{bc}	9.52^{bc}	14.59^{bc}	14.80^{ab}	14.69^{b}	13.21^{a}	13.33^{ab}	13.27^{ab}
T_6	4.98^{de}	5.02^{abc}	5.00^{cd}	9.32^{b}	9.35^{bcd}	9.35^{cd}	14.30^{cd}	14.40^{cd}	14.35^{d}	11.45^{c}	11.24^{d}	11.35^{def}
T_7	5.03^{cde}	4.97^{bc}	5.00^{cd}	9.21^{b}	9.24^{d}	9.23^{d}	14.24^{cd}	14.22^{d}	14.23^{d}	10.97^{cd}	11.13^{d}	11.05^{ef}
T_8	5.38^{a}	5.15^{a}	5.26^{a}	9.43^{b}	9.56^{b}	9.55^{b}	14.81^{ab}	14.82^{ab}	14.81^{b}	13.05^{ab}	12.39^{bc}	12.72^{bc}
T_9	5.21^{abc}	5.13^{ab}	5.17^{ab}	9.26^{b}	9.29^{cd}	9.28^{d}	14.47^{bcd}	14.44^{cd}	14.45^{cd}	13.26^{a}	13.32^{ab}	13.29^{ab}
S. Em±	0.066	0.061	0.046	0.109	0.112	0.064	0.127	0.113	0.077	0.384	0.327	0.289
C. D. at 5%	0.20	0.18	0.14	0.32	0.33	0.19	0.37	0.33	0.23	1.13	0.96	0.85
C. V. (%)	12.25	12.13	11.57	12.03	12.05	11.19	11.53	11.36	10.93	15.51	14.62	14.11

Treatment details

T_1 – 100 per cent of RDF through soil application (control), T_2 – 100 per cent of RDF application through fertigation, T_3 – 75 per cent of RDF application through fertigation, T_4 – 50 per cent of RDF application through fertigation, T_5 – 100 per cent of RDF: N and K application through fertigation: P as soil application, T_6 – 75 per cent of RDF: N and K application through fertigation: P as soil application, T_7 – 50 percent of RDF: N and K application through fertigation: P as soil application, T_8 – 100 per cent of RDF: N application through fertigation: P and K as soil application, T_9 – 100 per cent of RDF: K application through fertigation: P and N as soil application

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