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Effect of Green Manures and Bio-fertilizers on quality and Yield of Mango (*Mangifera indica* L.) cv. Amrapali

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ABSTRACT: Mango, known as the "King of Fruits," is the most important fruit crop in India. However, residual toxicity from agro-chemicals presents a significant challenge for capturing international markets. By adopting organic farming we can go for the production of safe and high-quality mangoes. To explore this approach, a study was undertaken to evaluate the response of mango trees to a combination of bio-fertilizers and green manure-based organic treatments. The study, titled "Effect of Green Manures and Bio-Fertilizers on Quality and Yield of Mango (*Mangifera indica* L.) cv. Amrapali," was carried out during the years 2018-19 and 2019-20 at the Horticultural Research Farm and P.G. Laboratory of the Department of Horticulture at B.A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). The results showed that the treatment of double green manuring of sunhemp and 10ml of Bio NPK consortium per tree produced the best quality mangoes. This treatment resulted in the highest levels of total soluble solids (23.05 ºBrix), reducing sugar (8.01%), total sugar (19.98%), ascorbic acid content (43.73 mg/100g pulp) and lower titrable acidity (0.175%). Additionally, this treatment led to the maximum fruit yield with the greatest number of fruits per tree (268.98), highest fruit weight (192.39 g), maximum fruit yield (52.86 kg/tree or 14.64 t/ha) and graded fruit yield A, B, and C kg per tree. Overall, the study demonstrates the efficacy of green manuring and bio-fertilizers as an organic approach to enhance mango quality and yield.

Keywords: Organic Farming, Mango, Sunhemp, Dhaincha, Biofertilizer.

INTRODUCTION

Mango (*Mangifera indica* L.), a member of the Anacardiaceae family, is an important fruit crop in tropical and subtropical regions. Its original home is believed to be the Indo-Burma region. The major mango-growing states in India are Andhra Pradesh, Bihar, Gujarat, Uttar Pradesh, Maharashtra, Karnataka, Kerala, Tamil Nadu, Orissa, and West Bengal. In Gujarat, mango is cultivated in all districts, with major growing districts including Valsad, Navsari, Surat, Bharuch, Rajkot, Jamnagar, Kutch, and Junagadh, due to favourable agro-climatic conditions. Mango is a major fruit crop in Asia and has gained importance worldwide (Bose *et al*., 2001). India is the largest producer of mango in the world with 21,882 thousand MT production on an area of 2,258 thousand hectare and productivity of 9.70 MT per hectare (Anonymous, 2018). Mango fruits are nutritionally valuable, with every 100 g of mango pulp containing 81.7 g water, 16 g carbohydrates, 0.7 g protein, 0.4 g fat, and 0.1 g fibers. Mangoes are rich in calcium, phosphorus, iron, magnesium, vitamins A, B, and C, as well as a fair amount of antioxidants. A single fruit can provide up to 40% of the daily dietary fiber needs (Singh *et al*., 2005). The variety Amrapali introduced in 1971 as a hybrid of Dashehari and Neelum. The demand for organic mangoes has increased both nationally and internationally due to which farmers start showing interest on organic cultivation in order to receive higher prices for their produce. However, managing nutrient levels in organic farming can be a challenge for the farmers as traditional methods like using farmyard manure (FYM) or vermicompost is difficult to produce and expensive to purchase. As a result, many farmers have turned to green manuring and bio-fertilizers as alternative options for nutrient management. Green manuring involves ploughing undecomposed plant material into the soil to improve soil structure and fertility, ultimately contributing to crop yield. Among green manure crops, sunhemp and dhaincha are notable for their high biomass production and nitrogen contribution. Application of green manure crop sunhemp (*Crotalaria juncea* L.) resulted in significantly maximum porosity (60.27%), water holding capacity (60.31%), organic carbon (1.90 %), soil N (405.56 %), P (22.02 %), K (419.00 %) as reported by (Mir *et al*., 2013). Double green manuring of sunhemp recorded significant effect on yield and quality parameters of banana (Anon., 2020). Kundu *et al*. (2011); Dutta and Kundu (2012) reported improvement in fruit quality of Amrapali and Himsagar mango varieties by applications of bio-fertilizers. Mouco *et al*. (2015) concluded improvement in soil properties by green manuring of sunhemp in the mango orchard. Bio-fertilizers, on the other hand, improve soil fertility through biological nitrogen fixation, solubilizing phosphorus from soil, and mobilizing

micronutrients for plant uptake. Rhizobium strains play a major role in symbiotic N- fixation in legumes. *Azotobacter* spp. and *Azospirilium* spp. help in N-fixation in fruit crops. Bio-fertilizers like Bio-NPK consortium, PSB, Azotobacter, etc., should be used for higher quantity as well as quality productions with minimum cost. Application of green manuring of sunhemp along with bio-fertilizer application registered the maximum yield parameters of banana (Vanilarasu *et al.*, 2016). Application of bio-fertilizers along with liquid organic manures like Azotobacter and Azospirillum resulted in higher mango production with quality fruits. (Sau *et al*., 2017). Hence, very little information is available on nutrient management through green manuring with bio-fertilizers particularly in mango and other fruit crops. So, the considering the paucity of research on these aspects and looking to the importance and need for the growers, the research was performed.

MATERIALS AND METHODS

Experimental Site: The present investigation was carried out at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, A. A. U., Anand during *Kharif - Summer* season of the years 2018-19 and 2019-20 in mango (*Mangifera indica* L.) cv. Amrapali. Experimental orchard has been in place for 16 years, with mango trees planted at 6m × 6m. The site is situated geographically at 22°-35' North latitude and 72°-56' East longitude and is located at an altitude of 45.1 meter above mean sea level.

Experimental design and treatments: The experiment was laid out in a Completely Randomized Design with ten treatments and three repetitions. The experiment involved ten treatments T_1: Single green manuring of sunhemp, T_2: Double green manuring of sunhemp, T_3: Single green manuring of dhaincha, T_4: Double green manuring of dhaincha, T_5: Single green manuring of sunhemp + 10 ml Bio NPK consortium per tree, T_6: Double green manuring of sunhemp + 10 ml Bio NPK consortium per tree, T_7: Single green manuring of dhaincha + 10 ml Bio NPK consortium per tree, T_8: Double green manuring of dhaincha + 10 ml Bio NPK consortium per tree, T_9: NAU recommendation: FYM: 100kg + 100 % RDN through Neem cake + *Azotobacter* @ 250 g + PSB @ 250 g/plant, T_{10}: Control: Recommended dose of fertilizers: FYM: 100 kg + NPK=750:160:750 g/tree/year.

The treatments in the experiment involved different methods of green manuring, either single or double, with either sunhemp or dhaincha, and with or without the application of Bio NPK consortium and other fertilizers recommended by NAU. The green manure seeds were sown using line sowing at 15cm between the lines, with a seed rate of 25-35kg/ha for sunhemp and 20-25kg/ha for dhaincha. The first sowing of green manure was done before the onset of monsoon, followed by irrigation for uniform germination of seeds. Bio-fertilizers were applied after the onset of monsoon, with neem cake applied around the trunk in July. After 45-50 DAS, the fully green leaves of sunhemp and dhaincha plants were incorporated into the soil using a rotavator machine in both seasons of the experiment for both single and double green manuring.

RESULT AND DISCUSSION

A. Quality Parameters

The yield parameter of mango fruit serves as an index of their market value, while the quality parameter is an essential measure for assessing customer acceptance. To determine the quality of mango fruit samples collected at harvest, we conducted analyses for TSS, acidity, total sugar, reducing sugar, non-reducing sugar, and ascorbic acid. The results of these analyses are presented in Table 1 and summarized below.

Total Soluble Solid (°Brix). Table 1 showed significantly higher 23.05 °Brix TSS was observed in Treatment T_6 (double green manuring of sunhemp and 10 ml of Bio NPK consortium per tree) in the pooled results. In contrast, the control treatment (T_{10}) had a lower value of 18.14 °Brix. The observed difference in °Brix values may be attributed to the beneficial effects of organic fertilizers, such as nitrogen fixation, production of phytohormones, and increased nutrient uptake, which can improve soil biological attributes. These findings are in consistent with previous studies on Mango (Dutta *et al*., 2016) and Aonla (Yadav and Shukhla 2009).

Acidity (%). The acidity of mango fruit was analyzed to assess the effects of different treatments on fruit quality. Treatment T_6 (double green manuring of sunhemp and 10 ml of Bio NPK consortium per tree) produced significantly lower acidity values of 0.175% in the pooled results as reflected in Table 1. In contrast, the control treatment (T_{10}) had the highest fruit acidity. The observed difference in acidity values may be attributed to the positive effects of organic treatments on the total leaf area, leading to greater carbohydrate accumulation through the photosynthesis process. This finding is in accordance with the findings of Binepal *et al.* (2013) in Guava.

Total sugar (%). Higher total sugar values of 19.98% in the pooled results showed in Table 1 which was found in Treatment T_6 (double green manuring of sunhemp and 10 ml of Bio NPK consortium per tree). This might be due to the improved nutrient supply, hormonal and enzymatic activity induced by green manures and bio-fertilizers, as well as better water uptake and nutrient deposition, leading to increased qualitative parameters such as total sugar percentage. Similar findings have been reported in kiwi fruit (Khachi *et al*., 2015), Mango (Dutta *et al.,* 2016) and Mango (Sau *et al.,* 2017).

Reducing sugar (%). Treatment T_6 (double green manuring of sunhemp and 10 ml of Bio NPK consortium per tree,) produced significantly higher reducing sugar values of 8.01% in the pooled results showed in Table 1. In contrast, the control treatment (T_{10}) had the lowest reducing sugar value of 6.35%. This finding may be due to the positive effects of organic treatments on the accumulation and translocation of carbohydrates, resulting in higher reducing sugar content. Similar results were reported in Banana (Tamuli, 2017) and Guava (Ram *et al.*, 2007).

Non- Reducing Sugar (%). Results regarding non-reducing sugar in mango fruit as influenced by different treatments of green manures and bio-fertilizer showed non-significant result.

Ascorbic acid (mg / 100 g pulp). Ascorbic acid is an important component of mango fruit that contributes to its nutritional value. The results showed that treatment T6, involving double green manuring of sunhemp and 10 ml of Bio NPK consortium per tree, had significantly higher ascorbic acid content values of 43.73 mg/100 g pulp in the pooled results as depicted in Table 1. In contrast, the control treatment (T_{10}) had significantly lower values of 36.88 mg/100 g pulp in the pooled analysis. These findings are consistent with the results reported in strawberry (Gupta and Tripathi 2012) and banana (Chhuria *et al*., 2016).

B. Yield Parameters

The application of green manures and bio-fertilizers on number of fruits per tree, average fruit weight, fruit yield kg per tree and estimated fruit yield tonnes per hectare were found significant effect on yield parameters. The results showed that the application of green manures and bio-fertilizers had a significant effect on these yield parameters, as summarized in Table 2 and 3.

Numbers of fruits per tree. Analysis of the different treatments revealed that T_6 (double green manuring of sunhemp + 10 ml Bio NPK consortium per tree) produced the highest number of fruits per tree (268.98) in pooled data, while treatment T_{10} (control) resulted in the lowest number of fruits per tree (199.30) in pooled analysis as showed in Table 2. Increase in fruit yield is due to the higher availability of nutrients provided by double green manuring, as well as the use of bio-fertilizers, which may have contributed to higher fruit setting and increased the number of fruits per plant. These results are consistent with those of Marathe *et al.* (2009), who observed a similar effect in Sweet orange.

Fruit Weight (g). Based on the pooled data, it was observed that the treatment T_6, *i.e*. double green manuring of sunhemp + 10 ml Bio NPK consortium per tree, resulted in significantly higher fruit weight of 192.39 g, while the lowest fruit weight of 127.04 g was recorded in treatment T_{10} (control) as showed in Table 2. The application of double green manures and bio-fertilizers might have resulted in better nutrient uptake, leading to improved physiological and biochemical activity, ultimately resulting in bigger fruit size. Similar findings were also reported by Kanamadi *et al*. (2004) in Banana, Korwar *et al*. (2006) in Aonla and Singh *et al*. (2017) in Mango.

Fruit Yield (Kg/tree). The data in Table 2 showed that treatment T_6, which involved double green manuring of sunhemp and the application of 10 ml of Bio NPK consortium per tree, resulted in the highest fruit yield of 52.86 kg during the pooled result. On the other hand, treatment T_{10} (control) yielded the lowest fruit yield of 31.92 kg during the pooled result. Treatment T_6 also produced a higher number of fruits per plant and bigger fruit sizes, leading to a higher fruit yield per tree. These findings are consistent with previous studies such as Ram *et al*. (2017) in Mango, Sau *et al*. (2017) in Mango, Baviskar *et al.* (2011) in Sapota and Jamra *et al.* (2018) in Aonla.

Fruit Yield (t/ha). From the Table 2, it was found that treatment T_6 (double green manuring of sunhemp and the application of 10 ml of Bio NPK consortium per tree) produced the highest fruit yield compared to the other treatments. The pooled result showed a significantly higher fruit yield of 14.64 t/ha for treatment T_6, while the control treatment T_{10} yielded a significantly lower fruit yield of 8.84 t/ha. These results are consistent with previous studies conducted by Vanilarasu *et al.* (2016) in Banana and Faria *et al*. (2004) in Grape.

Grade wise fruit yield kg per tree. The data presented in Table 3, it can be observed that treatment T_6, which involved double green manuring of sunhemp and the application of 10 ml of Bio NPK consortium per tree, resulted in significantly higher yields of "A" grade, "B" grade, and "C" grade fruits compared to the other treatments. The two-year pooled result showed that treatment T_6 yielded 23.16 kg of "A" grade fruits, 16.57 kg of "B" grade fruits, and 13.13 kg of "C" grade fruits per tree. On the other hand, the lowest yields of "A" grade (13.42 kg), "B" grade (10.94 kg), and "C" grade (7.56 kg) fruits were recorded with treatment T10 (control). The use of bio-fertilizers and organic fertilizers can be attributed to their ability to provide plants with optimal levels of nutrients and growth hormones during the desired period of fruit growth, resulting in increased fruit weight and yield. It has been found that the application of organic sources of bio-fertilizers and nutrients at the same level can be more effective in improving yield and yield attributes.

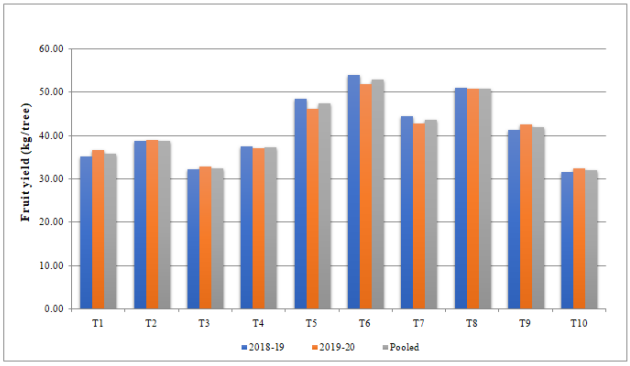

Fig. 1. Effect of green manures and bio-fertilizers on fruit yield kg per tree of mango cv. Amrapali.

Table 1: Effect of green manures and bio-fertilizers on Quality parametersin mango cv. Amrapali.

Treat. No.	Treatment details	Total soluble solid (°Brix)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/ 100 g pulp)
		Pooled Data (2018-19 and 2019-20)					
T_1	Single green manuring of sunhemp	18.52	0.268	16.58	6.80	9.91	37.64
T_2	Double green manuring of sunhemp	18.85	0.248	17.45	6.90	10.57	39.24
T_3	Single green manuring of dhaincha	18.27	0.274	16.27	6.46	9.93	37.28
T_4	Double green manuring of dhaincha	18.58	0.266	17.22	6.87	10.39	38.31
T_5	Single green manuring of sunhemp + 10 ml Bio NPK consortium per tree	20.40	0.221	18.68	7.64	11.00	41.50
T_6	Double green manuring of sunhemp + 10 ml Bio NPK consortium per tree	23.05	0.175	19.98	8.01	11.80	43.73
T_7	Single green manuring of dhaincha + 10 ml Bio NPK consortium per tree	19.38	0.238	18.42	7.39	10.98	40.55
T_8	Double green manuring of dhaincha + 10 ml Bio NPK consortium per tree	21.32	0.199	19.60	7.87	11.59	42.14
T_9	FYM: 100 kg + 100 % RDN through neem cake + *Azotobacter* @ 250 g + PSB @ 250 g/plant	18.90	0.243	18.00	7.27	10.72	39.88
T_{10}	Control: FYM: 100 kg + NPK= 750:160:750 g/tree/year	18.14	0.295	16.23	6.35	10.09	36.88
T	S.Em.±	0.42	0.004	0.39	0.14	0.46	0.62
	C.D. (P =0.05)	1.22	0.013	1.11	0.41	NS	1.77
Y × T	S.Em.±	0.60	0.006	0.55	0.20	0.64	0.87
	C.D. (P =0.05)	NS	NS	NS	NS	NS	NS
C.V. %		5.32	4.48	5.33	4.86	10.43	3.82

Table 2: Effect of green manures and bio-fertilizers on Yield parameters in mango cv. Amrapali.

Treat. No.	Treatment details	Number of fruits per tree	Average Fruit weight (g)	Fruit yield (kg/tree)	Estimated fruit yield (t/ha)
		Pooled Data (2018-19 and 2019-20)			
T_1	Single green manuring of sunhemp	207.85	143.90	35.86	9.93
T_2	Double green manuring of sunhemp	216.84	156.60	38.83	10.75
T_3	Single green manuring of dhaincha	203.08	132.39	32.44	8.99
T_4	Double green manuring of dhaincha	210.66	145.91	37.21	10.31
T_5	Single green manuring of sunhemp + 10 ml Bio NPK consortium per tree	251.82	163.67	47.30	13.10
T_6	Double green manuring of sunhemp + 10 ml Bio NPK consortium per tree	268.98	192.39	52.86	14.64
T_7	Single green manuring of dhaincha + 10 ml Bio NPK consortium per tree	242.40	160.79	43.59	12.08
T_8	Double green manuring of dhaincha + 10 ml Bio NPK consortium per tree	263.19	189.12	50.79	14.07
T_9	FYM: 100 kg + 100 % RDN through neem cake + *Azotobacter* @ 250 g + PSB @ 250 g/plant	238.19	160.07	41.84	11.59
T_{10}	Control: FYM: 100 kg + NPK= 750:160:750 g/tree/year	199.30	127.04	31.92	8.84
T	S.Em.±	7.14	5.87	1.02	0.28
	C.D. (P =0.05)	20.48	16.83	2.92	0.81
Y × T	S.Em.±	10.10	8.30	1.44	0.40
	C.D. (P =0.05)	NS	NS	NS	NS
C.V. %		7.60	9.14	6.05	6.05

Table 3: Effect of green manures and bio-fertilizers on grade wise fruit yield kg per tree of the two-year pooled in mango cv. Amrapali.

Treat. No.	Treatment details	Pooled Year Data(2018-19 and 2019-20)			
		"A" grade fruit yield (kg/tree)	"B" grade fruit yield (kg/tree)	"C" grade fruit yield (kg/tree)	Total fruit yield (kg/tree)
T_1	Single green manuring of sunhemp	207.85	143.90	35.86	9.93
T_2	Double green manuring of sunhemp	216.84	156.60	38.83	10.75
T_3	Single green manuring of dhaincha	203.08	132.39	32.44	8.99
T_4	Double green manuring of dhaincha	210.66	145.91	37.21	10.31
T_5	Single green manuring of sunhemp + 10 ml Bio NPK consortium per tree	251.82	163.67	47.30	13.10
T_6	Double green manuring of sunhemp + 10 ml Bio NPK consortium per tree	268.98	192.39	52.86	14.64
T_7	Single green manuring of dhaincha + 10 ml Bio NPK consortium per tree	242.40	160.79	43.59	12.08
T_8	Double green manuring of dhaincha + 10 ml Bio NPK consortium per tree	263.19	189.12	50.79	14.07
T_9	FYM: 100 kg + 100 % RDN through neem cake + *Azotobacter* @ 250 g + PSB @ 250 g/plant	238.19	160.07	41.84	11.59
T_{10}	Control: FYM: 100 kg + NPK= 750:160:750 g/tree/year	199.30	127.04	31.92	8.84
T	S.Em.±	7.14	5.87	1.02	0.28
	C.D. (P =0.05)	20.48	16.83	2.92	0.81
Y × T	S.Em.±	10.10	8.30	1.44	0.40
	C.D. (P =0.05)	NS	NS	NS	NS
C.V. %		7.60	9.14	6.05	6.05

CONCLUSIONS

The findings of the present investigation suggest that the application of double green manuring of sunhemp in the canopy area along with the use of 10 ml Bio NPK consortium per tree can significantly improve quality parameters such as TSS, acidity, total sugar, reducing sugar, and ascorbic acid. Moreover, it can enhance yield contributing parameters such as the number of fruits per tree, average fruit weight, fruit yield in kg per tree, and estimated fruit yield in tonnes per hectare in mango cv. Amrapali. These results provide useful information for farmers and researchers who are interested in adopting organic farming practices to achieve better quality and yield in fruit crops.

FUTURE SCOPE

By using these findings the level of these parameters may be manipulated in order to get more yield and better quality parameters. Similarly other parameters like changes in nutrients levels and biochemical levels are need to be studied for better understanding by employing the different biofertilizers and green manuring in different region and for different variety.

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Conflict of Interest. None.

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