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RESEARCH PAPER

Influence of bio-fertilizers in combination with chemical fertilizers on growth, flowering and yield of mango (*Mangifera indica* L.) cv. AMRAPALI

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Abstract : A field experiment was conducted to find out most appropriate combination of bio-fertilizers and chemical fertilizers for mango production during 2011 - 13 at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The trial was laid out in Randomized Block Design, replicated thrice, with thirteen treatments including control. It was found that the application of 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) significantly increased tree height (m) at initial and harvesting stage, tree spread N- S (m) at initial and harvesting stage and canopy volume (m^3) at initial stage, whereas tree spread E - W at harvesting stage and canopy volume (m^3) at harvesting stage was found superior with 100% N + 100% P_2O_5 + *Azotobacter* + PSB (T_4). The application of 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) appeared as the most suited combination for providing maximum number of panicles per branch, length of panicle (cm), number of flowers per panicle, sex ratio, total chlorophyll content of leaf (mg/g) at 50 per cent flowering and before harvesting, leaf area (cm^2) at 50 per cent flowering and before harvesting, marketable fruit weight (g), number of fruits per tree and fruit yield (kg/tree). Shelf- life (days) and fruit volume (cc) significantly increased with 70% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{13}). Tree spread E - W at initial stage was found non- significant. Treatment 85% N + 85% P_2O_5 + *Azotobacter* + PSB proved as the next better treatment followed by 100% RDF.

Key Words : Mango, Growth, Flowering, Yield, Amrapali

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INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae. It is grown almost in 63 countries of the world. This fruit crop occupies a unique place amongst the fruit crops grown in India. In Western India, several mango varieties *viz.*, Alphonso, Kesar, Rajapuri, Pairi, Dashehari, Langra, Neelum, Amrapali and Mallika are commercially grown and accepted by the consumers. Amrapali is a hybrid developed at IARI, New Delhi through crosses between Dashehari × Neelum. It is precocious dwarf (suitable for high density planting), regular bearer and good cropper. Fruits are green, apricot

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yellow, medium sized sweet in taste with high T.S.S. and pulp content (75%), while flesh is fibreless and deep orange red. Application of manures and fertilizers through soil is not enough to produce qualitative mango fruits. Decline in soil health due to excessive dependence on chemical inputs left us with no other option but to utilising biological inputs like biofertilizers which is sought to be one of the answers to restore the soil health apart from solving nutrition problem of plants. Biofertilizers are microbial preparations containing living cells of different micro-organisms which have the ability to mobilize plant nutrients in soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. It is mainly used for field crops but now-a-days it is used for fruit crops also. Biofertilizers are able to fix 20–200 kg N/ha/year, solubilize P in the range of 30–50 kg P_2O_5 ha/year and mobilizes P, Zn, Fe, Mo to varying extent. Biofertilizers are used in live formulation of beneficial micro-organism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost micro flora and in turn improved the soil health in general (Hazarika and Ansari, 2007). Considering the importance and future scope of mango fruit, it was decided to conduct the present experiment with the objectives to find out the effect of bio-fertilizers in combination with chemical fertilizers on growth of mango cv. AMRAPALI.

MATERIAL AND METHODS

A field experiment was conducted at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi* – summer season of the year 2011-12 and 2012-13. The soil samples of location before conducting experiment in main field were analyzed for essential nutrients, organic carbon, EC and pH (Jackson, 1973). The details of value is given in Table A, which shows the soils to be medium in available nitrogen and available phosphorus was low, whereas available potash is high at location of experiment, while organic carbon was low at the location. The experiment consisted of thirteen treatment combinations, comprised of three nitrogen levels (100, 85 and 70% of RDF), two levels of phosphorus (100 and 85% of RDF) and bio-fertilizers (*Azotobacter*, PSB each of 5 ml/ tree). The details of treatments are given in Table B. According to treatment, 50% N and 100% P_2O_5 of each treatment were applied at the time of onset of monsoon by (18^{th} July and 12^{th} July during 2011-12 and 2012-13, respectively) making ring with 15 cm deep and 1.5 m away from main trunk. Second dose of 50% N was applied at flowering stage (21^{st} February and 12^{th} February during 2011-12 and 2012-13, respectively).

Table A : Chemical properties of the experimental soil

1.	Organic carbon (%)	0.34
2.	Available nitrogen (kg ha^{-1})	260.37
3.	Available phosphorus (kg ha^{-1})	21.84
4.	Available potash (kg ha^{-1})	415.71
5.	Soil pH (1:2.5, soil : water ratio)	7.08
6.	EC (dsm^{-1})	0.29

Table B : The treatment details in the present investigation are as under

Sr. No.	Treatments	Treatment details
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	Control - 750 N + 160 P_2O_5 g/tree (RDF) (100% N + 100% P_2O_5)
T_2	100% N + 100% P_2O_5 + *Azotobacter*	750 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_3	100% N + 100% P_2O_5 + PSB	750 N g/tree + 160 P_2O_5 g/tree + PSB (5ml/tree)
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	750 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_5	100% N + 85% P_2O_5 + PSB	750 N g/tree + 136 P_2O_5 g/tree + PSB (5ml/tree)
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	750 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_7	85% N + 100% P_2O_5 + *Azotobacter*	637.5 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	637.5 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_9	85% N + 85% P_2O_5 + PSB	637.5 N g/tree + 136 P_2O_5 g/tree + PSB (5ml/tree)
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	637.5 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	525 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree)
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	525 N g/tree + 160 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	525 N g/tree + 136 P_2O_5 g/tree + *Azotobacter* (5ml/tree) + PSB (5ml/tree)

According to treatment, 5ml of each of *Azotobacter* and PSB were dissolved in 1 litre water and mixed with 80 kg FYM (well decomposed organic manure). This mixture was applied at the time of onset of monsoon (1st August and 23rd July during 2011-12 and 2012-13, respectively). At the time of flowering stage 5ml of each of *Azotobacter* and PSB were dissolved in 1 litre water and mixed with 20 kg finely powdered FYM. This mixture was given on 3rd March and 23rd February during 2011-12 and 2012-13, respectively.

Potassium 100%, FYM @ 100 kg/tree were applied as a common dose to ten year old experimental trees. The experiment was laid out in a Randomized Block Design with four replications. The soil of the experimental site was sandy loam, locally known as "*Goradu*". Data obtained from study for two consecutive years were pooled and statistically analyzed as procedure given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

In respect of growth parameters (Table1) the results revealed that, pooled results recorded significantly maximum tree height at initial stage by the application of 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) which was at par with T_4, T_2, T_{13}, T_{10}, T_5, T_8, T_3 and T_{12}. Tree height at harvesting stage was found non-significant during first year of study. On pooled basis, maximum tree height at harvesting stage was found by the application of 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) and was at par with T_4, T_2, T_{13}, T_{10} and T_8 as compared to control T_1. Initially tree spread East – West (E-W) was found non-significant due to the combined application of biofertilizers and chemical fertilizers. Later on at harvesting stage significantly higher tree spread was observed under 100% N+100 % P_2O_5 + *Azotobacter* + PSB (T_4) in pooled results, which was at par with T_{10}, T_8, T_{12}, T_6, T_{13}, T_3 and T_2.

Likewise, the influence of biofertilizers in combination with chemical fertilizers on tree spread N – S at initial stage on pooled basis significantly maximum tree spread were obtained under T_6 (100% N + 85 % P_2O_5 + *Azotobacter* + PSB) and it was at par with T_{13} followed by T_2, T_3, T_5, T_4, T_{11}, T_{12}, T_8 and T_7. However, maximum tree spread N – S at harvesting stage during pooled results were recorded under T_6 (100% N + 85% P_2O_5 + *Azotobacter* + PSB). It was at par with T_4, T_{13}, T_3, T_5, T_2 and T_8.

In pooled analysis, maximum canopy volume at

Table 1: Growth parameters at initial and harvesting stage of mango cv. AMRAPALI as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	Tree height (m)		Tree spread E - W (m)		Tree spread N - S (m)		Canopy volume (m^3)	
		At initial stage	At harvesting stage	At initial stage	At harvesting stage	At initial stage	At harvesting stage	At initial stage	At harvesting stage
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	5.55	5.79	5.38	5.59	5.44	5.74	88.65	101.50
T_2	100% N + 100% P_2O_5 + *Azotobacter*	6.12	6.46	5.76	6.16	6.17	6.53	118.75	140.13
T_3	100% N + 100% P_2O_5 + PSB	5.84	6.18	5.96	6.33	6.16	6.58	109.22	129.79
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	6.16	6.68	6.12	6.81	6.13	6.76	124.48	160.75
T_5	100% N + 85% P_2O_5 + PSB	5.93	6.28	5.42	5.79	6.14	6.54	108.25	129.11
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	6.19	6.69	6.04	6.64	6.34	6.91	125.81	160.72
T_7	85% N + 100% P_2O_5 + *Azotobacter*	5.76	6.10	5.46	5.81	5.89	6.34	102.41	121.54
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	5.91	6.37	6.13	6.71	5.91	6.45	112.68	142.32
T_9	85% N + 85% P_2O_5 + PSB	5.44	5.81	5.49	5.86	5.44	5.87	85.98	105.18
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	5.97	6.43	6.22	6.76	5.77	6.27	113.33	142.27
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	5.53	5.88	5.57	5.95	6.00	6.37	93.86	112.89
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	5.82	6.21	6.20	6.69	5.94	6.40	109.25	133.95
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	6.03	6.44	5.98	6.58	6.31	6.76	118.59	146.53
S.E. ±		0.14	0.13	0.25	0.24	0.17	0.17	5.11	5.63
C. D. (P =0.05)		0.40	0.38	NS	0.68	0.48	0.48	14.39	15.93
C. V. (%)		7.19	6.45	12.61	11.72	8.70	7.96	13.58	12.31

NS= Non-significant

initially was observed with the application of 100% N + 85% P_2O_5 + *Azotobacter* + PSB (T_6) and was at par with T_4, T_{13}, T_2, T_{10} and T_8. It is seen that significantly higher canopy volume at harvesting stage by the application of 100% N + 100% P_2O_5 + *Azotobacter* + PSB (T_4) and was at par with T_6 and T_{13}.

The positive influence of bio-fertilizers in combination with chemical fertilizers on growth performance in respect of tree height, tree spread and canopy volume might be due to the application of NPK and FYM along with *Azotobacter* and PSB. The useful effect of nitrogen is certainly reflected by an increase in growth attributes. As nitrogen is the major constituent of fertilizers and it is a constituent of the protein, which is essential for formation of protoplasm and thus increasing the cell division and cell elongation and there by more vegetative growth. The application of N made more rapid synthesis of carbohydrate, which is converted into protein and protoplasm and increasing the size of cells. Similarly inoculation of *Azotobacter* a biological nitrogen fixer improved the nitrogen use efficiency of the plant (Dutta *et al*., 2009).

In addition to this phosphorus plays an important role in energy transformation which potassium plays an important role in maintenance of cellular organization by regulating the permeability of cellular membrane.

Treatment T_{10} *i.e.* 85% N+85% P_2O_5+*Azotobacter* +PSB recorded significantly the highest number of panicles per branch as compared to rest of the treatments except T_{13} and T_8 (Table 2). The length of panicle was significantly increased by the application of T_{10} (85% N + 85% P_2O_5 + *Azotobacter* + PSB) which remained at par with T_{11} and T_8. It is clearly indicated that, treatment 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) significantly increased the number of flowers per panicle and reduction in sex ratio *i.e.* male and hermaphrodite flowers. It remained at par with T_8 followed by T_{13} and T_{12} during pooled analysis. These might be due to facts that in conditions of adequate nutrition provided through NPK, FYM and biofertilizers, the trees remained more vegetative and hence, accumulation of carbohydrates induce early flowering. It also helpful in maintaining a particular C: N ratio (CCC: NN) in shoots which is essential to produce flowers (Kunte *et al.,* 2005). The increased in flowers may be due to increased in nutrients availability from FYM, the organic phosphorus through phosphobacteria and IAA from *Azotobacter* which may have increased various endogenous hormonal levels in plant tissue might be responsible for enhancing flowering.

In the present study treatment of 85% N + 85% P_2O_5 + *Azotobacter* + PSB (T_{10}) recorded significantly the maximum total chlorophyll content of the leaf at 50%

Table 2 : Flowering and physiological parameters of mango cv. AMRAPALI as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	No. of panicles per branch	Length of panicle (cm)	No. of flowers per panicle	Sex ratio	Total chlorophyll content of leaf (mg/g)		Leaf area (cm^2)	
						At 50% flowering	Before harvesting	At 50% flowering	Before harvesting
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	5.75	23.50	1470.63	1.50	2.14	1.27	50.36	51.18
T_2	100% N + 100% P_2O_5 + *Azotobacter*	6.63	26.38	1520.25	1.38	2.14	1.25	61.02	61.93
T_3	100% N + 100% P_2O_5 + PSB	6.75	30.13	1527.50	1.28	2.18	1.25	73.04	73.90
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	7.50	30.13	1606.25	0.95	2.33	1.32	79.12	79.99
T_5	100% N + 85% P_2O_5 + PSB	7.50	30.00	1570.63	1.20	2.18	1.22	78.47	79.33
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	7.75	33.88	1682.50	0.93	2.37	1.36	85.91	86.84
T_7	85% N + 100% P_2O_5 + *Azotobacter*	6.25	36.63	1558.13	1.10	2.22	1.21	77.07	78.13
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	8.88	41.50	1764.13	0.74	2.38	1.30	81.74	82.99
T_9	85% N + 85% P_2O_5 + PSB	7.38	37.63	1595.63	1.08	2.22	1.23	79.73	80.74
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	9.38	43.38	1779.38	0.73	2.41	1.32	83.03	82.26
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	6.25	42.38	1550.38	1.15	2.19	1.19	73.22	72.89
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	8.13	37.88	1728.13	0.83	2.35	1.27	79.21	80.38
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	9.13	39.38	1760.13	0.79	2.33	1.28	81.03	83.22
S.E. ±		0.38	0.94	38.19	0.06	0.4	0.2	2.07	2.18
C. D. (P =0.05)		1.08	2.65	107.58	0.18	0.12	0.6	5.83	6.14
C. V. (%)		14.32	8.21	7.17	18.24	5.38	5.35	8.35	8.63

flowering stage and it remained at par with T_{12} followed by T_6, T_4 and T_{13}. While, before harvesting total chlorophyll content of leaf was significantly increased under T_6 (100% N + 85% P_2O_5 + *Azotobacter* + PSB) and remained at par with T_{10}, T_8 and T_4.

The maximum leaf area was noticed under T_6 (100% N + 85% P_2O_5 + *Azotobacter* + PSB) at 50% flowering stage and just before harvesting, during the period of experiment and on pooled basis and it remained at par with T_8, T_{10} and T_{13}.

The increased in chlorophyll content and leaf area might be due to the application of NPK along with FYM and biofertilizers secreted plant growth promoting substances like IAA, GA_3 and cytokinins besides increasing the availability of atmospheric nitrogen which enhanced rapid synthesis of carbohydrate. While, phosphobacteria bring about dissolution of bound forms of phosphates in soil. Thus, phosphorus plays an important role in energy transformation and potassium plays an important role in maintenance of cellular organization by regulating the permeability of cellular membrane.

Treatment T_{10} *i.e.* 85% N+85% P_2O_5+ *Azotobacter* + PSB recorded significantly the maximum fruit weight as compared to rest of the treatments on pooled basis (Table 3). This might be due to accumulation of more food material in the trees by an efficient utilization for development of fruits. The marked effect of nitrogen on various characters of fruits was due to increased in the efficiency of metabolic processes and thus, encouraged the growth of the plant in general and consequently the various parts of the plant including fruit. The application of N, P and K fertilizers might have resulted in high rate of photosynthesis results leads to higher carbohydrate accumulation in fruit and thereby increasing in fruit size and weight. They also enhanced the plant growth through their beneficial effects, which in turn resulted in higher fruit size (Singh *et al*., 2003).

Significantly the highest number of fruits per tree was recorded in treatment T_{10} *i.e.* 85% N + 85% P_2O_5 + *Azotobacter* + PSB and remained at par with treatments T_8. Similarly, the highest fruit yield per tree was also recorded by the treatment T_{10} *i.e.* 85% N + 85% P_2O_5 + *Azotobacter* + PSB and it remained at par with treatments T_8 and T_{13}. The increased in number of fruits per tree and fruit yield (kg/plant) might be attributed due to increasing levels of nutrients near the assimilating area of plant enhanced the rate of dry matter production and its rational partitioning to economic part improved the yield (Dalal *et al*., 2004).

Maximum shelf-life was reported by the treatment T_{13} (70% N + 85% P_2O_5 + *Azotobacter* + PSB) which was closely followed by the treatments T_{12}, T_8, T_{10} and T_{11}. Similarly, the fruit volume was also significantly highest with the treatment T_{13} (70% N + 85% P_2O_5 +

Table 3 : Yield parameters, shelf-life and fruit volume of mango cv. AMRAPALI as influenced by bio-fertilizers in combination with chemical fertilizers

Sr. No.	Treatments	Marketable fruit weight (g)	Number of fruits per tree	Fruit yield (kg/tree)	Shelf- life (Days)	Fruit volume (cc)
T_1	Control - 750 N + 160 P_2O_5 g/tree (RDF)	132.38	341.00	36.63	10.00	107.12
T_2	100% N + 100% P_2O_5 + *Azotobacter*	146.23	351.13	37.88	10.88	119.09
T_3	100% N + 100% P_2O_5 + PSB	153.18	361.00	38.38	10.88	115.76
T_4	100% N + 100% P_2O_5 + *Azotobacter* + PSB	164.11	367.68	46.00	11.50	124.80
T_5	100% N + 85% P_2O_5 + PSB	151.43	359.88	37.38	10.63	118.06
T_6	100% N + 85% P_2O_5 + *Azotobacter* + PSB	160.91	401.38	41.25	11.00	124.11
T_7	85% N + 100% P_2O_5 + *Azotobacter*	152.89	360.63	37.50	11.50	121.51
T_8	85% N + 100% P_2O_5 + *Azotobacter* + PSB	166.95	541.75	52.13	12.63	125.14
T_9	85% N + 85% P_2O_5 + PSB	151.55	371.00	38.14	11.75	125.94
T_{10}	85% N + 85% P_2O_5 + *Azotobacter* + PSB	179.21	556.00	54.00	12.38	126.13
T_{11}	70% N + 100% P_2O_5 + *Azotobacter*	143.08	354.50	42.13	12.38	122.63
T_{12}	70% N + 100% P_2O_5 + *Azotobacter* + PSB	155.11	432.75	47.63	12.88	122.84
T_{13}	70% N + 85% P_2O_5 + *Azotobacter* + PSB	160.83	483.63	53.13	13.50	128.68
S.E. ±		4.27	15.03	2.00	0.45	2.64
C. D. (P =0.05)		12.02	42.35	5.64	1.25	7.44
C. V. (%)		8.23	10.99	13.92	11.49	6.39

Azotobacter + PSB) as compared to rest of the treatments, except T_{10} followed by T_9, T_8, T_4, T_6, T_{12}, T_{11} and T_7.

The NPK application along with bio-fertilizers *viz.*, *Azotobacter* and PSB and FYM resulted in an overall improvement in fruit quality and thereby shelf-life of mango. The increased in fruit quality may be attributed to use of these bio-fertilizers which enhances the nutrient availability by enhancing the capability of plants to better solute uptake from rhizosphere and also helped in mitigating stresses in plants (Patel *et al*., 2009). The potassium is known to be a vital element for the development of fruit, movement of sugar and indirectly photosynthesis. The increased in fruit volume was due to use of NPK along with FYM and biofertilizers which caused accumulation of more food material and leads to an efficient utilization of the same for the development of fruits.

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