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Effect of biofertilizers and inorganic fertilizers on mango cv. Himsagar

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ABSTRACT

An experiment was conducted to study the effect of different combinations of biofertilizers and inorganic fertilizers on 10 years old mango cv. Himsagar during 2012-14 at Horticulture Research Station of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India. The experiment was laid out in a Randomized Block Design with nine treatments and three replications. Ttreatments include 100% NPK (T_1), 75% NPK + Azotobacter + PSB + K-mobilizer (T_2), 75% NPK + Azospirillum + PSB + K-mobilizer (T_3), 50% NPK + Azotobacter + PSB + K-mobilizer (T_4), 50% NPK + Azospirillum + PSB + K-mobilizer (T_5), 25% NPK + Azotobacter + PSB + K--mobilizer (T_6), 25% NPK + Azospirillum + PSB + K-mobilizer (T_7), Azotobacter + PSB + K-mobilizer (T_8) and Azospirillum + PSB + K-mobilizer (T_9). Combinations of inorganic and biofertilizers (T_2 - T_6) were effective in increasing soil microbial population, leaf and soil nutrient status, flowering shoots, yield and also in improving fruit quality as compared with control (100% NPK) or only biofertilizers (T_8 and T_9). Combinations of higher rates (75% or 50%) of inorganic fertilizer and biofertilizers (T_2, T_3, T_4 and T_5) were more effective in this regard. In contrast, population of nitrogen fixing bacteria was reduced with the addition of inorganic fertilizer. It may be concluded that the treatments 75% NPK + Azotobacter + PSB + K-mobilizer (T_2) and 75% NPK + Azospirillum + PSB + K-mobilizer (T_3) were most effective in all respect and can reduce the use of 25% inorganic fertilizer.

***Keywords*:** Biofertilizers, inorganic fertilizers, mango, microbial population, soil nutrient status and yield

Mango (*Mangifera indica* L.) is the most important fruit in the tropical and subtropical region of the world. The nutritional and economic importance makes mango very popular over the world. India is the largest producer of mango and contributes about 45.1% to the world mango (including guava) production (Saxena, 2015). Nutrition of trees is an important part of mango orchard management practices and fertilizer is one of the major inputs accounting for nearly 30.91 per cent of the cost of cultivation (Banerjee, 2011). But the increasing cost of fertilizer and global concern of ground water pollution through leaching from the soil are discounting the use of fertilizers. Heavy application of nitrogenous fertilizers causes accumulation of high quantities of nitrates in orchards which makes the produce hazardous for human consumption. So, it is necessary, to maintain the soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner (Chundawat, 2001). Biofertilizers are the living micro organism which add, conserve and mobilize the plant nutrients in the soil (Yawalkar *et al*., 1996). Biofertilizer based on renewable energy source are cost effective supplement to chemical fertilizers, (Motsara *et al*., 1995) and these organic sources of microbial inoculants are choices of the farmers (Kumar *et al.*, 2009; Srivastava *et al.*, 2009). Bio-fertilizers provide strength against soil borne diseases and also help in composting and effective recycling of solid waste which results in improved soil health. Therefore, biofertilizers provide an eco-friendly and need based use of chemical fertilizers which enhance soil quality and higher yield of plant. The effect of biofertilizers either alone or in combination with organic manures or inorganic fertilizers have been well established in many fruit crops particularly in papaya, banana etc. (Dutta *et al.*, 2010; Chhuria *et al*., 2016). However, very few works (Sau *et al.*, 2017) have been done in mango cv. Himsagar particularly under new alluvial zone of West Bengal. Keeping this in view, an experiment entitled "effect of biofertilizers and inorganic fertilizers in mango cv. Himsagar" was taken up.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Station, Mondouri of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the year 2012-2014. The area is in new alluvial zone which is situated between 21.5 ^{0}N latitude and 86-89 ^{0}E longitude with an average altitude of 9.75 m above sea level. The soil of experimental field had 6.06 pH, 0.72% organic carbon, 247.7 kg ha^{-1} available nitrogen, 13.2 kg ha^{-1} available phosphorus and 237.8 kg ha^{-1} available potassium. The experiment was laid out in a Randomized Block Design with nine treatments and three replications on ten years old Himsagar cultivar. The different treatments were 100% NPK (T_1), 75% NPK + *Azotobacter* + PSB + K-mobilizer (T_2), 75% NPK + *Azospirillum* + PSB + K-mobilizer (T_3), 50% NPK + *Azotobacter* + PSB + K-mobilizer (T_4), 50% NPK + *Azospirillum* + PSB + K-mobilizer (T_5), 25% NPK + *Azotobacter* + PSB + K--mobilizer (T_6), 25% NPK +

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Azospirillum + PSB + K-mobilizer (T_7), *Azotobacter* + PSB + K-mobilizer (T_8) and *Azospirillum* + PSB + K-mobilizer (T_9). Control plants (T_1) were fertilized with 1000g nitrogen, 500g phosphorous and 1000g potassium. Inorganic or chemical fertilizers were applied to the concerned plants according to their levels of treatments. Full dose of phosphorous and potassium and 50 % of nitrogen were given after fruit harvest (July) and remaining 50% of nitrogen were given at pea stage of fruit (March). Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Three different biofertilizers @ 250g each were incorporated to the concerned plants in the month of August by thoroughly mixing these three inoculums of biofertilizers with 10 kg of FYM. Each control plant was given 10 kg of FYM but without biofertlizer. Both inorganic and biofertilizer were applied in a ring 1 meter away from the trunk and at a depth of 30 cm which were mixed in soil and covered.

Soil samples were collected at 0-30 cm depth in the month of May for determination of soil nutrient characters and at 0-15 cm depth in the month of February for counting microbial populations. Microbial populations were counted by serial dilution technique and pour plating method as described by Collins *et al.* (2004). Soil pH, organic carbon, available nitrogen and available potassium content of soil were estimated by following the standard method (Jackson, 1973) whereas available phosphorus content was estimated by the method as described by Olsen *et al*. (1954). Four to seven month old leaves (latest mature flush) from the middle of the shoot were sampled in November and May for analysis of leaf nutrient content. Nitrogen was determined by micro-kjeldahl method as described by Black (1965). Phosphorus was estimated by vandomolybdate yellow colour method and potassium was determined with the help of flame photometer (Jackson, 1973). Four branches consisting of approximately 100 shoots from each plant were selected before flowering for counting flowering shoots. The physical and chemical characters of ripened fruits were recorded after thorough washing with tap water to remove adhering impurities. Fruit weight and fruit size were recorded from the average of 10 fruits for each replication using electronic (digital) balance and slide calipers respectively. Bio-chemical constituents were analyzed for each replication from ten fruits. Total soluble solids content of fruits was determined with the help of a digital refractometer calibrated in ^{0}brix at 20^{0}c. The sugars, acidity and ascorbic acid content of fruit were estimated by following the standard method (AOAC, 1984). The pooled data of two years were analyzed statistically by the analysis of variance method as suggested by Goon *et al.* (2001) and the significance of different source of variation was tested by error mean square by Fisher's 'F' test of probability level of 0.05 per cent.

RESULTS AND DISCUSSION

Present study revealed that different microbial populations in soil varied significantly among the different treatments of inorganic and biofertilizers. Higher population of *Azotobacter* in the soil was found with the treatment T_2, T_4, T_6 and T_8 (Table1). Again, *Azospirillum* population was much higher with the treatment T_3, T_5, T_7 and T_9. The higher population of *Azotobacter* or *Azospirillum* for a particular treatment was simply due to inoculation of that particular nitrogen fixing bacteria. Treatments of *Azotobacter* + PSB + K-mobilizer (T_8) and *Azospirillum* + PSB + K-mobilizer (T_9) resulted maximum soil microbial populations of *Azotobacter* (781×10^4 cfu g^{-1} of soil) and *Azospirillum* (727×10^4 cfu g^{-1} of soil), respectively (Table1). Population of these nitrogen fixing bacteria in soil decreased with the increased dose of inorganic fertilizer. On the other hand, population of PSB and K-mobilizer increased with the increased dose of inorganic fertilizers. Populations of phosphate solubilizing bacteria (PSB) and K-mobilizer were found maximum with the treatment 75% NPK + *Azotobacter* + PSB + K-mobilizer (496 x 10^4 cfu g^{-1} of soil) and 75% NPK + *Azospirillum* + PSB + K-mobilizer (679 x 10^4 cfu g^{-1} of soil), respectively (Table1). Less microbial populations of *Azotobacter*, *Azospirillum*, PSB and K-mobilizer were recorded in the control plots (fertilization of 100% NPK), was simply due to uninoculation of biofertilizers to the soil.

The available soil nutrient status (nitrogen, phospohorus and potassium) and organic carbon were found more when the soils were provided with combination of higher doses (75% or 50%) of inorganic fertilizer and biofertilizers (Table 2). Soil available nitrogen and potassium were found maximum (308.0 and 248.4 kg ha^{-1}, respectively) when the soil is treated with 75% NPK +*Azospirillum* + PSB + K Mobilizer (T_3) whereas maximum soil available phosphorus (25.91 kg ha^{-1}) and organic carbon (1.19 %) were recorded with the treatment 75% NPK + *Azotobacter* + PSB + K Mobilizer

(Table 2). The higher soil nutrient status due to the application of combined treatments (inorganic fertilizers + biofertilizers) might be due to the effect of biofertilizers. This is in agreement with the findings of Motsara *et al.* (1995) who reported that in addition to chemical fertilizer, nitrogen fixing bacteria (*Azotobacter* and *Azospirillum*) can fix 20 – 25 kg nitrogen per ha and PSB can solubilize 20 – 30 % of insoluble phosphate in soil. Positive relationship between biofertilizer

Table 1: Effect of biofertilizers and inorganic fertilizers on microbial population of mango orchard

Treatments	*Azotobacter* ($\times 10^4$ cfu g^{-1} soil)	*Azospirillum* ($\times 10^4$ cfu g^{-1} soil)	PSB ($\times 10^4$ cfu g^{-1} soil)	K-mobilizer ($\times 10^4$ cfu g^{-1} soil)
T_1: 100% NPK (Control)	110	121	69	88
T_2: 75% NPK + *Azotobacter* + PSB + K- mobilizer	416	135	496	646
T_3: 75% NPK + *Azospirillum* + PSB+ K- mobilizer	112	459	401	679
T_4: 50% NPK + *Azotobacter* + PSB + K- mobilizer	583	147	348	437
T_5: 50% NPK + *Azospirillum* + PSB + K- mobilizer	132	507	357	523
T_6: 25% NPK + *Azotobacter* + PSB +K- mobilizer	510	154	252	380
T_7: 25% NPK + *Azospirillum* + PSB +K- mobilizer	143	513	267	394
T_8: *Azotobacter* + PSB + K- mobilizer	781	178	248	276
T_9: *Azospirillum* + PSB + K- mobilizer	143	727	239	247
SEm (±)	**71.47**	**55.57**	**34.61**	**55.07**
LSD (0.05)	**205.89**	**160.07**	**99.71**	**158.64**

Table 2: Effect of biofertilizers and inorganic fertilizers on soil nutrient status of mango orchard

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})	Organic carbon (%)	pH
T_1	254.1	20.93	227.6	0.86	6.4
T_2	272.6	25.91	237.8	1.19	6.7
T_3	308.0	23.66	248.4	0.99	6.2
T_4	261.8	22.99	246.7	0.99	6.4
T_5	277.2	21.96	227.6	1.16	6.5
T_6	254.1	16.54	204.8	0.82	6.3
T_7	238.7	19.38	202.5	0.96	6.4
T_8	223.5	14.91	214.1	0.73	6.5
T_9	223.5	18.69	207.2	0.84	6.2
SEm (±)	**8.52**	**1.72**	**9.20**	**0.04**	**0.11**
LSD (0.05)	**25.31**	**5.10**	**27.34**	**0.13**	**0.32**

Note: Before starting experiment: available nitrogen- 247.7 kg ha^{-1}, available phosphorus – 13.2 kg ha^{-1}, available potassium- 237.8 kg ha^{-1}, organic carbon-0.72% and pH-6.06

application and soil nutrients (nitrogen, phosphorus, potassium) was also obtained earlier by Tiwari *et al*. (1999) and Manna *et al.* (2011 a). In the present findings higher soil nutrient content at final stage (at harvesting) indicated that plants have received the required nutrients for their growth and yield from the applied source without hampering the initial status (before application of treatments).

Leaf nutrient status in terms of nitrogen, phosphorus and potassium were higher in the month of November as compared to leaf nutrient status in the month of May (just before harvesting). The reduction of leaf nutrient content is quite natural due to the transportation of nutrients from source (leaf) to sink (fruit). Use of 100% NPK (T_1) or combination of higher rates (75% or 50%) of inorganic fertilizer and biofertilizers (T_2, T_3, T_4 and T_5) resulted higher leaf nitrogen, phosphorus and potassium content (Table 3). However, 75% NPK + biofertilizers (T_2 and T_3) were more responsive in higher leaf nutrient content particularly in the month of November (1.98-2.12% nitrogen, 0.17-0.18% phosphorus and 1.15-1.20% potassium). Higher

Table 3: Effect of biofertilizers and inorganic fertilizer on leaf nutrient status of mango cv. Himsagar

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	November	May	November	May	November	May
T_1	1.89	1.51	0.16	0.11	1.05	0.85
T_2	1.98	1.45	0.18	0.12	1.20	0.75
T_3	2.12	1.59	0.17	0.12	1.15	0.80
T_4	1.91	1.50	0.16	0.11	1.10	0.85
T_5	1.91	1.48	0.16	0.10	1.05	0.75
T_6	1.74	1.42	0.15	0.09	0.95	0.60
T_7	1.77	1.39	0.14	0.10	0.90	0.65
T_8	1.64	1.39	0.13	0.09	0.90	0.70
T_9	1.68	1.39	0.12	0.10	0.90	0.75
SEm (±)	**0.05**	**0.03**	**0.01**	**0.01**	**0.06**	**0.08**
LSD (0.05)	**0.15**	**0.10**	**0.02**	**NS**	**0.16**	**NS**

Note: Before starting experiment: nitrogen - 1.48%, phosphorus - 0.07% and potassium – 0.65%

Table 4: Effect of biofertilizers and inorganic fertilizers on yield and yield attributing characters of mango cv. Himsagar

Treatments	Flowering shoot (%)		Numbers of fruits plant^{-1}	Yield plant^{-1} (kg)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
T_1	35.1	(35.9)	194.6	50.4	258.3	9.40	7.56
T_2	42.7	(40.4)	225.7	60.4	267.2	9.62	7.74
T_3	41.9	(39.9)	215.3	56.7	263.8	9.43	7.60
T_4	42.7	(40.5)	210.7	56.0	263.6	9.37	7.63
T_5	46.1	(42.7)	210.7	56.5	266.8	9.45	7.68
T_6	35.4	(36.0)	171.1	43.8	253.8	9.41	7.62
T_7	32.2	(33.7)	181.5	45.9	252.2	9.29	7.51
T_8	28.5	(31.3)	154.5	38.8	251.7	9.25	7.40
T_9	28.3	(31.1)	153.6	38.2	247.6	9.15	7.48
SEm (±)	**1.28**		**10.31**	**2.85**	**2.98**	**0.13**	**0.11**
LSD (0.05)	**3.70**		**29.69**	**8.20**	**8.59**	**NS**	**NS**

Note: Figures in the parentheses are angular transformed values

Table 5: Effect of biofertilizers and inorganic fertilizers on fruit quality of mango cv. Himsagar

Treatments	TSS (^{0}brix)	Acidity (%)	TSS: Acid	Total sugar (%)	Reducing sugar (%)	Ascorbic acid (ml 100^{-1} ml juice)
T_1	17.48	0.22	79.5	12.73	3.62	34.0
T_2	18.60	0.24	77.5	13.40	4.12	38.6
T_3	18.23	0.22	82.9	13.61	4.28	39.9
T_4	17.95	0.25	71.8	12.83	3.83	36.4
T_5	18.03	0.21	85.9	14.11	4.13	38.0
T_6	17.85	0.16	111.6	12.80	3.92	34.6
T_7	18.25	0.14	130.4	12.15	3.60	34.2
T_8	17.45	0.15	116.3	11.85	3.48	31.8
T_9	16.75	0.15	111.7	12.16	3.66	32.8
SEm (±)	**0.54**	**0.03**	**17.83**	**0.71**	**0.21**	**1.92**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

nitrogen, phosphorus and potassium content in leaves were also recorded by Kundu *et al*. (2011) when mango plants treated with NPK (100%) + VAM + *Azotobacter*. Biofertilizers like *Azotobacter* and *Azospirillum* results in production of plant growth regulators *viz*. indole acetic acid and gibberellins enhance the uptake of NO_3^-, NH_4^+, $H_2PO_4^-$ and Fe improves nitrate reductase enzyme activity (Wani, 1990). All these are responsible for increased leaf nutrient status. The positive influence with nitrogen might be due to its enhanced availability in the rhizosphere resulting in better uptake. Rao and Das (1989) also obtained higher leaf nitrogen by *Azotobacter chrococcum* in ber and pomegranate.

The results of the present investigation revealed that the biofertilizers or inorganic fertilizers alone or in combinations significantly influenced the production of flowering shoots, fruit yield and weight (Table 4). But the combinations of higher doses (75% or 50% NPK) of inorganic fertilizers and biofertilizers (T_2, T_3, T_4 & T_5) were more effective in this regard. The treatment 50% NPK + *Azospirillum* + PSB + K-mobilizer (T_5) produced maximum flowering shoots in plants (46.1%) though maximum yield was obtained with the treatment 75% NPK + *Azotobacter* + PSB + K-mobilizer (225.7 numbers plant^{-1} and 60.4 kg plant^{-1}) followed by 75% NPK + *Azospirillum* + PSB + K-mobilizer (215.3 numbers plant^{-1} and 56.7 kg plant^{-1}). The improved result in terms of flowering, yield, fruit weight and size by the application of higher doses of inorganic and biofertilizers combinations is due to receiving required amount of major nutrients like nitrogen, phosphorus and potassium by the plants. These major nutrients in proper amount help to complete the vegetative and reproductive cycle of the plant. Nitrogen is the major constituents of many compounds of great physiological importance in metabolism, such as chlorophyll, nucleotides, phosphatides, as well as many enzymes, hormones and vitamins (Yawalkar *et al*., 1996). The deficiency of phosphorus decreased deoxyribonucleic acid synthesis as well as that of ribonucleic acid, and thereby restricted plant growth (Hewitt, 1963). Potassium is directly involved in photosynthetic phosphorylation. Its deficiency also interferes the translocation of metabolites. In the present experiment, sole use of inorganic fertilizers (100% NPK) was more effective than sole use biofertilizers (T_8 and T_9) or biofertilizers in combination with lower dose (25% NPK) of inorganic fertilizer (T_6 and T_7).

Biofertilizers like *Azotobacter* and *Azospirillum* produce growth regulators like IAA and GA besides nitrogen fixation. They also increase the availability of N in the soil and its uptake by the crop increases the fruit yield (Rao and Das, 1989). Potassium solubilizing bacteria are capable of solubilizing rock K and mineral powder like, mica, illite etc. through production and excretion of organic acids (Friedrich *et al*., 1991). Increased yield by 15 to 20 per cent due to application of potash solubilizing bacteria and in combination with other biofertilizers was also reported (Chandra *et al*., 2005). Increased flowering and fruiting were also recorded when mango plants were treated with inorganic, organic and biofertilizers (Ahmad *et al*., 2003; Kundu *et al*., 2011; Yadav *et al*., 2011a; Yadav *et al*., 2011b and Manna *et al*., 2011b). Different treatments of biofertilizers and or inorganic fertilizers showed non-significant effect on chemical constituents of fruits. These results are in conformity with the earlier findings of Gautam *et al*. (2012). However, combinations of inorganic and biofertilizers (T_2-T_7) were more effective in mproving fruit quality as compared with control (100% NPK) or sole use of biofertilizers (Table 5).

The present study unveiled that the treatments comprising 75% NPK + *Azotobacter* + PSB + K-mobilizer and 75% NPK + *Azospirillum* + PSB + K-mobilizer were most effective in increasing leaf and soil nutrient content, soil microbial population, fruit yield and in improving fruit quality. These two treatments may be adopted which can reduce the use of 25% inorganic fertilizer.

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