



## Effect of biofertilizers on soil microbial count, nutrient availability and uptake under november sown onion

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**Abstract:** Biofertilizers improves the soil microbial content, Soil nutrient status and nutrient uptake by plant. In an experiment, fifteen treatments comprised of various combinations of biofertilizers, organic manures and chemical fertilizers were compared to access the impact of different sources of nutrient on performance of onion. The highest soil organic carbon (0.40%) was observed in the treatments T<sub>12</sub> (Farm Yard Manure (FYM) @ 20 t/ha) and T<sub>11</sub> (FYM @ 20 t/ha + *Azotobacter* + *Vesicular-Arbuscular Mycorrhizae* (VAM)). Highest bacterial (24.5 X 10<sup>6</sup>) and actinomycetes count (29.9 X 10<sup>4</sup>) was recorded in T<sub>11</sub> (FYM @ 20 t/ha + *Azotobacter* + VAM) treatment while highest fungal count (17.5 X 10<sup>3</sup>) was observed in T<sub>3</sub> (*Azospirillum* + Recommended dose of NPK) treatment. At the time of harvesting, available nitrogen (N), Available phosphorus (P) and Available potassium (K) were higher in treatment T<sub>3</sub> (*Azospirillum* + Recommended dose of NPK), T<sub>9</sub> (*Azotobacter* + VAM + Recommended dose of NPK) and T<sub>13</sub> (Poultry Manure @ 5t/ha) treatments respectively than that in other treatments. *Azospirillum* and *Azotobacter* application along with recommended dose of N, P and K improved the fertility status of soil. The N uptake was significantly higher in T<sub>3</sub> treatment (162.6 Kg ha<sup>-1</sup>) as compared to all other treatments except T<sub>1</sub> and T<sub>9</sub> treatments while P uptake (13.6 Kg ha<sup>-1</sup>) was significantly higher in T<sub>9</sub> treatment than that in other treatments except T<sub>1</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>7</sub> treatments. The K uptake was significantly higher in T<sub>3</sub> treatment (126.9 Kg ha<sup>-1</sup>) as compare to all other treatments except T<sub>1</sub> and T<sub>9</sub> treatments. The present study highlights the need of use of biofertilizers along with organic and inorganic manures/fertilizer to enhance the nutrient availability and improve soil health.

**Keywords:** Chemical fertilizers, Nutrient uptake, Organic carbon, Organic manures, *Vesicular-Arbuscular mycorrhizae*

### INTRODUCTION

Onion is used in raw form as well as in dehydrated form to add flavor and taste to Indian foods as a culinary ingredient in wide range of food preparations. It is also used as salad. Onion is also a rich source of minerals like phosphorus, calcium, vitamin C, protein and carbohydrates. Onion is used in pharmaceutical preparations due to its medicinal values. Onion is also known to cure heart diseases as it checks the deposition of cholesterol in blood vessels (Barakade *et al.*, 2011). India is the second largest producer of onion (with area of 117.4 thousand hectare and production of 203.3 lakh tonnes) in the world next only to China and third largest exporter after Netherland and Spain (Anonymous, 2016a). In Punjab, it is cultivated over an area of 8264 hectare with a production of 183 thousand metric tonnes and average productivity of 22.3 tons per hectare (Anonymous, 2016b).

Onion is a shallow rooted and high nutrient demanding vegetable; its productivity depends on soil fertility status and nutrients applied. Under inadequate fertilization considerable yield losses have been reported (Balemi *et al.*, 2007). The increasing cost and

decreasing availability of inorganic fertilizers in peak periods is making crop production uneconomical particularly for small and marginal farmers. Therefore it is essential to evolve and adopt a suitable strategy for integrated nutrient supply by using combination of inorganic fertilizers, organic manures and biofertilizers. The use of nitrogen fixing microbes will help in reducing the dependence on urea, while phosphorus solubilizing microbes will increase the availability of P from relatively unavailable pools, thus use of integrated source of nutrients will help in curtailing over dependence on inorganic fertilizers alone for nutrient supply to onion.

Biofertilizers are products containing live or latent microorganisms that are capable of mobilizing nutrients from unavailable form to available form through biological processes (Gaur, 2010). Proper use of biofertilizers on farm organic wastes and microbial inoculants help in maintaining the fertility of agricultural soils (Kannaiyan, 2002). *Azotobacter* and *Azospirillum* are free living bacteria which colonize near the root zone and enhance the available nitrogen in the soil by N fixation, whereas *phosphate solubilizing bacteria* (PSB) solublize the unavailable phosphorus in

the soil and make it available for the plants (Devi *et al.*, 2003, Gupta and Samnotra, 2004, Yadav *et al.*, 2004, Singh and Singh, 2007, Kachari and Korla, 2009). *Vesicular-Arbuscular Mycorrhizae* (VAM) help in the development of stronger root system, increase root surface area, improve growth (Zandavalli *et al.*, 2004), nutrient uptake and increased tolerance of host roots to soil borne pathogens (Nelson and Achar, 2001, Singh and Singh, 2007). The present investigation was initiated to access the effect of biofertilizers, organic manures and synthetic fertilizers on microbial count, nutrient availability and uptake by onion plant.

## MATERIALS AND METHODS

The present investigation was carried out at Vegetable Research Farm of Punjab Agricultural University, Ludhiana during the *rabi* season 2013-14. The soil was loamy sand in texture with pH 7.6. Soil was low in organic carbon and nitrogen, high in phosphorus and medium in potassium. The onion cultivar Punjab Naroya was sown in nursery beds during November and transplanted in January with space of 15 cm X 7.5 cm between rows and plants respectively. The experiment was carried out in a randomized block design with fifteen treatments replicated thrice. The detail of treatments has been given in Table 1.

Organic carbon was determined by Walkley and Black method (1934). Bacterial count was determined by using serial dilution pour plate method (Gerhardt *et al.*, 1981). Actinomycetes count was determined by using serial dilution pour plate method (Nonomura and Ohara, 1969). Fungi count was determined by using serial dilution pour plate method (Kanwar *et al.*, 1997). Available Nitrogen in soil was estimated by alkaline potassium permanganate method by Subbiah and Asija (1965). Available Phosphorus in soil was estimated by method given by Olsen *et al.* (1954). Available Potassium in soil was estimated with ammonium acetate and estimated by Hange's flame photometer (Jackson, 1967).

The N, P and K uptake by bulb was computed by multiplying the percentage N, P and K content in bulb with bulb dry mass as given in the equation.

Nutrient uptake by bulb ( $\text{Kg ha}^{-1}$ ) = nutrient content (%) x bulb dry mass ( $\text{Kg ha}^{-1}$ )

Plant N, P and K uptake was computed by multiplying the N, P and K content with plant dry mass. Finally total N, P and K uptake was calculated by sum of N, P and K uptake by bulbs and N, P and K uptake by plants, respectively.

## RESULTS AND DISCUSSION

**Microbial count of soil at the time of transplanting and harvesting:** At the time of transplanting, organic carbon in the soil was 0.26 per cent, bacterial count was  $20.5 \times 10^6$ , Actinomycetes count was  $24.3 \times 10^4$  and fungus count was  $15 \times 10^3$  (Table 2). After

harvesting, biofertilizers improved the soil organic carbon status and highest soil organic carbon was found in T<sub>12</sub> (FYM @ 20 t ha<sup>-1</sup>) and T<sub>11</sub> (FYM @ 20 t ha<sup>-1</sup> along with *Azotobacter* and VAM) that was 0.40 per cent followed by T<sub>13</sub> (Poultry manure @ t ha<sup>-1</sup>) that was 0.38 per cent. Highest number of bacteria was found in T<sub>11</sub> where FYM along with *Azotobacter* and VAM was applied ( $24.5 \times 10^6$ ) followed by T<sub>13</sub> where poultry manure was applied @ 5 t ha<sup>-1</sup> ( $23.8 \times 10^6$ ) (Table 2). Highest number of Actinomycetes were found in treatment T<sub>11</sub> (FYM along with *Azotobacter* and VAM) that was  $29.9 \times 10^4$  and T<sub>12</sub> (FYM @ 20 t ha<sup>-1</sup>) that was  $29.1 \times 10^4$ . The application of *Azospirillum* along with recommended dose of fertilizers (T<sub>3</sub>) had highest number of fungi microorganism ( $17.5 \times 10^3$ ) at the time of harvesting followed by T<sub>7</sub> ( $16.8 \times 10^3$ ) where VAM along with recommended dose of fertilizers was applied (Table 2). Thus, biofertilizers had improved the microorganisms in the soil. FYM treatments improved the microbial count at harvesting time due to slow releasing of nutrients. The plots without inoculation of biofertilizers and application of chemical fertilizer did not differ significantly than inoculated ones initially at time of transplanting. At harvesting, application of chemical fertilizer alone showed lower microbial count for bacterial group compared to inoculated ones. The results corroborate with the finding of Mandic *et al.* (2011) and Javoreková *et al.* (2015) who reported that the application of biofertilizers alone with organic manures resulted in enhanced microbial activity.

**Nutrient status of soil:** At the time of transplanting N level in soil was 140 kg ha<sup>-1</sup>, P level was 32 kg ha<sup>-1</sup> and K level was 150 kg ha<sup>-1</sup>. N level in soil at time of harvesting was maximum in treatment T<sub>3</sub> (*Azospirillum* and recommended dose of N, P and K) that was 156 kg ha<sup>-1</sup> followed by treatment T<sub>1</sub> (*Azotobacter* along with recommended dose of fertilizers) that was 154 kg ha<sup>-1</sup>, treatment T<sub>9</sub> (*Azotobacter* along with VAM and recommended dose of N, P and K) and treatment T<sub>12</sub> (FYM @ 20 t ha<sup>-1</sup>) that was 150 kg ha<sup>-1</sup> and minimum level of N in soil was found in treatment T<sub>15</sub> (control) that was 136 kg ha<sup>-1</sup> (Table 2). While P level was found maximum in treatment T<sub>9</sub> (*Azotobacter* along with VAM and recommended dose of N, P and K) that was 42 kg ha<sup>-1</sup> followed by treatment T<sub>7</sub> (VAM along with recommended dose of fertilizers), treatment T<sub>11</sub> (FYM @ 20 t ha<sup>-1</sup> along with *Azotobacter* and VAM) and treatment T<sub>13</sub> (Poultry Manure @ 5 t ha<sup>-1</sup>) that was 40 kg ha<sup>-1</sup> and minimum level of P in soil was found in treatment T<sub>15</sub> (control) that was 30 kg ha<sup>-1</sup>. While K level was found maximum in treatment T<sub>13</sub> (poultry manure @ 5 t ha<sup>-1</sup>) that was 160 kg ha<sup>-1</sup> followed by treatment T<sub>11</sub> (FYM @ 20 t ha<sup>-1</sup> along with *Azotobacter* and VAM) and treatment T<sub>12</sub> (FYM @ 20 t ha<sup>-1</sup>) that was 158 kg ha<sup>-1</sup> and minimum level of K in soil was found in treatment T<sub>15</sub> (control) that was

**Table 1.** Detail of treatments

Treatments	Treatment detail
T <sub>1</sub>	<i>Azotobacter</i> + Recommended dose of NPK
T <sub>2</sub>	<i>Azotobacter</i> + 75% of recommended dose of N + Recommended dose of PK
T <sub>3</sub>	<i>Azospirillum</i> + Recommended dose of NPK
T <sub>4</sub>	<i>Azospirillum</i> + 75% of recommended dose of N + Recommended dose of PK
T <sub>5</sub>	<i>Phosphate Solubilizing Bacteria</i> (PSB) + Recommended dose of NPK
T <sub>6</sub>	<i>Phosphate Solubilizing Bacteria</i> (PSB) + 75% of recommended dose of P + Recommended dose of NK
T <sub>7</sub>	<i>Vesicular-Arbuscular Mycorrhizae</i> (VAM) + Recommended dose of NPK
T <sub>8</sub>	<i>Vesicular-Arbuscular Mycorrhizae</i> (VAM) + 75% of recommended dose of P + recommended dose of NK
T <sub>9</sub>	<i>Azotobacter</i> + <i>Vesicular-Arbuscular Mycorrhizae</i> (VAM) + Recommended dose of NPK
T <sub>10</sub>	<i>Azotobacter</i> + <i>Vesicular-Arbuscular Mycorrhizae</i> (VAM) + 75% of recommended dose of N + 75% recommended dose of P + recommended dose of K
T <sub>11</sub>	FYM @ 20 t/ha + <i>Azotobacter</i> + <i>Vesicular-Arbuscular Mycorrhizae</i> (VAM)
T <sub>12</sub>	FYM @ 20 t/ha
T <sub>13</sub>	Poultry Manure @ 5t/ha
T <sub>14</sub>	Recommended dose of NPK
T <sub>15</sub>	Control

Recommended dose of fertilizers (100:50:50, N: P: K kg per hectare).

146 kg ha<sup>-1</sup>(Table 2).

Biofertilizers improved the N status of the soil due to N fixation by *Azotobacter* and *Azospirillum*. These bacterium convert the unavailable form of nitrogen (nitrate) to available form of nitrogen (nitrite), thus improved the nitrogen availability in the soil (Kalyani *et al.*, 1992). PSB and VAM improved the phosphorus status in the soil by solubilization process. PSB and VAM solubilize the unavailable form of phosphorus into available form (Jayatilake *et al.*, 2002). Our results are in conformity with Mengistu and Singh (1999). Biofertilization had moderately enhanced the fertility level of the soil after crop harvest. Application of *Azospirillum* and VAM resulted in increase 13.81 % soil N and 13.41 % soil P as compared to initial fertility status of the soil of onion crop. Similarly, Nelson and Achar (2001), Devi *et al.* (2003), Yadav *et al.*, (2004), Gupta and Samnotra (2004), Singh and Singh (2007) and Kachari and Korla (2009) also reported increase in soil N and P with the application of biofertilizers alone with manures.

#### Nutrient uptake

**Total nitrogen uptake:** The data pertaining to the effect of different treatments on the total uptake of N, P and K nutrients has been presented in Table 3. Application of *Azospirillum* along with recommended dose of N, P and K (100 Kg N, 50 Kg P and 50 Kg K per ha<sup>-1</sup>) resulted in maximum total nitrogen uptake (162.6 Kg ha<sup>-1</sup>) which was statistically at par with *Azotobacter* along with recommended dose of fertilizers (T<sub>1</sub>) and *Azotobacter* along with VAM and recommended dose of fertilizers (T<sub>9</sub>) and was

significantly higher from rest of treatments. Among organic manure, maximum N uptake was recorded with farm yard manure (T<sub>12</sub>) that was 115.2Kg ha<sup>-1</sup> but the difference among other organic manure treatments was non-significant. Total N uptake attained with treatment T<sub>14</sub> where recommended dose of fertilizers (105.7 kg ha<sup>-1</sup>) was significantly higher than treatment T<sub>15</sub> (53.3 kg ha<sup>-1</sup>) where no fertilizer was applied.

**Total phosphorus uptake:** The maximum total phosphorus uptake of 13.6 Kg ha<sup>-1</sup> was attained in treatment T<sub>9</sub> followed by treatment T<sub>6</sub> (PSB along with recommended dose of fertilizers) that was 12.6 Kg ha<sup>-1</sup> which was significantly higher than rest of treatments except treatment T<sub>1</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>7</sub>. The minimum total uptake of 2.9 Kg ha<sup>-1</sup> phosphorus was observed in control (T<sub>15</sub>) that was significantly lower from treatment T<sub>9</sub> where maximum P content was found. Total uptake of P attained with application of recommended dose of fertilizers (T<sub>14</sub>) was statistically at par with treatment T<sub>15</sub>.

**Total potassium uptake:** Application of *Azospirillum* along with N, P and K (T<sub>3</sub>) resulted in maximum total potassium uptake of 126.9 Kg ha<sup>-1</sup>(Table 3) which was significantly higher than rest of treatments except T<sub>1</sub> and T<sub>9</sub>. Minimum total potassium uptake of 59.8 Kg ha<sup>-1</sup> was observed in control. Total K uptake attained with T<sub>14</sub> where recommended dose of fertilizers (86.3 Kg ha<sup>-1</sup>) was significantly higher from T<sub>15</sub> where no fertilizer (59.8 kg ha<sup>-1</sup>) was applied.

The application of full dose of nitrogen along *Azospirillum* and *Azotobacter* showed significantly higher total nitrogen uptake as compared to reduced

**Table 2.** Effect of different treatments on Microbial count and Nutrient status of soil at the time of transplanting and harvesting

Treatments	O.C. %	Microbial count			Soil nutrient status (kg/ha)		
		Bacterial (10 <sup>6</sup> )	Actinomycetes (10 <sup>4</sup> )	Fungi (10 <sup>3</sup> )	N	P	K
At Transplanting time	0.26	20.5	24.3	15.0	140	32	150
At harvesting time							
T <sub>1</sub>	0.30	19.2	25.8	16.3	154	38	155
T <sub>2</sub>	0.28	18.3	25.1	15.2	145	35	150
T <sub>3</sub>	0.31	20.2	26.3	17.5	156	36	156
T <sub>4</sub>	0.28	22.4	26.1	17.0	146	34	148
T <sub>5</sub>	0.32	21.7	28.0	16.5	142	38	150
T <sub>6</sub>	0.27	19.4	27.4	16.1	140	36	146
T <sub>7</sub>	0.31	19.6	26.6	16.8	148	40	152
T <sub>8</sub>	0.28	19.1	26.2	16.2	145	35	148
T <sub>9</sub>	0.30	20.8	26.8	16.1	150	42	156
T <sub>10</sub>	0.28	20.4	26.2	16.3	146	38	155
T <sub>11</sub>	0.40	24.5	29.9	16.2	150	40	158
T <sub>12</sub>	0.40	23.7	29.1	15.7	150	38	158
T <sub>13</sub>	0.38	23.8	28.3	16.1	148	40	160
T <sub>14</sub>	0.32	19.1	23.9	16.7	142	36	152
T <sub>15</sub>	0.26	20.5	24.3	15.0	136	30	146

**Table 3.** Effect of different treatments on total nutrient uptake of onion

Treatments	Nutrient uptake (Kg ha <sup>-1</sup> )		
	Total N	Total P	Total K
T <sub>1</sub>	154.0	11.5	119.9
T <sub>2</sub>	119.5	9.4	108.4
T <sub>3</sub>	162.6	12.4	126.9
T <sub>4</sub>	133.8	10.1	105.8
T <sub>5</sub>	87.7	12.6	102.1
T <sub>6</sub>	78.7	8.6	95.9
T <sub>7</sub>	109.2	12.0	104.9
T <sub>8</sub>	76.5	8.8	84.8
T <sub>9</sub>	142.1	13.6	125.4
T <sub>10</sub>	103.2	5.9	91.9
T <sub>11</sub>	103.1	5.1	82.8
T <sub>12</sub>	115.2	5.6	86.1
T <sub>13</sub>	98.8	6.5	84.0
T <sub>14</sub>	105.7	4.9	86.3
T <sub>15</sub>	53.3	2.9	59.8
CD (P = 0.05)	24.5	3.26	13.4

nitrogen application. The higher total nitrogen uptake could be due to the improved availability of nitrogen to plants due to N fixation by biofertilizers that helped in improvement vegetative growth and reproductive cycle. This may also be due to increased dry matter production due to the effects of plant growth substances

and nitrogen fixation or assimilation by *Azospirillum* (Devi *et al.*, 2003, Gupta and Samnotra, 2004). Increase in P uptake with application of PSB and VAM may be attributed to accelerated root development and enhanced root surface area which might have resulted

in effective mining of soil phosphorus and higher availability of P in soil (Kachari and Korla, 2009).

## Conclusion

The inorganic/chemical fertilizers are costly, result in soil and environmental pollution and also pose human health hazards, while, biofertilizers are eco-friendly, non-toxic and relatively cheaper natural products. The integrated use of biofertilizers along with organic and inorganic manures/fertilizers will help in improving nutrient use efficiency, protect nutrients against losses (such as leaching and volatilization losses) and reduce soil and environmental degradation. The results revealed that highest soil organic carbon (0.40%) was observed in the treatments T<sub>12</sub> and T<sub>11</sub>. Highest bacterial and actinomycetes count was recorded in T<sub>11</sub> treatment while highest fungal count (17.5 X 10<sup>3</sup>) was observed in T<sub>3</sub> treatment. The soil available nitrogen (N), Available phosphorus (P) and Available potassium (K) were higher in treatment T<sub>3</sub>, T<sub>9</sub> and T<sub>13</sub> treatments, respectively than that in other treatments. The N uptake was significantly higher in T<sub>3</sub> treatment (162.6 Kg ha<sup>-1</sup>) as compare to all other treatments except T<sub>1</sub> and T<sub>9</sub> treatments while P uptake (13.6 Kg ha<sup>-1</sup>) was significantly higher in T<sub>9</sub> treatment than that in other treatments except T<sub>1</sub>, T<sub>3</sub>, T<sub>5</sub> and T<sub>7</sub> treatments. The K uptake was significantly higher in T<sub>3</sub> treatment (126.9 Kg ha<sup>-1</sup>) as compare to all other treatments except T<sub>1</sub> and T<sub>9</sub> treatments. The application of biofertilizers along with recommended dose of fertilizers not only improves nutrient availability but also improves the yield and protects the soil against degradation.

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