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Research Article

GROWTH, YIELD AND QUALITY OF ONION AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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Abstract- A Field experiment was conducted to access the effect of different combinations of bio-fertilizer along with inorganic fertilizers and organic manures on growth, yield and quality of onion during kharif season. The experiments consisted of fifteen treatments of bio-fertilizers and organic manures with or without chemical fertilizers. The results revealed that the number of leaves per plant, plant height and leaf area was maximum with the application of *Azotobacter* along with recommended dose of fertilizers. Minimum neck thickness was recorded in treatment where *Azospirillium* was applied along with recommended dose of fertilizers. Likewise, the *Azospirilum* produced the maximum bulb weight 138.3g and total yield 299.6 q/ha when it was applied with recommended dose of fertilizer. But bulb diameter were maximum of *Azotobacter* along with recommended dose of fertilizers (T_1) followed by *Azospirillium* along with recommended dose of fertilizers. Maximum TSS (13.9^0 brix) and ascorbic acid (14.1 mg/100g fresh weight) was found also *Azospirilum* with recommended dose of fertilizer. It is concluded that *Azotobacter* along with 100% NPK improves vegetative growth, while *Azospirillium* along with 100% NPK improves yield and yield attributes of onion as far as the sustainability and environmental consideration are concerned.

Keywords- *Azotobacter*, *Azospirillium*, PSB, Inorganic fertilizers and VAM.

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Introduction

Onion is grown as spice and vegetable crops and used for culinary purpose. Raw onion has an antiseptic value, promotes bile production and reduces blood sugar. It is rich source of phosphorus, calcium, vitamin C, protein and carbohydrates. Onion is known to check the deposition of cholesterol in blood vessels, thus protect against cure heart diseases resulting from blockage of arteries [1].

India is second largest producer of onion after china in the world, cultivating onion over an area of 1173.4 thousand hectare with total production of 203.3 lakh tonnes [2]. In Punjab, it grown over an area of 8.2 thousand hectare with a production of 183 thousand metric tonnes [2]. Onion is a shallow rooted crop and is highly responsive to fertilizers in terms of improvement in yield and quality of onion [3]. Heavy application of inorganic fertilizers degrade the soil health by adversely affecting the microbial biodiversity, physical and chemical environment of soil, water bodies and capital inputs like soil, water and thus overall ecology. The increasing cost of inorganic fertilizers is making onion production an uneconomical occupation for small and marginal farmers. The use of bio-fertilizers and organic fertilizers may act as alternative to costly chemical fertilizers for sustainable production. The present investigation was conducted to access the effect of use of different bio-fertilizers and organic manures on *kharif* season onion so that dependence on inorganic fertilizers can be reduced.

MaterialsandMethods

The study was conducted at vegetable research farm, Punjab Agricultural University, Ludhiana during the kharif season of 2014 to access the impact of different combinations of bio-fertilizer (*Azotobacter, Azospirillium*, VAM, PSB) along with inorganic fertilizers and organic manures (poultry manure and FYM) on growth, yield and qualitative character of onion (cultivar Agrifound dark red). The soil of the experimental field was loamy sand texture with pH 7.8, EC 0.21 mmho/cm, OC 0.32 %, Available N 142 kg/ha, Available P 20.2 kg/ha and Available K 120 kg/ha. The fifteen treatments [Table-1] were replicated three times in randomized block design in 3.0m × 3.0m plots. Recommended dose of phosphorus (50 kg P_2O_5/ha) and potash (50 kg K_2O/ha) was applied at the time of transplanting. The recommended amount of nitrogen (100 kg N/ha) was applied in two splits i.e. half was applied as basal and the remaining dose of N was applied 30 days after planting. The *Azospirillum, Azotobacter* and phosphate solublizing bacteria @ 500g/hectare each was dissolved separately in a small quantity of water along with jiggery. The onion seedlings were dipped in the inoculums for an hour. *Vasicular Arbuscular Mycorrhiza* was directly applied to soil @ 500g/hectare at time of transplanting. FYM was applied at time of preparation of field. Plant height was measured at 30, 60 and 90 days after transplanting by using scale method. Number of leaves per plant was measured at maturity stage. Leaf area was measured graphically at maturity stage. Bulb diameter and neck thickness was measured by using verniear caliper. Bulb weight and bulb yield was measured at harvesting stage. The bulbs were harvested on maturity when >50% leaves dried and fallen. The standard method for estimations of TSS (Refractometer method) and ascorbic acid (2,6-Dicholorophenol indophenol dye method) were employed. Dry matter was determined after drying in oven at 62 ± 2 °C temperature till the constant weight was achieved. Total minerals were determined by keeping the known amount of onion in crucible heated in furnace at 600 °C temperature. The statistical analysis was done as per the standard procedure for analysis of variance for RCBD[13]. Least significant difference was employed for mean comparison.

Results

Effect of integrated nutrient management on growth, yield and yield attributes

Periodic plant height

After 30 days of transplanting (DAT), plant height attained with application of *Azotobacter* and *Azospirillium* along with recommended dose of fertilizers (T_1 and T_3) was significantly higher than that recorded with T10, T12 and T15 treatments [Table-1]. Plant height with recommended dose of fertilizers (T14) was statistically at par with all other treatments. Among organic manures, application of poultry manure @ 5 t ha^{-1} (T13) or *Azotobacter* along with VAM and FYM (T11) resulted in significantly higher plant height than application of FYM @ 20 t ha^{-1} (T12).

Table-1 *Effect of different treatments on periodic plant height (cm) of onion at different growth stages*

Treatments	Treatment detail	Plant height (cm)		
		30 DAT	60 DAT	90 DAT
T_1	*Azotobacter* + RD NPK	32.4	57.3	83.8
T_2	*Azotobacter* + 75% N +RD PK	29.8	51.3	73.8
T_3	*Azospirillium*+ RD NPK	32.2	56.7	82.2
T_4	*Azospirillium*+ 75% N +RD PK	28.6	50.5	73.2
T_5	PSB+ RD NPK	30.5	52.5	77.5
T_6	PSB + 75% P +RD NK	28.0	50.3	71.8
T_7	VAM + RD NPK	31.2	53.2	78.4
T_8	VAM + 75% P +RD NK	29.7	50.5	74.0
T_9	*Azotobacter* +VAM + RD NPK	31.5	54.7	80.3
T_{10}	*Azotobacter* + VAM + 75% N + 75% P + RD K	27.3	49.9	71.2
T_{11}	FYM @ 20 t/ha +*Azotobacter* + VAM	30.5	53.1	78.0
T_{12}	FYM @ 20 t/ha	25.2	47.3	70.3
T_{13}	Poultry Manure @ 5t/ha	30.3	51.6	74.2
T_{14}	RD NPK	27.7	49.9	71.4
T_{15}	Control	24.7	46.1	68.3
LSD (P = 0.05)		4.7	5.9	8.3

At 60 DAT, maximum plant height was achieved in treatment with *Azotobacter* along with recommended dose of fertilizers (T1) that was 57.3 cm which was significantly higher from rest of treatments except T3 (56.7 cm), T5 (52.5 cm), T7 (53.2cm), T9 (54.7 cm), T11 (53.1 cm) and T13 (51.6 cm) [Table-1]. Among organic manures, maximum plant height (51.6 cm) was obtained with T11 but the differences among other organic manure treatments was non-significant. Minimum plant height was attained in the treatment where no fertilizer was applied (T15).

At 90 DAT, application of Azotobacter along with recommended fertilizer dose (T1) resulted in maximum plant height (83.8 cm) which was significantly higher from T2 (73.8 cm), T4 (73.2 cm), T6 (71.8 cm), T8 (74.0 cm), T10 (71.2 cm), T12 (70.3 cm), T13 (74.2 cm), T14 (71.4 cm) and T15 (68.3 cm). All the treatments except T1 were statistically at par among themselves [Table-1]. Plant height in case of without application of fertilizers (T15) was significantly lower than all treatments of bio-fertilizers along with recommended dose of N, P and K. Application of *Azotobacter, Azospirillium* and *Azotobacter* along with VAM and recommended dose of fertilizers resulted in significantly higher plant height than that of recommended dose of N, P and K alone.

The integration of bio-fertilizers along with recommended dose of chemical fertilizers gave maximum plant height at 30, 60 and 90 days after transplanting as compared to treatments where chemical fertilizers alone or 75% chemical fertilizers in combination with bio-fertilizers were applied because bio-fertilizers increase the nutrient fixation and availability to the plants and increase the photosynthetically active compounds which increases the metabolic activities in the plant by production of growth promoting hormones which improves the vegetative growth of plant [4]. The results are in corroboration with the findings of Jayathilake et al [4] who observed significant increase in plant height at 30 and 60 days after transplanting in treatments receiving *Azotobacter* along with recommended fertilizer dose as compared to *Azospirillium* inoculation alone.

Number of leaves per plant:

Maximum number of leaves per plant (13.4) was observed with application of *Azotobacter* along with recommended dose of fertilizers (T1) was significantly higher than T6, T12, T14 and T15 (no fertilizer) and was statistically at par with all other treatments [Table-2]. Number of leaves per plant observed with recommended dose of fertilizers (T14) was statistically at par with control (T15) and significantly lowers from T1 where maximum number of leaves per plant was found. Highest number of leaves per plant was observed in T1 and T3 treatment as compared to control may be attributed to the production of growth promoting substances by bio-fertilizers. Direct relationship between yield and vegetative growth represented by plant height and number of leaves per plant might be assigned to photosynthetic factors [5].

Table-2 *Effect of different treatments on growth, yield and yield attributes of onion*

Treatments	Parameters					
	Number of leaves per pant	Leaf area (cm^2)	Neck thickness (cm)	Bulb diameter (cm)	Bulb weight (g)	Bulb yield (Q/ha)
T_1	13.4	36.5	1.4	5.6	125.7	296.4
T_2	11.9	30.6	1.3	5.3	110.7	252.0
T_3	12.9	31.7	1.2	5.5	138.3	299.6
T_4	11.4	30.4	1.3	5.2	111.7	248.9
T_5	12.6	31.4	1.4	5.4	116.7	279.6
T_6	10.7	26.0	1.4	5.2	100.3	212.4
T_7	12.8	31.6	1.4	5.5	115.0	256.9
T_8	11.7	30.0	1.3	5.2	81.7	192.0
T_9	11.4	29.9	1.4	5.5	121.7	293.8
T_{10}	11.4	29.5	1.4	5.5	121.7	261.8
T_{11}	12.5	31.2	1.6	5.2	109.3	239.6
T_{12}	9.7	27.4	1.4	4.9	91.7	202.4
T_{13}	12.3	30.6	1.5	5.1	103.3	211.8
T_{14}	10.7	25.5	1.4	4.9	110.0	243.3
T_{15}	9.5	23.6	1.4	4.8	80.0	180.0
LSD (P = 0.05)	2.0	4.9	0.2	0.4	23.8	46.1

Leaf area (cm^2)

Leaf area is used to predict primary photo synthate (compound) production, evapo-transpiration and as a reference tool for crop growth. Leaf area plays an essential role in theoretical production ecology [6]. Leaf area in treatment with *Azotobacter* along with recommended dose of N, P and K (T1) was significantly higher than that of all treatments except T3 and T7 [Table-2]. Application of *Azotobacter* along with VAM and FYM (T11) resulted in higher leaf area (31.2 cm2) among organic manure treatments but it was statistically at par with other organic manure treatments i.e. T12 and T13 and it was significantly lower from T1 where maximum leaf area was found. Leaf area with application of recommended dose of fertilizers (T14) was at par with control (T15) but significantly lower from T1. Minimum leaf area was found in T15 (23.6 cm^2) treatment that was significantly lower than other treatments. *Azotobacter* and *Azospirillium* inoculation gave maximum leaf area due to higher plant height and photosynthetically active compounds produced in plants.

Neck thickness (cm)

The bulb yield has positive relationship with plant height, number of leaves per plant, diameter and weight of bulb, while negative relationship with neck thickness of onion [5]. Minimum neck thickness was found in T3 (1.2 cm). Highest neck thickness was attained in T11 which was statistically at par with all other treatments except T2 (1.3 cm), T3 (1.2 cm), T4 (1.3 cm) and T8 (1.3 cm) [Table-2]. The findings are in consonance with the observations of Sidhu et al [7] but deviate from Soni et al [8] for neck thickness.

Bulb diameter (cm)

Plant growth characters such as plant height and bulb diameter are known to enhance the yield of onion [9]. The application of different bio-fertilizers significantly affect the bulb diameter [Table-2]. Application of *Azotobacter* along with recommended dose of N, P and K (T1) resulted in maximum bulb diameter (5.6 cm) that was significantly higher than that attained with T12 (4.9 cm), T13 (5.1 cm), T14 (4.9 cm) and T15 (4.8 cm) and was statistically at par with rest of the treatments. Among organic manure treatments, maximum bulb diameter was recorded with T11 (5.2 cm) but differences among other organic manure treatments was non-significant. The treatments T1 and T3 produced highest bulb diameter due to direct role of bio-fertilizer in nitrogen fixation, production of substances like phytohormones and increased nutrient uptake [4].

Bulb weight (g)

Bulb weight is an important parameter in promoting the yield of the onion crop. Bulb weight has direct and positive correlation with bulb yield. Maximum bulb weight [Table-2] of onion was recorded in the treatment T3 where *Azospirillium* along with recommended dose of fertilizers was applied (138.3 g) which was statistically at par with T1, T5, T7, T9 and T10 and it was significantly higher from all other treatments. Minimum bulb weight was recorded with T15 where no fertilizer was applied (80.0 g). The treatments T3 and T9 had highest bulb weight as compare to other treatments due to enhanced Dihydrozeatin resulted in enhanced physiological activity of plants there by increased bulb diameter, bulb weight and bulb yield [4]. The *Azotobacter* and *Azospirillium* treatments along with recommended dose of fertilizers gave maximum bulb weight as compared to treatments with application of organic manures particularly farm yard manure and poultry manure that may be due to fixation of nitrogen by *Azotobacter* and *Azospirillium* in soil [10].

Bulb yield (q/ha)

Bulb yield is an important growth contributing parameter in onion. Bulb yield represents the benefit or losses from the crop. The perusal of data showed bulb yield of onion [Table-2] recorded with *Azospirillium* along with recommended dose of fertilizers (T3) was significantly higher than that with application of T2 (252 q ha-1) and T4 (248.9 q ha-1), T6 (212.4 q ha-1), T8(192 q ha-1), T11 (239.6 q ha-1), T12 (202.4 q ha-1), T13 (211.8 q ha-1), T14 (243.3 q ha-1) and T15 (180 q ha-1). Bulb yield achieved under treatment T14 was 35.1 per cent higher than that in control treatment. The minimum yield of 180.0 q ha-1 was recorded in T15 where no fertilizer was applied. Among organic manures, maximum bulb yield (239.6 q ha-1) was attained with T11 but the difference among other organic manure treatments was non-significant but significantly higher from control (T15). Increased yield in these treatments could be attributed to better synthesis of metabolites due to application of higher levels of fertilizers in combination with bio-fertilizers [4].

Effect of integrated nutrient management on quality attributes:

Total Soluble solids (º brix)

Total soluble solids (TSS) is an indicator of total sugars present in the bulb. Maximum TSS (13.90 brix) was attained with *Azospirillium* along with recommended fertilizer (T3) and it was statistically at par with T5 (130 brix), T7 (12.90 brix) and T9 (13.30 brix) and was significantly higher from rest of treatments [Table-3]. Application of organic manure alone or along with bio-fertilizers resulted in significantly higher TSS than that attained with control (T15) where no fertilizer was applied.

The improvement in quality of onion with application of bio-fertilizers along with recommended dose of fertilizers may be attributed to the enhanced metabolic activities synthesizing higher amounts of acids that contribute to synthesis of TSS %, acidity and ascorbic acid in vegetables [11].

Table-3 *Effect of different treatments on quality attributes of onion*

Treatments	Total soluble solids (º brix)	Ascorbic Acid (mg/100 g fresh wt)	Dry matter %	Total minerals (mg/100 g dry weight)
T_1	12.2	12.4	15.4	2.7
T_2	11.0	11.5	14.9	3.0
T_3	13.9	14.1	15.2	2.0
T_4	11.8	11.0	15.0	2.3
T_5	13.0	12.6	12.8	4.0
T_6	11.3	11.9	14.9	3.0
T_7	12.9	12.6	15.1	2.0
T_8	10.9	10.9	14.8	2.0
T_9	13.3	13.3	15.3	2.3
T_{10}	11.8	12.6	15.1	2.3
T_{11}	12.0	11.7	14.8	3.7
T_{12}	12.1	10.8	12.8	3.3
T_{13}	10.6	10.5	14.3	3.7
T_{14}	10.5	11.2	14.1	3.7
T_{15}	10.1	10.1	12.4	1.3
LSD (P = 0.05)	1.6	2.6	NS	NS

Ascorbic acid (mg/100 g fresh weight)

Among the various treatments [Table-3], application of *Azospirillium* along with recommended dose of N, P and K led to maximum increase in ascorbic acid content of 14.1 mg/100 g fresh weight on an average, which was significantly higher from T4, T8, T12, T13, T14 and T15 and statistically at par with rest of treatments. Minimum ascorbic acid content was found in control (10.1 mg/100 g

fresh weight) which was significantly lower from T3 where maximum ascorbic acid was found. Among organic manures alone or along with bio-fertilizers, maximum vitamin C was recorded with farm yard manure along with *Azotobacter* and VAM (T11) that was 11.7 mg/100g fresh weight.

The microbial inoculants fix atmospheric nitrogen and secret growth promoting substances that accelerate the physical process [12] enhancing the ascorbic acid content of onion with bio-fertilizer inoculation.

Dry matter (%)

The data depicted on the effect of different treatments on dry matter content of bulb is given in [Table-3]. The results have shown that all treatments showed similar trends for percentage dry matter content in onion bulb.

Total minerals (mg/100 g dry weight)

The data depicted on the effect of different treatments on total minerals content of bulb is given in [Table-3]. The results have shown that all treatments showed similar trends for total minerals in onion.

Conclusion

The results revealed that plant height, number of leaves per plant and leaf area was maximum with the application of *Azotobacter* along with recommended dose of fertilizers. The maximum bulb weight, total yield, TSS and ascorbic acid was recorded in treatment where *Azospirilum* was applied along with recommended fertilizer dose. The present investigation encourage the use of bio-fertilizers along with organic and inorganic fertilizers for sustainable onion production.

Conflict of Interest: None declared

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