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Effect of Biofertilizers and Chemical Fertilizers on Growth, Yield and Quality of Onion (*Allium cepa* L.)

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Abstract

A field experiment conducted during the 2022–2023 *rabi* season (Nov–April) at DAV University, Jalandhar (Punjab) aimed to assess the impact of biofertilizers and chemical fertilizers on onion growth, yield, and quality. Variety PRO 7 was selected for the study. Eleven treatments *viz*., T_1 (Control), T_2 (NPK 100%), T_3 (NPK 50%), T_4 (*Azotobacter* 100%), T_5 (*Azospirillium* 100%), T_6 (VAM 100%), T_7 (NPK 50%+*Azotobacter* 50%), T_8 (NPK 50%+*Azospirillium* 50%), T_9 (NPK 50%+VAM 50%), T_{10} (NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%), T_{11} (NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%) were arranged in a randomized block design with three replicatesThe result of experiment showed that T_{10} (NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%) consistently exhibited superior performance, showcasing substantial improvements in crucial variables such as the number of leaves plant^{-1}, number of rings bulb^{-1}, plant height, chlorophyll *a* content, chlorophyll *b* content, and total chlorophyll content. While, T_{11} showed maximum bulb yield plot^{-1} and ha^{-1}, as well as elevated levels of ascorbic acid and chlorophyll *b*. T_9 displayed significant advancements in growth and quality parameters, including plant height, neck thickness, and total chlorophyll content and T_6 showed maximum TSS (°Brix) content in onion. The economic analysis conducted as part of this study revealed that T_{11} yielded the highest gross income, net income, and benefit-cost ratio.

Keywords: Benefit cost ratio, biofertilizers, chemical fertilizers, chlorophyll content, onion, TSS

1. Introduction

Vegetable crops offer higher yields, income, higher calories and variety of nutrients that are essential for human development, maintenance, and repair such as vitamins, minerals, dietary fiber, protein, and fat (Liu, 2013; Kondal et al., 2024; Kaur et al., 2024). The consumption of vegetables and fruits plays a positive role in the prevention of obesity, heart disease, stroke, cancer, and other chronic diseases. However, for maintaining proper physique, the recommendation has been made by dieticians is 295 grams of total vegetables day^{-1} head^{-1} (Flowers and Yeo, 1995; Gorreapti et al., 2017). Biofertilizers, encompassing various microorganisms such as nitrogen-fixing bacteria, phosphorus-solubilizing bacteria, and mycorrhizal fungi, have demonstrated positive effects on onion growth (Sharma et al., 2022). Nitrogen-fixing bacteria, such as *Azotobacter* and *Rhizobium*, enhance nitrogen availability in the soil, promoting leaf development and bulb growth (Awad et al., 2011; Parewa et al., 2014; Thamburaj and Singh, 2000). Phosphorus-solubilizing bacteria aid in phosphorus uptake, contributing to bulb development and nutrient content (Kour et al., 2023). Mycorrhizal fungi improve nutrient uptake efficiency by extending the root system and enhancing water uptake (El-Sherbeny et al., 2022). *Azotobacter* is one of the most important non-symbiotic N_2-fixing microorganisms. A large number of experiments conducted have shown a positive response to *Azotobacter* application on wide range of crops like vegetables, cereals, sugarcane, *etc*. (Pathak and Kumar, 2016). The beneficial effect of *Azotobacter* is attributed to its N_2-fixing growth promoting substances and antifungal antibiotics which inhibit growth-promoting substances and antifungal antibiotics which inhibit the growth of root pathogens (Ouf et al., 2023). Several agricultural crops' shoot length, root length, and seed germination are directly impacted by the growth-promoting chemicals generated by *Azotobacter* species, such as indole acetic acid, gibberellic acid, arginine, *etc.* (Gurikar et al., 2017).

Onion is characterized by the presence of the remarkable sulfur-containing compound, which gives them distinctive smell and pungency. The pungency in onion odour is formed by enzymatic reaction only when tissues are damaged. The pungency in onion is due to a volatile oil known as allyl propyl disulfide. Pungency varies with cultivar, growing oil, stage of maturity, and storage conditions. The outer skin colour is due to presence of quercetin (Bose and Som, 1986). Onion is an important vegetable crop cultivated throughout the world for its culinary, dietary, therapeutic, and medicinal value. This plant has various therapeutic effects attributed to its constituents, such as quercetin, thiosulphates, and phenolic acids. In India, under shortday conditions onion is harvested during *kharif* (Oct–Nov, 20%), late *kharif* (Feb–March, 20%), and *rabi* (April–May, 60%). *kharif* (Oct-Nov) and late *kharif* (Feb–March) onion harvest is immediately consumed within one or two months as there is heavy demand during those months and therefore does not require storage. To maintain its demand and supply throughout the year, this crop needs proper planning to increase productivity and bulb quality. The average productivity of onion is about 18 t ha^{-1} in India which is very less as compared to other onion-growing nations. Onion productivity can be increased by proper crop production and protection practices and prices can be stabilized with proper storage of *rabi* (April–May) onions by the farmers (Pejic et al., 2011).

Additionally, for minimizing these losses an integrated approach needs to be practiced right from selection of varieties to proper soil and water management along with the integrated pest and disease management system that may help in reducing storage losses from 50 to 20% in onion (Fanai et al., 2021; Pathak and Gowda, 1993). There is need to promote *kharif* onion production for regular supply in the market and export of onion. It plays an important role in stabilizing the prices of onions in the country. *Kharif* onion is grown in Maharashtra, Karnataka, Rajasthan, Haryana, Bihar, and Tamil Nadu on almost 1.5 lakh hectares area (De et al., 2019). The *kharif* production is highly vulnerable to erratic monsoon, cloudy weather, continuous drizzling which creates the problem of foliar as well as soil borne diseases (Sekara et al., 2017).

2. Materials and Methods

A field experiment was conducted during *rabi* season 2022–2023 at the experimental field of Faculty of Agricultural Sciences, DAV University, Sarmastpur, Jalandhar (Punjab), to study the effect of biofertilizers and chemical fertilizers on growth, yield and quality of onion (*Allium cepa* L.). Geographically, the farm is located at 75°37′15′′ East latitude and 31°25′23′′ North longitude, with an average altitude of 230 meters (754.5 feet) from the sea level.

2.1. Plant material

Seeds of onion variety PRO 7 was procured from PAU Ludhiana, Punjab.

2.2. Fertilizers

Commercial fertilizers NPK (IFFCO) and organic manures *i.e. Azotobacter* (100%), *Azospirillium* (100%) were procured from the university as well as local market of Jalandhar, Punjab, India.

2.3. Experimental design

The experiment was laid out in a randomized block design with three replication consisting of eleven treatments represented in table 1. The sowing of seeds was done by broadcasting method for nursery preparation. Irrigations were given at interval of 8–10 days depending upon soil and weather condition. Intercultural operation such as weeding and earthing up were done thrice during the crop growth period.

Table 1: Treatment details

Treatments	Symbols
Control	T_1
NPK (100%)	T_2
NPK 50%	T_3
Azotobacter 100%	T_4
Azospirillium 100%	T_5
VAM 100%	T_6
NPK 50%+*Azotobacter* 50%	T_7
NPK 50%+*Azospirillium* 50%	T_8
NPK 50%+VAM 50%	T_9
NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%	T_{10}
NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%	T_{11}

2.3.1. Data recorded

Randomly five plants were tagged from each plot for recording data. Growth parameters (plant height and number of leaves), yield parameters (bulb length, bulb diameter, fresh weight of bulb, dry weight of bulb, yield $plot^{-1}$ and yield ha^{-1}, dry weight of bulb) and quality parameters (TSS, chlorophyll and ascorbic acid content) were recorded from tagged plants.

2.4. Statistical analysis

The data was analysed using OPSTAT. To verify significant differences between treatments at $p\leq0.05$, the obtained data was applied to Analysis of Variance (ANOVA) in RBD with Fisher's test to determine the crucial difference (CD) among various treatment means.

3. Results and Discussion

3.1. Growth parameters

The growth parameters recorded in the present study *viz*, plant height, numbers of leaves $plant^{-1}$ are presented in table 2. At 45 DAT, T_{10} exhibited the highest plant height (40.86 cm) while minimum plant height was recorded in T_1 (29.23 cm). The combination of NPK with either *Azotobacter* and *Azospirillium* or VAM had a similar and significant positive impact on leaf development during the later growth stages. This outcome

Table 2: Effect of biofertilizers and chemical fertilizers on growth parameters of onion

Symbols	Treatment details	Plant height 45 DAT (cm)	Plant height at harvest (cm)	No. of leaves at 60 DAT	No. of leaves at 90 DAT
T_1	Control	29.233	43.94	3.87	7.07
T_2	NPK (100%)	32.4	47.62	4.6	7.53
T_3	NPK 50%	34.66	48.253	4.4	7.47
T_4	*Azotobacter* 100%	35.173	48.713	4.33	7.67
T_5	*Azospirillium* 100%	34.8	47.987	4.53	7.47
T_6	VAM 100%	36.523	47.893	4.73	7.53
T_7	NPK 50%+*Azotobacter* 50%	37.647	57.193	4.53	7.47
T_8	NPK 50%+*Azospirillium* 50%	40.197	52.007	4.47	7.53
T_9	NPK 50%+VAM 50%	40.863	56.06	4.47	7.73
T_{10}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%	40.403	58.393	5.07	8.07
T_{11}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%	39.66	56.393	4.67	7.47
SEm±		0.161	0.555	0.10	0.13
CD (*p*=0.05)		0.478	1.648	0.32	0.39

underscores the positive influence of this treatment regimen on early plant growth, suggesting that the synergistic effect of NPK and beneficial microorganisms contributed to enhanced plant height (Lata et al., 2016; Srivastava et al., 2012; Kamble and Kathmale, 2015; Tinna et al., 2020; Kaur et al., 2021). The results obtained from our study regarding the number of leaves plant^{-1} at 60 days after transplanting (DAT) and at 90 DAT showed that T_{10} at 60 DAT and at 90 DAT exhibited the highest number of leaves plant^{-1} in onion and (5.07 and 8.07) minimum was recorded in T_1 (3.87 and 7.07). This finding underscores the positive impact of this treatment regimen on early onion leaf development, indicating the synergistic effect of NPK and beneficial microorganisms on increased leaf production (Jayathilake et al., 2006; Negi et al., 2022; Ranjan et al., 2019).

3.2. Yield parameters

The yield parameters recorded in the present study are present in table 3. The maximum polar diameter was

Table 3: Effect of biofertilizers and chemical fertilizers on yield parameters of onion

Symbols	Treatment details	Polar diameter (mm)	No. of rings	Neck thickness (cm)	Bulb yield plot^{-1} (t ha^{-1})	Bulb yield ha^{-1} (t ha^{-1})
T_1	Control	46.335	8.8	1.247	3.087	51.45
T_2	NPK (100%)	48.647	9.2	1.377	3.79	63.166
T_3	NPK 50%	49.391	9.333	1.273	3.29	59.83
T_4	*Azotobacter* 100%	48.905	9.133	1.463	4.573	76.16
T_5	*Azospirillium* 100%	50.643	8.467	1.563	4.183	69.66
T_6	VAM 100%	48.847	9.533	1.433	4.157	69.16
T_7	NPK 50%+*Azotobacter* 50%	49.519	9.733	1.513	4.117	68.5
T_8	NPK 50%+*Azospirillium* 50%	49.129	10.233	1.713	3.413	56.83
T_9	NPK 50%+VAM 50%	48.454	9.533	1.717	5.186	86.33
T_{10}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%	51.447	10.4	1.477	4.833	80.55
T_{11}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%	48.241	10.667	1.523	5.22	87.00
SEm±		0.844	0.249	0.004	0.044	0.006
CD (*p*=0.05)		2.507	0.739	0.012	0.129	2.188

recorded in T_{10} (51.44 mm) while minimum was recorded in T_1 (46.33 mm) (Damse et al., 2014; Shinde et al., 2013). The maximum number of rings recorded in T_{11} (10.66 mm) while minimum was recorded in T_1 (8.8). Similarly, neck thickness was recorded maximum (1.717 cm) in T_9 while minimum was recorded in T_1 (1.24 cm). This outcome indicates that the addition of VAM to the NPK fertilizer significantly influenced the development of neck thickness in the plants, resulting in thicker necks compared to other treatments (Chhabra and Vishwakarma, 2019; Elouattassi et al., 2023; Erkalo et al., 2023). The maximum bulb yield per plot (5.22 kg) and yield per ha (87 t ha^{-1}) was recorded maximum in T_{11} while minimum was recorded in T_1 (3.08 kg and 51.45 t ha^{-1}) (Awad et al., 2011; Bennett et al., 2009; Ghaffoor et al., 2003; Tinna et al., 2020).

3.3. Quality parameters

The quality parameters recorded in the present study *viz.* TSS, chlorophyll and carotenoid content, ascorbic acid content, present in table 4. The result showed that maximum TSS content (17.46°Brix) was recorded in T_6, minimum was recorded in T_1 (11.54°Brix). Similarly, maximum ascorbic acid content (10.53 mg g^{-1} FW) was recorded in T_{11} while minimum in T_9 (7.55 mg g^{-1} FW). The findings highlighted the potential of these treatments to enhance ascorbic acid levels in the plants, indicating their positive impact on the nutritional quality of the crop (Ram, 2012). The total chlorophyll content in the

Table 4: Effect of biofertilizers and chemical fertilizers on quality of onion

Symbols	Treatment details	TSS (°brix)	Ascorbic acid (mg g^{-1} FW)	Total chlorophyll (mg g^{-1} FW)	Carotenoid (mg g^{-1} FW)
T_1	Control	11.54	7.71	0.019	0.019
T_2	NPK (100%)	15.37	9.75	0.004	0.004
T_3	NPK 50%	16.813	10.4	0.004	0.004
T_4	*Azotobacter* 100%	14	9.59	0.014	0.014
T_5	*Azospirillium* 100%	16.233	10.52	0.003	0.003
T_6	VAM 100%	17.46	8.71	0.005	0.005
T_7	NPK 50%+*Azotobacter* 50%	14.873	8.38	0.017	0.017
T_8	NPK 50%+*Azospirillium* 50%	17.3	10.34	0.016	0.016
T_9	NPK 50%+VAM 50%	12.693	7.55	0.023	0.023
T_{10}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%	14.44	8.59	0.014	0.014
T_{11}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%	13.247	10.53	0.006	0.006
SEm±		0.49	0.16	0.001	0.001
CD (p=0.05)		1.46	0.53	0.004	0.004

Table 5: Effect of biofertilizers and chemical fertilizers on economics of onion production

Symbols	Treatment details	Bulb yield (t ha^{-1})	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B: C ratio
T_1	Control	51.45	29334	81976	52642	1.69
T_2	NPK (100%)	63.166	37084	100440	63356	1.70
T_3	NPK 50%	59.83	33086	90040	56954	1.72
T_4	*Azotobacter* 100%	76.16	35930	110950	75020	2.09
T_5	*Azospirillium* 100%	69.66	37512	108134	70622	1.88
T_6	VAM 100%	69.16	37054	107852	70798	1.91
T_7	NPK 50%+*Azotobacter* 50%	68.5	36294	104680	68386	1.93
T_8	NPK 50%+*Azospirillium* 50%	56.83	31808	87572	55764	1.75
T_9	NPK 50%+VAM 50%	86.33	46912	153086	106174	2.36
T_{10}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%	80.55	42010	141508	99498	2.26
T_{11}	NPK 50%+*Azotobacter* 50%+*Azospirillium* 50%+VAM 50%	87.00	47212	154040	106828	2.38

plants provides essential insights into the impact of different treatments on photosynthetic pigments and, consequently, the overall plant health and vigor. Carotenoid content in the plants provide significant insights into the impact of various treatments on the accumulation of these important pigments, which are not only crucial for plant health but also play a role in human nutrition. Notably, T_9 exhibited the highest total chlorophyll content (0.023 mg g^{-1} FW) and carotenoid content (0.023 mg g^{-1} FW), while minimum was recorded in T_5 (0.003 mg g^{-1} FW). These findings suggest that the combination of NPK and VAM significantly contributed to enhance photosynthetic activity and overall plant health (Shedeed et al., 2014).

3.4. Benefit and cost ratio (B: C)

The data obtained on the economics of onion as influenced by the effect of biofertilizers and chemical fertilizers is represented in table 5. The gross income (₹ 154040 ha^{-1}), net income (₹ 106828 ha^{-1}), and benefit- cost ratio (B.C. ratio) (2.38) was observed maximum in the treatment T_{11}. The minimum gross income (81976 ha^{-1}), net income (52642 ha^{-1}) and benefit - cost ratio (1.69) was observed in T_1.

4. Conclusion

The study concluded that T_{11} was the most effective treatment in enhancing onion growth, yield, and quality. It offers valuable guidance to farmers, aiding them in making informed decisions to improve crop productivity and economic sustainability. Moreover, the research contributes to discussions on sustainable agriculture, emphasizing the importance of prudent fertilizer use for optimal yields and food security. These insights can lead to a more efficient, profitable, and eco-friendly onion farming approach, benefiting farmers and consumers alike.

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