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EFFECT OF BIO-FERTILIZERS ON GROWTH AND YIELD OF ONION (*Allium cepa* L.) var. AFLR

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ABSTRACT----------
A field experiment was conducted during the rabi season of 2025–2026 at the Horticulture Research Farm, Faculty of Agriculture Science, SAM Global University, Raisen, Madhya Pradesh, to study the response of onion (Allium cepa L.) var. AFLR to different bio-fertilizer combinations. The trial was laid out in Randomized Block Design with ten treatments and three replications. The treatments included control and different combinations of vermicompost, Azospirillum, vesicular arbuscular mycorrhizae and phosphate solubilizing bacteria. The results showed a clear improvement in growth, yield, quality and economics due to combined bio-fertilizer application. Among all treatments, T_8, consisting of vermicompost @ 5 t ha^{-1} + Azospirillum @ 666 g ha^{-1} + VAM @ 666 g ha^{-1} + PSB @ 833 g ha^{-1}, gave the best performance. This treatment recorded the highest plant height, leaf production, leaf area, bulb weight, bulb diameter, total bulb yield, marketable yield and total soluble solids. T_8 produced 301.58 q ha^{-1} total bulb yield and 280.86 q ha^{-1} marketable yield. It also gave the highest net return of ₹2,35,688 ha^{-1} and benefit-cost ratio of 6.21. The study indicates that balanced use of vermicompost with one-third dose of Azospirillum, VAM and PSB is an effective and economical nutrient-management practice for onion var. AFLR under Raisen conditions.
KEYWORDS: *onion, AFLR, bio-fertilizer, vermicompost, Azospirillum, VAM, PSB, marketable yield*---------

INTRODUCTION

Onion (*Allium cepa* L.) is an important bulb crop valued for daily consumption, processing, storage and market demand. In India, onion is grown across different agro-climatic regions and forms a major component of vegetable-based farming systems. The crop has high commercial importance, but its productivity depends strongly on nutrient availability, soil condition and crop-management practices.

Onion has a shallow root system, which restricts its capacity to explore deeper soil layers for nutrients and moisture. For this reason, the crop responds strongly to nutrient management in the upper soil zone. Chemical fertilizers support quick crop growth, but continuous and unbalanced use increases production cost and affects soil health. Sustainable onion production requires practices that improve yield while maintaining soil structure, microbial activity and nutrient-use efficiency.

Bio-fertilizers offer a practical approach for improving nutrient availability through biological processes. *Azospirillum* supports nitrogen availability and root growth through associative nitrogen fixation and growth-promoting substances. VAM improves phosphorus and micronutrient uptake by increasing the effective absorbing surface of roots. PSB converts fixed phosphorus into plant-available forms. Vermicompost improves soil physical condition, adds organic matter and creates a better environment for beneficial microorganisms.

The present investigation was conducted to identify a suitable bio-fertilizer combination for improving growth, bulb yield, quality and profitability of onion var. AFLR.

MATERIALS AND METHODS

The experiment was carried out during rabi 2025–2026 at the Horticulture Research Farm, Faculty of Agriculture Science, SAM Global University, Raisen, Madhya Pradesh. The experimental field was uniform and suitable for irrigation, drainage and field operations. The soil was medium black, well drained and slightly alkaline, with low available nitrogen and medium available phosphorus and potassium.

The experiment was arranged in Randomized Block Design with ten treatments and three replications. The plot size was 2.1 m × 1.8 m. Onion seedlings of var. AFLR were transplanted at 15 cm × 10 cm spacing. Transplanting was done on 12 December 2025 and harvesting on 18 April 2026. Vermicompost and bio-fertilizers were applied according to treatment schedule.

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Table 1. Treatment combinations

Treatment	Description
T_1	Control
T_2	Vermicompost + *Azospirillum* full dose
T_3	Vermicompost + VAM full dose
T_4	Vermicompost + PSB full dose
T_5	Vermicompost + *Azospirillum* full dose + VAM half dose
T_6	Vermicompost + *Azospirillum* full dose + PSB half dose
T_7	Vermicompost + VAM full dose + *Azospirillum* half dose
T_8	Vermicompost + *Azospirillum* + VAM + PSB at one-third dose
T_9	Vermicompost + *Azospirillum* + VAM + PSB at half dose
T_{10}	Vermicompost + *Azospirillum* + VAM + PSB at full dose

The full dose consisted of vermicompost @ 5 t ha^{-1}, *Azospirillum* @ 2 kg ha^{-1}, VAM @ 2 kg ha^{-1} and PSB @ 2.5 kg ha^{-1}. In T_8, one-third dose of each bio-fertilizer was applied with vermicompost.

Growth observations were recorded for plant height, number of leaves, leaf length, leaf width, leaf area, leaf area index and neck thickness. Yield observations included fresh bulb weight, dry bulb weight, equatorial diameter, polar diameter, bolting percentage, number of scales per bulb, bulb yield and marketable yield. Total soluble solids were recorded as a quality parameter. Economics were calculated through cost of cultivation, gross return, net return and benefit-cost ratio.

RESULTS AND DISCUSSION

Growth Characters

Bio-fertilizer application improved vegetative growth of onion. Treatment T_8 recorded the highest plant height at all growth stages: 29.27 cm at 30 DAT, 38.37 cm at 45 DAT, 45.63 cm at 60 DAT and 66.80 cm at 90 DAT. The control treatment recorded the lowest values at each stage. T_8 also recorded the highest number of leaves per plant, with 4.33, 5.67, 8.33 and 11.00 leaves at 30, 45, 60 and 90 DAT, respectively.

The improvement in vegetative growth under T_8 was linked with the combined action of vermicompost, *Azospirillum*, VAM and PSB. Vermicompost improved the root-zone environment and supplied nutrients gradually. *Azospirillum* supported nitrogen availability and root activity. VAM improved uptake of phosphorus and other immobile nutrients, while PSB helped release fixed phosphorus. The combined effect produced better leaf growth and canopy development.

Leaf length, leaf width, leaf area and leaf area index also showed superior values under T_8. At 90 DAT, T_8 recorded 50.90 cm leaf length, 1.80 cm leaf width, 247.03 cm^2 leaf area and 1.30 leaf area index. Better leaf area increased the photosynthetic surface, which supported assimilate production and later bulb enlargement.

Yield-Attributing Characters

Yield-attributing traits improved under combined bio-fertilizer treatments. T_8 recorded the highest fresh bulb weight of 147.67 g and dry bulb weight of 27.67 g. The control recorded only 127.67 g fresh bulb weight and 16.67 g dry bulb weight. Higher bulb weight under T_8 indicates better dry matter accumulation and efficient movement of photosynthates from leaves to bulbs.

Bulb size also improved under T_8. The highest equatorial diameter was 5.53 cm, and the highest polar diameter was 5.40 cm. The control recorded the lowest equatorial and polar diameters, 4.17 cm and 3.83 cm, respectively. T_8 also recorded the lowest bolting percentage of 0.35% and the highest number of scales per bulb, 12.67. Lower bolting is desirable because flowering diverts stored food away from bulb development and reduces marketable quality.

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Table 2. Effect of bio-fertilizers on growth parameters of onion var. AFLR

Treatment	Plant height at 90 DAT (cm)	Leaves plant^{-1} at 90 DAT	Leaf length at 90 DAT (cm)	Leaf width at 90 DAT (cm)	Leaf area at 90 DAT (cm^2)	LAI at 90 DAT	Neck thickness at 45 DAT (cm)
T_1	62.00	8.00	45.53	1.03	178.80	0.83	1.13
T_2	62.87	8.33	47.07	1.17	192.80	0.84	1.17
T_3	62.83	8.33	48.67	1.13	184.93	1.22	1.23
T_4	64.67	8.67	47.80	1.07	186.33	1.06	1.17
T_5	65.10	9.67	46.97	1.23	185.33	0.90	1.23
T_6	66.27	9.33	48.40	1.37	198.00	1.06	1.20
T_7	65.47	9.67	47.40	1.30	206.43	0.86	1.20
T_8	66.80	11.00	50.90	1.80	247.03	1.30	1.37
T_9	65.83	10.33	49.50	1.77	205.00	1.06	1.27
T_{10}	65.47	10.00	50.33	1.77	223.10	1.08	1.33
S.Em ±	1.91	0.45	1.13	0.05	14.50	0.10	0.04
C.D. at 5%	5.68	1.34	3.35	0.15	43.07	0.30	0.12

Bulb Yield and Marketable Yield

Total bulb yield differed among treatments. T_8 recorded the highest bulb yield of 11.40 kg plot^{-1} and 301.58 q ha^{-1}. T_9 was close behind with 11.37 kg plot^{-1} and 300.70 q ha^{-1}. The lowest bulb yield was recorded in T_1 control, with 9.67 kg plot^{-1} and 255.73 q ha^{-1}.

Marketable yield followed the same pattern. T_8 produced the maximum marketable yield of 10.62 kg plot^{-1} and 280.86 q ha^{-1}. T_9 recorded 10.38 kg plot^{-1} and 274.68 q ha^{-1}. The control produced the lowest marketable yield, 7.85 kg plot^{-1} and 207.67 q ha^{-1}. The higher marketable yield under T_8 resulted from better bulb size, higher bulb weight, more scales and lower bolting.

Table 3. Effect of bio-fertilizers on yield-attributing characters of onion var. AFLR

Treatment	Fresh bulb weight (g)	Dry bulb weight (g)	Equatorial diameter (cm)	Polar diameter (cm)	Number of bolted plants plot^{-1}	Bolting (%)	Scales bulb^{-1}
T_1	127.67	16.67	4.17	3.83	2.00	1.04	8.67
T_2	134.67	18.33	4.27	4.23	1.00	0.52	11.00
T_3	131.00	17.00	4.20	4.23	2.00	1.04	11.33
T_4	129.33	17.67	4.63	4.13	1.00	0.52	10.00
T_5	139.33	24.33	5.17	4.73	2.00	1.04	9.00
T_6	136.67	25.33	4.93	4.20	1.00	0.52	9.00
T_7	137.33	24.33	5.03	4.43	1.00	0.52	11.33
T_8	147.67	27.67	5.53	5.40	0.67	0.35	12.67
T_9	144.67	26.67	5.07	5.23	1.00	0.52	10.33
T_{10}	143.00	26.00	4.90	5.00	1.67	0.87	12.00
S.Em ±	4.05	1.04	0.21	0.22	0.14	0.07	0.78
C.D. at 5%	12.03	3.09	0.62	0.64	0.42	0.22	2.30

Quality Parameter

Total soluble solids varied significantly among treatments. T_8 recorded the highest TSS of 13.00 °Brix. T_{10} recorded 12.67 °Brix, while the control recorded the lowest value of 11.00 °Brix. Higher TSS under T_8 suggests better carbohydrate synthesis and movement of assimilates into the bulb.

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Table 4. Effect of bio-fertilizers on bulb yield, marketable yield and TSS

Treatment	Bulb yield (kg plot^{-1})	Bulb yield (q ha^{-1})	Marketable yield (kg plot^{-1})	Marketable yield (q ha^{-1})	TSS (°Brix)
T_1	9.67	255.73	7.85	207.67	11.00
T_2	9.77	258.37	8.13	215.16	11.33
T_3	9.87	261.02	8.72	230.81	12.00
T_4	9.83	260.14	8.72	230.59	12.33
T_5	10.37	274.24	9.20	243.38	11.33
T_6	10.40	275.13	9.14	241.79	12.00
T_7	10.77	284.83	9.53	252.20	12.33
T_8	11.40	301.58	10.62	280.86	13.00
T_9	11.37	300.70	10.38	274.68	12.33
T_{10}	10.57	279.54	9.70	256.61	12.67
S.Em ±	0.31	8.27	0.29	7.57	0.42
C.D. at 5%	0.93	24.55	0.85	22.46	1.26

Economics

Economic analysis showed that T_8 was the most profitable treatment. It recorded gross income of ₹2,80,860 ha^{-1}, net income of ₹2,35,688 ha^{-1} and benefit-cost ratio of 6.21. T_9 was the second-best treatment, with net income of ₹2,28,990 ha^{-1} and benefit-cost ratio of 6.07. The control recorded the lowest net income of ₹1,63,530 ha^{-1} and benefit-cost ratio of 4.70.

The higher profitability of T_8 is important because it used only one-third dose of the bio-fertilizers along with vermicompost. This indicates that a balanced microbial combination at moderate dose was more efficient than applying the full dose of all bio-fertilizers. The result may be due to better microbial compatibility and lower competition among microbial populations in the rhizosphere.

Table 5. Economics of different bio-fertilizer treatments in onion

Sale rate of onion bulb: ₹10 kg^{-1}

Treatment	Gross income (₹ ha^{-1})	Expenditure (₹ ha^{-1})	Net income (₹ ha^{-1})	B:C ratio
T_1	207670	44140	163530	4.70
T_2	215160	45390	169770	4.74
T_3	230810	45390	185420	5.08
T_4	230550	44740	185810	5.15
T_5	243380	45390	197990	5.36
T_6	241790	45690	196100	5.29
T_7	252200	46015	206185	5.48
T_8	280860	45172	235688	6.21
T_9	274680	45690	228990	6.07
T_{10}	256610	47240	209370	5.43

CONCLUSION

The study confirmed that bio-fertilizer combinations significantly improved growth, yield, quality and economics of onion var. AFLR. Among all treatments, T_8, consisting of vermicompost @ 5 t ha^{-1} + *Azospirillum* @ 666 g ha^{-1} + VAM @ 666 g ha^{-1} + PSB @ 833 g ha^{-1}, performed best. It recorded the highest plant height, number of leaves, leaf area, bulb weight, bulb diameter, total bulb yield, marketable yield, TSS, net return and benefit-cost ratio.

The treatment produced 301.58 q ha^{-1} total bulb yield and 280.86 q ha^{-1} marketable yield, with a benefit-cost ratio of 6.21. Based on these results, the combined use of vermicompost with one-third dose of *Azospirillum*, VAM and PSB is recommended as an efficient and economical nutrient-management practice for onion var. AFLR under the agro-climatic conditions of Raisen, Madhya Pradesh.

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