

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(5): 407-409
www.biochemjournal.com
Received: 15-03-2025
Accepted: 19-04-2025

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Effect of various bioformulation, gibberellic acid and humic acid on growth and yield of onion

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DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i5e.4349>

Abstract

Onion is also known as *Allium cepa* L., is a bulbous biennial herb from the Alliaceae family. Inoculation with *Azotobacter* increases sporulation and mycorrhizal infection in onions due to growth-promoting substances produced by the bacteria, leading to enhanced plant growth, nitrogen and phosphorus uptake, ultimately improving crop productivity. Similarly, *Azospirillum* bacteria, through symbiosis with onion roots, fix atmospheric nitrogen, increasing nitrogen availability in the soil. Gibberellic acid (GA₃) is a plant growth regulator that influences onion growth by promoting stem elongation, increased internode length and cell division in leaves, stems, and bulbs. Result of this study, it can be deduced that the optimal approach to achieving a favorable crop growth, yield parameters, coupled with an impressive highest yield (248.69 q/ha) involves the application treatments. Specifically, the combined utilization of *Azotobacter* (5 kg), *Azospirillum* (5 kg), GA₃ (100 ppm) and humic acid (2 kg) has proven to be highly effective.

Keywords: Onion, *Azotobacter*, *Azospirillum*, gibberellic acid (GA₃), humic acid, growth, yield

Introduction

Onion, scientifically known as *Allium cepa* L., is a bulbous biennial herb from the Alliaceae family, believed to have originated from Central Asia and the Mediterranean region; known as the "Queen of the kitchen". The total area under onion cultivation in India is 1914.18 thousand hectares, with a production of 312721.71 thousand tonnes and productivity is 16337 kg/ha in 2021-22. The major onion-producing states in India are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Rajasthan, Bihar, West Bengal, Andhra Pradesh, Tamil Nadu, Haryana, Uttar Pradesh. In Uttar Pradesh (2023-24), onions were sown in 196.7 thousand hectare area with production 4740.6 thousand tonnes and productivity is 24101 kg/ha. (National Horticulture Board).

Inoculation with *Azotobacter* increases sporulation and mycorrhizal infection in onions due to growth-promoting substances produced by the bacteria, leading to enhanced plant growth, nitrogen and phosphorus uptake, ultimately improving crop productivity. Similarly, *Azospirillum* bacteria, through symbiosis with onion roots, fix atmospheric nitrogen, increasing nitrogen availability in the soil.

Gibberellic acid (GA₃) is a plant growth regulator that influences onion growth by promoting stem elongation, increased internode length and cell division in leaves, stems, and bulbs. Its application during the vegetative stage leads to larger bulbs, while during bulb initiation, it increases the number of bulbs produced. Humic acid, an organic compound, enhances onion growth by improving soil structure, nutrient uptake, root growth and water retention. It also boosts beneficial microorganisms in the soil, leading to increased yield, larger bulb size and improved bulb quality in onion cultivation. Proper application of GA₃ and humic acid can contribute to the healthy growth and development of onions (Bhonde *et al.*, 1997, and Dibute *et al.*, 1993) [1, 3].

Methods and Materials

The present investigation was carried out at Department of Biological Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj Uttar Pradesh, India.

Results and Discussion

Effect of *Azotobacter*, *Azospirillum*, GA₃ and humic acid on growth and yield parameters

Growth Parameters

The growth in height of onion plants recorded notable sensitivity to various treatments. The most remarkable plant height, measured at 60 days after planting (DAP), in T₁₀ is (51.56 cm) (GA₃, *Azotobacter*, *Azospirillum* and Humic acid), which was at par with T₁₁ (RDF + Humic acid + *Azotobacter* + *Azospirillum*) (50.93 cm), while, the control plot (T₁₂) exhibited the smallest height at (43.17 cm). Similarly, at 90 DAP, the tallest plant stature (64.48 cm) was observed in T₁₀, which was at par with T₁₁ (62.72 cm), whereas, the lowest height (53.13 cm) persisted in the control plot T₁₂. Notably, the greatest plant height was consistently achieved in T₁₀ (RDF + GA₃ + *Azotobacter* + *Azospirillum* + Humic acid), contrasting with the lowest height observed in the control plot (T₁₂), both at the 60 and 90 DAP respectively. These factors collectively promote elongation of plant cells and expansion of the root system, resulting in enhanced plant height. These findings were also reported by Sajid *et al.* (2012) [8] and Mohammed and Ibraheem (2020) [7].

The influence of various treatments on the leaf count per plant of onion plants displayed significant significance. Plant growth regulator that promotes cell elongation, which can lead to increased leaf formation. At 60 days after planting (DAP), the treatment T₁₀, which encompassed GA₃, *Azotobacter*, *Azospirillum*, and Humic acid, exhibited the highest leaf count per plant of (8.40). Which was at par with T₁₁ (8.20). In contrast, the control plot (T₁₂) recorded the lowest leaf count per plant of (7.18). Similarly, at 90 DAP,

T₁₀ also achieved the highest leaf count per plant (11.43), while T₁₁ was at par with a count of (10.70). On the other hand, the lowest leaf count of 7.47 persisted in the control plot T₁₂. This consistent trend was also reported by Singh *et al.* 2002 [9].

After 60 days after planting (DAP), the treatment designated as T₁₀, which consisted of a combination of GA₃, *Azotobacter*, *Azospirillum* and Humic acid, these stimulate cell division, elongation and overall leaf expansion, leading to an increase in leaf length. They obtain the most substantial leaf length recorded (46.16 cm). In contrast, the control plot labeled as (T₁₂) recorded the lowest leaf measurement of (40.70 cm) during the same period. Similarly, at the 90-DAP, T₁₀ exhibited a remarkable maximum leaf length of (55.33 cm), while, T₁₂ demonstrated the lowest measurement of (46.50 cm) within the same timeframe. This consistent trend was also reported by Sajid *et al.* (2012) [8] and Kumar *et al.* (2017) [5].

The treatment T₁₀, which included the application of GA₃, *Azotobacter*, *Azospirillum* and Humic acid, leaf area per plant exhibited significant. collectively stimulate cell growth, expansion and overall leaf area. Treatment T₁₀ resulted the highest recorded leaf area per plant (321.94 cm²) at 60 DAT and 624.65 cm² at 90 DAT. Treatment T₁₁, which was at par treatment, noted a leaf area of (315.99 cm²) at 60 DAT and (597.28 cm²) at 90 DAT, showing comparable results. In contrast, the control treatment (T₁₂) had the lowest leaf area per plant recorded, measuring (244.40 cm²) and (362.00 cm²) at 60 and 90 DAT respectively. The findings are in line with a study conducted by Singh *et al.* (2002) [9].

Table 1: Effect of *Azotobacter*, *Azospirillum*, GA₃ and humic acid on growth parameters

S. No.	Treatment	Plant Height (cm)		Number of leaves/plant		Leaf Length (cm)		Leaf Area per plant (cm ²)	
		60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT	60 DAT	90 DAT
T ₁	(NPKS: 100:50:50:40 Kg/ha)	48.16	57.93	7.1	8.34	42.86	49.91	263.23	446.39
T ₂	<i>Azotobacter</i> (5 kg/ha)	50.15	59.36	7.34	9.12	43.88	50.99	311.62	502.51
T ₃	<i>Azospirillum</i> (5 kg/ha)	49.4	59.13	7.24	9.05	44.15	51.1	291.92	451.65
T ₄	GA ₃ (100 ppm)	48.34	60.5	7.46	9.77	42.82	51.84	274.24	507.08
T ₅	Humic acid (2 kg/ha)	48.25	60.64	7.47	9.85	42.94	51.98	269.04	517.99
T ₆	<i>Azotobacter</i> + <i>Azospirillum</i>	50.34	61.09	7.48	10.05	44.99	52.84	318.39	534.41
T ₇	GA ₃ + <i>Azotobacter</i>	49.36	61.4	7.99	10.12	43.92	53.9	287.02	592.3
T ₈	GA ₃ + <i>Azospirillum</i>	49.38	61.38	7.67	10.13	43.75	53.83	291.47	547.31
T ₉	GA ₃ + Humic acid	49.13	61.26	8.03	10.44	42.54	53.79	280.33	543.57
T ₁₀	GA ₃ + <i>Azotobacter</i> + <i>Azospirillum</i> + Humic acid	51.56	63.48	8.40	11.43	46.16	55.33	321.94	625.9
T ₁₁	Humic acid + <i>Azotobacter</i> + <i>Azospirillum</i>	50.93	62.72	8.20	10.7	45.4	54.77	315.99	597.28
T ₁₂	Control	43.17	53.13	7.18	7.47	40.7	46.5	242.4	362
	Sem±	0.55	0.33	0.36	0.34	0.63	0.27	3.78	16.09
	CD at 5%	1.65	0.99	1.09	0.99	1.91	0.81	15.86	47.18

Yield parameters

The impact of different treatments on neck thickness exhibited significant variation. The highest neck thickness (2.22 cm) was observed in treatment T₁₀ (GA₃, *Azotobacter*, *Azospirillum* and Humic acid), which was on par with T₁₁ (Humic acid, *Azotobacter* and *Azospirillum*) (2.21 cm). Conversely, the control plot T₁₂ recorded the lowest neck thickness (1.94 cm). These all combined applications stimulate cell elongation, division, and overall tissue expansion. These findings are consistent with the studies conducted by Banjare *et al.* (2015) [2].

The application of, GA₃, *Azotobacter*, *Azospirillum* and Humic acid had a significant impact on bulb weight. These

combined treatments stimulate cell growth, division, and nutrient storage, resulting in larger and heavier bulbs. The highest bulb weight (70.65 gm) was recorded in treatment T₁₀ (GA₃, *Azotobacter*, *Azospirillum* and Humic acid), which was at par with T₁₁ (Humic acid, *Azotobacter* and *Azospirillum*) (70.16 gm). Conversely, the lowest bulb weight (57.36 gm) was observed in the control plot T₁₂. These findings are consistent with the research conducted by Kumar *et al.* in 2019b [6]. The application of GA₃, *Azotobacter*, *Azospirillum* and Humic acid had been shown to significantly influence both yield per plot and yield per hectare based on present study. The combined effects of GA₃, *Azotobacter*, *Azospirillum* and Humic acid

synergistically contribute to increased plant vigor, nutrient uptake, and overall productivity, ultimately leading to higher crop yield. The maximum yield per plot (16.10 kg) and per hectare (248.69 q) were recorded in T₁₀, which were at par with the yield per plot (15.45 kg) and yield per

hectare (237.97 q) in treatment T₁₁. In contrast, the control plot T₁₂ exhibited the lowest yield per plot (12.36 kg) and yield per hectare (186.42 q). These findings align with the results reported by Waghmode *et al.* in 2010^[10] and Jamir *et al.* in 2013^[4].

Table 2: Effect of *Azotobacter*, *Azospirillum*, GA₃ and humic acid on yield parameters

S. No.	Treatment	Neck Thickness (cm)	Weight of bulb (g)	Bulb Yield (kg)	Bulb Yield (q/ha)
T ₁	(NPKS: 100:50:50:40 Kg/ha)	2.02	61.52	13.52	205.67
T ₂	<i>Azotobacter</i> (5 kg/ha)	2.06	63.34	14.24	217.8
T ₃	<i>Azospirillum</i> (5 kg/ha)	2.05	63.12	14.16	216.36
T ₄	GA ₃ (100 ppm)	2.07	65.75	14.28	218.36
T ₅	Humic acid (2 kg/ha)	2.09	64.52	14.47	221.58
T ₆	<i>Azotobacter</i> + <i>Azospirillum</i>	2.1	67.7	14.7	225.47
T ₇	GA ₃ + <i>Azotobacter</i>	2.18	68.69	14.81	227.25
T ₈	GA ₃ + <i>Azospirillum</i>	2.15	68.41	14.73	225.97
T ₉	GA ₃ + Humic acid	2.2	69.96	15.24	234.36
T ₁₀	GA ₃ + <i>Azotobacter</i> + <i>Azospirillum</i> + Humic acid	2.22	70.65	16.1	1.25
T ₁₁	Humic acid + <i>Azotobacter</i> + <i>Azospirillum</i>	1.25	1.25	1.25	248.69
T ₁₂	Control	2.21	70.16	15.45	1.25
	Sem±	0.06	0.24	0.32	4.08
	CD at 5%	0.18	0.73	0.96	12.24

Conclusion

Based on the outcomes of this study, it can be deduced that the optimal approach to achieving a favorable crop growth, yield parameters, coupled with an impressive highest yield (248.69 q/ha) involves the application treatments. Specifically, the combined utilization of *Azotobacter* (5 kg), *Azospirillum* (5 kg), GA₃ (100 ppm) and humic acid (2 kg) has proven to be highly effective in enhancing crop productivity and economic benefits.

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