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Effect of foliar application of biostimulants on growth, yield and quality of onion cv. Akola Safed

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Abstract

A field experiment was conducted at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during rabi 2024-25, to evaluate the effect of foliar application of biostimulants on the growth, yield and quality of onion (*Allium cepa* L.) cv. Akola Safed. The experiment was laid out in a Randomised Block Design with three replications and seven treatments, viz., Humic acid (0.2%), PDKV Humi-K (2.5%), Fulvic acid (0.1%), Amino acid (0.2%), Silicic acid (0.5%), Seaweed extract (0.2%) and an untreated control. Among the growth parameters, plant height was significantly maximum with Amino acid (0.2%), the highest number of leaves per plant was recorded with Seaweed extract (0.2%), and the minimum days for harvest were observed with Fulvic acid (0.1%). Foliar application of Fulvic acid (0.1%) also gave the significantly maximum average bulb weight (122.47 g), total yield (28.87 t ha⁻¹), maximum marketable yield (26.74 t ha⁻¹) and A-grade bulb percentage (42.35%), and the least bulb splitting (1.18%) with Seaweed extract (0.2%). The untreated control recorded the lowest values for all growth and yield parameters. Economic analysis revealed that Fulvic acid (0.1%) fetched the highest net monetary return (Rs. 2,17,308 ha⁻¹) and benefit: cost ratio (2.67). The study indicates that foliar application of Fulvic acid (0.1%) is the most promising biostimulant for enhancing the growth, yield and profitability of onion cv. Akola Safed under Vidarbha conditions.

Keywords: Onion, Akola Safed, biostimulants, foliar application, fulvic acid, growth, yield, benefit: cost ratio

Introduction

Among the bulb vegetables of the Alliaceae family, onion (*Allium cepa* L.) holds a distinct place in Indian agriculture, valued not only as an everyday culinary condiment but also as a crop that supports farmers' incomes and contributes meaningfully to horticultural exports. During 2024-25, the country grew onion on close to 1.97 million hectares, producing 30.77 million tonnes at a productivity of 15.62 t ha⁻¹, with Maharashtra, Madhya Pradesh and Karnataka accounting for the bulk of national output (Government of India, 2025) [6]. Akola Safed, a white-bulbed variety developed at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, is prized locally for its bulb quality and its ability to store well after harvest. Even so, field-level productivity of this and other varieties keeps running into trouble because of erratic weather and the usual mix of biotic and abiotic stresses that vegetable growers face problem about.

Against this problem, biostimulants have gained popularity as a comparatively sustainable way to lift crop performance, working through improved nutrient-use efficiency and physiological resilience rather than by supplying nutrients straight away. Broadly, these are substances or microorganisms that, once applied, switch on natural physiological pathways in the plant that improve how well it takes up and uses nutrients, cope with abiotic stress, and finish with better quality produce-and they do this irrespective of what nutrients they themselves contain. Each of the biostimulants examined here works somewhat differently: humic and fulvic acids aid nutrient absorption and root proliferation; PDKV Humi-K, a humic-acid formulation enriched with phosphorus and potassium, adds a nutritional component on top of the usual humic-substance effects; amino-acid biostimulants act as ready-made building blocks for protein synthesis and help plants recover metabolically under stress; silicic acid reinforces cell walls and improves stress tolerance; and seaweed extracts, being naturally rich in cytokinins and other bioactive molecules, drive cell division and slow down senescence.

Despite this range of known modes of action, there is still little comparative evidence on how these particular biostimulants perform on onion cv. Akola Safed under Vidarbha's agro-climatic conditions. The present study was undertaken to fill that gap and examine the effect of their foliar application on the growth and yield of this variety.

Materials and Methods

This study was conducted at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), during rabi 2024-25. Seven treatments were tested in a Randomised Block Design with three replications: T₁ (Humic acid 0.2%), T₂ (PDKV Humi-K 2.5%), T₃ (Fulvic acid 0.1%), T₄ (Amino acid 0.2%), T₅ (Silicic acid 0.5%), T₆ (Seaweed extract 0.2%) and T₇, an untreated control sprayed with plain water. All treatments were applied as foliar sprays. Seedlings of onion cv. Akola Safed went into the field on 10th January 2025, spaced at 15 × 10 cm, with a gross plot size of 3 × 2 m². Before transplanting, FYM was worked in at 25 t ha⁻¹ along with a basal dose of 50:50:50 kg N:P₂O₅:K₂O ha⁻¹; a further 50 kg N ha⁻¹ was top-dressed 30 days later. Other than these treatments, the crop was managed as per the standard package of practices followed in the region. Growth was tracked through plant height and number of leaves per plant, both recorded at 30, 60 and 90 days after transplanting (DAT), along with the number of days taken to reach harvest maturity. On the yield side, the parameters recorded included average bulb weight, total yield, marketable yield, grading of bulbs into A, B and C categories based on equatorial diameter, and the percentage of splitted bulbs, all following standard procedures for onion. Data were analysed statistically following Panse and Sukhatme (1989) [9]; standard error of mean (S. Em±) and critical difference (CD) at the 5% level were computed for every character studied.

Results and Discussion

A. Growth parameters

Plant height (cm): Treatment differences in plant height (Table 1) had not yet shown up at 30 DAT, but became statistically significant by 60 and 90 DAT. By 60 DAT, plants sprayed with Amino acid 0.2% (T₄) had grown tallest, at 58.03 cm, a figure statistically on par with T₃, Fulvic acid 0.1% (57.33 cm); the control (T₇) lagged behind at 50.80

cm. This pattern held at 90 DAT as well-T₄ again led at 65.87 cm, on par with T₃ at 63.63 cm, with T₇ once more the shortest at 56.40 cm. Amino acids applied to the foliage are absorbed quickly and can be used almost directly in protein synthesis, sparing the plant the metabolic cost of assimilating nitrogen from scratch; the energy saved appears to be redirected towards cell division and elongation, which would explain the taller plants under T₄. Comparable responses have been reported by El-Shabasi *et al.* (2005) [4] in garlic, Shafeek *et al.* (2018) [10] in onion, Tejada and Gonzalez (2003) [11] in asparagus, and Zewail (2014) [12] in common bean.

Table 1: Effect of foliar application of biostimulants on plant height (cm)

Treatments	30 DAT	60 DAT	90 DAT
T ₁ (Humic acid 0.2%)	31.43	54.83	61.27
T ₂ (PDKV Humi-K 2.5%)	32.16	55.13	62.53
T ₃ (Fulvic acid 0.1%)	30.95	57.33	63.63
T ₄ (Amino acid 0.2%)	33.51	58.03	65.87
T ₅ (Silicic acid 0.5%)	32.17	54.37	61.17
T ₆ (Seaweed extract 0.2%)	32.17	54.97	61.27
T ₇ (Control-water spray)	30.61	50.80	56.40
'F' test	NS	Sig.	Sig.
S.Em±	0.65	0.93	1.02
CD (5%)	-	2.85	3.15

Number of leaves per plant: A similar pattern emerged for leaf number (Table 2): no clear separation between treatments at 30 DAT, followed by significant differences at 60 and 90 DAT. Plants receiving Seaweed extract 0.2% (T₆) carried the most leaves at 60 DAT (13.07), statistically at par with T₄, Amino acid 0.2% (11.27), while T₇ trailed with just 9.53 leaves. By 90 DAT the same treatment, T₆, was still ahead, on par with T₄ (14.00), and T₇ remained the lowest at 12.00. The naturally occurring cytokinins in seaweed extract are known to drive cell division and slow the ageing of leaf tissue, which would keep the shoot apex active and encourage a steady flow of new leaves; the betaines and polysaccharides it also contains may help hold onto chlorophyll and keep photosynthate moving, reinforcing this effect. Similar leaf-number responses to seaweed extract have been documented by Hidangmayum and Sharma (2017) [7] and Ahmed *et al.* (2019) [12] in onion.

Table 2: Effect of foliar application of biostimulants on number of leaves per plant

Treatments	30 DAT	60 DAT	90 DAT
T ₁ (Humic acid 0.2%)	5.57	9.87	12.73
T ₂ (PDKV Humi-K 2.5%)	5.67	10.00	12.40
T ₃ (Fulvic acid 0.1%)	6.07	11.47	13.87
T ₄ (Amino acid 0.2%)	6.10	11.27	14.00
T ₅ (Silicic acid 0.5%)	5.37	10.57	13.70
T ₆ (Seaweed extract 0.2%)	6.07	13.07	15.80
T ₇ (Control-water spray)	5.83	9.53	12.00
'F' test	NS	Sig.	Sig.
S.Em±	0.19	0.60	0.60
CD (5%)	-	1.85	1.83

Days for harvest: Biostimulant treatment also shifted the time taken to reach harvest maturity (Table 3). Bulbs sprayed with Fulvic acid 0.1% (T₃) were ready earliest, in 118.33 days, statistically comparable to T₁, Humic acid 0.2% (119.00 days) and T₂, PDKV Humi-K 2.5% (118.67 days); the control took longest at 122.67 days. Fulvic acid's

small molecular size and strong cation-exchange capacity allow it to chelate and move micronutrients through the plant quickly, and this faster internal nutrient traffic appears to speed up bulb development, maturation and neck fall-consistent with what Mahmoud *et al.* (2019) [8] observed.

Table 3: Effect of foliar application of biostimulants on days for harvest

Treatments	Days for harvest
T ₁ (Humic acid 0.2%)	119.00
T ₂ (PDKV Humi-K 2.5%)	118.67
T ₃ (Fulvic acid 0.1%)	118.33
T ₄ (Amino acid 0.2%)	120.67
T ₅ (Silicic acid 0.5%)	122.33
T ₆ (Seaweed extract 0.2%)	122.33
T ₇ (Control-water spray)	122.67
'F' test	Sig.
S.Em±	1.03
CD (5%)	3.18

B. Yield and yield attributing and quality parameters

Average bulb weight and total yield: Treatment effects on bulb weight and total yield (Table 4) followed each other closely, as one would expect. T₃, Fulvic acid 0.1%, produced the heaviest bulbs (122.47 g) and the highest yield (28.87 t/ha), on par with T₂, PDKV Humi-K 2.5%, and T₁, Humic acid 0.2%; the control gave the lightest bulbs (88.83 g) and lowest yield (23.17 t/ha). Because fulvic acid molecules are small, they chelate and move nutrients-phosphorus in particular-from the leaves to the bulb, which is the main sink during the bulbing stage, quite efficiently. It is also known to stimulate root activity and improve how efficiently the plant uses both nutrients and water, so bulbs stay in an active filling phase for longer, ending up bigger and heavier. Mahmoud *et al.* (2019)^[8] and El-Shafie *et al.* (2019)^[5] reported broadly similar gains with fulvic acid in onion.

Marketable yield

The marketable fraction of the crop showed the same lead for T₃, Fulvic acid 0.1% (26.74 t/ha), on par with T₂, PDKV Humi-K 2.5% (25.74), T₁, Humic acid 0.2% (25.21) and T₆, Seaweed extract 0.2% (23.66), against a low of 20.71 t/ha in the control. Fulvic acid's low molecular weight and strong chelating ability appear to have driven this jump in marketable output, by improving nutrient absorption and translocation and, in turn, photosynthate accumulation in the bulb-resulting in better-developed bulbs and fewer culls needing to be discarded at grading. The broadly similar performance of PDKV Humi-K (T₂) and humic acid (T₁)

likely stems from a related mechanism: both are known to encourage root proliferation and more efficient nutrient utilisation, which supports better bulb bolting even without fulvic acid's sharper chelating action. The control (T₇), receiving no biostimulant, fell short on marketable yield simply because bulb development itself remained insufficient. These trends for onion agree with the findings of Mahmoud *et al.* (2019)^[8] and Alhrout and Hasan (2021)^[3] in onion.

Table 4: Effect of foliar application of biostimulants on average bulb weight (g), total yield (t/ha) and marketable yield (t/ha)

Treatments	Avg. bulb weight (g)	Total yield (t/ha)	Marketable yield (t/ha)
T ₁ (Humic acid 0.2%)	118.45	27.14	25.21
T ₂ (PDKV Humi-K 2.5%)	120.34	27.70	25.74
T ₃ (Fulvic acid 0.1%)	122.47	28.87	26.74
T ₄ (Amino acid 0.2%)	95.72	24.17	22.08
T ₅ (Silicic acid 0.5%)	93.00	24.00	21.71
T ₆ (Seaweed extract 0.2%)	104.82	25.57	23.66
T ₇ (Control-water spray)	88.83	23.17	20.71
'F' test	Sig.	Sig.	Sig.
S.Em±	1.31	0.35	0.64
CD (5%)	4.05	1.09	1.97

Grading of onion bulbs: Grading the bulbs into A, B and C categories (Table 5) turned up clear treatment effects across all three grades. T₃ (Fulvic acid 0.1%) put out the largest share of premium A-grade bulbs, 42.35%, clearly ahead of every other treatment, while the control managed only 25.30%. B-grade bulbs peaked under T₆, Seaweed extract 0.2% (39.56%), on par with T₁ and T₂, and were lowest under T₃ (31.88%)-which makes sense, since fulvic acid was pushing more of its bulbs up into the A category instead. The control also carried the largest share of small, C-grade bulbs (31.20%), pointing to weaker bulb development where no biostimulant was used, whereas T₃ again had the fewest (20.76%). Taken together, these numbers suggest fulvic acid was not simply widening the spread of bulb sizes but genuinely pushing overall bulb development upward, likely through the same chelation-driven nutrient availability discussed above-a pattern also reported by Mahmoud *et al.* (2019)^[8] and El-Shafie *et al.* (2019)^[5].

Table 5: Effect of foliar application of biostimulants on grading of onion bulbs (%)

Treatments	A grade (>5.5 cm)	B grade (5.5-4.5 cm)	C grade (4.5-3.5 cm)
T ₁ (Humic acid 0.2%)	33.30(35.24) [^]	38.56(38.37)	22.59(28.32)
T ₂ (PDKV Humi-K 2.5%)	35.41(36.50)	37.10(37.52)	21.36(27.48)
T ₃ (Fulvic acid 0.1%)	42.35(40.59)	31.88(34.35)	20.76(27.04)
T ₄ (Amino acid 0.2%)	32.59(34.81)	35.05(36.30)	25.60(30.40)
T ₅ (Silicic acid 0.5%)	32.80(34.51)	35.66(36.67)	23.21(28.02)
T ₆ (Seaweed extract 0.2%)	32.11(34.51)	39.56(38.97)	22.08(28.02)
T ₇ (Control-water spray)	25.30(30.18)	35.85(36.77)	31.20(33.96)
'F' test	Sig.	Sig.	Sig.
S.Em±	0.92	0.67	1.06
CD (5%)	2.82	2.08	3.27

([^] Figures in parentheses are arc sine transformation)

Splitting bulbs: Bulb splitting also differed significantly across treatments (Table 6), with T₆ (Seaweed extract 0.2%) keeping it lowest at 1.18%, on par with T₄, Amino acid 0.2% (1.25%), against a high of 2.96% in the control. Splitting happens when a bulb ends up with more than one growing point instead of one, usually because the hormonal balance driving growth has shifted and apical dominance

has broken down. Seaweed extract's effect here likely traces back to the same cytokinin activity discussed earlier-by helping the primary growing point hold its dominance, it appears to keep secondary growing points from taking off, giving more compact, evenly formed bulbs. Abbas *et al.* (2020)^[1] reported a similar reduction in splitting with seaweed extract.

Table 6: Effect of foliar application of biostimulants on splitted bulbs (%)

Treatments	Splitted bulbs (%)
T ₁ (Humic acid 0.2%)	1.60(1.26) [#]
T ₂ (PDKV Humi-K 2.5%)	1.30(1.14)
T ₃ (Fulvic acid 0.1%)	2.34(1.53)
T ₄ (Amino acid 0.2%)	1.25(1.12)
T ₅ (Silicic acid 0.5%)	1.85(1.36)
T ₆ (Seaweed extract 0.2%)	1.18(1.08)
T ₇ (Control-water spray)	2.96(1.72)
'F' test	Sig.
S.Em±	0.05
CD (5%)	0.14

(# Figures in parentheses are square root transformation)

Economics

Benefit: Cost ratio

Working through the cost and returns for each treatment (Table 7), T₃ (Fulvic acid 0.1%) came out well ahead on both counts-a net monetary return of Rs. 2,17,308 ha⁻¹ and a benefit:cost ratio of 2.67-with T₂ (PDKV Humi-K 2.5%)

close behind at Rs. 2,02,808 ha⁻¹ and a ratio of 2.52. The control brought up the rear, returning only Rs. 1,48,508 ha⁻¹ at a B:C ratio of 2.15. On the whole, spraying Fulvic acid at 0.1% turned out to be the most profitable option among those tested for onion cv. Akola Safed.

Table 7: Effect of foliar application of biostimulants on Benefit : Cost ratio

Treatments	Yield (t/ha)	Cost of cultivation (Rs ha ⁻¹)	GMR (Rs ha ⁻¹)	NMR (Rs ha ⁻¹)	B:C ratio
T ₁ (Humic acid 0.2%)	26.77	1,32,460	3,21,240	1,88,780	2.43
T ₂ (PDKV Humi-K 2.5%)	28.02	1,33,432	3,36,240	2,02,808	2.52
T ₃ (Fulvic acid 0.1%)	28.97	1,30,452	3,47,760	2,17,308	2.67
T ₄ (Amino acid 0.2%)	25.24	1,32,412	3,02,880	1,70,468	2.29
T ₅ (Silicic acid 0.5%)	25.25	1,38,472	3,03,000	1,64,528	2.19
T ₆ (Seaweed extract 0.2%)	25.57	1,32,412	3,06,840	1,74,428	2.32
T ₇ (Control-water spray)	23.17	1,29,532	2,78,040	1,48,508	2.15

Future Scope

There is still room to work out the ideal concentration, spray frequency and growth stage for applying each of these biostimulants, and to see how they behave when combined or applied in sequence rather than alone. It would also help to test them across other onion cultivars, seasons and agro-climatic zones before drawing broader conclusions, and to look more closely at how economically consistent they are under actual farmers' field conditions-something this single-season trial cannot fully answer on its own.

Conclusion

Putting these findings together, no single biostimulant swept every parameter, but clear patterns did emerge. Amino acid (0.2%) gave the tallest plants, Seaweed extract (0.2%) produced the most leaves per plant, and Fulvic acid (0.1%) brought bulbs to harvest earliest. On the yield side, Fulvic acid (0.1%) again led for average bulb weight, total yield, marketable yield and the share of premium A-grade bulbs and Seaweed extract (0.2%) kept bulb splitting to a minimum. Weighing yield performance against the economics of each treatment, Fulvic acid (0.1%) stands out overall as the most effective and profitable biostimulant for boosting growth and yield in onion cv. Akola Safed.

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