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INFLUENCE OF MULCHING AND FOLIAR APPLICATION OF BIO-STIMULANTS ON VEGETATIVE GROWTH OF ONION (*Allium cepa* L.) UNDER SEMI-ARID CONDITIONS OF RAJASTHAN, INDIA

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ABSTRACT

A field experiment was carried out during the *Rabi* seasons of 2024-25 and 2025-26 at the Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) to study the influence of mulching and foliar application of bio-stimulants on growth yield and quality of onion (*Allium cepa* L.) cv. RO-59. The experiment was laid out in a factorial randomized block design with three replications, comprising three mulching treatments (M_0 - without mulch, M_1 - polythene mulch and M_2 - mustard straw mulch) and five bio-stimulant treatments (B_0 - control, B_1 - humic acid @ 0.2%, B_2 - humic acid @ 0.4%, B_3 - seaweed extract @ 0.1% and B_4 - seaweed extract @ 0.3%). Pooled analysis of the two years experimentation revealed that polythene mulch produced the tallest plants (56.13 cm), the highest number of leaves (8.21/plant), chlorophyll content in leaves (0.908 mg/g), leaf area (88.00 cm²/plant) and leaf area index (0.589) and advanced crop maturity by 13 days over the unmulched control. Among the bio-stimulants, foliar application of seaweed extract @ 0.3% recorded the maximum plant height (57.57 cm), leaves (8.22/plant), chlorophyll content (0.904 mg/g), leaf area (87.55 cm²) and leaf area index (0.589) with the earliest maturity (108 days),over other bio-stimulant treatment except humic acid @ 0.4 % which was found statistically at par to it. The improvement in plant height and chlorophyll content under seaweed extract @ 0.3% was 18.19 and 18.64 per cent, respectively, over control in pooled analysis. The study indicates that polythene mulch together with foliar spray of seaweed extract @ 0.3% or humic acid @ 0.4% can be adopted for vigorous vegetative growth of onion under semi-arid conditions.

Key words : Onion, mulching, Humic acid, Seaweed extract, Polar diameter, Chlorophyll, Leaf area index.

Introduction

Onion (*Allium cepa* L.), a member of the family Amaryllidaceae, is one of the most important bulb crops grown in India for domestic consumption as well as export. It is valued for its characteristic flavour and pungency, which arise from sulphur-containing compounds and is used as a salad, a spice and a vegetable throughout the year. Although, India is among the leading producers of onion, the productivity of the crop fluctuates widely and the supply often falls short of demand during certain parts of the year, which calls for the adoption of improved production practices (Sharma and Chauhan, 2024). In the arid and semi-arid tracts of Rajasthan, the crop frequently experiences moisture stress, high evaporative demand, low organic matter in soil and heavy weed infestation, all of which restrict its vegetative growth and consequently, the size of the bulb.

The vegetative phase of onion determines the final bulb yield, because the photosynthates synthesised by the leaves during this phase are later translocated to the bulb. Management practices that favour a larger and more active leaf canopy are therefore expected to improve productivity. Efficient management of soil moisture is one such practice; for example, raising onion on drip-irrigated beds increased the bulb yield from 25.0 to 32.5 t/ha with a markedly higher water use efficiency (Kahlon, 2017).

Mulching is a simple and effective technique that conserves soil moisture, regulates soil temperature and suppresses weeds, particularly in water-scarce regions (Kader *et al.*, 2019 and Shilpa *et al.*, 2022). Both synthetic mulches such as polyethylene films and organic mulches such as crop residues have been used successfully in vegetable production (Choudhary *et al.*, 2022 and Nithisha *et al.*, 2022) and their benefits for onion have been reviewed by Suthar and Rawat (2020).

Bio-stimulants are another group of inputs that have attracted considerable attention in recent years. These are substances or micro-organisms which, when applied to plants, improve nutrient use efficiency, tolerance to abiotic stress and crop quality, irrespective of their own nutrient content (du Jardin, 2015). Seaweed extracts and humic substances are the two most widely used non-microbial bio-stimulants (Akanksha and Dahiya, 2024). Seaweed extracts contain cytokinins, auxins, gibberellins, betaines and a range of mineral nutrients (Khan *et al.*, 2009 and Begum *et al.*, 2018), whereas humic acid exhibits auxin-like activity and stimulates root growth and nutrient uptake (Nardi *et al.*, 2002 and Canellas *et al.*, 2015). Positive responses of onion to seaweed extract (Dogra and Mandradia, 2012; Hidangmayum and Sharma, 2017) and to humic acid (Verma *et al.*, 2023) have been reported, but information on the combined use of mulches and bio-stimulants on the vegetative growth of onion under the semi-arid conditions of Rajasthan is scarce. The present investigation was therefore undertaken to assess the effect of different mulches and foliar application of bio-stimulants on the growth attributes of onion.

Materials and Methods

Experimental site

The field experiment was conducted during the *Rabi* seasons of 2024-25 and 2025-26 at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). Jobner is situated about 50 km west of Jaipur at 26°5′ N latitude and 75°20′ E longitude, at an altitude of 427 m above mean sea level, and falls under Agro-climatic Zone IIIA (Semi-arid Eastern Plain Zone) of Rajasthan. The climate of the region is semi-arid, characterised by extremes of temperature in summer and winter, an average annual rainfall of 350-500 mm received mostly during July to early September, and temperatures that may fall below freezing point in December and January.

Soil and irrigation water

Composite soil samples drawn from 0-15 cm depth before the application of treatments revealed that the soil of the experimental field was loamy sand in texture and slightly alkaline in reaction (pH 8.20 and 8.15), with an ECe of 1.25 and 1.36 dS/m (Richards, 1954). The soil was low in organic carbon (0.20 and 0.18%) (Piper, 1950) and available nitrogen (135.60 and 132.50 kg/ha) (Subbiah and Asija, 1956), low in available phosphorus (16.50 and 15.78 kg/ ha) (Olsen *et al.*, 1954) and medium in available potassium (152.50 and 148.98 kg/ha) (Metson, 1956). The tube-well water used for irrigation had a pH of 7.75 and 7.68, an EC of 1.01 and 1.02 dS/m and an SAR of 5.15 and 5.23 in the two years, respectively, and was classified as C_3S_1 (high salinity and low sodium hazard).

Experimental design and treatments

The experiment was laid out in a factorial randomized block design with three replications and the treatments were allotted to the plots randomly using the random number tables of Fisher and Yates (1963). The treatments comprised three levels of mulching, *viz.*, M_0 - without mulch (control), M_1 - polythene mulch (30 micron) and M_2 - mustard straw mulch (5 t/ha) and five bio-stimulant treatments, *viz.*, B_0 - control (water spray), B_1 - humic acid @ 0.2%, B_2 - humic acid @ 0.4%, B_3 - seaweed extract @ 0.1% and B_4 - seaweed extract @ 0.3%, thus making fifteen treatment combinations and 45 plots. The plot size was 2.0 m × 1.5 m.

Crop management

Onion cv. RO-59, high-yielding red onion variety released by the Rajasthan Agricultural Research Institute, Durgapura, was used in the study. Seeds treated with Thiram @ 2 g/kg were sown on raised nursery beds (3 m × 1 m × 0.15 m) enriched with well-decomposed FYM during the second week of October and seedlings of 8 weeks age (12-15 cm height) were transplanted on 17 and 20 December in 2024-25 and 2025-26, respectively, at a spacing of 15 cm × 10 cm. The field was prepared by ploughing followed by harrowing to a fine tilth. The full dose of phosphorus and potassium and half dose of nitrogen were applied at the time of bed preparation, and the remaining nitrogen was top-dressed later. Polythene mulch was laid on the beds one day before transplanting (16 and 19 December in 2024-25 and 2025-26 respectively), whereas mustard straw mulch was spread between the rows after establishment of the seedlings (28 and 30 December) in the respective years. The bio-stimulants were applied as foliar sprays twice, at about 30 and 45 days after transplanting (17 January,1 February in 2024-25; 20 January,4 February in 2025-26), while the control plots were sprayed with water. Irrigation was given immediately after transplanting and thereafter at 10-12 day intervals, and was stopped 10 days before harvest. Three shallow hoeings were done to control weeds, and Dithane M-45 @ 0.25% as well as insecticide

sprays were applied to manage purple blotch, *Stemphylium* blight and thrips. The crop was harvested on 1st and 3rd May in 2024-25 and 2025-26, respectively.

Observations recorded

Five plants were randomly selected and tagged in each plot for recording the observations. Plant height was measured from the soil surface to the tip of the longest leaf, and the number of functional leaves/plant was counted at 90 DAT. Total chlorophyll content of the fully expanded leaf from the top was estimated at 60 DAT following the method of Arnon (1949), in which 50 mg fresh leaf tissue was extracted in 80% acetone and the absorbance was read at 663 and 645 nm. Leaf area/ plant (cm^2) was also recorded on the tagged plants at 60 DAT and the leaf area index was computed by dividing the leaf area/plant by the ground area occupied by the plant (150 cm^2). The number of days from transplanting to the stage when 60-70 per cent of the tops had fallen was recorded as days taken to maturity.

Statistical analysis

The data of both the years were analysed statistically by the analysis of variance technique for factorial randomized block design (Fisher, 1950) and pooled analysis over the two years was also carried out. The significance of treatment effects was tested by the F-test at 5 per cent level of significance, and the critical difference (CD) was calculated wherever the effects were significant.

Results and Discussion

The data pertaining to the vegetative growth of onion as influenced by mulching and bio-stimulants in the individual years and pooled analysis are presented in Tables 1 to 3 and illustrated in Figs. 1 to 3. Both the factors significantly influenced all the growth attributes studied during both the years and in the pooled analysis.

Plant height and number of leaves

Among the mulches, polythene mulch (M_1) produced the tallest plants (55.21, 57.06 and 56.13 cm) and the maximum number of leaves (8.15, 8.28 and 8.21/plant) during 2024-25, 2025-26 and in the pooled analysis, respectively, followed by mustard straw mulch (M_2), whereas the shortest plants (50.23 cm) with the fewest leaves (7.03/plant) were recorded in the unmulched plots on pooled basis (Table 1, Fig. 1). Polythene mulch thus increased the plant height and number of leaves by 11.75 and 16.79 per cent, respectively, over no mulch. The better growth of plants under polythene mulch may be attributed to the warmer and moister root zone created under the film. Black plastic mulch has been reported to raise the soil temperature by about 1 to 10 °C (Shilpa *et al.*, 2021) and to maintain higher soil moisture with an optimum soil temperature in the root zone (Maurya *et al.*, 2020). During the cool *Rabi* seasons, such conditions promote root growth and nutrient absorption, and consequently enhance cell division and elongation in the shoot. The suppression of weeds under mulch further reduces competition for water and nutrients; mulching along with drip irrigation has been shown to save up to 44 per cent irrigation water and to reduce weed intensity by 95 per cent (Basar *et al.*, 2023). Similar increases in plant height and leaf number of onion under black polythene mulch have been reported by Karangiya *et al.* (2023) and Brar *et al.* (2019), and favourable effects of mulches on onion

Table 1 : Effect of mulching and bio-stimulants on plant height and number of leaves of onion at 90 DAT.

Treatments	Plant height (cm) at 90 DAT			Number of leaves at 90 DAT		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
Mulching						
M_0 (Without mulch)	49.65	50.80	50.23	6.95	7.12	7.03
M_1 (Polythene mulch)	55.21	57.06	56.13	8.15	8.28	8.21
M_2 (Mustard straw mulch)	52.56	53.98	53.27	7.60	7.73	7.67
SEm±	1.16	0.98	0.76	0.16	0.20	0.13
CD (P=0.05)	3.37	2.84	2.15	0.47	0.54	0.36
Bio-stimulants						
B_0 (Control)	47.88	49.53	48.71	7.04	7.20	7.12
B_1 (Humic acid @ 0.2%)	51.14	52.16	51.65	7.40	7.47	7.43
B_2 (Humic acid @ 0.4%)	54.29	55.54	54.91	7.76	7.98	7.87
B_3 (Seaweed extract @ 0.1%)	52.10	53.82	52.96	7.49	7.60	7.54
B_4 (Seaweed extract @ 0.3%)	56.46	58.67	57.57	8.13	8.31	8.22
SEm±	1.50	1.27	0.98	0.21	0.25	0.16
CD (P=0.05)	4.35	3.67	2.78	0.60	0.73	0.46

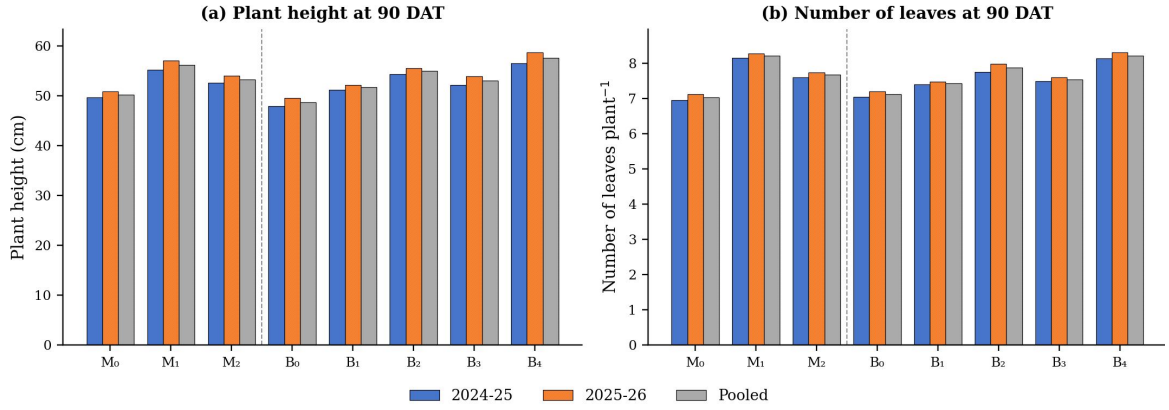


Fig. 1 : Effect of mulching and bio-stimulants on (a) plant height and (b) number of leaves of onion at 90 DAT.

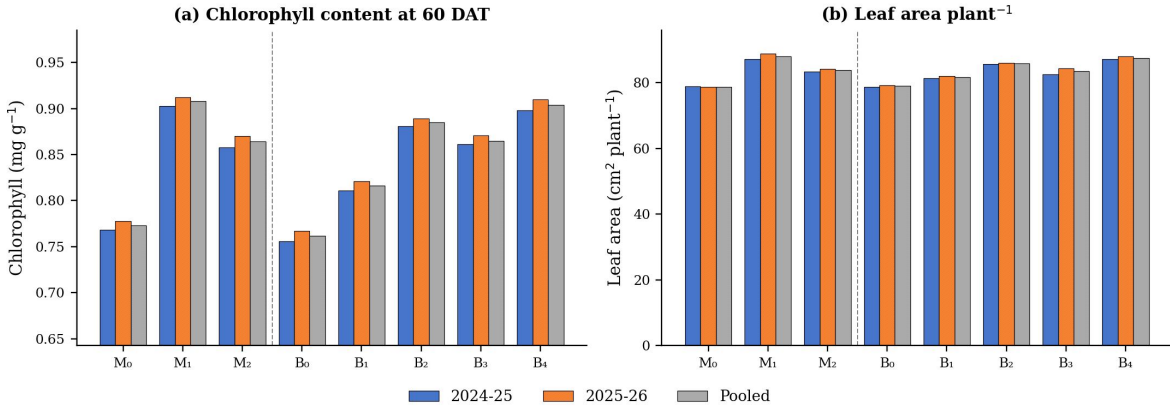


Fig. 2 : Effect of mulching and bio-stimulants on (a) chlorophyll content and (b) leaf area of onion at 60 DAT.

Table 2 : Effect of mulching and bio-stimulants on leaf area and leaf area index of onion at 60 DAT.

Treatments	Leaf Area /plant (cm²)			Leaf Area Index at 60 DAT		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
Mulching						
M_0 (Without mulch)	78.82	78.76	78.79	0.521	0.523	0.522
M_1 (Polythene mulch)	87.16	88.83	88.00	0.581	0.597	0.589
M_2 (Mustard straw mulch)	83.29	84.26	83.78	0.554	0.560	0.557
SEm±	1.27	1.43	0.96	0.009	0.010	0.007
CD (P=0.05)	3.68	4.15	2.71	0.026	0.029	0.019
Bio-stimulants						
B_0 (Control)	78.67	79.28	78.98	0.524	0.531	0.528
B_1 (Humic acid @ 0.2%)	81.39	82.10	81.74	0.536	0.543	0.539
B_2 (Humic acid @ 0.4%)	85.67	86.08	85.87	0.571	0.576	0.573
B_3 (Seaweed extract @ 0.1%)	82.58	84.34	83.46	0.547	0.555	0.551
B_4 (Seaweed extract @ 0.3%)	87.14	87.96	87.55	0.581	0.596	0.589
SEm±	1.64	1.85	1.24	0.011	0.013	0.009
CD (P=0.05)	4.75	5.35	3.50	0.033	0.038	0.025

growth were also observed by Islam *et al.* (2013) and Setyowati *et al.* (2021).

Among the bio-stimulants, foliar application of seaweed extract @ 0.3% (B,,) recorded the maximum plant height (56.46, 58.67 and 57.57 cm) and number of leaves (8.13, 8.31 and 8.22 /plant) during the two years and in the pooled analysis, respectively, but this treatment found was statistically at par with humic acid @ 0.4% (B_2), while the minimum values were recorded under control (Table 1). The increase in plant height and number of leaves with seaweed extract over control was registered 18.19 and 15.45 per cent, respectively, on

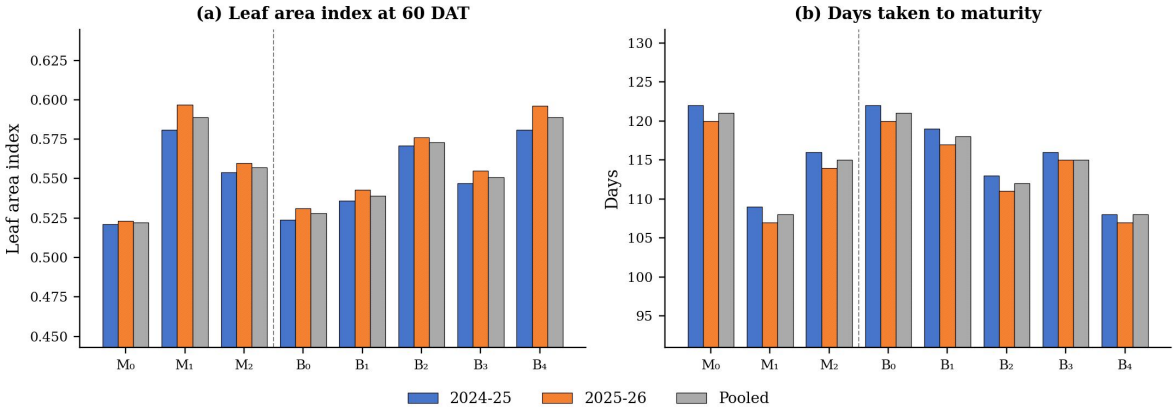


Fig. 3 : Effect of mulching and bio-stimulants on (a) leaf area index at 60 DAT and (b) days taken to maturity of onion.

pooled basis. The growth-promoting effect of seaweed extract can be explained by the presence of natural plant growth regulators such as cytokinins, auxins and gibberellins, together with macro and micronutrients, which stimulate cell division and cell enlargement (Begum *et al.*, 2018; Singh *et al.*, 2019). Hidangmayum and Sharma (2017) obtained the maximum plant height and number of leaves of onion with foliar spray of *Ascophyllum nodosum* extract, Dogra and Mandradia (2012) recorded a marked increase in the shoot height of onion with seaweed extract. Increased plant height with seaweed products has also been reported in tomato (Lal *et al.*, 2025; Selvakumari and Venkatesan, 2017) and broccoli (Baldaniya *et al.*, 2023). The effectiveness of humic acid may be ascribed to its auxin-like activity and its stimulatory effect on root development and nutrient absorption (Nardi *et al.*, 2002), which is in line with the higher plant height and leaf number of onion reported by Verma *et al.* (2023) and of okra by Pasha *et al.* (2021).

Chlorophyll content, leaf area and leaf area index

Polythene mulch (M_1) recorded the highest chlorophyll content in leaves (0.908 mg/g), leaf area (88.00 cm²/plant) and leaf area index (0.589) on pooled basis, and all the three mulching treatments differed significantly from one another in respect of these characters (Tables 2 and 3, Figs. 2 and 3). The corresponding increases over no mulch were 17.46, 11.69 and 12.84 per cent. The higher chlorophyll content and leaf expansion under mulch may be due to the better availability of moisture and nutrients, which favours the synthesis of chlorophyll and the enlargement of leaf cells. Mulches also improve the physical condition of soil; black polythene mulch reduced the bulk density and increased the porosity and water holding capacity of soil under the semi-arid conditions of Rajasthan (Choudhary and Singh, 2021), while organic mulch increased the organic carbon and available nitrogen of soil (Jamir and Dutta, 2020). Enhanced leaf area and leaf area index under plastic

Table 3 : Effect of mulching and bio-stimulants on chlorophyll content and days taken to maturity.

Treatments	Chlorophyll content at 60 DAT (mg/g)			Days taken to maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
Mulching						
M€ (Without mulch)	0.768	0.778	0.773	124	118	120
M□ (Polythene mulch)	0.903	0.912	0.908	109	107	108
M, (Mustard straw mulch)	0.858	0.870	0.864	116	114	115
SEm±	0.010	0.010	0.007	1.97	1.63	1.28
CD (P=0.05)	0.029	0.028	0.020	5.70	4.74	3.62
Bio-stimulants						
B€ (Control)	0.756	0.767	0.762	122	120	121
B□ (Humic acid @ 0.2%)	0.811	0.821	0.816	119	117	118
B, (Humic acid @ 0.4%)	0.881	0.889	0.885	113	111	112
Bƒ (Seaweed extract @ 0.1%)	0.861	0.871	0.865	116	115	115
B„ (Seaweed extract @ 0.3%)	0.898	0.910	0.904	108	107	108
SEm±	0.012	0.013	0.013	2.54	2.11	1.65
CD (P=0.05)	0.037	0.037	0.025	7.36	6.11	4.68

mulch have similarly been observed in okra (Shivaraj *et al.*, 2018) and chilli (Rani *et al.*, 2020).

Among the bio-stimulants, seaweed extract @ 0.3% (B_4) registered the maximum chlorophyll content in leaves (0.898, 0.910 and 0.904 mg/g), leaf area (87.14, 87.96 and 87.55 cm^2/plant) and leaf area index (0.581, 0.596 and 0.589) during the two years and in the pooled analysis, respectively, this treatment was found statistically at par with humic acid @ 0.4%. The higher chlorophyll content under seaweed extract may be linked to the betaines present in the extract, which have been shown to enhance the chlorophyll levels of treated plants by reducing chlorophyll degradation (Blunden *et al.*, 1996). Cytokinins in the extract are also known to delay leaf senescence, thus maintaining a larger functional leaf area for a longer period (Khan *et al.*, 2009). Humic substances activate the plasma membrane Hz -ATPase of root cells, which energises nutrient uptake and promotes lateral root formation (Canellas *et al.*, 2015), resulting in a larger leaf canopy. The present findings are in agreement with Hidangmayum and Sharma (2017), who recorded the highest chlorophyll content in onion leaves with seaweed extract and with the improvement in leaf area and chlorophyll content of okra following humic acid application (Pasha *et al.*, 2021). Positive effects of seaweed extracts on the growth of brinjal (Ramya *et al.*, 2015) and tomato (Kumari *et al.*, 2011) further support these results.

Days taken to maturity

The crop matured earliest under polythene mulch (109, 107 and 108 days), followed by mustard straw mulch (115 days, pooled), whereas it took 120 days to mature in the unmulched plots (Table 3 and Fig. 3). Thus, polythene mulch advanced the maturity of onion by 13 days (10.74 per cent). The earlier maturity under polythene mulch may be attributed to the higher soil temperature under the film during later stage, which hastens physiological processes and the accumulation of heat units, enabling the crop to complete bulb development earlier. Earlier flowering and maturity under polythene mulch have been reported in chilli (Maida *et al.*, 2019), brinjal (Bagele *et al.*, 2022) and strawberry (Yadav *et al.*, 2020).

Among the bio-stimulants, seaweed extract @ 0.3% (B_4) recorded matured earliest (108, 107 and 108 days) during the two years and in the pooled analysis and was statistically at par with humic acid @ 0.4% (B_2). The control plots took the longest time to mature (121 days). The earlier maturity of plants treated with bio-stimulants may be due to their improved nutrient use efficiency and physiological status (du Jardin, 2015). Bio-stimulants improve nutrient acquisition through increased soil enzymatic and microbial activity, modification of root architecture and better micronutrient mobility (Dhanda, 2022) and they help plants cope with environmental stresses (Shreya *et al.*, 2023). The role of seaweed extract and humic acid in improving the growth of vegetable crops has been reviewed by Chaudhari *et al.* (2023).

Conclusion

On the basis of the two-years investigation, it may be concluded that polythene mulch significantly improved the vegetative growth of onion in terms of plant height, number of leaves, chlorophyll content, leaf area, leaf area index, and advanced crop maturity by 13 days over the unmulched control. Among the bio-stimulants, foliar application of seaweed extract @ 0.3% proved most effective for all the growth attributes and was statistically at par with humic acid @ 0.4%. Hence, polythene mulch along with foliar spray of seaweed extract @ 0.3% (or humic acid @ 0.4%) may be recommended for achieving vigorous vegetative growth of onion under the semi-arid conditions of Rajasthan.

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