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Influence of Growth Regulators and Their Time of Application on Yield of Onion

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Abstract: Application of gibberellic acid (GA_3) and indoleacetic acid (IAA) increased the root number, root length and root weight, bulb diameter and bulb weight of onion. The highest bulb diameter and bulb weight was found at 200 ppm each of GA_3 and IAA. Better increase in bulb diameter and bulb weight was achieved by the double dose than single dose. Application of GA_3 and IAA increased the bulb yield. The highest bulb yield (15.57 t ha^{-1}) was observed at 200 ppm GA_3 followed by 200 ppm of IAA (15.53 t ha^{-1}). In conclusion, the yield contributing characters and yield of onion could be manipulated by the application of GA_3 and IAA.

Key words: *Allium cepa*, GA_3, growth regulator, IAA, mode of application

Introduction

Onion (*Allium cepa* L.) is an important spice crop cultivated all over the world. It is also used as a vegetable and salad and has preservative and medicinal values. Onion is widely used to increase taste of different types of food and curries. It grows in almost all the districts of Bangladesh as a winter crop. The total area under onion cultivation is 33,198 hectares and its production is about 1,31,000 metric tons (Anonymous, 1999) which is only half of the demand. The average per hectare yield of onion in Bangladesh is quite low in comparison with that of the other neighboring countries like China, India and Pakistan.

Very little attention has so far been given in producing good quality onion. Some agronomic practices and planting materials that are considered as important factors in onion bulbs as well as onion seed production have been studied extensively. Growth regulators are considered to be the key factors in vegetative growth, flowering, fruit setting and seed production in plants including onion and are well studied. Maleic hydrazide, chlormequat, GA_3 and ethephon at various concentrations have been reported for having remarkable influence on flowering behaviour (Sinnadurai *et al*., 1971; Levy *et al*., 1972; Corgan, 1975). Very few authors reported that foliar spray of growth regulators increased the onion yield (Mathur, 1971; Singh *et al*., 1984). However, the researches carried out to explore feasibility of using growth regulators in increasing the yield of onion are not adequate, especially in conditions of Bangladesh. Although most of these experiments were based on the foliar application of the growth regulators, there are reports that pre-sowing treatments are also effective in enhancing plant growth and yield.

The present investigation was undertaken to study the effects of different concentrations of GA_3 and IAA, applied in different times, on growth and yield of onion cv. Faridpuri to clarify the role of GA_3 and IAA in modifying the morpho-physiological characters and yield of onion.

Materials and Methods

The experiment was conducted during the period from December 2000 to May, 2001 at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. Seedlings (45-day old) of the onion variety Faridpuri were collected from Horticultural Farm in BAU. Two growth regulators viz. Gibberellic acid (GA_3) and Indoleacetic acid (IAA) were applied at 50, 100 and 200 ppm as root treatments while transplanting (T_1), root treatment during transplanting followed by foliar spray at 28 DAT (double application, T_2) and foliar spray at 28 DAT (T_3) only. The experiment was laid out in randomized complete block design (RCBD) with three replications. The experimental plot was first divided into three blocks. Each block was further divided into twenty four unit plots. The size of each unit plot was 1 x 1 m^2. A distance of 1.0 and 0.5 m was maintained between blocks and unit plots, respectively.

The land was ploughed and cross-ploughed several times with a country plough to obtain a good tilth. Cowdung (2 t ha^{-1}) was added before final preparation of land. The weeds and stubbles were completely removed and clods were broken before laying out the land. Urea (108 Kg ha^{-1}), triple superphosphate (TSP) (55 Kg ha^{-1}) and muriate of potash (MP) (104 Kg ha^{-1}) were also applied. Half of the urea, the total quantity of TSP and half of the MP were applied during the final land preparation. The rest of urea and MP were applied as top dressing in two equal installments after 30 and 50 days of transplanting, respectively.

Healthy and disease free seedlings of age 45 days were collected from seed bed and transplanted in the rows on 16 December, 2000. Uniform seedlings were used for transplanting. The distance between row to row and plant to plant was 10 cm and 10 cm respectively. The depth of planting was 1.5 cm from the surface of the soil. Weeding, mulching, gap filling and all other intercultural operations were done as per requirement to keep the crop in a good condition. After each weeding, irrigation was done by watering can. As the plant grew older, irrigation was done by flood method.

A 50 ppm solution was prepared by dissolving 50 mg of GA_3 or IAA completely in a small quantity of absolute alcohol. Then distilled water was added to make the volume 1 litre to get 50 ppm solution. In a similar way, 100 and 200 ppm concentrations were made. Three plants were selected randomly from each plot and uprooted carefully by a "Akhurpi" in order to ensure total root extraction and they were carried to the laboratory in properly labeled polyethylene bags. Then the plants were washed in running tap water to remove soil and blotted with blotting paper to remove the adhering water on them. The plants were separated into leaves, roots and bulbs. Number of leaves and roots per plant was recorded separately. The following characters were studied at maximum plant growth stage (75 DAT): number of leaves per plant, leaf length, leaf diameter, number of roots per plant, root length and root weight per plant. Bulb diameter, bulb weight and yield were recorded at maturity. ANOVA followed by LSD test was used to find out the relative effects of the treatments.

Results

Leaf characters: The average number of leaves per plant varied significantly due to application of GA_3 and IAA (Table 1). Among the growth regulator treatments, 200 ppm of GA_3 induced maximum number of leaves (6.56) followed by 200 ppm of IAA (6.33). There was a gradual increase in leaf number with the concentration of both GA_3 and IAA. Among the time of application, root treatments followed by foliar spray (T_2) had higher number of leaves per plant (Table 1). It indicated that double application of growth regulators was better than single application. The growth regulators had stimulatory effect on leaf elongation (Table 1). The data revealed that GA_3 applied at 200 ppm produced the longest leaf (47.01 cm). Application of IAA also had stimulatory effect on leaf elongation (46.15 cm) of onion plants. A dose dependent effect was observed and GA_3 was slightly superior to IAA. Significant variation in leaf length was

Table 1: Effect of grow regulators and their time of application on leaf characters of onion

Treatments	Conc. (ppm)	Leaf number per plant	Leaf length (cm)	Leaf diameter (cm)
Growth regulator				
Control	0	4.95c	40.22b	0.99b
GA_3	50	5.11bc	42.98ab	1.05b
	100	5.98b	44.44ab	1.15a
	200	6.56a	47.01a	1.19a
IAA	50	5.63bc	43.11ab	1.05b
	100	6.11ab	44.99ab	1.14a
	200	6.33a	46.15a	0.99b
LSD (5%)		0.49	0.42	0.10
Time of application				
Root treatment (T_1)		5.79b	42.46ab	0.96b
Root treatment and spray at 28 DAT (T_2)		6.17a	44.08a	1.15a
Spray at 28 DAT (T_3)		5.96ab	41.21b	0.95b
LSD (5%)		0.52	1.64	0.05

Table 2: Effect of growth regulators and their time of application on root characters of onion

Treatments	Conc. (ppm)	Root number	Root length (cm)	Root weight (g)
Growth regulators				
Control	0	40.22c	10.11b	0.20c
GA_3	50	43.78b	10.78ab	0.21bc
	100	44.67ab	10.22b	0.22bc
	200	43.91b	11.78a	0.25ab
IAA	50	45.44ab	10.40b	0.23abc
	100	45.67ab	10.89ab	0.25ab
	200	46.89a	11.78a	0.27a
LSD (5%)	2.36	1.00	0.04	
Time of application				
Root treatment (T_1)		42.17b	10.79b	0.22b
Root treatment and spray at 28 DAT (T_2)		45.50a	11.853a	0.26a
Spray at 28 DAT (T_3)		44.29a	10.45b	0.25ab
LSD (5%)		1.446	0.703	0.023

Table 3: Effect of growth regulators and their time of application on bulb weight, bulb diameter and yield of onion

Treatments	Conc. (ppm)	Bulb weight (g)	Bulb diameter (cm)	Yield (t ha^{-1})
Growth regulators				
Control	0	10.95c	3.51c	13.59d
GA_3	50	13.72ab	3.88c	15.52a
	100	14.89ab	4.06bc	14.84bc
	200	13.97ab	4.84a	15.57a
IAA	50	14.85a	4.07bc	14.73c
	100	12.96abc	4.50b	15.06b
	200	15.41a	4.92a	15.53a
LSD (5%)		0.225	0.232	0.233
Time of application				
Root treatment (T_1)		11.74c	3.81b	14.73b
Root treatment and spray at 28 DAT (T_2)		15.36a	4.18a	14.99a
Spray at 28 DAT (T_3)		13.20b	4.05ab	14.70b
LSD (5%)		0.138	0.125	0.142

Values with different letter (s) within a column differ significantly at 5% probability (LSD)

found among different times of application (Table 1). Double application (T_2) was more effective than single spray or root treatment. It produced the longest leaf (44.08 cm) and the shortest one was recorded in T_3 (41.21 cm). The data displayed that both GA_3 and IAA significantly increased leaf diameter (Table 1). However, GA_3 displayed slight superiority to IAA. The highest leaf diameter (1.19 cm) was recorded with 200 ppm GA_3 (Table 1). It is evident from this study that 200 ppm of GA_3 and 100 ppm of both GA_3 and IAA had statistically similar values for leaf diameter. Double application was better than single application and spray at 28 DAT was better than application during transplanting of the seedlings (Table 1). The highest leaf diameter (1.15 cm) was found in T_2 (double application).

Root characters: Root number per plant was counted and the data revealed a variation due to the application of GA_3 and IAA (Table 2). Among the treatments, the highest number of roots per plant (46.89) was found in 200 ppm IAA and the lowest (43.78) in 50 ppm GA_3. All the treatments of IAA had equal promotive effect in root generation. However, the untreated plants had the lowest number of 40.22 roots per plant. The average root number per plant varied due to different times of application (Table 2). The highest root number (45.50) per plant was obtained by double application (T_2) and the lowest root number (42.17) was obtained with root treatment (T_1). Significant variation in root length was found due to the application of growth regulators (Table 2). The highest root length (11.78 cm) was recorded with the concentration of 200 ppm of both GA_3 and IAA. It was clear that both the growth regulators increased the length of roots over the control. Unlike root number, GA_3 and IAA had equal effectiveness in root elongation. Root length varied significantly among different times of application. Double application (T_2) was better than single spray. It produced the longest root (11.85 cm). The foliar spray (T_3) was the most ineffective in root elongation (Table 2). Application of growth regulators increased the root weight per plant. The root weight increased with the increase of concentration of the growth regulators (Table 2). IAA was more effective than GA_3. The highest root weight (0.27 gm) was obtained with 200 ppm IAA. The highest root weight/plant (0.26 g) was found in T_2 (double application of growth regulators) while the lowest one was obtained in T_1 (root treatment) (Table 2).

Bulb and yield: Both GA_3 and IAA significantly increased the weight of bulb (Table 3) and 200 ppm of IAA produced the highest bulb weight (15.41 g). There was no statistical difference among the treatments of GA_3 and IAA. However, the growth regulators showed a clear superiority over the control in increasing the weight of bulbs. Application of growth regulators at different times and frequency showed significant difference in bulb weight (Table 3). Double application (T_2) produced the heaviest bulb (15.36 g) while root treatment (T_1) produced the smallest bulb weight (11.74 g). The data revealed that both GA_3 and IAA increased bulb diameter (Table 3). The highest bulb diameter (4.84 cm) was recorded with 200 ppm GA_3 followed by 200 ppm IAA (4.92 cm) with statistically the same rank. The 100 ppm concentration of the two growth regulators were statistically similar to 200 ppm. However, the lowest concentration of the growth regulators and the control did not differ significantly. Time of application of growth regulators had significant effect on bulb diameter of onion (Table 3). The data revealed that bulb diameter was the highest (4.18 cm) in double application (T_2) and the lowest (3.81 cm) in root treatment (T_1).

The data of yield due to the application of growth regulators revealed that both GA_3 and IAA significantly increased the bulb yield (Table 3). The highest bulb yield (15.57 t ha^{-1}) was obtained by 200 ppm GA_3 followed by 200 ppm IAA (15.53 t ha^{-1}). It is evident from this study that 200 ppm both of GA_3 and IAA had equal promotive effect on yield. The other treatments were clearly superior to the control. The average yield differed due to different times of application (Table 3). The highest bulb yield (14.99 t ha^{-1}) was obtained by double application (T_2) and the lowest bulb yield (14.70 t ha^{-1}) was obtained with single spray (T_3). There was no difference between the root treatment and the foliar spray.

Discussion

Both the growth regulators have been found to increase leaf number, length and diameter in this study. Gibberellic acid was more efficient than indoleacetic acid. However, the difference was statistically non-significant (Table 1). Root treatment followed by spray at 28 DAT had much pronounced effect than root treatment and spray at 28 DAT (Table 1). The present results support the earlier reports that 200 ppm of IAA increased the number of

leaves per plant in onion (Mathur, 1971) and GA_3 increased the number of leaves per plant (Shishido and Saito, 1984). The increase in leaf length due to application of GA_3 was also reported earlier (Singh *et al.*, 1983; Salah *et al.*, 1989). However, this was contradicted by the report of decreased leaf number of grapevine due to GA_3 treatment (Khurshid *et al.*, 1992).

A significant increase in number, length and weight of roots was caused by 200 ppm dose of IAA in present study. Both the growth regulators were equally effective in elongating the onion root when applied at 200 ppm. The effect of auxin on the promotion of root initiation of certain plant seedlings has been the subject of several studies (Baninasab and Mobli, 2002). Elongation and increase in number of roots, similar to the present study, was reported in garlic due to IAA treatment (Bareen *et al.*, 1988).

IAA and GA_3 at 200 ppm exhibited the statistically equal efficiency in promoting bulb diameter, weight and yield of onion. Mode of application had influence and root treatment followed by foliar spray was the best application method to obtain higher bulb diameter, weight and yield. Bulb diameter increased due to application of GA_3 in onion (Mathur, 1971). Length and weight of okra fruits were positively influenced at all concentrations of GA_3 application (Rahman *et al.*, 1994). The result of the present study is in agreement with the above reports. Matsubara and Kimura (1991), however, reported that *in vitro* bulbing of onion plantlets from apices was neither promoted nor inhibited by the exogenous application of GA.

Yield of onion has been increased by the application of GA_3 and IAA. Deore and Bharud (1990) also reported the improved yield and physico-chemical characteristics of a leafy vegetable. Awan and Alizia (1989) and Reena *et al.* (1999) reported that 100 ppm IAA increased the yield of rice and soybean, respectively. There is much information regarding the increase of yield by GA_3. Application of 100 ppm GA_3 increased yield in rice (Verma and Singh, 1979; Awan and Alizia, 1989), Soybean (Deotale *et al.*, 1998), onion (Hore *et al.*, 1998) and okra (Rahman *et al.*, 1994). The influence of growth substances in increasing the yield depends on the plant height, leaf number, leaf area and to some extent upon the assimilatory efficiency (Deore and Bharud, 1990). In present study we found higher yield of the plants treated with IAA and GA_3. The yield improvement in this study seems to be correlated with the increased number and size of leaf (Table 1) and leaf area (data not presented) of the growth regulator treated onion plants. It is also evident that IAA and GA_3 at 200 ppm have the potential applicability in the improvement of onion yield in Bangladesh.

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