Original Research Article

Effect of Plant Growth Regulators on Growth and Yield of Onion (*Allium cepa* L.)

Abstract

A field experiment entitled "Effect of Plant Growth Regulators on Growth and Yield of Onion (*Allium cepa* L.)" was conducted during two consecutive years 2019-20 and 2020-21 in rabi season at Agriculture Research Farm, Veer Bahadur Singh Purvanchal University, Jaunpur(U.P) to study the effect of plant growth regulators on growth and quality of onion (*Allium cepa* L.) . The trial was laid down in randomized block design (RBD) with three replications and ten treatments *viz*. T_1- Control- Distilled Water, T_2. GA3- 50 ppm, T_3. GA3-100 ppm, T_4. GA3- 150 ppm, T_5- NAA – 50 ppm, T_6- NAA- 100 ppm, T_7- NAA – 150 ppm, T_8- Kinetin- 50 ppm, T_9- Kinetin- 100 ppm, T_{10}- 150 ppm . Study results revealed that, there was significant statistical variation in plant height (cm), Number of leaves per plant , collor width (cm) collar width (cm) Polar Diamter (cm) Equatorial diameter (cm) , Yield per plot, Marketable yield, Total yield (q/ ha). Basis on the pooled the data study result revealed that maximum plant height(34.05cm at 30 DAT, 51.15 at 60 DAT and 69.90 cm DAT) , number of leaves(6.60at 30 DAT, 8.90 at 60 DAT and 13.60 at 90 DAT) , Fourth leaf length (23.60 cm at 30 DAT, 45.0 cm at 60 DAT and 48. 93 cm at 90 DAT)fourth leaf width(0.52at 30 DAT, 1.32 at 60 DAT, 1.70 at 90 DAT) , collor width (1.24 m), Equatorial diameter (6.35), Polar diameter (5.75 cm), Bulb weight (41.02) , Bulb yield per plot (2.71 kg), marketable yield (257.21) and yield per ha. (270.75 q).

Keywords: Equatorial diameter, Polar diameter, Plant Growth Regulators and Onion

Introduction

Onion (*Allium cepa* L.) is one of the most important bulbous vegetable crop, belongs to family *alliaceae* and is said to be native of Central Asia and Mediterranean region (Ulbricht, 1977). Onion is popularly known as "Queen of Kitchen". Onion is an export oriented crop which is helps in earning valuable foreign exchange for the country. Onions are found in most of the all markets of the world throughout the year and it can be grown under wide range of Agro-climatic conditions of country. Onion crop export is done primarily to Malaysia, Singapore, Philippines, Indonesia, Gulf countries and Pakistan as it is primarily used as seasoning for a wide variety of dishes in kitchen as condiments as well as vegetables, despite its price. Now-a-days white onion is widely used in dehydrated form. **(Hanley and Fenwick, 1985).** In addition to being consumed uncooked, onion serves as a very excellent raw material for the food preparation industries and it can be manufactured into rings, shreds, powder, or onion in vinegar or brine. In India particularly in Maharashtra and Gujarat, the crop has gained importance of cash crop rather than a vegetable crop because of its very high export potential. Onion contains many bioactive compounds and its nutritive value 100 g of edible portion is moisture (86.8 %), Carbohydrates (11.0 g), protein (1.2 g), fiber (0.6 g), mineral (0.4 g), thiamine (0.08 mg), vitamin (11 mg), calcium (180 mg), phosphorus (50 mg), iron (0.7 mg), nicotinic acid (0.4 mg) and riboflavin (0.01 mg) **(Mishra, 1963).** Onion is characterized by their rich content of odoriferous sulfur compounds such as thiosulfinates, sulfides and sulfoxides etc. The eye-irritating chemicals that cause lacrimation and the compound thiosulfinates of cysteine sulfoxides, which create the onion taste and it have antimicrobial qualities. The pungency in onion is caused by a volatile substance known as allyl propyl disulphide, which is useful against many disease causing pathogens such as *Bacillus subtilis*, *Salmonella* sp., and *E. coli*. Onion is well known for its medicinal properties and it plays an important role in preventing heart diseases and other ailments. The medicinal reports have shown that onion can lower blood lipids and prevents the hardening of arteries, cancer, liver and intestinal problems. Besides, onion flavonoids have anti-diabetic, anti-aging, and bacterial inhibition effects. It is said to possess stimulant, diuretic, expectorant properties and is considered useful in flatulence, fevers, heart and dysentery. Onion is a vital rejuvenator and revitalizer (**Rai and Yadav, 2005 and Augusti, 1990**).

In India major onion producing states are Maharashtra, Karnataka, Uttar Pradesh, Gujarat production, Madhya Pradesh and Bihar **(Anonymous 2021b; Anonymous 2021c).**The growth and yield of crops are mainly influenced by genetical and cultural factors. The first factor deals with the various plant breeding techniques used for the improvement of crop varieties. The second factor deals with supply of adequate nutrition, growth substances and plant protection etc. Both these factors have been fully exploited by various research workers in respective field with varied success. The productivity of onion is low as compare to other countries. Beside use of improved varieties, nutrition and irrigation factors play a significant role in increasing productivity. Application of plant growth regulators (PGRs) is one of the easy and sustainable way to enhance onion production and productivity. Now a days, plant growth regulators are playing very important role in increasing the growth and yield of onion crops, if applied in proper concentration and at proper time **(Singh *et al.* 1983)**. S**ingh, (2006), Ibrahim, (2005), Mondal, (2005) and Rashid (2010)**reported that yield of onion can be increased through different PGRs. The growth regulators are considered as a key factor in controlling the vegetative growth, flowering and seed production in plants. Now a days, plant growth regulators speed up production time as well as production of high quality and market friendly products by farmers and manufacturers of agricultural products (**Safdari *et al*., 2014).**

Growth regulators are organic compounds other than nutrients produced in small amount and modifying or regulate growth and development **(Leopold, 1963**). Such organic compounds occurring naturally in plants as well as synthetic other than nutrients which in small amount promote, inhibit or modify any physiological process are called plant growth regulators. The term phytohormone is derived for hormone of plants. Among the growth regulators auxin causes enlargement of plant cell and gibberellins stimulate cell division, cell enlargement or both **(Roy and Nasiruddin, 2011).**

Plant growth regulators are known to regulate and modify various physiological processes in plant and they exhibit their effect on morphological characters and yield. The production and distribution of photosynthates is related to various physiological and biological processes, which are influenced by the plant growth regulators. Plant growth regulators are effectively utilize in vegetable crops for improving seed germination, breaking dormancy, flower induction, increasing fruit setting and yield, fruit ripening, sex expression, hybrid seed production, gametocidal action and in male sterility **(Bajracharya *et al*., 1979; Choudhury and Singh, 1960; Kalloo, 1974)**. Number of techniques are used for application of plant growth substances have been investigated on various vegetables crops. The methods adopted successfully are seed treatment, seedling treatment and foliar application for higher production, whereas post-harvest treatment for increasing shelf-life in various vegetables. Different growth regulators like auxins, gibberellins have been used in onion. Although the naturally occurring (endogenous) growth substances normally control plant growth, modification of growth can be produced by application of exogenous growth substances, some of which may produce beneficial effects (**Weaver, 1972).**Today various plant growth promoters, inhibitors and retardants are available in the market in synthetic forms and they act as mimic as natural hormones. Among the different plant growth regulators, gibberellins fall in growth promoter group. In gibberellins, GA3 is the most important growth regulator for cell elongation and cell enlargement. Gibberellin is beneficial for increase in shoot elongation in many plant species that is especially marked when certain dwarf mutants are treated **(Uddeen, 2009**). Gibberellic acid is an important growth regulator that can be used in a variety of ways to modify plant development, production, and yield-contributing traits. **(Rafeeker et al., 2002).** When applied as a foliar spray, gibberellic acid improves the bulb yield's in onion. **(Asgharzadeh, 2014).**Gibberellins promote shoot growth by accelerating the cell elongation and cell division in sub apical meristem region. It regulates the mitotic activity of sub apical meristem and it increases the size of leaves, breaking dormancy and prevent senescence. GA_3 inhibits senescence mainly by modulation of lipid peroxidation through maintaining high levels of such cellular scavengers as SOD and catalase **(Dhindsa *et al.*, 1982).**

The primary physiological effect of auxins on growth of a plant is the elongation of cells. The cell elongation is activated by auxin in three ways, by increasing osmotic solutes, by decreasing wall pressure and by increasing permeability of cytoplasm to water **(Katyayan, 2001).** Naphthalene Acetic Acid (NAA) belongs to synthetic forms of auxins. It play key role in cell elongation, cell division, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting and flowering (Davies, 1987). NAA had a significant effect on plant height, number of leaves, bulb diameter, bulb weight, bulb yield and total soluble solids of onion **(Bista *et al*.,2022).**

Gibberellic acid, NAA and its combination treatments as pre-harvest foliar application has gained prominence effect in various physiological activities of plants. Application of GA3 and NAA in combination at different leaf stages stimulates morphological characters like plant height, number of leaves, bulb diameter, neck thickness, bulb weight and bulb yield. Therefore it is necessary to find out the effective doses of GA3 and NAA in promoting growth and yield components and quality of onion.

Nephthalene acetic acid (NAA) cause cell elongation, resulting in curvature of stems, epinasty of leaves, proliferations involving cell division and emergence of adventitious roots, inhibition of buds and regulation of growth **(Thimann and Went, 1934).**Application of NAA, in different concentration the highest bulb length, bulb diameter, bulb weight plantper plantand bulb yield per hectare was recorded by the application of NAA at the rate 100ppm **(Gupta *et al.*, 2022).**

Material and Method

A field experiment was conducted during two consecutive rabi season of 2019-20 and 2020-21 Agriculture Research Farm, Veer Bahadur Singh Purvanchal University, Jaunpur(U.P).. The trial was laid down in randomized block design (RBD) with three replications and ten treatments *viz*. T_1- Control- Distilled Water, T_2. GA3- 50 ppm, T_3. GA3- 100 ppm, T_4. GA3- 150 ppm, T_5- NAA – 50 ppm, T_6- NAA- 100 ppm, T_7- NAA – 150 ppm, T_8- Kinetin- 50 ppm, T_9- Kinetin- 100 ppm, T_{10}- 150 ppm . The crop was raised at spacing of 20 cm x 10 cm and plot size of 1x1m. Standard culture practices recommended for onion was followed uniformly in all experimental plots.

Table 1. Details of treatments.

Treatment	Doses
T1 =Control	Distilled water
T2= GA3	50 ppm
T3 = GA3	100 ppm
T4= GA3	150 ppm
T5 =NAA	50 ppm
T6= NAA	100 ppm
T7= NAA	150 ppm
T8= Kinetin	50 ppm
T9= Kinetin	100 ppm
T10 =Kinetin	150 ppm

Observation recorded

1.Plant height (cm) – Five plants were randomly selected from each plot, tagged permanently and used for measurement of the plant height with the help of meter scale and then average plant height was calculated.

2. Number of leaves per plant –Number of leaves in selected plants were counted at the time of harvesting and then averaged.

3. Fourth Leaf length (cm) –Leaf length of selected plants was measured with the help of centimetre scale and the average number of leaves per plant was worked out.

4. Fourth Leaf width (cm) – Leaf width of selected plant was measured with the help of centimetre scale and average leaf width was calculated.

5. **Total soluble solids (T.S.S.)** - A hand refractometer was used to estimate the total soluble solids in bulbs that were selected at random from each plot.

1. 6. **Collar width (cm)-** The color width of fully matured bulb from five plants of each treatment was taken by using vernier calipers.

2. **Fourth leaf length (cm)-** The fourth emerged leaf of every selected plant of each treatment was tagged and it was measured frequently at seven days interval, when the constant value reached it was taken as the measurement for fourth leaf length.
3. **Yield parameters details**

    1. **Polar diameter of bulb (cm) -** Thebulbobtainedfromobservationplantsweremeasuredfromthebothpolarends withthehelpofverniercaliper.
    2. **Equatorial diameter of bulb (cm) -** Thebulbobtainedfromobservationplantsweremeasuredfromthebothequatorial endswiththehelp ofverniercaliper.
    3. **Average dry weight of bulb (g) -**After recording the fresh weight of bulbs, the bulbs were cut into pieces with knife and kept in verandah for natural drying for 7-8 days. After natural drying, the sample were kept in the hot air over for 12 to 24 hours at 60C till constant weight has been achieved and weighted on digital balance. The average dry weight was calculated by subtracting total weight of dry bulbs by total number of bulbs.

    4. **Marketable yield (t/ha) -** The bulb grade yield of A^{+}, A, B and C were considered for marketable yield.
    5. **Total yield (t/ha) -** The bulb grade A^{+}, A, B, C, D yield were considered under total yield (t/ha).

Biometrical Analysis

Experimental data was subjected to biometrical analysis as per the standard as procedure given by Gomez and Gomez (1984).

Table 2. The result of the treatments based on plant height and number of leaves.

Treatment	Plant Height									Number of leaves								
	At 30DAT			60DAT			90DAT			30DAT			60DAT			90DAT		
	I year	**II year**	**Pooled**	**I year**	**II year**	**Pooled**	**I year**	**II year**	**Pooled**	**I year**	**II year**	**Pooled**	**I year**	**II year**	**Pooled**	**I year**	**II year**	**Pooled**
T1	22.05	21.20	21.63	37.50	35.60	36.55	51.10	50.20	50.65	2.50	2.20	2.35	5.50	5.10	5.30	9.50	10.10	9.80
T2	26.90	26.80	26.85	43.50	44.60	44.05	63.10	65.20	64.15	4.50	4.80	4.65	7.00	6.50	6.75	11.00	11.50	11.25
T3	28.40	29.70	29.05	45.80	47.40	46.60	66.40	67.10	66.75	5.00	5.40	5.20	7.50	7.80	7.65	12.00	12.10	12.05

T4	32.40	32.60	32.50	48.60	50.80	49.70	69.10	69.00	69.05	6.00	6.30	6.15	8.50	8.60	8.55	12.50	13.80	13.15
T5	26.50	28.40	27.45	44.50	46.50	45.50	63.50	66.10	64.80	4.00	5.10	4.55	6.50	7.60	7.05	10.50	11.40	10.95
T6	30.30	31.30	30.80	47.20	49.20	48.20	67.50	68.10	67.80	5.50	6.00	5.75	7.50	8.20	7.85	11.50	12.90	12.20
T7	33.90	34.20	34.05	50.20	52.10	51.15	70.60	69.20	69.90	6.50	6.70	6.60	9.00	8.90	8.95	13.00	14.20	13.60
T8	25.60	27.60	26.60	41.40	43.60	42.50	61.20	63.50	62.35	4.00	4.20	4.10	6.50	6.90	6.70	10.00	10.20	10.10
T9	28.40	28.20	28.30	43.60	46.50	45.05	64.20	65.70	64.95	4.50	4.70	4.60	7.00	7.40	7.20	11.50	11.80	11.65
T10	29.60	31.02	30.31	46.90	48.10	47.50	66.20	66.90	66.55	5.00	5.20	5.10	8.00	7.90	7.95	12.00	12.30	12.15
CV%	**2.556**	**2.391**		**2.321**	**2.971**		**3.017**	**1.805**		**2.508**	**2.506**		**1.393**	**2.56**		**2.946**	**2.041**	
CD %	**0.965**	**0.916**		**1.630**	**2.161**		**2.313**	**1.415**		**0.206**	**0.219**		**0.176**	**0.331**		**0.578**	**0.424**	

Table 3. The result of the treatments based on Fourth Leaf Length, Fourth Leaf Width and Collar Width.

Treatment	Fourth Leaf Length						Fourth Leaf Width								Collar Width					
	At 30DAT	60DAT			90DAT			30DAT			60DAT			90DAT			Collor Width (cm)			
T1	19.50	19.80	19.65	37.20	38.28	37.74	41.28	42.40	41.84	0.40	0.41	0.41	1.10	1.14	1.12	1.34	1.36	1.35	1.11	1.11	1.11
T2	21.40	21.90	21.65	40.20	41.20	40.70	43.20	43.90	43.55	0.44	0.45	0.45	1.15	1.17	1.16	1.47	1.49	1.48	1.13	1.14	1.14
T3	22.20	22.40	22.30	41.00	41.90	41.45	43.90	44.50	44.20	0.46	0.46	0.46	1.19	1.20	1.20	1.48	1.50	1.49	1.15	1.16	1.16

T4	23.00	23.20	23.10	42.50	44.50	43.50	47.80	48.30	48.05	0.49	0.50	0.50	1.25	1.27	1.26	1.67	1.69	1.68	1.20	1.20	1.20
T5	21.00	21.30	21.15	39.00	40.70	39.85	42.60	43.50	43.05	0.43	0.43	0.43	1.13	1.14	1.14	1.44	1.47	1.46	1.13	1.13	1.13
T6	22.70	22.90	22.80	42.00	44.00	43.00	46.00	47.60	46.80	0.47	0.48	0.48	1.25	1.26	1.25	1.56	1.59	1.58	1.18	1.19	1.19
T7	23.40	23.80	23.60	43.00	45.00	44.00	48.50	49.40	48.95	0.51	0.52	0.52	1.30	1.33	1.32	1.70	1.72	1.71	1.24	1.23	1.24
T8	20.60	20.90	20.75	38.40	39.90	39.15	40.90	42.60	41.75	0.41	0.41	0.41	1.11	1.18	1.15	1.38	1.40	1.39	1.12	1.12	1.12
T9	22.12	22.42	22.27	40.70	41.50	41.10	42.80	43.68	43.24	0.45	0.46	0.46	1.18	1.20	1.19	1.40	1.44	1.42	1.15	1.15	1.15
T10	22.50	22.90	22.70	42.10	43.70	42.90	46.50	47.45	46.98	0.47	0.47	0.47	1.20	1.22	1.21	1.52	1.56	1.54	1.17	1.18	1.18
CV%	**2.556**	**2.391**		**2.321**	**2.971**		**3.017**	**1.805**		**1.57**	**3.188**		**3.462**	**2.21**		**2.862**	**2.313**				
CD %	**0.965**	**0.916**		**1.630**	**2.161**		**2.313**	**1.415**		**0.012**	**0.025**		**0.071**	**0.046**		**0.074**	**0.061**				

Table 4. treatments details of various parameter in year interval.

Treatment	Equatorial Diameter			Polar Diameter			Bulb Weight			Bulb Yield (per plot)			marketable bulb yield (q/ha)			Bulb yield (q/ha)		
	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled	I year	II year	Pooled
T1	4.910	4.200	4.56	4.85	4.23	4.54	27.27	27.58	27.42	1.80	1.82	1.81	144.00	145.60	144.80	180.00	182.00	181.00
T2	4.980	4.600	4.79	4.93	4.87	4.90	33.18	33.18	33.18	2.19	2.19	2.19	201.48	201.48	201.48	219.00	219.00	219.00
T3	5.230	5.100	5.17	5.01	5.01	5.01	36.14		36.20	2.39	2.39	2.39	219.42	220.20	219.81	238.50	239.35	238.93
T4	5.860	**6.100**	**5.98**	5.63	5.54	5.59	38.64	38.83	38.73	2.55	2.56	2.56	239.70	240.92	240.31	255.00	256.30	255.65
T5	4.920	4.200	4.56	5.12	5.12	5.12	32.52	32.64	32.58	2.15	2.15	2.15	193.14	193.86	193.50	214.60	215.40	215.00
T6	5.130	5.800	5.47	5.37	5.23	5.30	38.00	38.11	38.05	2.51	2.52	2.51	233.24	233.90	233.57	250.80	251.50	251.15
T7	6.200	6.500	6.35	5.85	5.65	5.75	40.91	41.14	41.02	2.70	2.72	2.71	256.50	257.93	257.21	270.00	271.50	270.75
T8	4.990	4.300	4.65	4.97	4.45	4.71	31.86	32.09	31.98	2.10	2.12	2.11	185.06	186.38	185.72	210.30	211.80	211.05
T9	5.000	4.960	4.98	5.11	4.65	4.88	35.23	35.41	35.32	2.33	2.34	2.33	216.23	217.34	216.78	232.50	233.70	233.10

T10	5.070	5.300	5.19	5.23	4.97	5.10	36.88	37.12	37.00	2.43	2.45	2.44	226.36	227.85	227.11	243.40	245.00	244.20
CV%	0.204	0.259		2.450	2.409		3.487	2.578		3.486	2.578		2.633	2.749		3.487	2.577	
CD%	0.26	0.67		0.204	0.259		2.113	1.57		0.139	0.104		9.629	10.102		13.948	10.362	

Result and Discussion

Effect of plant growth regulators on growth parameters

The different plant growth regulators and their levels on plant height did differ significantly at 30, 60 and 90 DAP on pooled analysis. Whereas, maximum plant height (34.05, 51.15 and 69.90 cm) was recorded under T7 (NAA 150 ppm) followed by (32.50, 49.70 and 69.05 cm) and (30.80, 48.50 and 67.80 cm) T4 (GA3 150 ppm) and T6 (NAA 100 ppm) respectively. The results showed that T_7 (NAA 150 ppm) and ($GA_3$150 ppm) was found effective for increasing the plant height of onion.
Among different levels of plant growth regulators, the maximum number of leaves per plant (13.60) was obtained under NAA 150 ppm in pooled data at 90 DATP, followed by (13.15) in GA3 150 ppm.
Among different levels of plant growth regulators, the maximum leaf length (48.95cm) was obtained under NAA 150 ppm in pooled data at 90 DATP, followed by(48.05cm) GA3 150 ppm.

The collar width of bulb was affected by various concentrations of plant growth regulators. The maximum collar width (1.24 cm) was obtained under NAA 150 ppm in pooled data at 90 DATP, followed by(1.20 cm) GA3 150 ppm.

Similarly, the plant growth regulators and their levels showed a significant effect on the leaf area index at 30, 60 and 90 DATP on a pooled basis Among different levels of plant growth regulators, the maximum leaf width (1.71 cm) was obtained under NAA 150 ppm in pooled data at 90 DATP, followed by(1.68cm) GA_3 150 ppm.

Effect of plant growth regulators on Yield

Similarly, the plant growth regulators and their levels showed a significant effect on the equatorial diameter and polar diameter of the bulb. The equatorial diameter of bulb (6.35 cm) and polar diameter of bulb (5.75 cm) were found significantly higher in NAA 150 ppm on pooled basis followed by (5.98cm) and (5.59) in GA3 150ppm

Significantly maximum values for an average weight of bulb (41.02 g) in NAA 150 ppm followed by (38.73g) in GA3 150 ppm

The different concentrations of plant growth regulators differed significantly in respect to yield of marketable bulb for both the years and in pooled data. The maximum marketable bulb yield (257.21 q/ha) was reported with NAA 150 ppm followed by (240.31 q/ha), whereas, the minimum bulb yield (144.80 q/ha) was registered in control on a pooled basis

The different concentrations of plant growth regulators differed significantly in respect to yield of onion bulb for both the years and in pooled data. The maximum bulb yield (270.75 q/ha) was reported with NAA 150 ppm followed by (255.65 q/ha), whereas, the minimum bulb yield (181 q/ha) was registered in control on pooled basis.

CONCLUSION

On the basis of the results, it could be concluded that, the foliar application of NAA 150 ppm and GA3 150 ppm for the onion crop found to be superior treatment, where it recorded significant maximum plant height number of leaves Collor width, Fouth leaf length fourth leaf width, Equatorial diameter, Polar diameter , Bulb weight , Bulb yield , marketable yield, bulb yield / ha.In glow of the results obtained from two years investigation, it may be inferred that for securing maximum bulb yield. It is advisable to use NAA150 ppm in onion crop under Jaunpuragro-climatic conditions.

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