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Studies on effect of different PGR's and their application method on yield and yield attributing parameters of onion (*Allium cepa* L.) cv. N-53

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Abstract
The present experiment was conducted at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season of year 2022-23 and 2023-24 with onion cultivar N-53. The experiment was comprised of eighteen treatment combinations of GA_3, NAA and Brassinoloides and their application methods with one control (water spray). The outcome showed that because of the impact of PGR's maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm) and number of scales was recorded in P_4 (GA_3 60 ppm). Due to effect of method of application maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm), number of scales was recorded in M_3 (Seedling Dipping + Foliar Spray). Interaction of PGR's and method of application maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm) and number of scales was recorded in P_4M_3 (GA_3 60 ppm - Seedling Dipping + Foliar Spray).

Keywords: Plant growth regulators, Brassinoloides, GA_3, NAA, application methods, onion, yield

Introduction
Onion (*Allium cepa* L.) is one of the most important vegetable crops belonging to family Amaryllidaceae. It is an important bulbous crop used widely both as condiment and vegetable. Onion having unique flavour made it an excellent food source that provides taste to many dishes. The onion is an essential vegetable for the mass, used in salads, pickles, frying, boiling, and pickling, as well as being consumed raw. It has medicinal value it is used in some pharmaceutical preparation. The pungency in onion is due to a volatile oil known as allyl-propyl disulphide. It rejuvenates the body, removes toxins, revitalises the bloodstream and stimulates blood circulation in the body (Tripathi and Lawande, 2006) [18].

The composition of onion varies according to variety, agronomic and environmental conditions of growth. It is a rich source of amino acids, anthocyanin's, flavones and phenolics (Pérez-Gregorio *et al.*, 2014) [12]. The onion bulb is rich in minerals like phosphorous, calcium and carbohydrate (Bhattacharjee *et al.*, 2013) [4]. Common onion ranks medium in the supply of proteins, caloric value and vitamin B and C. Also, onions are a common source of folic acid. However small onions were more nutritive than big onions. Nutritive value of onion (nutritive value per 100 g onion scales) water (89 g), lipids (0.16 g), carbohydrate (8.6 g), fibre (1.8 g), potassium (157 mg), sulphur (70 mg), phosphorus (33 g), calcium (20 g), vitamin C (6.4 g), vitamin E (0.26 g), vitamin B_6 (0.116 g), folic acid (19 mcg), glutamic acid (0.118 g), argentine (0.156 g), lysine (0.055 g) and leucine (0.041 g) estimated by Kumar *et al*. (2019) [7].

According to Anon.., 2022 [1], India ranks first in area (1.9 million hectares) followed by China (1.08 million hectares). In production, India contributes 31.6 million MT of world onion production followed by China at 24.5 million MT**.** Even though the largest onion producer, India significantly lags behind in productivity 17.36 MT/hectare (Anon., 2023) [2, 3]. In Chhattisgarh it is grown in about 23.681 thousand hectares with a production of 393.244 thousand MT productivity 16.61 MT/ha (Anon., 2023) [2, 3].

Since, Onion is one of the largely exported vegetable, the efforts are being made by onion growing countries to produce high yield.

Higher yield can be attained by the use of better cultivars, nutrition, and irrigation. If used in the right concentration and at the right time, plant growth regulators are highly significant in boosting the development and production of onion yield (Singh *et al.* 1983) [15]. PGR is also one of the easiest and cheapest sources to enhance the production of onion to some extent. Now a days, plant growth regulators make it easier for farmers and agricultural product manufacturers to produce high-quality, marketable goods faster (Safdari *et al.*, 2014) [13]. Plant growth regulators have a beneficial effect on yield of onion at low concentration. Keeping above facts its need to identify suitable PGR's and their appropriate combinations, concentration and method of application for enhancing yield of onion under Chhattisgarh condition.

Materials and Methods

The present experiment was conducted at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season of year 2022-23 and 2023-24 to investigate the effect of Brassinoloides, GA_3 and NAA and their method of application on growth parameters of onion (*Allium cepa* L.) cv. N-53. The experiment was conducted in Factorial Randomized Block Design (FRBD) with three replications, which included nineteen treatments namely, T_1 (P_1M_1): BRs 1.0 ppm - Seedling Dipping, T_2 (P_2M_1): BRs 1.5 ppm - Seedling Dipping, T_3 (P_3M_1): GA_3 50 ppm - Seedling Dipping, T_4 (P_4M_1): GA_3 60 ppm - Seedling Dipping, T_5 (P_5M_1): NAA 100 ppm - Seedling Dipping, T_6 (P_6M_1): NAA 200 ppm - Seedling Dipping, T_7 (P_1M_2): BRs 1.0 ppm – Foliar Spray, T_8 (P_2M_2): BRs 1.5 ppm - Foliar Spray, T_9 (P_3M_2): GA_3 50 ppm - Foliar Spray, T_{10} (P_4M_2): GA_3 60 ppm - Foliar Spray, T_{11} (P_5M_2): NAA 100 ppm - Foliar Spray, T_{12} (P_6M_2): NAA 200 ppm - Foliar Spray, T_{13} (P_1M_3): BRs 1.0 ppm – Seedling Dipping + Foliar Spray, T_{14} (P_2M_3): BRs 1.5 ppm - Seedling Dipping + Foliar Spray, T_{15} (P_3M_3): GA_3 50 ppm - Seedling Dipping + Foliar Spray, T_{16} (P_4M_3): GA_3 60 ppm - Seedling Dipping + Foliar Spray, T_{17} (P_5M_3): NAA 100 ppm - Seedling Dipping + Foliar Spray, T_{18} (P_6M_3): NAA 200 ppm - Seedling Dipping + Foliar Spray T_{19} (P_0M_0): Control (water spray). The schedules of different pre and post-sowing cultural operations carried out timely during the crop season. Growth and yield attributing parameters were observed during course of investigation.

Results and Discussion

On the basis of pooled data, the Polar diameter (cm) of onion was recorded highest with treatment T_{16} (5.95 cm) followed by T_{15} (5.66 cm), T_{18} (5.51 cm) and T_{14} (5.51 cm). The lowest result on polar diameter recorded with T_{19} (3.32 cm) control.

The maximum equatorial diameter (cm) was recorded in treatment T_{16} (6.81 cm) followed by T_{14} (6.75 cm), T_{15} (6.60 cm) and T_{13} (6.57 cm). However, minimum equatorial diameter (cm) was recorded with T_{19} (4.21 cm) control.

A minor bulb diameter increase under GA_3 treatment was observed in the present study and might be attributed to cell growth and cell elongation. These findings are in contrast with other studies which noted that GA_3 can affect the growth and development of bulb crops as well as promoting bulb diameter and similar findings were also supported by findings of Shukla *et al*., 2010 [14], Mondal and Shukla, 2005 [10] and Devi *et al.*, 2018 [5].

The maximum weight of fresh bulb was recorded in treatment T_{16} (33.04 g) followed by T_{18} (32.71 g), T_{15} (31.71 g) and T_{17} (31.43 g). However, minimum weight of fresh bulb was recorded with T_{19} (20.64 g) control.

Foliar application of growth regulators recorded the significant difference with respect to fresh weight of onion plant. It may be due to the role of these materials on enhancing cell division activity, increasing of proline accumulation of plant and increasing of endogenous phytohormones i.e., increasing promotion hormones (NAA, and GA_3) and reducing ABA content which found that bio-regulators make a shift in hormonal balance characterized by increasing in endogenous phytohormone in plant. Results of the present investigation were also in confirmatory with the findings of Ledesma *et al*., 2000 [8], Islam *et al*., 2007 [6] and Ouzounidou *et al*., 2011 [11].

The maximum bulb yield per plot was recorded in treatment T_{16} (1.98 kg) followed by T_{18} (1.96 kg), T_{15} (1.90 kg) and T_{17} (1.89 kg). However, minimum bulb yield per plot was recorded with T_{19} (1.24 kg) control.

The maximum bulb yield per hac. was recorded in treatment T_{16} (198.22 q.) followed by T_{18} (196.24 q.), T_{15} (190.27 q.) and T_{17} (188.59 q.). However, minimum bulb yield per hac. was recorded with T_{19} (123.81 q.) control.

Increase in bulb yield with GA_3 application might be due to the fact that GA_3 initiate the physiological process and permeability of cell to produce more food for reserve. The present studies are in congruent with Memane *et al.*, 2008 [9] who reported that increased bulb growth observed in large sized clove due to more reserve food materials might had helped in increasing the overall yield of garlic. Singh *et al.* 1995 [17] have reported that application of growth regulators increases the accumulation of food materials and bulb yield in onion. It can be concluded the GA_3 was found most effective in enhancing the bulb yield.

The maximum weight of dry bulb was recorded in treatment T_{16} (4.48 g) followed by T_{18} (4.33 g), T_{15} (4.22 g) and T_{17} (4.20 g). However, minimum weight of dry bulb was recorded with T_{19} (1.97 g) control.

Ouzounidou *et al*. (2011) [11] agrees to this analogy with the report of the stem elongation of onion and garlic by 35% and 25% as compared to control. There was a significant increase in both dry and fresh shoot biomass of both onion and garlic that led to higher yields in the plots treated with GA_3.

The maximum neck diameter was recorded in treatment T_{16} (2.12 cm) followed by T_{18} (2.09 cm), T_{15} (2.06 cm) and T_{17} (2.01 cm). However, minimum neck diameter was recorded with T_{19} (1.38 cm) control.

The maximum number of scales per bulb was recorded in treatment T_{16} (10.35) followed by T_{18} (10.28), T_{15} (10.19) and T_{17} (10.09 cm). However, minimum number of scales per bulb was recorded with T_{19} (6.28) control.

Singh *et al.*, 2018 [16] reported increased total yield, bulb fresh weight and diameter which may be due to cell division and rapid cell elongation induced by GA_3 and NAA in the growing portion that helped vegetative performance of onion plants resulted in increase the bulb size. Both NAA and Gibberellic acid play a role in auxin production within plant metabolism. The improved vegetative traits of onion improved the photosynthesis in plants leading to accumulation of more photosynthates which in turn increased the number of bulb scales. These research findings are parallel with the findings of Devi *et al.*, 2018 [5].

Table 1: Shows the effects of plant growth regulators and methods on bulb characteristics, including diameters, weights, and yields.

Treatments	Polar diameter (cm)	Equatorial diameter (cm)	Weight of fresh bulb (g)	Bulb yield per plot (kg)	Bulb yield per ha (q)	Weight of dry bulb (g)	Neck diameter (cm)	Number of scales
	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
PGRs								
P_1	4.64	5.79	27.70	1.66	166.20	3.70	1.64	8.44
P_2	4.65	5.79	26.04	1.56	156.25	3.66	1.63	8.31
P_3	4.80	5.90	28.56	1.71	171.39	3.83	1.70	8.62
P_4	5.08	6.15	29.68	1.78	178.09	4.04	1.76	8.89
P_5	4.71	5.91	28.11	1.69	168.64	3.75	1.67	8.56
P_6	5.00	6.06	29.33	1.76	175.96	3.96	1.72	8.80
CD (P=0.05)	NS	NS	1.25	0.08	7.51	NS	NS	NS
Methods								
M_1	4.14	5.36	24.06	1.44	144.35	3.37	1.44	7.33
M_2	4.72	5.85	28.93	1.74	173.57	3.85	1.57	8.33
M_3	5.58	6.58	31.72	1.90	190.34	4.25	2.04	10.14
CD (P=0.05)	0.57	0.60	0.89	0.05	5.31	0.31	NS	0.74
Interaction (P X M)								
P_1M_1	4.08	5.09	23.03	1.38	138.16	3.18	1.41	7.20
P_2M_1	4.00	4.98	21.84	1.31	131.04	3.16	1.40	7.04
P_3M_1	4.14	5.36	24.66	1.48	147.96	3.46	1.45	7.30
P_4M_1	4.18	5.67	25.85	1.55	155.09	3.60	1.52	7.64
P_5M_1	4.12	5.47	23.59	1.42	141.53	3.27	1.43	7.27
P_6M_1	4.32	5.61	25.39	1.52	152.32	3.57	1.47	7.55
P_1M_2	4.49	5.70	28.74	1.72	172.46	3.78	1.53	8.08
P_2M_2	4.43	5.64	25.91	1.55	155.49	3.70	1.53	8.00
P_3M_2	4.61	5.75	29.57	1.77	177.42	3.82	1.58	8.37
P_4M_2	5.11	5.97	30.16	1.81	180.97	4.05	1.64	8.68
P_5M_2	4.53	5.83	29.30	1.76	175.79	3.78	1.56	8.32
P_6M_2	5.17	6.22	29.89	1.79	179.32	3.98	1.61	8.57
P_1M_3	5.35	6.57	31.33	1.88	187.99	4.15	1.99	10.06
P_2M_3	5.51	6.75	30.37	1.82	182.23	4.12	1.95	9.89
P_3M_3	5.66	6.60	31.46	1.89	188.77	4.22	2.06	10.19
P_4M_3	5.95	6.81	33.04	1.98	198.22	4.48	2.12	10.35
P_5M_3	5.49	6.44	31.43	1.89	188.59	4.20	2.01	10.09
P_6M_3	5.51	6.33	32.71	1.96	196.24	4.33	2.09	10.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Control Vs Others								
Control	3.32	4.21	20.64	1.24	123.81	1.97	1.38	6.28
CD (P=0.05)	0.82	0.87	1.29	0.08	7.72	0.46	NS	1.07
CV (%)	7.11	7.48	11.81	11.81	11.81	6.25	8.99	7.28

Conclusions

It was concluded that the impact of PGR's maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm) and number of scales was recorded in P_4 (GA_3 60 ppm). Due to effect of method of application maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm), number of scales was recorded in M_3 (Seedling Dipping + Foliar Spray). Interaction of PGR's and method of application maximum polar diameter (cm), equatorial diameter (cm), weight of fresh bulb (g), bulb yield per plot (kg), bulb yield per hectare (q), weight of dry bulb (g), neck diameter (cm) and number of scales was recorded in P_4M_3 (GA_3 60 ppm - Seedling Dipping + Foliar Spray)

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