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Effect of various concentrations of plant growth regulators on growth, yield and yield attributes of onion (*Allium cepa* L.)

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Abstract
The present investigation entitle Effect of various concentrations plant growth regulators on growth, yield and yield attributes of onion (*Allium cepa* L.) was conducted at Research and instruction-cum farm, Department of Horticulture, BTC, College of Agriculture and Research Station, Bilaspur (C.G.) during *rabi* season of 2022-23. The experiment is carried out in RBD design with three replications and nine treatments. The treatments were created with different doses of plant growth regulators in onion var. N – 53. The treatments application as a seedling treatment and foliar spray at 22 DAT and the recommended package of practices in onion were followed as per requirement. Observations were recorded at 30, 60 and 90 days after transplanting. The results showed that treatment T8, which involved Gibberellic Acid (GA3) at 60 ppm and Naphthalic Acetic Acid (NAA) as a foliar spray at 30 ppm, had the greatest impact on the growth parameters, yield parameters. Specifically, plant height, number of leaves per plant, leaf area per plant, shoot length, neck thickness, polar diameter, equatorial diameter, average weight of bulb, total yield.

Details of treatments

Notations	Treatments
T_1	GA_3 – Seedling treatment @ 40 ppm
T_2	GA_3 – Seedling treatment @ 50 ppm
T_3	GA_3 – Foliar spray @ 75 ppm
T_4	GA_3 - Foliar spray @ 100 ppm
T_5	NAA - Foliar spray @ 100 ppm
T_6	NAA - Foliar spray @ 150 ppm
T_7	GA_3 @ 40 ppm + NAA - Foliar spray @ 20 ppm
T_8	GA_3 @ 60 ppm + NAA - Foliar spray @ 30 ppm
T_9	Control Plot

Keywords: Plant growth regulators, growth, yield, GA3, NAA, onion

Introduction
Onion (*Allium cepa* L.) 2n =16, belongs to family Amaryllidaceae (Alliaceae). The major vegetables grown all over the world among these, onion (*Allium cepa* L.) is one of the most important commercial bulbous and conventional vegetable cum-condiment crop commercially grown in India as a cash crop. It is an indispensable item in every kitchen and used to enhance flavour of different recipes. Therefore, onion is popularly referred as 'Queen of the kitchen.' Onion is used in the preparation of salads, pickles, spices, condiments. Fresh as well as dehydrated onions are the good source of earning foreign exchange.

The nutritive value of onion varies from variety to variety. Nutritionally per 100 g, fresh onion contains about 89.1 g moisture, 40 kcal energy, 9.34 g carbohydrates, 1.1 g protein, 146 mg potassium, 29 mg phosphorus, 23 mg calcium, 7.4 mg ascorbic acid and traces of iron. (Anonymous). Its major value is in flavour. Onion ranks medium in caloric, low in protein and very low in vitamins. The pungency in the onion bulb is due to a volatile oil known as the allyl-propyl – disulphide ($C_6H_{12}S_2$). The colour of the outer skin/yellow colour of onion bulbs is due to quercetin.

India ranks second in the world sharing 11.4 percent in onion export after Netherlands. Among the different states Maharashtra is leading state in terms of (925200 ha.) area and (13301700 M.T./ ha) production (Anonymous 2022) [1]. Other major onion producing states are Bihar,

Gujrat, Karnataka, Orissa, Uttar Pradesh, Andhra Pradesh and Madhya Pradesh. The area of onion in India is 1914.18 thousand hectare and its production is 31272.71 thousand M.T. of bulb (Anonymous 2022) [1]. In Chhattisgarh total area under cultivation is 23681 hectares area and production are 393244 M.T (Anonymous 2022) [1], whereas in Bilaspur onion is grown in (301 ha.) area of with the (3102 M.T/ ha.) production.

Total export of onion to different countries like Bangladesh (37.91%), Malaysia (14.30%), Sri Lanka (11.99%), Nepal (8.14%), United Arab Emirates (8.13%), Indonesia (2.53%), Qatar (2.28%), Hong Kong (2.15%), Kuwait (1.67%) Vietnam social republic (1.36%), Singapore (1.34%) and others (8.2%). The export of onion during 2021-2022 was 15.37 lakh metric tons (Anonymous, 2022) [1]. Bangladesh is the major importer of onion from India and the total import is 658721.58 MT (Anonymous, 2022) [1].

Growth regulators are 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. Plant growth regulators play key role in contributing internal mechanism of plant growth by interacting with key metabolic processes such as nucleic acid metabolism and protein synthesis. Among the growth regulators auxin causes enlargement of plant cell and gibberellins stimulate cell division, cell enlargement or both (Nickell, 1982) [12].

Plant growth regulators (PGR's) are known to improve physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yields. Various plant growth regulators are responsible for stimulate cell division, cell elongation, auxin metabolism altering, cell wall plasticity. They are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, thereby increasing the productivity. In Greece and other European countries the PGRs are commonly used on food crops (onion, Garlic, Melon, Pepper, Celery etc). The application of plant growth regulators is known to play an important role in plant response to various stresses (chakrabarti and Mukerjee, 2003) [6].

Materials and Method

The experiment was conducted at Horticulture Research cum Instructional Farm, Department of Vegetable Science, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur, Chhattisgarh in Rabi 2022-23. Bilaspur The experimental field was well drained with uniform topography. The experiment was laid out in Randomized block design (RBD) with nine treatments and three replications. The treatments were randomly allotted to different plots. The gross plot size measured 2.10 m X 3.0 m, amounting to 6.3 m^2, while the net plot size was 1.80 m X 2.8 m, covering an area of 5.04 m^2, the crop was spaced at 15 cm × 10 cm, and transplanting took place on 07 December, 2022. For fertilizer application, nitrogen, phosphorus and potassium were used at a rate of 125 kg ha^{-1}, 100 kg ha^{-1} and 100 kg ha^{-1}, respectively.

Results

Growth parameters

1. Maximum plant height (28.55 cm), (55.34 cm) and (67.02 cm) at 30, 60 and at 90 DAT respectively was recoded in treatment T_8 [Gibberellic Acid (GA_3) @ 60 ppm + Naphthalic Acetic Acid (NAA) Foliar spray @ 30 ppm] which was significantly superior over other growth regulator treatment but was at par with treatment T_7 [Gibberellic Acid (GA_3) @ 40 ppm + Naphthalic Acetic Acid (NAA) Foliar spray @ 20 ppm]. However the minimum plant height (20.10 cm), (40.26 cm) and (52.86 cm) at 30 DAT, at 60 DAT and at 90 DAT respectively was observed in T_9 (Control Plot). These outcomes are consistent with findings of Chakraborty *et al.* (2008) [7] and Sisodia *et al*. (2012) [13].
2. Maximum number of leaves $plant^{-1}$ (5.18), (8.97) and (11.23) at 30, 60 and at 90 DAT respectively was recoded in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) which was significantly superior over other growth regulator treatment but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm). However the minimum number of leaves $plant^{-1}$ (2.91), (5.00) and (8.10) at 30, 60 and at 90 DAT respectively was observed in T_9 (Control Plot). These findings are in agreement with the findings of Sisodia *et al*. (2012) [13] and Tsiakaras *et al.* (2014).
3. Significantly maximum leaf area $plant^{-1}$ (6.38 cm^2), (23.30 cm^2) and (32.89 cm^2) at 30, 60 and at 90 DAT respectively was recoded in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) which was significantly superior over other growth regulator treatment but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm). However the minimum leaf area $plant^{-1}$ (4.02 cm^2), (17.49 cm^2) and (23.15 cm^2) at 30, 60 and at 90 DAT respectively was observed in T_9 (Control Plot) The results of the present investigation are in accordance with the observations of Dwivedi and Asati (2019) [8] and Sravani *et al.* (2020) [15].
4. Significantly maximum shoot length (1.63 cm), (2.72 cm) and (5.02 cm) at 30, 60 and at 90 DAT respectively was recoded in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) which was significantly superior over other growth regulator treatment but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm). However the minimum shoot length (0.39 cm), (1.48 cm) and (3.79 cm) at 30, 60 and at 90 DAT respectively was observed in T_9 (Control Plot). The results obtained in the present study are supported by the works of Ouzounidou *et al*. (2011) [12].
5. Significantly maximum (13.50mm) neck thickness was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) over other treatments but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (13.20mm). Minimum neck thickness (8.90mm) was observed in treatment T_9 (Control Plot). Similar results were also observed by Kumar *et al.* (2021) [10] and Kumar and Shashidhar (2016) [11].
6. Significantly maximum (128.77) number of days taken to maturity was found in treatment T_9 (Control Plot) over other treatments but was at par with treatment T_1 (GA_3 Seedling treatment @ 40 ppm) (121.01). Minimum number of days taken to maturity (107.01) was observed in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm). Similar result was also reported by Suseela *et al*. (2005) [16].

Yield parameters

1. Significantly maximum (50.46) polar diameter was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) followed by treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (48.67). Minimum polar diameter (30.21) was observed in treatment T_9 (Control

Plot). These outcomes are consistent with findings of Dwivedi and Asati (2019) [8].

2. Significantly maximum (55.97) equatorial diameter was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) over other treatments but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (53.54). Minimum equatorial diameter (38.45) was observed in treatment T_9 (Control Plot). Similar result was also reported by Dwivedi and Asati (2019) [8].
3. Significantly maximum (65.12g) average weight of bulb was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) followed by treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (60.47g). Minimum average weight of bulb (50.12g) was observed in treatment T_9 (Control Plot). The finding of present study is in accordance with those of Kumar and Shashidhar (2016) [11].
4. Significantly maximum (19346.76 kg/ha) total yield was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) over other treatments but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (18197.66 kg/ha). Minimum total yield (14143.39 kg/ha) was observed in treatment T_1 (GA_3 Seedling treatment @ 40 ppm). The results obtained in the present study are supported by the works of Jyoti *et al.* (2018) [9] and Samy *et al.* (2021).
5. Significantly maximum (19.35 t/ha) total yield was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) over other treatments but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (18.20 t/ha). Minimum total yield (14.14) was observed in treatment T_1 (GA_3 Seedling treatment @ 40 ppm). Similar result was also found by Bagale *et al.* (2022) [5] and Manna *et al.* (2013).
6. Significantly maximum (0.91) bulb shape index was found in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) over other treatments but was at par with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) (0.90). Minimum bulb shape index (0.78) was observed in treatment T_9 (Control Plot). Similar results were reported by Bagale *et al.* (2022) [5].

Conclusion

- The observation on Growth Parameters *i.e.* Plant height (cm), Number of leaves plant^{-1}, Leaf area (cm^2 plant^{-1}), Shoot Length (cm), Neck thickness (mm) and Number of days taken to maturity of onion were recorded significantly superior in treatment T_8 [Gibberellic Acid (GA_3) @ 60 ppm + Naphthalic Acetic Acid (NAA) Foliar spray @ 30 ppm] and similar results were found in treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm).
- The Yield parameters were found significantly superior in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) for the following variables *i.e.* Polar diameter (mm), Equatorial diameter (mm), Bulb shape index, Average weight of the bulb (g) and Total yield (kg ha^{-1}) and similar trend find with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm).
- The economics parameter showed highest values in treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) and similar trend find with treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm)
- On the basis of the present investigation, from the overall performance and association studies of all parameters stand could be best recommended to prioritize treatment T_8 (GA_3 @ 60 ppm + NAA Foliar spray @ 30 ppm) for achieving optimal growth, yield, quality, and economic outcomes in onion cultivation. However, treatment T_7 (GA_3 @ 40 ppm + NAA Foliar spray @ 20 ppm) can also be considered as a viable option.

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