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Effect of Foliar Application of bio-regulators (GA_3 and NAA) on Vegetative Growth characters and Establishment of Lemon *Citrus limon* (L.) cv. Eureka under Subtropical Prayagraj Agro Climatic Condition

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ABSTRACT: To improve the vegetative growth of the eureka lemon, studies were performed to standardize the doses of bio-regulators (GA_3 and NAA), experiment was carried out during 2020 September to 2021 February in an open field, Central Research Farm, Department of Horticulture, from, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experimental field was laid out in a randomized block design (RBD) with nine treatments of different concentrations of two kinds of bio regulators, namely NAA and GA_3 with just one variety replicated thrice. The variety used in this experiment was Eureka Lemon. The experiment comprised eight foliar applications consisting of GA_3 @ 10 ppm l^{-1}, 15 ppm l^{-1}, 20 ppm l^{-1}, 25 ppm l^{-1}; NAA @ 20 ppm l^{-1}, 30 ppm l^{-1}, 40 ppm l^{-1}, 50 ppm l^{-1} with Control. Experiment results revealed that the imposition of different treatments had a significant effect on improving vegetative growth and establishment of the eureka lemon plants. The results of the study indicated that vegetative growth parameters viz., maximum number of leaves per plant (66.33), number of branches per plant (21.33), maximum extent in stem girth per plant (3.23 mm), maximum plant spread per plant (62.22 cm) was recorded by treatment NAA @ 50 ppm l^{-1} bio-regulator. Whereas, maximum plant height (60.03 cm), more chlorophyll content in leaves (51.92%) was recorded by treatment GA_3 @ 25 ppm l^{-1} bio-regulator. Because the eureka lemon was just brought into India as a seedless variety, there is a need to research it and screen it in all sorts of regions and climatic circumstances to achieve the optimum growth and development of the eureka lemon.

Keywords: Eureka lemon, Seedlings, GA_3, NAA, Bio-regulators, vegetative growth, establishment.

INTRODUCTION

Citrus belongs to the Rutaceae family, with chromosome number 2n=18 the genera *Citrus* (oranges, mandarins, pomelos, grapefruit, lemons, limes and citrons), *Fortunella* (kumquats) and *Poncirus* (trifoliate oranges) contain the principal commercial species (Swingle and Reese, 1967). The most common commercial citrus species are oranges, mandarins, pomelos, grapefruit, lemons, limes, and citrons. These plants are among the first cultivated fruit crops, having evolved in tropical and subtropical Southeast Asia. India is the world's sixth largest citrus producer. After mango and banana, it is India's third most popular fruit. Citrus fruits are cultivated predominantly in Maharashtra, Andhra Pradesh, Punjab, Karnataka, Uttaranchal, Bihar, Orissa, Assam, and Gujarat in India. At present, India's total citrus fruit production area is 1042.0 thousand hectares (13.3 percent of total fruit production area), with a production of 10090.0 thousand MT (12.4 percent of total fruit output) and a productivity of 9.87 MT/ha (Anon *et al.*, 2014) and during the 2010-11 season, the total area under lemon and lime cultivation in India was 219 hectares, with a production of 2108 tonnes and a productivity of 9.75 t/ha. (NHB 2010-11). Lemon *Citrus limon* (L.) is a prominent prime citrus and is widely produced in India's northern plains, mostly in arid-irrigated regions and the submontane zone. It's particularly interesting because of its high vitamin C concentration (Katz and Weaver, 2003). Global production of citrus fruit has significantly increased during the past few years and has reached 82 million tons in the years 2009–2010, of which 34% of which was used for juice production, yielding about 44% peel as by-product (Li *et al.*, 2006). Lemon juice is extensively employed in the creation of soft beverages, lemonade, and culinary preparations such as pies, cakes, vegetable, fish, meat, and salad meals, and it has particular dietetic and therapeutic properties due to its high vitamin C concentration (Devi *et al.*, 2018). Thomas Garey, who propagated the first Eureka lemon tree, was the inspiration for the name "Garey's Eureka". Because of its constant flavour, firm texture, high oil content and practically year-round growing season, eureka lemon is the standard

commercial lemon cultivar around the world. Eureka lemons are big, having an oblong form and a diameter of 5 cm. They have bright yellow skin with sunken oil glands and a rough surface. The rind is rich in volatile oils, giving it a strong citrus fragrance. Eureka lemons feature a prominent blossom-end knob known as a mammilla and medium-thick white pith. The flesh is juicy and golden, with few to no seeds and a tangy and acidic flavour. It is grown mostly in Gujarat, Andhra Pradesh, Uttar Pradesh, and Assam. Eureka lemons are available all year, with a peak season from late winter to early spring.

Plant growth regulators are artificially generated chemicals that operate in extremely low levels at places other than the site of synthesis to influence various physiological processes that modulate plant growth and development. It is a collection of tiny molecules produced from different key metabolic processes that are structurally unrelated (Santner *et al.*, 2009; Davies, 2010). Plant growth regulators, also known as phytohormones, are organic compounds spontaneously produced in higher plants that govern growth or other physiological processes at a distance from their source and are only active in trace amounts. Plant growth regulators include auxin, gibberellins, cytokinins, ethylene, and growth regulators. Auxins were the first hormones identified in plants, followed by gibberellins and cytokinins. Auxin promotes root development by disrupting the cytokinin-induced root apical dominance (Cline, 2000). Plant growth regulators are used to improve the vegetative growth, production, and quality of numerous horticultural crops. NAA is a popular fertiliser in horticultural crops. The vegetative development of citrus trees is dependent on the nutrients applied to both young and maturing trees (Morgan *et al.*, 2009). It also has an effect on the physiological process, hastens maturity, and produces higher quality fruits, as well as certain other features such as increasing the number of branches, fresh weight, and yield. GA3 is also one of the most significant growth stimulants used in agriculture for a long time. It may increase cell elongation and division, therefore aiding in the growth and development of many plant species. Gibberellins influence shoot elongation, flower initiation, stigma location, fruit set, breaking dormancy and fruit size.

MATERIALS AND METHODS

An experiment entitled "Effect of foliar application of bio-regulators (GA_3 and NAA) on vegetative growth characters and establishment of lemon *Citrus limon* (L.) cv. Eureka", was carried out in the agro-climatic conditions of Prayagraj in the Central Research Farm Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences during 2020-2021. The region is located on the right bank of the Yamuna, 6 kilometres south of Prayagraj city, on the rewa road. It is located at 25°57' North latitude, 81°51' East longitude, and is 98 metres above sea level (MSL) this can represented by Fig. 1. Prayagraj district is located in Uttar Pradesh's subtropical region, which has very hot summers and relatively mild winters. The location's highest temperature ranges from 46°C to 48°C, with temperatures seldom falling below 4°C or 5°C. The relative humidity levels range from 20% to 94%. The average yearly rainfall in this area is about 1013.4 mm. According to Table 1, Randomized Block Design (RBD) with three replications is used to test eight different GA3 and NAA combinations with control. After weighing, the growth regulators were dissolved in a tiny amount of 95% absolute alcohol. Each growth regulator's stock solution was first produced by diluting it with distilled water. Further dilutions of the measured volume of stock solution with distilled water were used to create the desired concentration solution. Spraying was done per the treatment for each plant, using an equal volume of solution for each. A compressed air hand sprayer was used to spray in the evening. The control plant was sprayed with distilled water. Statistical analysis of variance was performed on the data collected throughout the experiment. The significance of the treatments was determined using the 'F' test at a level of significance of 5%.

Fig. 1. Location of Prayagraj district in Uttar Pradesh (India).

Table 1: Details of treatments combination.

Treatments	Treatment Combination
T_0	Control
T_1	GA_3 @ 10 ppm l^{-1}
T_2	GA_3 @ 15 ppm l^{-1}
T_3	GA_3 @ 20 ppm l^{-1}
T_4	GA_3 @ 25 ppm l^{-1}
T_5	NAA@20 ppm l^{-1}
T_6	NAA@30 ppm l^{-1}
T_7	NAA@40 ppm l^{-1}
T_8	NAA@50 ppm l^{-1}

RESULTS AND DISCUSSION

According to the data in Table 2 and Fig. 2, highest plant height was recorded in treatment T_4 GA_3@ 25 ppm l^{-1} (60.03cm), which was at par with treatment T_1 GA_3@ 10 ppm l^{-1} (57.40 cm), and the lowest plant height was recorded in treatment T_0 control (40.53 cm).

Table 2: Vegetative Growth parameters of eureka lemon seedling by different concentration of bio regulators (GA_3 and NAA).

Notation	Plant Height (cm)	No. of Leaves/plant	No. of branches/plant	Stem girth/plant (cm)	Plant spread/plant (cm)	Chlorophyll content/plant
T_0	40.53	32.66	10.67	2.30	23.93	32.62
T_1	57.40	53.66	11.00	2.63	41.16	33.73
T_2	49.66	50.00	13.67	2.43	30.43	40.98
T_3	45.73	48.00	16.33	2.70	41.27	47.27
T_4	60.03	50.33	15.67	2.90	56.09	51.92
T_5	54.20	50.33	14.33	2.57	29.50	48.45
T_6	44.50	63.33	13.33	2.67	41.91	34.57
T_7	46.30	50.00	20.00	2.60	54.29	40.58
T_8	52.13	66.33	21.33	3.23	62.22	49.27

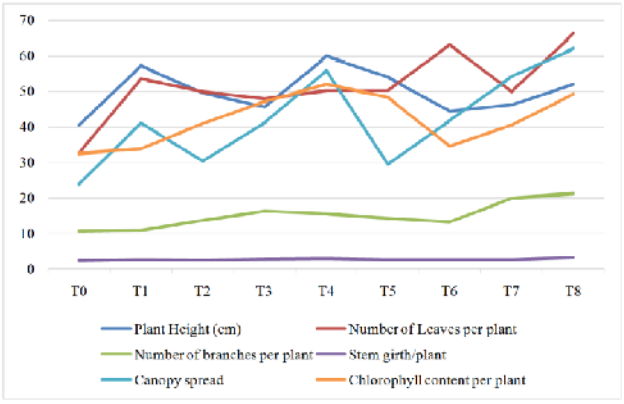

Fig. 2. Vegetative Growth parameters of eureka lemon seedling by different concentration of bio regulators (GA_3 and NAA).

The association of nitrogen in the synthesis of protoplasm and in the primary manufacturing of amino acids, as well as enhanced gibberellin activities, may be ascribed to the rise in vegetative development of the plant with the spray of plant growth regulators. As a result, meristematic activity increased, resulting in enhanced vegetative growth, Kumar *et al.,* (2014) in phalsa. GA_3 increase the plant height by increase in size of meristematic region and cell elongation, Dalal *et al*., (2002) also reported the same results. More number of leaves per plant was recorded in the treatment T_8 NAA@ 50 ppm l^{-1} (66.33), which was at par with treatment T_6 NAA@ 30 ppm l^{-1} (63.33), and less number of leaves per plant was recorded in T_0 control (32.66). The beneficial effects of bio regulators contribute to cell multiplication, which leads to improved photosynthetic activity and its transfer to stimulate vegetative development. As a result of the NAA spray, the number of leaves per shoot rose, the findings are in agreement with result of Singh *et al.,* (2011). More number of branches per plant was recorded in treatment T_8 NAA@ 50 ppm l^{-1} (21.33), which was at par with treatment T_7 NAA@ 40 ppm l^{-1} (20.00), and less number of branches was recorded in treatment T_0 control (10.67). The increase in the number of branches might be attributed to the fact that NAA is a constituent of protein, which is required for protoplasm production, therefore impacting cell division and cell elongation. All of these helped to increase the number of branches per plant. The present findings are in conformed to the report of Moon *et al.,* (2003) in Satsuma mandarin. Highest stem girth was recorded in treatment T_8 NAA@ 50 ppm l^{-1} (3.23 cm), which was followed by treatment T_4 GA3@ 25 ppm l^{-1} (2.90 cm) and the lowest stem girth was recorded in treatment T_0 control (2.30cm). The present findings are supported by Kalalbandi *et al.,* (2003) in Kagzi lime. The increase in stem girth caused by NAA might be attributable to cell expansion rather than cell division, application of NAA growth regulator gave better result in terms of stem girth. It was found that the highest stem girth might be due to the increased concentration in T_8 @ 50 ppm l^{-1}. Maximum plant spread was recorded in the treatment T_8 NAA@ ppm l^{-1} (62.22cm), which was followed by treatment T_4 GA_3@ 25 ppm l^{-1} (56.09cm) and the minimum plant spread was recorded in the treatment T_0 control (23.93cm). The increased plant spread caused by NAA spraying might be attributed to the favourable effect of 50ppm NAA on cell elongation and enlargement. These findings are similar to Kacha *et al.,* (2012) in phalsa. The possible reason of significant increase in number of leaves per plant, number of branches per plant, stem girth, plant spread might be due to the invigoration of the plant's physiological processes and the stimulatory action of NAA on the formation of new cells at a faster rate. These results are consistent with the findings of Tomar *et al*., (2007-2008); Bani and Bhatt (2014); Yadav *et al.,* (2010). Maximum chlorophyll content was recorded in the treatment T_4 GA_3@ 25 ppm l^{-1} (51.92), which was at par with the treatment T8 NAA @50 ppm l^{-1} (49.27) and minimum chlorophyll content was recorded in treatment T_0 control (32.62). The beneficial effect of GA_3 on vegetative plant development may be ascribed to an increase in absorption of these element, which, as

a component of protoplasm's protein component, positively affected chlorophyll concentration in leaves. The findings are in agreement with result of Karole and Tiwari (2016) in ber.

CONCLUSION

From the foregoing discussion it can be concluded that among the different suitable doses of NAA and GA_3 treatment T_8 NAA @ 50 ppm l^{-1} significantly bore maximum number of leaves, branches, stem girth and plant spread, whereas treatment T_4 GA_3@ 25 ppm l^{-1} gave significantly taller plants, maximum of chlorophyll content. Overall, treatment T_8 NAA @ 50 ppm l^{-1} showed better result in the term of vegetative growth. Hence, for better growth and establishment it is recommended to apply the foliar application of bio-regulators at initial stage of eureka lemon seedlings under Prayagraj agro-climatic conditions.

FUTURE SCOPE

The application of NAA enhances root growth, allowing the plant to withstand heavy wind and soil erosion. Besides that, the use of bio regulators which drives gene expression at specific development stage which further regulates hormones synthesis, this will facilitate the crop to flourish under abiotic stresses with minimal yield loses. As eureka lemons are accessible year-round, with a peak season in late winter, this application of bio regulators NAA and GA_3 at higher concentrations may stimulate vegetative development, resulting in a higher yield in the future. As a result, both producers and sellers will see higher returns or profits.

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Conflict of Interest. As a Corresponding Author, I Payel Das, confirm that none of the others have any conflicts of interest associated with this publication.

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