Effect of different IBA concentrations on stemcuttings of Scented Geranium (*Pelargonium graveolens* L.).

ABSTRACT

The present investigation entitled "Effect of different IBA concentrations on stem cuttings of scented geranium (*Pelargonium graveolens* L.)" was carried out at Medicinal and Aromatic Plants Research Station, (MAPRS) Rajendranagar, Sri KondaLaxman Telangana State Horticultural University, Hyderabad during December 2022 to February 2023. The experiments were conducted using a Completely Randomized Design (CRD) with three replications under a shade net house. Each replication consisted of seven treatments, which included a control group and six different concentrations of IBA (500 ppm, 1000 ppm, 1500 ppm, 2000 ppm, 2500 ppm, 3000 ppm). The results indicated that, that among the various IBA concentrations tested, specifically IBA @ 2000 ppm for stem cuttings, proved to be more effective than all other treatments in terms of various rootparameters. It recorded minimum days taken for root initiation and sprouting and also recorded better results for number of roots per cutting, average length of roots per cutting, length of longest root per cuttings, fresh weight of roots per cuttings, dry weight of roots per cuttings.

Keywords: - Scented geranium, Terminal stem cuttings, different concentrations of IBA.

Introduction

Pelargonium graveolens is commonly known as rose scented geranium, as the leaves of the plant produce the fragrance of rose. It belongs to family geraniaceae. It originated from the Republic of South Africa in the Mediterranean climate of Cape Province. Geranium is most important, perennial, high-value aromatic shrub that can reach a height of up to 1.5 m and has spread of 1m. The leaves are velvety to the touch, green, grey, and intensely smelled of roses. They can be large or little, whole or severely serrated. The five-petalled flowers range in color from whitish to pale pink and vary in size from 0.5 to 4 cm. The plant blooms from August to January. When young, its hairy stems are herbaceous; as they grow in age, they turn woody (Sharopov*et al.*, 2014). The oil derived from this plant contains geraniol and citronellol, both of which contribute to its distinct and robust rose-like fragrance. It has several medicinal and aromatic values of commercial importance (Matthews, 1995). Geranium is now indispensable aromatherapy oil and is considered as balancing oil for the mind and body (Dormon and Deans, 2000). The extracts of *Pelargonium graveolens* are

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reported to be used as antibacterial and insecticidal agents (Tabanca *et al.*, 2013), Rose-scented geranium is propagated vegetatively through rooted terminal stem cuttings of 10-15 cm length having 4-6 leaves. Multiplication of geranium through seed is difficult since there is no seed set under plains or hilly conditions and hence vegetative propagation is the only means of prolongation. In order to get uniform plant material of desired genetic constitution on a large scale, vegetative propagation is a must.

Auxins (IBA) has speeding up effect on rooting percentage and development of cuttings, that's why after preparation of cuttings, they are treated with auxins mostly IBA. Plants produce natural auxin in young shoots and leaves, but the syntheticauxin should be used for successful rooting to prevent cuttings death (Kasim and Rayya, 2009; Stefanic *et al*., 2007). Several studies have documented the advantageous impact of auxin application in stimulating the development of adventitious roots in cuttings. Indole butyric acid (IBA) has been successfully used to increase rooting of *Poinsettia pulcherrima* L. (Ramtin *et al*., 2011) and*Stevia rebaudiana* (Debnath, 2008).

Material and methods

The Experiment was carried out at Medicinal and Aromatic Plants Research Station, (MAPRS) Rajendranagar, Hyderabad. The experimental site falls under semi-arid tropical climate with an average rainfall of 800 mm per annum located at an altitude of 542.3 m above mean sea level at latitude of $17^0$19' and longitude of $79^0$23'.

The terminal cuttings of geranium, 10-15 cm length with 2-4 leaves were taken from the matured shoots of past seasons growth. The various concentrations of IBA (500, 1000, 1500, 2000, 2500 and 3000 ppm) a rooting hormone was applied to stimulate root development was prepared by dissolving 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 g of each growth regulator in small quantity of ethanol after dissolving the volume was made up to 1000 ml by adding distilled water to make the exact concentration of IBA. cuttings were dipped in different concentrations of IBA as per treatment for ten minutes. The cuttings under control were dip in distilled water.Treated cuttings were planted in polybags and the collar region of cuttings were pressed firmly.The cuttings were carefully removed from polybags at 45 and 60 days after planting without damaging newly developed root system by cutting the polyethylene bags for recording the various parameters i.e., Days taken for root initiation, number of roots per cutting, average length of roots per cutting, length of longest root per cuttings, fresh weight of roots per cuttings, dry weight of roots per cuttings.

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Results and discussion

Days taken for root initiation

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

Minimum duration of days (9.81) required for root initiation with the application of T_5; IBA @2000 ppm followed by T_6; IBA @2500 ppm (10.47), while longest time (20.60) was noticed in T_1; control.

The early rooting in best treatment (T_5) might be due to the internal auxin concentration sufficient for root induction of cuttings. Thimann (1969) observed that auxin activates the messenger type of RNA, which induces synthesis of specific enzymes to help in cell wall extension by way of insertion of new materials into the cell wall.Since IBA increase cell wall elasticity which accelerate cell division and in turn increase root up to a certain level.Similar findings have been reported by Kazankaya*et a*l. (2005) in case of cultivars of rose, Akshay (2013) in *Piper nigrum* and Shivaji *et al.* (2014).

Number of roots per cutting

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

The data indicated that among different IBA concentrations evaluated, at all the stages of observation, significantly a greater number of roots per cutting (45.68 and 58.40) were observed with application T_5; IBA @2000 ppm followed by T_6; IBA @2500 ppm (42.36 and 55.67) at 45 and 60 DAP respectively, while lowest number was noticed in T_1; control (11.38 and 19.67) at 45 and 60 DAP respectively.

In general, the endogenous auxins reaching the cambial zone may not be adequate for initiation of rooting primordia. With external application of IBA at optimum level, roots were initiated earlier in larger numbers. The exogenous application has supplemented endogenous auxin levels and brought about certain anatomical and physiological changes in number of roots or due to enhanced cell divisions, numerous root primordia are formed from root initials (Rolston *et al*., 1996). The present investigation lends support from the results obtained by Singh, A. K (2001) in (*J.sambac*) 'Double Mogra', Singh (2002) in bougainvillea*var*. Thimma and Rajashekara (2004) in stevia cuttings. Similar findings were reported by Rani *et al*. (2018) in guava.

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Average length of roots per cutting (cm)

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

Perusal of the data indicated that among different IBA concentrations evaluated, significantly maximum average length of roots per cutting(11.46 cm and 13.58 cm) were observed with application T_5; IBA @2000 ppm at par with T_6; IBA @2500 ppm (11.19 cm and 13.25 cm) at 45 and 60 DAP respectively, while least was noticed in T_1; control (10.17 cm and 12.43 cm) at 45 and 60 DAP respectively.

The presence of externally applied hormones boosts hydrolytic activity, resulting in the development of callus tissue and the transformation of meristematic cells into root primordium, expediting the initiation of root formation. This is subsequently accompanied by an elevated rate of respiration and the accumulation of greater amounts of amino acids at their respective bases. The heightened sensitivity of tissues, brought about by an increase in internal free auxin levels, led to an increase in both the quantity and size of roots (Ingle, 2008). Similar findings were observed by Sharma *et al*. (2014) in Apple clonal rootstocks and Bharathy *et al*. (2004) in carnation. These results are supported by the findings of Gupta *et al*. (2005) in nerium, Netam *et al*. (2018) in jasmine, Torkashvand *et al*. (2012) in hibiscus, Bosila*et al*. (2010) in bougainvillea, Susila*et al*. (2013) in adathodaand Parmar*et al*. (2010) in bougainvillea.

Length of longest root per cuttings (cm)

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

The data indicated that among different IBA concentrations evaluated, at all the stages of observation (45 and 60 DAP), significantly maximum length of longest root per cuttings(28.74 cm and 32.00 cm) were observed with application T_5; IBA @2000 ppm followed by T_6; IBA @2500 ppm (25.69 cm and 30.53 cm) at 45 and 60 DAP respectively, while small longest root was noticed in T_1; control (13.49 cm and 19.74 cm) at 45 and 60 DAP respectively.

Auxin induces the breakdown and movement of carbohydrates and nitrogenous compounds, while also promoting the synthesis of new proteins at the cutting's base. This accelerates the processes of cell elongation and division, ultimately leading to the attainment of maximum root length (Singh *et al*., 2003). Increased levels of growth-promoting

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substances, the presence of ample auxin in leaves, efficient mobilization of food reserves, and early initiation of rooting may contribute to the production of a higher number of roots and the achievement of maximum root length in terminal cuttings. Similar results were reported by Ullah *et al*. (2013) in African marigold and Kumar *et al*. (2014) in carnation. Dhruve*et al*. (2018) and Siddiqua*et al*. (2018) observed maximum length of longest root in dragon fruit cuttings when treated with 6000 and 7000 ppm respectively.

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Fresh weight of roots per cuttings (g)

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

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The fresh weight of roots per cuttingswas significantly higher with the application of T_5; IBA @2000 ppm at 45 and 60 DAP (0.659 g and 0.806 g respectively), followed by T_6; IBA @2500 ppm (0.618 g and 0.765 g) at 45 and 60 DAP respectively, while lowest was recorded in T_1; control (0.250 g and 0.328 g) at 45 and 60 DAP respectively.

Comment [M82]: mg L^{-1}
Comment [M83]: mg L^{-1}

The application of auxin treatment led to an increased quantity of roots, potentially fostering their elongation through cellular division (Debnath and Maiti, 1990). This, in turn, could explain the greater fresh weight of the roots. Similarly, highest average fresh weight of root per cutting (0.39 g) was recorded under 5g l^{-1} concentration of IBA in Duranta golden reported by Singh *et al*. (2014), Sharma (2014) in African marigold, Gowda (2017) in carnation and Shahi (2017) in magnolia.

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Dry weight of roots of rooted cuttings (g)

The data recorded on number of days taken for root initiation as influenced by the different concentrations of IBA are presented in Table 1.

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At 45 days after planting, the dry weight of roots of rooted cuttingswas significantly higher with the application of T_5; IBA @2000 ppm (0.224 g), followed by T_6; IBA @2500 ppm (0.210 g), while lowest was noticed in T_1; control (0.085 g).

Comment [M86]: mg L^{-1}
Comment [M87]: the lowest

At 60 days after planting, the dry weight of roots of rooted cuttingswas significantly higher with the application of T_5; IBA @2000 ppm (0.274 g), at par with T_6; IBA @2500 ppm (0.260 g), while lowest was noticed in T_1; control (0.111 g).

Comment [M88]: mg L^{-1}
Comment [M89]: mg L^{-1}
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The likely explanation could be attributed to the action of auxin, which initiates the hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of

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cuttings, subsequently expediting cell elongation and division under conducive conditions (Singh *et al*., 2003). Cell division and cell elongation, consequently, contribute to an increased fresh weight, which in turn results in a higher dry weight of the roots which was reported by Sharma (2014) in African marigolds, Gowda (2017) in carnation, and Shahi (2017) in magnolia.

CONCLUSION

In conclusion, based on the findings of the study entitled, "Effect of different IBA concentrations on stem cuttings of scented geranium (*Pelargonium graveolens* L.)", it can be concluded that among the various IBA concentrations tested, specifically IBA @ 2000 ppm for stem cuttings, proved to be more effective than all other treatments in terms of various root, growth and physiological parameters. It recorded minimum days taken for root initiation and sprouting and also recorded better results for number of roots per cutting, average length of roots per cutting, length of longest root per cuttings, fresh weight of roots per cuttings, dry weight of roots per cuttings, plant height, number of fully expanded new leaves per rooted cuttings, number of sprouts per cutting, lower mortality rate and high absolute growth rate and crop growth rate.

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Table 1; Effect of different IBA concentrations on Days taken for root initiation, number of roots per cutting, average length of roots per cutting in stem cuttings of Scented Geranium (Pelargonium graveolens L.).

Treatments	Days taken for root initiation	Number of roots		Average length of roots	
		45 DAP	60 DAP	45 DAP	60 DAP
T_1 - Control	20.60	11.38	19.67	10.17	12.43
T_2 - IBA @500 PPM	13.55	25.48	39.40	10.40	12.63
T_3 - IBA @1000 PPM	12.50	29.60	42.53	10.61	12.73
T_4 - IBA @1500 PPM	11.58	31.88	44.60	10.86	12.86
T_5 - IBA @2000 PPM	9.81	45.68	58.40	11.46	13.58
T_6 - IBA @2500 PPM	10.47	42.36	55.67	11.19	13.25
T_7 - IBA @3000 PPM	11.94	34.09	49.33	10.87	12.96
Mean	12.92	31.49	44.23	10.79	12.92
SE (m) ±	0.18	0.56	0.67	0.19	0.17
CD at 5%	0.56	1.71	2.07	0.58	0.53

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Comment [M102]: mg L^{-1}

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Table 2; Effect of different IBA concentrations on length of longest root per cuttings, fresh weight of roots per cuttings, dry weight of roots per cuttings instem cuttings of Scented Geranium (Pelargonium graveolens L.).

Treatments	Length of longest root (cm)		Fresh weight of roots (g)		Dry weight of roots (g)	
	45 DAP	60 DAP	45 DAP	60 DAP	45 DAP	60 DAP
T_1 - Control	13.49	19.74	0.250	0.328	0.085	0.111
T_2 - IBA @500 PPM	21.25	26.67	0.452	0.586	0.153	0.199
T_3 - IBA @1000 PPM	22.13	27.88	0.520	0.656	0.177	0.223
T_4 - IBA @1500 PPM	24.55	29.26	0.540	0.678	0.187	0.230
T_5 - IBA @2000 PPM	28.74	32.00	0.659	0.806	0.224	0.274
T_6 - IBA @2500 PPM	25.69	30.53	0.618	0.765	0.210	0.260
T_7 - IBA @3000 PPM	23.39	28.56	0.568	0.690	0.193	0.234
Mean	22.75	27.81	0.515	0.644	0.176	0.219
SE (m) ±	0.32	0.38	0.010	0.010	0.001	0.003
CD at 5%	0.972	1.16	0.030	0.030	0.004	0.010

Comment [M103]: *Pelargonium graveolens*

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Comment [M106]: mg L^{-1}

Comment [M107]: mg L^{-1}

Comment [M108]: mg L^{-1}

Comment [M109]: mg L^{-1}

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References

Akshay, K. R., Raviraja, S. G. and Narayanaswamy, M. 2013. Effect of growth regulators and media on rooting of black pepper (*Piper nigrum* L.) cuttings. *Proceedings of National Seminar on Production of Planting Material in Spices (Malhotra),* Advances in planting material production technology in spices, Calicut. 115-119.

Bharathy, P. V, Sonawane, P. C. and Sasnu, A. 2004. Effect of plant growth regulators, type of cutting and season on rooting of carnation (*Dianthus caryophyllus* L.) cuttings. *Indian Journal of Horticulture*. 61: 338-341.

Bosila, H. A., Zewil, M. A., Hamza, M. A. and Amin, M. M. 2010. Effect of auxins and ascorbic acid on propagation of *Bougainvillea glabra* through stem cuttings. *Journal of Plant Production.* 1(7): 893-901.

Debnath, G. C. and Maiti, S. C. 1990. Effect of growth regulators on rooting of softwood cuttings of guava (*Psidium guajava* L.) under mist. *Haryana Journal of Horticultural Sciences.* 19: 79-85.

Debnath, M. 2008. Clonal propagation and anti-microbial activity of an endemic medicinal plant *Stevia rebaudiana. Journal of Medicinal Plants Research.* 2(2): 45-51.

Dhruve, L., Suchitra, V., Sudhavani V., Subbaramamma, P. and Saravanan, L. 2018. Rooting and shooting behaviour of red and white pulped varieties of dragon fruit (*Hylocereusundatus*) in relation to indole butyric acid concentrations. *International Journal of Agriculture Sciences.* 14(1): 229-234.

Dormon, H. J. and Deans, S. G. 2000. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. *Journal of Applied Microbiology*. 88(2): 308–316.

Gowda, P. G., Dhananjaya, M. V. and Kumar, R. 2017. Effect of Indole-3-Butyric Acid (IBA) on rooting of different carnation (*Dianthus caryophyllus* L.) genotypes. *International Journal of Pure and Applied Bioscience*. 5(2): 1075-1080.

Gupta, Y. N. and Datta, S. K. (2005). Studies on the Effect of auxin on rooting of cuttings of ornamental plants under mist chamber. *BharatiyaVaigyanikEvamAudyogikAnusandhanPatrika.* 13(2): 192-195.

UNDER PEER REVIEW

Ingle, M. R. 2008. Effect of growth regulators and environments on rooting of stevia cuttings (*Stevia rebaudiana*Bertoni). *M.Sc. Thesis*. Department of Agriculture, College of Agriculture. Dharwad.

Kasim, N. E. and Rayya, A. 2009. Effect of different collection times and some treatments on rooting and chemical interminal constituents of bitter almond hardwood cutting. *Journal of agricultural and biological sciences.* 5(2): 116-122.

Kazankaya, A., Yoruk, E. and Dogan, A. 2005. Effect of IBA on rooting of *Rosa canina* hardwood cuttings from lake van region, Turkey. *ActaHorticulturae*. 690: 153-158.

Kumar, R., Ahmed, N., Sharma, O. C. and Lal, S. 2014. Influence of auxins on rooting efficacy in carnation (*Dianthus caryophyllus* L.) cuttings. *Journal of Horticultural Science*. 9(2): 157-160.

Matthews, A. J. 1995. Geranium leaves for cracked nipples. *Australian Journal of Hospital Pharmacy.* 25: 538-539.

Netam, N., Shukla, N., Sharma, G. and Sahu, K. J. 2018. Effect of different IBA concentration on survivability and rooting of Jasmine (*Jasminumsambac* L. Aiton) stem cuttings. *Journal Pharmacognosy and Phytochemistry*. SPI: 614-617.

Parmar, B. R., Patel, V. B., Bhalerao, P. P. and Tank, R. V. 2010. Effect of different plant growth regulators on vegetative propagation of *Bougainvillea peruvianacv*. Torch Glory through hardwood cutting. *The Asian Journal of Horticulture.* 5: 222-24.

Rajashekara. 2004. Standardization of vegetative propagation of stevia (*Stevia rebundiana*Bertoni) through stem cuttings. *M.Sc. (Hort) Thesis*, University of Agricultural Sciences, Bangalore.

Ramtin, A., Khalighi, A., Hadavi, E., Hekmati, J. 2011. Effect of different IBA concentrations and types of cuttings on rooting and flowering *Poinsettia pulcherrima* L. *International Journal of Agri Science.* 1(5): 303-310.

Rani, T. D., Srihari, D., Dorajeerao, A. V. D. and Subbaramamma, P. 2018. Effect of rooting media and IBA treatments on shoot production and survival of terminal cuttings in guava (*Psidium guajava* L.) *cv.* Taiwan Pink. *International Journal of Current Microbiology and Applied Sciences*. 11(7): 2319-7706.

UNDER PEER REVIEW

Rolston, S. H., Carlos, A. F. B. and Carlos, A. P. M. 1996. Adventitious root formation and development in cuttings of *Mussaendaerythrophylla* L. *Horticulture Science*. 31: 1023-1025.

Shahi, Z. G. G., Zarei, H., Alizadeh, M., Babarabie, M. 2017. Evaluation of rooting of stem cuttings of *Magnolia soulangeana* under influence of time and IBA treatment. *Journal of Chemical Health Risks*. 7(4): 259-72.

Sharma, R. 2014. Study on the effect of auxins on rooting, growth and flowering of African marigold (*Tageteserecta* L.) propagated through stem cuttings. *M.Sc. (Hort.) thesis*. Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Sharma, Y., Sharma, D. D. and Singh, K. 2014. Studies on the propagation of Apple clonal rootstock Merton 793 through hardwood cuttings. *Asian Journal of Horticulture*. 9 (1): 128-131.

Sharopov, F. S., Zhang, H. and Setzer, W. N. 2014. Composition of geranium (*Pelargonium graveolens*) essential oil from Tajikistan. *American Journal of Essential Oils and Natural Products*. *2*(2): 13-16.

Siddiqua, A., Thippesha, D., Shivakumar, B. S., Nagarajappa, A. and Ganapathi, M. 2018. *Journal of Pharmacognosy and Phytochemistry.* 7(5): 1595-1598.

Singh, A. K., 2001, Effect of auxins on rooting and survival of Jasmine (*Jasminumsambac* Ait) stem cuttings. *Progressive Horticulture*. 33: 174-177.

Singh, A. K., Singh, R., Mittal, A. K., Singh, Y. P. and Jauhari, S. 2003. Effect of growth regulator in long pepper (*Piper longum* L.). *Progressive Horticulture*. 35: 208-211.

Singh, D. R. 2002. Use of Growth regulator in Rooting of stem cutting of Bougainvillea *var*. Thimma. *Journal of Ornamental Horticulture.* 5: 60-62.

Singh, K. K., Choudhary, T., Kumar, P. and Rawat, J. M. S. 2014. Effect of IBA for inducing rooting in stem cuttings of Golden Duranta. *Hort Flora Research Spectrum*. 3(1): 77-80.

Sivaji, T., Madhavi, K. and Sudhavani, V. 2014. Effect of type of cuttings and IBA concentrations on the propagation of fig (*Ficuscarica*) *cv.* Poona under open conditions. *Trends Bioscience*. 7(11): 1087-1090.

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Stefanic, M., Stamper, F., Veberic, R. and Oster, G. 2007. The level of IAA, IAA sp and some phenolics in cherry rootstock, Gisela, leafy cutting pretreated with IAA and IBA. *ScientiaHorticulturae.* 112: 399-405.

Susila, T. and Reddy, G. S. 2013. Influence of IBA and NAA on Rooting of *Adathodavasica*. *Academic Journal of Plant Sciences.* 6: 61-63.

Tabanca, N., Wang, M., Avonto, C., Chittiboyina, A. G., Parcher, J. F., Carroll, J. F., Kramer, M. and Khan, I. A., 2013. Bioactivity-guided investigation of geranium essential oils as natural tick repellents. *Journal of Agriculture and Food Chemistry*. 25: 1-7.

Thimann, K. V. 1969. The auxins. In Wilkins. 2-45.

Torkashvanda, M. A. and Shadparvar, V. 2012. Rooting in *Hibiscus rosa- sinensis* (yellow double hybrid') by indole butyric acid and rooting substrates. *International Journal of Plant, Animal and Environmental Sciences.* 2(2): 194-197.

Ullah, Z., Abbas, S. J., Naeem, N., Lutfullah, G., Malik, T. and Khan, M. A. U. 2013. Effect of Indole-3-Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) plant growth regulators on marigold (*Tageteserecta* L.). *African Journal of Agricultural Research*. 8(29): 4015-4019.

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