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Effect of indolebutyric acid (IBA) and naphthaleneacetic acid (NAA) plant growth regulaters on Mari gold (*Tagetes erecta* L.)

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This experiment was conducted for the optimization of auxin [indolebutyric acid (IBA) and naphthaleneacetic acid (NAA)] required for the regeneration of Mari gold. Significant differences were observed for bloom flowers. The maximum branches per plant (6.8) were observed at 400 ppm. Maximum flower size (10.7) was exhibited at 100 ppm IBA concentration and minimum flower size (2.8) at 300 ppm. The 200 and 400 ppm IBA concentration showed maximum leaf size (4.0). The maximum leaves per plant (44.0) were observed at 100 ppm IBA concentration while 200 ppm showed minimum leaves per plant (6.0). At 100 ppm IBA concentration maximum plant height (9.40 cm) was observed and minimum plant height (5.92 cm) was recorded at 400. 200 and 300 ppm concentration of IBA have no significant effect on roots per plants (37.0) while 400 ppm has maximum effect on roots per plant (84.4). Root size increased (6.50) at 100 ppm IBA concentration, while increasing the IBA concentration decreases the root size (4.10) respectively. Maximum value (7.2) was observed at 100 ppm IBA for non-bloom flower and minimum value was (3.2) at 300 ppm. Maximum branches per plant (5.0) were recorded at 400 ppm NAA concentration followed by 300 ppm (4.0) while minimum value (3.2) was observed at 200 ppm. The three concentration of NAA 100, 300 and 400 ppm are significantly different from control for flower size and there is no difference between control and 200 ppm concentration of NAA. By dipping the seedling of Mari gold in NAA maximum leaf size (3.20) was recorded at 200 ppm concentration, while minimum leaf size was observed at 400 ppm. Increased in leaves per plant were observed with increase in NAA concentration. Maximum plant height (7.80) was recorded at 100 and 200 ppm NAA concentration while minimum value was (5.0) at 300 ppm concentration. By dipping the seedling in higher concentration of NAA showed the maximum increase in roots per plant (123.2) and root size (6.8). 300 ppm showed maximum value for non-bloom flower and 200 ppm showed the minimum value (3.2).

Key words: Gold, indolebutyric acid (IBA), naphthaleneacetic acid (NAA, auxins.

INTRODUCTION

Marigold (*Tagetes erecta* L.) belongs to family Asteraceae and grown as an ornamental crop for loose flowers, as a landscape plant, and as a source of pigment for poultry feed. Control of flowering is one of the most important practical aspects in application of plant growth regulators. There are many examples of utilization of plant growth hormones to regulate the flowering in aromatic plant (Shukla and Farooqi, 1990), for example,

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application of Ethrel (2-Chloroethyl phosphonic acid), Naphthalene acetic acid (NAA) and Kinetin improved flowering in Jasminum. Kaplan (1960) established that Marigold is a native of central and South America, especially Mexico. From Mexico it spread to different parts of the world during the early part of the 16th century. Both leaves and flowers are equally important from the medicinal point of view. Leaf paste is used externally against boils and carbuncles. Marigold is adaptable to different types of soil conditions and thus can be grown successfully in a wide variety of soils. However, a deep, fertile, friable and well drained soil (pH 7.00 to 7.5) having good water holding capacity, is the most desirable. Loose flowers are sold in the market which is mainly used in making garlands. The flower is also used as cut flowers arrangement. Furthermore, Marigolds are grown for beautification as landscape plants due to its variable height and various colors of flowers. It is highly suitable as a bedding plant, in an herbaceous border and is also ideal for newly planted shrubbery to provide color and fill spaces. French Marigold is ideal for rockeries, edging, hanging baskets and window boxes. Auxin is well known to stimulate the rooting of cuttings (Hartmann et al., 2002). However, it has been found in various studies that rooting percentage and rooting time was poor; of the two auxins tried for root regeneration IBA was more responsive than NAA The most widely used auxin for commercial rooting is IBA (Nickel, 1990). Two synthetic materials, indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA), were even more effective than the naturally occurring or synthetic IAA for rooting. Today, IBA and NAA are still the most widely used auxins for rooting stem cuttings and for rooting tissue-culture-produced micro cuttings Zimmerman and Wilcoxon (1935). It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or endogenous auxins (Gaspar et al., 1988; Stromquist and Hansen, 1980). IBA has been found to occur naturally. The formation of root primordium cells depends on the endogenous auxins in the cutting and on a synergic compound such as a diphenol. These substances lead to the synthesis of ribonucleic acid (RNA), which act upon root primordium initiation (Hartmann et al., 2002). The application of some plant growth retardants, together with auxin, has been used to improve the rooting capacity of cuttings in some species (Davis and Haissig, 1990; Pan and Zhao, 1994). Plant growth regulators have gained wide acceptance for optimizing the yield of plants by modifying growth, development and stress behaviour (Shukla and Farooqi, 1990). Synthetic plant growth regulators, such as auxins, cytokinins and various growth retardants when applied exogenously to the plant, influence various aspects of plant development and biosynthesis of its important components (Shukla and Farooqi, 1990; Kewalanand and Pandy, 1998). Marigold requires a mild climate for luxuriant growth and flowering. Marigold seedlings are easily transplanted and established in field without much mortality. At the time of transplanting, they should be stocky and bear three to four true leaves.

In the present study, the seedlings of Mari gold were treated by plant growth regulators IBA and NAA. The aim of this study was to test the potential effect of plant growth regulators on the Marigold plants and to select its optimum concentration.

MATERIALS AND METHODS

In this study a commercial cultivar *T. erecta* of Marigold was used as plant material and 2 different auxins Alpha-naphtalene acetic acid (NAA), and 3-indole butyric acid (IBA) were used as plant growth regulators. Four different concentrations e.g. 100, 200, 300 and 400 ppm were used as treatments of each plant growth regulators. The stem cuttings of the Marigold plants were treated with each concentration of each plant growth regulators for 1 min and then simultaneously transferred in the pots. These treatments were compared with the control which did not apply any growth regulator. The experiment was conducted in Completely Randomized Design (CRD) and each treatment was replicated 5 times. The recommended agronomic practices were applied equally to all the plants in the pots.

RESULTS AND DISCUSSION

Effect of different concentration of IBA on Marigold cuttings

Through statistical analysis it was observed that significant differences occurred between treatments containing IBA and control, while non-significant differences was observed among three different higher concentration of IBA (200, 300 and 400 ppm) (Table 1) used for bloom flower by dipping the root of Marigold cuttings. The longest flowering period was at 400 ppm although it had no positive effect on flower yield. In fact, late pruning time (near to flowering time) caused longer flowering period that was possibly due to late flower bud information; these results was supported by Saffari et al., (2004) and Mesen (1993) who observed inhibition in shooting with increased concentration of IBA in other species. It was observed that reduction in time of flowering not only affected seed yield but also the color of flowers. The maximum branches per plant (6.8) was observed by the treated seedling with 400 ppm IBA concentration while minimum branches per plant (3.6) was recorded by 300 ppm IBA (Table 1). These results showed that an adequate time is necessary in which branches can grow longer enough having more flower buds resulting in higher yield. Similar result was also reported by Paul et al. (1995). Maximum flower size (10.7) was exhibited at 100 ppm IBA concentration and minimum flower size (2.8) at 300 ppm positive effect on flowering (Table 1). At 100 ppm the flowers were normal and had abundant pollen with increased seed set. Other concentrations and treatment times were not so helpful and had either reduced number of flowers or aborted pollen with no or reduced seed set; these results are

Table 1. Effect of different concentration of IBA on bloom flower, branches plant^{-1}, flower size leaf size and leaves plant^{-1}.

Treatment	Bloom flower	Branches/plant	Flower size	Leaf size	Leaves/plant
Control	0.4^{b}	3.2^{b}	2.4^{b}	2.8^{ab}	27.4^{b}
100 ppm	1.4^{a}	5.0^{ab}	10.7^{a}	3.6^{ab}	44.0^{a}
200 ppm	1.6^{a}	4.2^{b}	3.8^{b}	4.0^{a}	6.0^{c}
300 ppm	1.6^{a}	3.6^{b}	2.8^{b}	2.6^{b}	9.2^{c}
400 ppm	1.6^{a}	6.8^{a}	5.2^{b}	4.0^{a}	30.2^{b}
$LSD_{0.05}$	0.72	2.11	5.35	1.30	8.58

*Means followed by a common letter in the respective column do not differ by $LSD_{0.05}$.

Table 2. Effect of different concentration of IBA on plant height, root plant^{-1}, root size and non-bloom flower.

Treatment	Plant height	Roots/plant	Root size	Non-bloom flower
Control	5.92^{b}	20^{c}	3.60^{d}	4.80^{b}
100 ppm	9.40^{a}	56.8^{b}	6.50^{a}	7.20^{a}
200 ppm	7.80^{ab}	37.4^{bc}	4.10^{cd}	4.20^{b}
300 ppm	7.00^{ab}	37.0^{bc}	5.20^{bc}	3.20^{b}
400 ppm	5.92^{a}	82.4^{a}	6.0^{ab}	4.60^{b}
$LSD_{0.05}$	2.72	22.67	1.13	2.13

*Means followed by a common letter in the respective column do not differ by $LSD_{0.05}$.

supported by Ozel et al. (2006). The 200 and 400 ppm IBA concentration showed maximum leaf size (4.0), while decreasing in IBA concentration the leaf size was also decreased (Table 1). The maximum leaves per plant (4.0) were observed by treating the seedling with 100 ppm IBA concentration while 200 ppm showed minimum leaves per plant (6.0). The effect of different IBA concentrations, leaf size and propagation media on rooting ability of leafy stem cuttings of *Milicea excelsa* was investigated by Ofori (1996). At 100 ppm IBA concentration, maximum plant height (9.40 cm) was observed and minimum plant height (5.92 cm) was recorded at 400 ppm. 200 and 300 ppm concentration of IBA have no significant effect on roots per plants (37.0) while 400 ppm has maximum effect on roots per plant (84.4) (Table 2). Root size increased (6.50) at 100 ppm IBA concentration while increasing the IBA concentration decreases the root size (4.10) respectively. Our results are in agreement with Felker and Clarke (1981), Klass et al. (1987), Ofori et al. (1996), Tchoundjeu and Leaky (1996), Mesen et al. (1997) and Berhe and Negash (1998) who reported differences in rooting frequency depending on the exogenous auxin or combination of auxins used, with IBA often giving the best results. However, Majeed et al. (2009) recorded the highest rooting rate (50%) for *Aesculus indica* cuttings treated with increasing the IBA concentration. Baul et al. (2008) also observed a similar trend in the vegetative propagation of *Stereospermum suaveolens* with cuttings treated with 0.2% IBA producing the longest root. Maximum value (7.2) was observed at 100 ppm IBA for non-bloom flower and minimum value was (3.2) at 300 ppm (Table 2).

Effect of different concentration of NAA on Marigold cuttings

Through mean comparison there are significant differences for bloom flower among treatments containing NAA and control, while non-significant differences among the four treatments of NAA (100, 200, 300, 400 ppm) (Table 3). Maximum branches per plant (5.0) were recorded at 400 ppm NAA concentration followed by 300 ppm (4.0) while minimum value (3.2) was observed at 200 ppm. The three concentration of NAA 100, 300 and 400 ppm are significantly different from control for flower size and there is no difference between control and 200 ppm concentration of NAA (Table 3). NAA caused higher amount of flowers in plants rather than other treatments and also control (Table 4). Farooqi et al. (1993) reported the same result for Kinetin application on Damask rose in India. By dipping the seedling of Marigold in NAA, maximum leaf size (3.20) was recorded at 200 ppm concentration, while minimum leaf size was observed at 400 ppm (Table 3). Increase in leaves per plant was observed with increase in NAA concentration. Waseem et al. (2007), who also found that the lowest concentration of NAA (0.5 mg L^{-1}), when used alone, showed its superiority over all the other concentration of NAA by producing the maximum number of shoots per explants, leaves and

Table 3. Effect of different concentration of NAA on bloom flower, branches plant^{-1}, flower size leaf size and leaves plant^{-1}.

Treatment	Bloom flower	Branches/plant	Flower size	Leaf size	Leaves/plant
Control	0.4^{b}	3.2^{ab}	2.4^{b}	2.84^{ab}	2.74^{a}
100 ppm	2.0^{a}	3.2^{ab}	6.6^{a}	2.60^{ab}	10.6^{b}
200 ppm	1.6^{a}	2.2^{b}	4.9^{ab}	3.20^{a}	9.00^{b}
300 ppm	2.0^{a}	4.0^{a}	6.5^{a}	2.90^{ab}	11.4^{b}
400 ppm	2.0^{a}	5.0^{a}	5.7^{a}	2.30^{b}	14.6^{b}
$LSD_{0.05}$	0.95	1.84	3.05	0.80	7.46

*Means followed by a common letter in the respective column do not differ by $LSD_{0.05}$.

Table 4. Effect of different concentration of NAA on plant height, root plant^{-1}, root size and non-bloom flower.

Treatment	Plant height	Roots/plant	Root size	Non-bloom flower
Control	5.92^{ab}	20.0^{d}	3.6^{b}	4.8^{abc}
100 ppm	7.80^{a}	60.2^{c}	5.2^{ab}	3.8^{bc}
200 ppm	7.80^{a}	85.0^{bc}	6.4^{a}	3.2^{c}
300 ppm	5.00^{b}	89.6^{b}	6.4^{a}	6.2^{a}
400 ppm	7.40^{a}	123.2^{a}	6.8^{a}	5.6^{ab}
$LSD_{0.05}$	2.06	26.70	1.60	2.13

*Means followed by a common letter in the respective column do not differ by $LSD_{0.05}$.

nodes per shoot. Ali et al. (2005) also reported in Chrysanthemum that an increase of NAA in MS medium resulted in decreasing the multiplication rate. Maximum plant height (7.80) was recorded at 100 and 200 ppm NAA concentration while minimum value was (5.0) at 300 ppm concentration (Table 4). By dipping the seedling in higher concentration of NAA showed the maximum increase in roots per plant (123.2) and root size (6.8) (Table 4). The effect of auxin in promoting rooting of cuttings is well known ((Nanda, 1970; Hartmann et al.1997; Husen and Mishra 2001; Husen and Pal 2003;2006;2007), while very little information is available on the effectiveness of auxin in relation to the branch position, 300 ppm showed maximum value for non-bloom flower and 200 ppm showed the minimum value (3.2) (Table 4).

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