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ACCELERATING THE GROWTH OF *ARAUCARIA HETEROPHYLLA* SEEDLINGS THROUGH DIFFERENT GIBBERELLIC ACID CONCENTRATIONS AND NITROGEN LEVELS

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ABSTRACT

A study was conducted to see whether the growth of *Araucaria heterophylla* seedlings could be hastened with the use of different gibberellic acid concentrations and nitrogen levels. The gibberellic acid (GA) concentrations used were 0ppm (control), 100 ppm, 200 ppm and 300 ppm, while nitrogen (N) levels were 0g N pot^{-1} (control), 1.0g N pot^{-1} and 2.0g N pot^{-1}. The effect both the GA and N was substantial for all the growth parameters studied. Maximum plant height (42.4 cm), stem thickness (1.43 cm), lateral branch length (22.7 cm), internode length (8.6 cm), root length (30.9 cm), root thickness (1.18 cm), number of roots (15.3) and plant survival (97.8%) were observed in plants treated with 300 ppm GA, while minimum values for all the mentioned parameters were recorded in control. In case of nitrogen dose, maximum plant height (36.1 cm), stem thickness (1.05 cm), lateral branch length (19.4 cm), internode length (6.2 cm), root length (25.5 cm), root thickness (0.89 cm), number of roots (11.8) and plant survival (98.3%) were observed for plants supplied with 2.0g N per plant, while the minimum for all the above parameters were found in control. The interaction between different gibberellic acid concentrations and nitrogen levels was non significant in case of all the parameters studied.

Keywords: *Araucaria heterophylla*, Norfolk Island pine, gibberellins, GA, nitrogen, growth promotion.

INTRODUCTION

Araucaria heterophylla (Norfolk Island pine) is a charming tall, evergreen and coniferous tree, which reaches a height of 30 meters under favourable conditions. In outdoor landscape, it is used as a specimen plant due to its beautiful form and attractive branches arrangement. The plant has an amicable profile, with whorls of horizontal branches bearing bright green, soft and glossy needles. Small plants are commonly potted and do best as indoor foliage plants. However, Araucaria grows very slow in the pot, especially at the seedling stage and nursery growers have to wait for several years to bring it to marketable size.

Chemical growth regulators especially gibberellins perform an important role in the growth and development of plants. The gibberellins are a rather diverse group of plant growth substances that enhance any physiological or bio-chemical processes in plants. The use of gibberellic acid (GA) for boosting the growth and vigour of various horticultural plants is very old and well documented. It enhances plant growth and internode length by increasing the cell division and enlargement (Feucht and Watson, 1958; Kline, 1958; Yermanos and Knowles, 1960). The application of GA increases cell size, stem height, stem thickness and number of leaves (Boes and Hamner, 1961; Horavka et al., 1962). Singh (1966) reported that GA increased the plant height, length of lateral shoots and brought about early flowering in treated plants. Chang and Park (1977) reported that application GA increased the length of the leaves, flower stalks and yields in young strawberry plants but did not affect the number of leaves. Likewise, Abou-Zied and Bakry (1978) also reported that GA treatment induced stem elongation and slightly reduced the inflorescence diameter but had no effect on leaf area.

Similarly, the key role of nitrogen (N), being a major essential element, is well known in plant growth and development. Its most important function is to stimulate vegetative growth particularly the production of leaves and stems. Plants receiving insufficient nitrogen are usually stunted in growth and possess restricted root system (Khan, 1998). Plant stem girth, shoot length, canopy and other growth parameters significantly increased with nitrogen application (Tripathy, 1962; Bordeionu and Bodi, 1966; Ishtiaq and Rehman, 1977). Kohstall *et al*. (1990) applied nitrogen doses to a number of ornamental shrubs and reported increased fresh weights, number of shoots and other growth parameters with increasing nitrogen levels.

The combination of nitrogen and gibberellins is also important for the regulation and enhancement of plant growth and development. Mehrota and Dadwal (1978) observed that GA applied as a foliar spray supplemented by weekly applications of urea and some trace elements increased the height of teak seedlings, which would allow nursery stock to be transplanted during the same season, reducing costs. Parsad and Singh (1980) found that 10 years old lime tree with foliar application of nitrogen and gibberellic acid resulted in increased shoot length and diameter.

Keeping in view the role of gibberellic acid and nitrogen in plant growth regulation, and the importance of *Araucaria heterophylla* as an ornamental plant, the present study was conducted to see whether quick growth could be achieved with the use of these two, i.e. GA and N. Various levels of GA as well as N were used in order to find out the most suitable dose(s) to achieve fast growth of *Araucaria heterophylla* seedlings. The objective of the investigation was to gain suitable information for the nursery growers, which would enable them to get marketable plants in shortest possible time, thereby reducing their production costs.

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MATERIALS AND METHODS

The experiment was conducted at Ornamental Nursery, Department of Horticulture, NWFP Agricultural University Peshawar during June 2004-05. *Araucaria heterophylla* seedlings of uniform size were planted in 15 cm clay pots in a media consisting of silt, garden soil and farm yard manure at 1:1:1 ratio. The soil medium was analyzed before planting, which had 0.082% nitrogen, 64.3ppm phosphorus, 286ppm potassium, 2.35% organic matter and the pH was 7.8. The experiment was laid out in shade house (55% shade) with two factors Randomized Complete Block design (RCBD) having twelve treatments replicated three times. Each treatment had 5 plants and a total of 180 plants were used in the experiment.

The plants were sprayed twice with gibberellic acid, first during the first week of June, 2004, and second during the last week of March, 2005. The GA concentrations used were 0ppm (control), 100 ppm, 200 ppm and 300 ppm solutions. These concentrations were prepared by adding 100, 200 and 300 mg of GA in one litre of distilled water to get 100, 200 and 300 ppm solutions respectively. Gibberellic acid was first dissolved in ethanol (95%) and later on water was added up to the desired volume. Plants in control treatment were sprayed with distilled water only. Urea was the source of nitrogen applied in solution form in four split doses. The different N levels were 0g N pot^{-1} (control), 1.0g N pot^{-1} and 2.0g N pot^{-1}.

The plants were regularly observed for their water and other requirements and data were recorded on different growth parameters including plant height, stem thickness (taken with vernier calliper 3 cm above soil surface), lateral branch length (cm), internode length (cm), root length (cm), root thickness (3 cm below soil surface), number of roots per plant, and plant survival.

RESULTS AND DISCUSSION

Several parameters, related to growth and development of *Araucaria heterophylla*, were studied. Promising results of differences among the main effects (i.e. GA concentrations and N levels) were observed. However, it is astonishing that none of the interactions between the GA concentrations and N levels were found to be significant. It indicates that the different GA concentrations studied would be similarly effective for all the N levels under consideration. Consequently, only the means of the main effects i.e. GA concentrations and N levels are presented in Table-1, and are discussed in details below.

Table-1. The effect of different gibberellic acid concentrations and nitrogen levels on the growth and development of *Araucaria heterophylla* seedlings. (No interactions were significant, only the main effects are shown here for paucity).

Gibberellic Acid Concentration	Plant height (cm)	Stem thickness (cm)	Branch length (cm)	Internode length (cm)	Root length (cm)	Root thickness (cm)	Number of roots	Plant survival (%)
Control	26.5 D	0.57 D	13.5 D	2.9 D	16.8 D	0.43 D	6.3 D	84.4 b
100 ppm	31.5 C	0.80 C	16.7 C	4.3 C	22.1 C	0.72 C	8.9 C	93.3 ab
200 ppm	36.4 B	1.03 B	19.8 B	6.6 B	26.3 B	0.91 B	12.4 B	95.6 a
300 ppm	42.4 A	1.43 A	22.7 A	8.6 A	30.9 A	1.18 A	15.3 A	97.8 a
Significance	***	***	***	***	***	***	***	*
LSD Values	*2.33*	*0.16*	*0.91*	*0.41*	*0.81*	*0.13*	*0.59*	*9.58*
Nitrogen levels								
0 g pot^{-1}	32.2 B	0.87 B	17.0 C	5.1 C	22.4 C	0.76 B	9.8 C	83.3 B
1 g pot^{-1}	34.3 A	0.95 AB	18.1 B	5.6 B	24.2 B	0.78 AB	10.6 B	96.7 A
2 g pot^{-1}	36.1 A	1.05 A	19.4 A	6.2 A	25.5 A	0.89 A	11.8 A	98.3 A
Significance	***	**	***	***	***	**	***	**
LSD Values	*2.02*	*0.14*	*0.79*	*0.36*	*0.70*	*0.11*	*0.51*	*11.3*
Interaction								
GA × N	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant; * = Significant at P≤0.05; ** = Significant at P≤0.01; *** = Significant at P≤0.001
+ Values followed by different letters are significantly different at P≤0.05 level (lower case) and P≤0.01 or P≤0.001 level (upper case) according to least significance difference (LSD) test.

Effects of GA concentrations:

The data recorded on plant height showed significant (P≤0.001) effects of different GA concentrations. Maximum plant height (42.4 cm) was recorded at 300 ppm followed by 200 ppm (36.4 cm), while minimum plant height (26.5 cm) was observed in plants that were not treated with GA. The increase in GA concentration has positive influence on plant height. Similar results were recorded by Mehrota and Dadwal (1978), where foliar application of gibberellic acid increased the plant height. The stem thickness was significantly (P≤0.001) affected by different GA concentration. Maximum stem thickness (1.43 cm) was recorded at 300 ppm followed by 200 ppm (1.03 cm), while minimum stem thickness (0.57 cm) was observed in control. The results are in accordance with the findings of Boes and Hamner (1961), who concluded that foliar application of gibberellic acid increased cell size, stem height and stem thickness.

The length of lateral branches was also affected significantly (P≤0.001) by GA concentrations. Maximum branch length (22.7 cm) was observed at 300 ppm followed by 200 ppm (19.8 cm), while minimum branch length (13.5 cm) was noted in control. The results are in accordance with the findings of Singh (1966), who observed that the length of lateral branch increases with the application of gibberellic acid. The internode length was significantly (P≤0.001) affected by GA concentrations. Maximum internode length (8.6 cm) was found at 300 ppm GA, followed by 200 ppm where the internode length was 6.6 cm, while minimum internode length (2.9 cm) was recorded in control. The results are in agreement with the findings of Feucht and Watson (1958), who observed that application of gibberellic acid not only increased the internode length of the seedlings but also increased the number and length of cells. Cell elongation is primarily responsible for the increase in internode length.

Araucaria root length was significantly (P≤0.001) affected by GA concentrations. Maximum root length (30.9 cm) was noted at 300 ppm of gibberellic acid followed by 200 ppm (26.3 cm), while minimum root length (16.8 cm) was recorded in control. The results are in accordance with the findings of Dycus (1960), who reported that gibberellins accelerated root growth in *Phaseolus vulgaris*. Root thickness was also significantly affected (P≤0.001) by GA concentrations. Maximum root thickness (1.18 cm) was found at 300 ppm of gibberellic acid followed by 200 ppm at which the root thickness was (0.91 cm), while minimum root thickness (0.43 cm) was recorded in control. The maximum root thickness at 300 ppm of gibberellic acid may be due to the greater stem height and branch length recorded in this treatment. They might have manufactured more food (photosynthates), which were translocated towards the root causing increase in diameter.

The number of roots per plant was significantly (P≤0.001) affected by GA concentrations. Maximum roots (15.3) were counted at 300 ppm GA, followed by 200 ppm at which the number of roots was (12.4), while minimum (6.3) was recorded in control. These results may again be attributed to the vigorous shoot growth obtained at 300 ppm GA. The vigorous the shoot system, the more food formation and downward supply and the more vigorous will be the root system to maintain proper root shoot ratio. Plant survival was also affected significantly (P≤0.05) by different GA concentrations. Maximum plant survival (97.8%) was recorded at 300 ppm GA concentration, followed by 200 ppm at which the survival was 95.6%, while minimum (84.4%) was observed in control. The highest percentage of survival at 300 ppm of gibberellic acid may be due to the vigorous root system in this treatment which provided the required amount of nutrients and hence increased the chance of survival.

Effects of N levels:

The data presented in Table-1 revealed that different nitrogen levels had also significant (P≤0.001) effects on *Araucaria* plant height. Maximum plant height (36.1 cm) was recorded in plants that received 2 g N plant^{-1} followed by 1 g N plant^{-1} with average plant height (34.3 cm), while minimum plant height (32.2 cm) was observed in control. The results are in line with the findings of Ishtiaq and Rehman (1997), who stated that increasing nitrogen levels favoured vegetative growth in *Nicodemia medagascercinsis*. Nitrogen effect on stem thickness was also significant (P≤0.01). The means indicate that application of 2 g N plant^{-1} produced the thickest (1.05 cm) stems, followed by 1 g N plant^{-1} with 0.95 cm stem diameter, while minimum stem thickness (0.87 cm) was recorded in plants that received no N fertilizer. The increased stem thickness might be due to the balanced nutrition. These results confirm the findings of Thomas and Teoh (1983), who obsered that stem thickness increased with nitrogen fertilization in *Ficus macrophylla*.

Regarding the branch length, the results indicate that the application of 2 g N plant^{-1} produced the longest (19.4 cm; P≤0.001) branches, followed by 1 g N plant^{-1} (18.1 cm), while the shortest branches (17.0 cm) were observed in plants that received no nitrogen. These results may be attributed to the vigorous root system in the treatment which might have resulted in greater absorption of water and nutrients thereby resulting in a rapid growth of the plants with longer branches. The aerial plant parts exclusively depend on the root system of plant. Thus, adequate nutrition must be provided to the root system to get proper growth of aerial plant parts (Ishtiaq, 1992). Maximum internode length (6.2 cm; P≤0.001) was observed in plants that received 2 g N plant^{-1} followed by those supplied with 1 g N plant^{-1} (5.6 cm), while minimum (5.1 cm) was recorded in control treatment (no N). The increase in internode length may be due to the fact that nitrogen enhances the vegetative growth by cell division and cell enlargement which ultimately resulted in longer internodes. It was also reported by Shah (1997) stating that the availability of more nutrients increase the internode length.

Maximum root length (25.5 cm; P≤0.001) was observed in plants that were given 2 g N plant^{-1}, while minimum root length (22.4 cm) was recorded in plants which received no nitrogen. This could be attributed to the vigorous vegetative growth in this treatment. So, more photosynthates were manufactured and translocated to the roots which enhanced the root elongation. Application of 2 g N plant^{-1} produced the thickest (0.89 cm; P≤0.01) roots, while the thinnest (0.76 cm) roots were noted in control plants (no nitrogen). The maximum root thickness may be due to the fact that plants receiving sufficient nitrogen have vigorous vegetative growth and root system as well (Khan, 1998). N supplied at 2 g plant^{-1} also produced maximum roots (11.8), followed by 1g N plant^{-1} (10.6 roots), while minimum roots (9.8) were produced by plants that received no nitrogen. Plant survival was also maximum (98.3%; P≤0.01) at 2 g N plant^{-1} dose, while minimum survival (83.3%) was recorded in control. This, again, could be attributed to the more number of roots, root length and root thickness in this treatment which absorbed more nutrients and increased survival percentage.

CONCLUSION

Araucaria heterophylla growth was highly influenced by gibberellic acid application. Its application at the rate of 300 ppm per plant resulted in maximum plant height, stem thickness, branch length, internode length, root length, root thickness, number of roots and plant survival. Similarly, nitrogen levels substancially affected all the mentioned parameters and its use at the rate of 2 g plant^{-1} gave the best results. Conversely, minimum values for these parameters were recorded where no GA or N were applied. The interaction between GA and N levels was non-significant meaning that that two will support growth linearly if applied in combination, at least to the levels tested here. Increasing GA concentration and N dose brought considerable improvement in *Araucaria* seedlings. Consequently, GA at 300 ppm and N at 2 g plant^{-1} could be recommended to the nurserymen for producing cost effective plants commercially. However, since regular increase in GA concentrations and N levels showed positive improvement in all growth parameters, further research is needed to explore the effects of higher doses than the ones tested in this experiment.

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