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THE EFFECT OF INDOLEACETIC ACID AND INDOLE-3-BUTYRIC ACID CONCENTRATIONS ON THE ROOTING AND GROWTH OF *THYMUS ATLANTICUS* CUTTINGS

Short communication

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ABSTRACT

This study aimed to evaluate the effect of indole-3-butyric acid (IBA) and indole-3-acetic acid (IAA) concentrations (0 ppm, 300 ppm, 500 ppm, 750 ppm, 1000 ppm, and 1500 ppm) on root development and sprouting of *Thymus atlanticus* stem cuttings. The results showed a significant effect of auxin type and concentration on survival rate, rooting percentage, root and shoot length, number of shoots, fresh and dry weight. The most efficient was IBA at 1000 ppm, which resulted in a survival rate of 62%, a rooting percentage of 57%, a shoot length of 7.5 cm, and 3.1 new shoots per cutting. These findings highlight the potential of IBA to improve the propagation of *Thymus atlanticus* using 3–4 cm long shoots, with has important implications for commercial propagation and ecological rehabilitation.

Key words: stem cuttings, survival rate, vegetative propagation

INTRODUCTION

The cultivation of medicinal plants is essential due to their bioactive properties and traditional medicinal uses (Verpoorte et al. 2002). *Thymus atlanticus*, a native Moroccan species, is valued for its therapeutic properties, including antioxidant and anti-inflammatory effects (Elbouny et al. 2022). However, this species is threatened with extinction due to climate change, overgrazing, and human activities (Mehdioui & Kahouadji 2007). While seed propagation has its challenges, vegetative propagation using stem cuttings offers a reliable alternative for conservation and commercial production.

The success of this method relies on the use of plant growth regulators, particularly auxins, which promote rooting (Davies 2010). However, optimal auxin type and concentration vary between species, requiring specific optimization for each plant species (De Klerk et al. 1999).

This study aimed to determine the optimal type and concentration of auxin for the propagation of *T. atlanticus* by evaluating the survival rate, root and shoot development parameters, and biomass accumulation.

MATERIALS AND METHODS

The study on *T. atlanticus* cuttings was conducted in a glasshouse at the Moulay Ismail University in Errachidia, Morocco. Cuttings were collected in April 2023 from Tizi n'Telghemt in the Oriental High Atlas, at an altitude of 2060 m, with an annual precipitation of 371 mm and a temperature range of 5.8–37.5 °C. The experiment used a completely randomized design with 11 treatments, including five concentrations each of IBA and IAA (300, 500, 750, 1000, and 1500 ppm), and a control. Each treatment comprised 5 replicates of 10 semi-lignified cuttings of 3–4 cm length. Auxins were applied by

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briefly immersing the cuttings in IBA and IAA solutions (300–1500 ppm), prepared by dissolving the auxins in 95% ethanol and diluting with distilled water to the desired concentrations. The cuttings were planted in a medium of sand and peat in a ratio of 2 : 1. Growth conditions were controlled with temperatures maintained at 20–25 °C during the day and 15–18 °C at night, humidity levels of 70–80%, and a photoperiod of 12–14 hours. Daily watering ensured consistent moisture in the growing medium. After 60 days, data were collected, including survival rate, root and shoot length, and fresh and dry weight. The samples were dried at 40 °C for 72 hours to measure the dry weight. Statistical analysis was performed using SPSS 26 software, ANOVA and Duncan's test at a significance level of $p < 0.05$ to evaluate the effect of different treatments on the measured parameters.

RESULTS AND DISCUSSION

The application of different concentrations of indole-3-butyric acid (IBA) and indole-3-acetic acid (IAA) significantly affected the survival, rooting, and growth of *T. atlanticus* cuttings, highlighting the importance of auxin type and concentration in promoting successful vegetative propagation. Survival and rooting increased with increasing IBA concentration up to 1000 ppm from 32% and 30% (300 ppm) to 62% and 57% (1000 ppm), respectively, for survival and rooting. At IBA 1500 ppm both parameters fell below the control level (Table 1). IAA treatment was less effective than IBA, although the same trend was observed. The survival percentage increased from 25.6% to 46% (300 ppm) and rooting from 22% to 44% (1000 ppm). At 1500 ppm it fell below the control value. Similar results were reported by Kösa (2021) for *Thymus revolutus* and Sabbouh et al. (2020) for *Thymus capitatus*.

A rooted seedling has a greater ability to take up water and nutrients from the substrate; therefore, with rooting, the ability to elongate shoots and roots, form new shoots, and increase the mass of shoots increases. It is therefore evident that rooting stimulating factors also increase the values of the above parameters. In terms of root length, 1000 ppm IBA significantly promoted root growth (7.7 cm), and IAA also showed significant root elongation (6.9 cm) at the same concentration, which was 1.2–1.3 longer (for IBA and IAA) than that of the control (Table 2). Similar proportions were calculated for other parameters. IAA, as a less persistent auxin, stimulated a better number of shoot than IBA. However, no significant difference in root length was observed between the 300 ppm IBA and the control, suggesting that lower concentrations of IBA may not be as effective in promoting root elongation. These results are consistent with studies showing that auxin concentrations should be evaluated to find the optimal root development because they enhance nutrient uptake and structural protein synthesis in plant tissues (Audus 1953). Similar findings describing shoot growth with IBA concentration have been reported for other species (Rawat et al. 2020).

Table 1. The effect of IBA and IAA on the survival and rooting percentage of *Thymus atlanticus* stem cuttings

Rooting parameter						
Concentration (ppm)	control	300	500	750	1000	1500
Survival percentage						
IBA	28^{a}	32.0 ± 3.5^{ab}	42.0 ± 4.9^{bc}	48.0 ± 3.5^{c}	62 ± 3.5^{d}	28.4 ± 1.2^{a}
IAA		25.6 ± 4.2^{ab}	26.4 ± 1.5^{ab}	33.6 ± 5.2^{b}	46 ± 2.9	17.7 ± 1.9^{a}
Rooting percentage						
IBA	25^{bc}	30.0 ± 3.2^{c}	39.0 ± 3.3^{d}	44.0 ± 2.4^{d}	57 ± 1.22^{e}	25.8 ± 1.1^{bc}
IAA		22.0 ± 1.2^{ab}	23.4 ± 1.9^{bc}	30.0 ± 3.2^{c}	44 ± 1.87^{d}	16.0 ± 1.0^{a}

Values represent means ± standard error (SE); Different lowercase letters within the same column (separately for surviving and rooting) indicate significant differences between treatments according to Duncan's multiple range test at $p \leq 0.05$

Table 2. Effect of IBA and IAA concentrations on the number of new shoots, shoot length, root length, fresh and dry weight of roots, fresh and dry weight of shoots of *Thymus atlanticus* cuttings

Concentration (ppm)		Number of new shoots	Shoot length (cm)	Root length (cm)	Fresh and dry weight of roots (g)		Fresh and dry weight of shoots (g)	
					fresh weight	dry weight	fresh weight	dry weight
Control		2.00±0.77^{bc}	6.00±1.85^{bc}	5.80±0.58^{bcd}	0.07±0.02^{abc}	0.03±0.017^{abc}	0.12±0.01^{abc}	0.02±0.0093^{a}
IBA	300	2.20±0.26^{cd}	6.24±0.33^{c}	6.34±0.27^{bcd}	0.13±0.02^{cde}	0.06±0.010^{cd}	0.17±0.01^{cde}	0.059±0.01^{abc}
	500	2.33±0.28c^{d}	6.30±0.37^{c}	6.64±0.31^{bcd}	0.17±0.03^{de}	0.07±0.011^{de}	0.18±0.03^{cde}	0.065±0.023^{abc}
	750	2.80±0.27^{cd}	6.48±0.27^{c}	7.46±0.61^{d}	0.18±0.04^{e}	0.07±0.013^{de}	0.22±0.03^{de}	0.09±0.024^{bc}
	1000	3.13±0.29^{d}	7.49±0.31^{c}	7.66±0.22^{d}	0.20±0.05^{e}	0.1±0.023^{e}	0.26±0.05^{e}	0.10±0.018^{c}
	1500	2.06±0.11^{bc}	6.02±0.33^{bc}	5.913±0.24^{bcd}	0.09±0.01^{abcd}	0.04±0.005^{abcd}	0.14±0.0^{bcd}	0.03±0.003^{a}
IAA	300	0.66±0.318^{a}	2.55±0.98^{a}	2.63±1.01^{a}	0.01±0.006^{a}	0.004±0.001^{a}	0.04±0.01^{a}	0.01±0.006^{a}
	500	0.80±0.17^{a}	3.29±0.74^{b}	4.41±0.85^{ab}	0.02±0.006^{ab}	0.01±0.002^{ab}	0.05±0.01^{a}	0.02±0.005^{a}
	750	2.06±0.18^{bc}	6.12±0.27^{bc}	6.08±0.93^{bcd}	0.07±0.10^{abc}	0.03±0.008^{abc}	0.12±0.0^{ab}	0.03±0.008^{a}
	1000	2.40±0.59^{cd}	6.36±0.45^{c}	6.86±0.39^{cd}	0.11±0. 02^{bcde}	0.04±0.01^{bcd}	0.14±0.02^{bcd}	0.04±0.015^{ab}
	1500	1.13±0.13^{ab}	4.26±0.81^{ab}	5.03±1.01^{bcd}	0.07±0.02^{abc}	0.02±0.006^{abc}	0.06±0.01^{ab}	0.02±0.01^{a}

Values represent means ± standard error (SE); Different lowercase letters within the same column indicate significant differences between treatments according to Duncan's multiple range test at $p \leq 0.05$



Figure 1. *Thymus atlanticus* stem cuttings treated with 1000 ppm IBA

Root dry weight was mostly stimulated by auxins, as at 1000 ppm it increased 3.3-fold for IBA and 1.3-fold for IAA. The same patterns were found for shoot dry weight, where differences between control and auxin-treated shoots were 5 times greater for IBA and 2 times greater for IAA. This confirms the results of Davies (1995) and Ali et al. (2022). Similar results were reported for *Pelargonium graveolens* (Rawat et al. 2020).

Overall, the results of this study show that 1000 ppm IBA is the optimal concentration for improving root and shoot growth in *T. atlanticus* cuttings (Fig. 1). These findings align with previous research on other plant species, where IBA at optimal concentrations significantly enhanced rooting and shoot growth (Bahadori & Ashorabadi 2017; Sevik & Guney 2013). However, the reduced rooting at higher IBA concentrations emphasizes the importance of carefully managing auxin applications to avoid adverse effects such as inhibition of rooting and sprouting (Tien et al. 2020; Yan et al. 2017).

CONCLUSION

Among the treatments, 1000 ppm IBA proved to be the most effective for *Thymus atlanticus* cuttings, giving the highest rates of survival and rooting, shoot and root growth, and biomass. Higher auxin concentrations hindered rooting and shooting, highlighting the need for precise auxin application in propagation efforts.

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