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Effect of foliar application with putrescine on various growth and flowering attributes of annual candytuft (*Iberis amara* L.)

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Abstract
An experiment was carried out in an open field to analyse the effect of foliar treatment of putrescine on growth and flowering attributes of annual candytuft at an experimental farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) during 2021-22. In the present study, significant differences among different concentrations of putrescine (0.00, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, and 3.00 mmol) on growth and flowering attributes of annual candytuft were observed. Plant height, (31.67 cm) at 60 DAT and 90 DAT (43.33 cm) was found greater in plants treated with 2.00 mmol putrescine concentration. Similarly, the maximum number of primary branches at 60 DAT (30.66) and 90 DAT (42.75) as well as the maximum number of secondary branches at 60 DAT (122.83) and 90 DAT (349.25) was also recorded from putrescine 2.00 mmol concentration. 2.00 mmol putrescine treatment also resulted in a maximum number of leaves per plant (1208.83). In the case of flowering, 2.50 mmol treatment was seen to have a better effect as compared with all other treatments by showing minimum days for bud initiation (36.08 DAT), flower bud development (49.42 DAT) and flower bud opening (53.50 DAT). 1.25 mmol of putrescine treatments resulted in delayed withering with maximum days (78.83 DAT). The highest number of flower buds per cluster (58.13) was recorded from the treatment of 2.75 mmol putrescine concentration while 2.00 mmol putrescine treatment resulted in a maximum number of flower clusters per branch (56.07) and maximum number of flower clusters per plant (511.92). The present experiment gave the precise database of the comparative performance of various growth and flowering parameters of candytuft with different concentrations of putrescine.

Keywords: Putrescine, withering, flower cluster

Introduction
Candytuft (*Iberis amara* L.) is a flowering plant that belongs to the Brassicaceae family. Genus *Iberis* is composed of about 40 species of Eurasian plants of the mustard family. Most species of the genus *Iberis* are native to southern Europe (Taghizadeh *et al*., 2021) [17]. Candytuft is a popular annual flower that blooms in the winter and spring. Well-drained soil is best suited for planting but can grow in a variety of conditions, including poor soil and very alkaline soil. Plants will not grow in shade or overly damp soil while acidic soil may need amendments such as lime to produce good flower bloom. Plants can be massed in beds, used as annual borders and also used for edging. Sometimes candytuft flowers are also used in bouquets and floral arrangements as cut flowers (Patil and Patil, 2008) [13]. It is a perfect small specimen for a sunny rock garden and border planting. Putrescine is made from arginine or ornithine and is most abundant in leaves and it is found to accumulate in the cytoplasm (Cai, *et al*., 2006) [2]. Putrescine is important because it has been shown that exogenous treatment can enhance the production or accumulation of bioactive chemicals that show a positive impact on plant growth and development. Cationic charge and aliphatic carbon chains between amino groups are thought to play a role in polyamine aggregation (Antony *et al*., 2003) [1]. Thus, putrescine is responsible for the aggregation of organic matter. Naturally occurring Polyamines such as Putrescine have been recognized as an effective anti-senescence agent and a lower level of putrescine was found in aged cells (Kusano *et al*., 2008) [8].

Materials and Methods

An experiment was carried out in an experimental farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, and Varanasi (U.P.) during 2021-22 to study the effect of foliar treatment of putrescine on growth and flowering attributes of annual candytuft. In this experiment, nine level of putrescine and control (distilled water) was studied. The experiment was set up in a Randomized Block Design (RBD) with three replications and data on various growth and flowering attributes were analysed using an experiment under RBD for analysis of variance (ANOVA). Seeds of the crop were procured from the Horticulturist unit of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) and sowing was done on 30th October 2021 on nursery beds of size 3.6 × 1 m^2 and mixing well rotten farmyard manure (FYM) at 8 kg/m^2 and raising the level of beds to about 15 cm. Healthy seedlings having uniform growth with 3-4 leaves of 30 days old were selected for transplanting and transplanted on main field during evening hours on 30th November 2021 at a spacing of 60 cm between the rows and 50 cm between the plants. Different concentration of putrescine (0.00, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, and 3.00 mmol) was prepared in mmol and sprayed on individual plants with the help of a hand-operated sprayer on 23rd December 2021. Control plants were sprayed with distilled water only. The cultural practices of all the treatments remain the same.

Results and Discussion

Effect of putrescine on growth attributes of annual candytuft

Ten different treatments were analysed and significant variations were recorded in treatments due to difference in the concentration of putrescine (Table-1). Among different treatments, Putrescine 2.00 mmol has recorded maximum plant height both at 60 DAT (31.67 cm) and 90 DAT (43.33 cm) while the minimum was from the untreated plot (23.68 cm and 36.16 cm, respectively). Similar results were well documented by Talaat and Gamal El-Din (2007) [18] in *Nigella sativa* and Talaat *et al*. (2005) [19] in periwinkle. The increase in plant height seems to be due to the fact that polyamines are related to enzyme activity regulation, synthesis of DNA and cell division hence greater polyamine results in more vigorous growth (Zhao *et al*., 2004) [21]. At 60 DAT maximum number of primary branches per plant (30.66) and secondary branches per plant (122.83) were recorded in Putrescine 2.00 mmol treatment while a minimum number of primary branches (26.25) and secondary branches (69.25) were recorded from untreated plants *i.e.* T_1 (Control). In the case of 90 Da AT, maximum number of primary branches per plant (42.75) and secondary branches per plant (349.25) was again obtained from Putrescine 2.00 mmol whereas, T_1 (Control) has again resulted in a minimum value of both the above parameters (30.50 and 235.33, respectively). These results are in agreement with previous findings of Park *et al.* (2012) [11] in gloxinia and Yousef *et al*. (2021) in rose. It can probably be related with the facts that PAs increases cell division and levels of phytohormone like auxin and gibberellin and also decreases ABA level (Hussein *et al*., 2006) [6]. The maximum number of leaves per plant (1208.83) was obtained from the plants sprayed with 2.00 mmol putrescine (T_6) while minimum number of leaves per plant (938.75) was recorded from control (T_1).Similar results were well documented by Nanvakenary *et al*. (2013) [9] in African violet. Paschalidis and Angelakis (2005) [12] reported that, PA and its precursors (arginine) are related with cell division, expansion and differentiation which may result in formation of new leaf buds.

Effect of putrescine on flowering attributes of annual candytuft

Treatments differ significantly in terms of various flowering parameters due to foliar application of putrescine (Table-2). Early flowering was observed in treated plants as compared with untreated plants with T_8 *i.e.* putrescine 2.50 mmol treated plants showing minimum days for bud initiation (36.08 DAT), development of flower bud (49.42 DAT) and opening of flowers (53.50 DAT) while maximum duration was noted from the untreated plot (51.10, 61.27 and 65.17 DAT, respectively). These findings are in line with the findings of by El-Sayed *et al*. (2018) [5] in snapdragon. PAs are known to promote the level of endogenous gibberellins (flowering hormone) which could be the possible reason for early flowering (El-Bassiouny *et al*., 2008) [3]. The maximum duration for flower withering (78.83 DAT) was recorded during the experiment was from treatment T_3 *i.e.* Putrescine 1.25 mmol while early withering (73.75 DAT) was recorded in T_8 (Putrescine 2.50 mmol). Similar results have been obtained by Kahrobaiyan *et al.* (2019) [7] in ornamental sunflowers and Singh and Bala (2020) [16] in chrysanthemum. A maximum number of flower buds per cluster (58.13) was produced in the plants treated with 2.75 mmol Putrescine solution (T_9) and minimum number of flower buds per cluster (48.30) was recorded from T_1 (Control). Similar observations were well documented by El-Quesni *et al*. (2007) [4] in bougainvillea. This might be due to promoting effects of PAs on photosynthetic pigments (Nassar *et al*., 2003). It was recorded that plants of T_6*i.e.* 2.00 mmol concentration of Putrescine resulted in a maximum number of flower clusters per branch (56.07) and maximum number of flower clusters per plant (511.92) whereas, minimum values of both parameters were recorded from control (34.92and 310.33, respectively). Similar results were also presented by El-Quesni *et al*. (2007) [4] in bougainvillaea and Saeed *et al*. (2019) [15] in gerbera. A positive correlation between the increase in growth rate, assimilating area and photosynthetic pigment contents in response to putrescine treatments was reported by Sadak *et al*. (2012) [14] which might be the possible reason behind the formation of more flower clusters.

Conclusion

From the present study, it was found that 2.00 mmol putrescine resulted in better plant growth with maximum plant height, number of primary and secondary branches per plant, the maximum number of flower clusters per plant (511.92) and flower clusters per branch (56.07). In the case of early flower bud initiation (36.08 DAT), flower bud development (49.42 DAT) and flower bud opening (53.50 DAT) 2.50 mmol putrescine has a more pronounced effect than any other treatment.

Table 1: Effect of putrescine on growth attributes of annual candytuft

Treatment	Treatment detail	Plant height at 60 DAT (cm)	Plant height at 90 DAT (cm)	Number of primary branches at 60 DAT	Number of primary branches at 90 DAT	Number of secondary branches at 60 DAT	Number of secondary branches at 90 DAT	Number of leaves per plant
T_1	Control	23.68	36.16	26.25	30.50	69.25	235.33	938.75
T_2	Putrescine 1.00 mmol	24.60	37.71	26.50	31.58	77.53	271.33	982.00
T_3	Putrescine 1.25 mmol	27.02	39.49	26.83	31.84	71.42	280.10	1000.25
T_4	Putrescine 1.50 mmol	26.81	40.11	27.19	34.25	101.83	275.25	1004.63
T_5	Putrescine 1.75 mmol	26.91	40.80	26.75	37.67	89.08	287.25	1070.17
T_6	Putrescine 2.00 mmol	31.67	43.33	30.66	42.75	122.83	349.25	1208.83
T_7	Putrescine 2.25 mmol	26.44	42.58	29.42	38.75	113.42	291.25	1098.25
T_8	Putrescine 2.50 mmol	28.56	40.33	29.67	36.42	96.17	280.50	1000.83
T_9	Putrescine 2.75 mmol	28.02	38.28	26.88	40.08	119.10	338.50	1182.50
T_{10}	Putrescine 3.00 mmol	29.74	42.50	30.58	37.33	96.19	314.33	1144.83
C.D. (5%)		2.07	1.91	0.95	4.28	4.58	27.55	80.20

Table 2: Effect of putrescine on flowering attributes of annual candytuft

Treatment	Treatment detail	Days required for flower bud initiation (DAT)	Days required for flower bud development (DAT)	Days required for flower bud opening (DAT)	Day required for flower withering (DAT)	Number of flower buds per cluster	Number of flower clusters per branch	Total number of flower clusters per plant
T_1	Control	51.10	61.27	65.17	76.31	48.30	34.92	310.33
T_2	Putrescine 1.00 mmol	48.67	59.67	64.17	75.61	52.75	37.53	398.25
T_3	Putrescine 1.25 mmol	47.83	59.33	64.42	78.83	52.42	48.02	497.32
T_4	Putrescine 1.50 mmol	45.75	58.58	64.35	77.97	54.92	40.97	453.17
T_5	Putrescine 1.75 mmol	45.42	57.25	61.17	75.80	54.17	41.20	408.18
T_6	Putrescine 2.00 mmol	46.75	56.00	61.83	75.27	54.78	56.07	511.92
T_7	Putrescine 2.25 mmol	43.27	56.63	61.73	74.73	56.47	40.68	469.97
T_8	Putrescine 2.50 mmol	36.08	49.42	53.50	73.75	57.32	51.33	435.85
T_9	Putrescine 2.75 mmol	38.55	50.43	56.07	75.58	58.13	52.93	509.42
T_{10}	Putrescine 3.00 mmol	41.92	54.92	59.72	75.67	56.78	50.51	496.67
C.D. (5%)		6.63	5.99	5.65	2.50	1.15	2.74	13.58

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