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Effect of foliar treatment of putrescine on growth and flowering of annual gypsophila (*Gypsophila elegance*)

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Gypsophila (*Gypsophila elegance* L.) belonging to Caryophyllaceae family is a native of Eastern Europe and is now grown everywhere in the world both in open field and under protected cultivation (Poornima *et al.* 2021). The word gypsophila is derived from Greek word gypsos (meaning gypsum) and philios (meaning loving) which refers to the flowers growing in gypsum rich soil. It is valued as a cut flower in floristry to add as a filler in a bouquet as well as in a dried flower arrangement. Polyamines (PAs) play important roles in varied plant growth and developmental processes and in environmental stress responses, they are considered as a new kind of plant biostimulant. With the development of molecular biotechnology techniques, there is increasing evidence that PAs, whether applied exogenously or produced endogenously via genetic engineering, can positively affect plant growth, productivity, and stress tolerance. Putrescine (Put) is the starting point of the polyamines pathway and the most common PA in higher plants. It is synthesized by two main pathways (from ornithine and arginine), but recently a third pathway from citrulline was reported in sesame plants (Chen *et al.* 2019). There is strong evidence that Put may play a crucial role not only in plant growth and development but also in the tolerance responses to the major stresses affecting crop production. It is not only a signal molecule by itself, but also interacts with numerous molecules such as phytohormones and gas molecules, among others (Anwar *et al.* 2015). In this research work, we attempted to know the positive response of putrescine on plant growth and flowering of annual flower gypsophila. The aim of the research was to identify how putrescine (Put) effect the plant response and to provide a basis for future research on the mechanism of action of PAs in plant growth and development of annual flower crops as the demand and scope for annual flower crop are increasing.

The present study was carried out in an experimental farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during 2021–22 to study the effect of foliar treatment of putrescine on growth and flowering of annual gypsophila. In this experiment, nine levels of putrescine with control (distilled water) were studied. The experiment was set up in a randomized block design (RBD) with three replications and data on various growth and flowering attributes were analyzed using an experiment under RBD for analysis of variance (ANOVA) (Panse and Sukhatme 1978). Different concentrations of putrescine were used in treatments, viz. T_1, Control; T_2, Putrescine 1.00 mmol; T_3, Putrescine 1.25 mmol; T_4, Putrescine 1.50 mmol; T_5, Putrescine 1.75 mmol; T_6, Putrescine 2.00 mmol; T_7, Putrescine 2.25 mmol; T_8, Putrescine 2.50 mmol; T_9, Putrescine 2.75 mmol; T_{10}, Putrescine 3.00 mmol. These were prepared and sprayed on individual plants with the help of hand operated sprayer. Control plants were sprayed with distilled water only.

Various growth attributes of annual gypsophila were found to be significantly affected by foliar treatment of putrescine (Table 1). Statistically maximum plant height at 60 days after transplanting (DAT) (50.28 cm) and 90 DAT (90.67 cm) was observed in 1.50 mmol putrescine treatment (T_4). Increase in plant height seems to be due to the fact that polyamines are related with enzyme activity regulation, synthesis of DNA and cell division hence greater polyamine results in more vigorous growth (Zhao *et al.* 2004). Similar results were well documented by Badawy *et al*. (2014) in *Celosia argentea* L., Mahgoub *et al*. (2011) in dahlia and El-Quesni *et al*. (2007) in bougainvillea. 1.50 mmol putrescine treatment (T_4) resulted in maximum number of primary branches per plant during 60 DAT (13.25) and 90 DAT (15.50), maximum number of secondary branches per plant at 60 DAT (9.50) and 90 DAT (49.00) whereas minimum values of all these parameters were recorded

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Table 1 Effect of putrescine on growth attributes of annual gypsophila

Treatment	Plant height		Number of primary branches		Number of secondary branches		Leaf area (cm^2)	Number of leaves per plant
	60 DAT (cm)	90 DAT (cm)	60 DAT (cm)	90 DAT (cm)	60 DAT (cm)	90 DAT (cm)		
T_1	41.68	80.50	9.42	12.33	4.33	35.58	86.27	303.85
T_2	35.54	88.75	10.42	13.42	4.58	39.87	111.93	309.27
T_3	42.54	83.72	12.42	13.17	5.25	42.25	116.50	432.80
T_4	50.28	90.67	13.25	15.50	9.50	49.00	101.37	444.83
T_5	42.14	90.17	12.38	13.75	7.00	36.83	102.97	332.10
T_6	46.63	85.00	11.92	13.33	7.58	37.33	111.33	367.10
T_7	45.54	81.78	12.46	13.67	7.17	36.07	110.53	318.32
T_8	40.60	79.89	12.08	15.42	7.40	38.52	111.77	422.17
T_9	38.87	82.67	13.08	15.46	8.92	41.73	114.80	392.92
T_{10}	40.16	83.92	10.33	13.68	7.83	35.16	107.43	358.00
CD (P=5%)	7.88	7.38	0.78	1.51	0.53	6.42	2.93	37.73

Refer to the methodology for treatment details.

from control (T_1). It might be due to the fact that putrescine has polycationic characters which bind with negatively charged proteins, amino acids and phospholipids and helps in formation of apical axis, differentiation of cell layer and meristem establishment (Tiburcio *et al.* 2014). These results are in agreement with previous findings of Talaat *et al*. (2005) on periwinkle and Park *et al.* (2012) in gloxinia. Maximum leaf area (116.50 cm^2) was recorded in 1.25 mmol putrescine treatment (T_3). This effect was supported by the fact given by Abd El-Wahed and Gamal El-Din (2005) as PAs increases total soluble sugar and phenolic compounds.

It was observed during the experiment that putrescine treatment of the plants resulted in early flowering as compared with control (Table 2). Putrescine is known to promote the level of endogenous gibberellins (flowering hormone) which could be a possible reason for early flowering (El-Bassiouny *et al.* 2008). T_6, i.e. putrescine 2.00 mmol treatment was recorded to show earliest bud initiation (60.39 DAT) which was at par with T_7 (61.05 DAT) and T_5 (61.47 DAT), early bud development (73.29 DAT) and earliest bud opening (74.91 DAT) while maximum days for bud initiation, flower bud development and flower bud opening was observed in untreated plants (67.27, 78.28 and 80.95 DAT, respectively). Xu *et al*. (2014) reported that polyamines are known to promote polyamine oxidase activity and lignin synthesis at the time of flower bud differentiation which promotes early bud differentiation. These findings are in good harmony with the findings of El-Sayed *et al*. (2018) in snapdragon. It was observed that T_3, i.e. putrescine 1.25 mmol treatment has taken the longest days for withering of flowers (86.20 DAT). This effect was supported by the fact that S-adenosyl methionine in biosynthetic pathway acts as a precursor of ethylene as well as polyamine biosynthesis, hence polyamine synthesis

Table 2 Effect of putrescine on flowering attributes of annual gypsophila

Treatment	Flower bud initiation (DAT)	Flower bud development (DAT)	Flower bud opening (DAT)	Flower withering (DAT)	Number of flower clusters per branch	Total number of flower cluster per plant
T_1	67.27	78.28	80.95	83.50	25.06	346.36
T_2	65.22	76.95	79.55	83.25	33.27	415.83
T_3	64.87	76.47	78.10	86.20	37.00	467.12
T_4	65.03	76.64	77.75	84.18	40.40	475.08
T_5	61.47	74.14	75.75	81.42	25.29	447.10
T_6	60.39	73.29	74.91	79.32	29.80	397.95
T_7	61.05	73.68	77.55	82.53	27.60	383.90
T_8	63.98	76.14	78.22	83.23	29.93	454.87
T_9	64.80	76.62	78.42	82.17	35.27	465.80
T_{10}	64.83	76.42	78.28	81.53	29.47	349.17
CD (P=5%)	3.60	2.84	2.17	0.46	7.06	13.40

Refer to the methodology for treatment details.

competes with ethylene synthesis and slow down the senescence process (Lasanajak *et al.* 2014). These results are in confirmation with the results obtained by Kahrobaiyan *et al.* (2019) in ornamental sunflowers and Singh and Bala (2020) in chrysanthemum. Putrescine 1.25 mmol treatment (T_3) also resulted in maximum fresh weight (6.42 g) and dry weight (1.22 g), maximum number of flower clusters per branch (40.40) and maximum number of flower clusters per plant (475.08). Promoting effects of polyamines on photosynthetic pigments had been reported by Nassar *et al*. (2003) while 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) which might be the possible reason behind production of more flowers.

SUMMARY

In this research work, we attempted to know the positive response of putrescine on plant growth and flowering of annual flower gypsophila. 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. Significant results were obtained in various growth and flowering parameters of annual gypsophila due to foliar treatment with putrescine. Maximum plant height, maximum plant spread, maximum number of leaves per plant, maximum number of primary branches and secondary branches per plant at 60 DAT and 90 DAT as well as maximum number of flower clusters per branch and maximum number of flower clusters per plant was recorded from 1.50 mmol of putrescine application.

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