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Effect of silicon dioxide nano fertilizer on the growth and yield marigold (*tagetes erecta. L*)

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Abstract

An experiment to study the "Effect of silicon dioxide nanofertilizer on the growth and yield of marigold *(Tagetes erecta L.)*" was laid out in Completely Randomized Design (CRD) with three replications. The experiment involved different concentrations of Silicon dioxide nano fertilizer, which was applied by foliar and soil application method. There were twelve treatments, *viz.,* from T_1 to T_{12}. Among them, T_1 is control, T_2 and T_3 are only foliar applications, T_4,T_5,T_6 is only soil application, and T_7 to T_{12} are both foliar and soil application. The treatment T_7 (Foliar application - 100 ppm, soil application - 200 ppm) recorded maximum values for all the growth, flower and yield parameters followed by T_8 (Foliar application - 100 ppm, Soil application - 400 ppm). From the present study, it is recommended that application of silicon dioxide nano fertilizer (SiO_2) as foliar spray at 100 ppm and soil application at 200 ppm improved growth and yield of marigold.

Keywords

Marigold, nanofertilizer, silicon dioxide, plant characters, quality

Introduction

Silicon (Si) is the second most abundant element in the earth's crust after oxygen. Plant physiologists and agronomists consider Si to be a useful element for plants, although its necessity has not been proven. Si benefits plants by increasing their tolerance to biotic and abiotic stresses such as pests, fungal attacks, salinity, and drought. Si can also act as a protective agent against various toxic metals such as aluminium, copper, manganese, zinc, and iron. Si protects plants from drought and wilt by increasing water use efficiency and reducing water loss through evapo-transpiration. There are various forms of Si used as fertilizers, such as silica, amorphous silica, and organic complexes. In agriculture, many nanoparticles have been used to increase the resistance of plants to various biotic and abiotic stresses and to increase their productivity. Recently, nanoscale silica has gained extraordinary importance as the main source of Si in agricultural production due to its large surface area and tiny size, allowing SiNPs (Silicon nanoparticles) to penetrate root cells. Due to these unique properties, SiNPs can be used in agriculture, especially to mitigate abiotic stress. Marigold is a potential commercial flower that is gaining popularity on account of its easy cultivation, wide adaptability, and increasing demand in the subcontinent. Also, marigold is grown as an ornamental crop for its flowers, which are sold in the market as loose flowers in bulk, as specialty cut flowers, or for making garlands. It is also one of the most important natural sources of xanthophylls for use as a natural food additive to brighten egg yolks and poultry skin. The present study was aimed to find the effect of silicon dioxide nano fertilizer on the growth and yield of marigold (*Tagetes erecta* L.).

Materials and methods

The experiment was conducted at Horticulture Nursery, SRM College of Agricultural Sciences, Vendhar Nagar, Chengalpattu District. There were twelve treatments imposed in Completely Randomized Design (CRD) which was replicated thrice. The experiment involved different concentrations of Silicon dioxide nano fertilizer, which was applied by foliar and soil application method. The cultivar "Top yellow" of marigold was subjected for the experiment. There were twelve treatments, *viz.,* from T_1 to T_{12}. Among them, T_1 is control, T_2 (100 ppm) and T_3 (200 ppm) are only foliar applications, T_4 (200 ppm), T_5 (400 ppm), T_6 (600ppm) is only soil application, and T_7 to T_{12} are both foliar and soil application of the above concentrations. The observations were recorded for the plant characters like plant height (cm), number of branches (nos.), days taken to first flower bud appearance (days), days taken to opening of first flower (days), stalk length (cm), the diameter of flower (cm), number of flowers per plant, the weight of the single flower (g), the yield of flowers per plant(g).

Results and discussion

In the present study, marigold plants significantly responded to the exogenous application of Silicon dioxide nanoparticles. Almost all measured vegetative and flower traits were higher in treated plants than control plants.

The plant growth parameters *viz.,* plant height, number of branches, stem girth were found to be significant in the treatment T_7, where silicon dioxide nanoparticle is applied through foliar and soil application method. Although the individual application by either foliar or soil(drench) application had a positive effect on plant growth and yield, the maximum effect was ascribed to the combined foliar and soil application that linearly increased the plant tissue Si content. Significantly and interestingly, the exogenous application of SiO_2NPs as a combined foliar and soil application resulted in higher plant height, stem girth, number of flowers, a shorter period of the initiation of the first bud, longer flowering period and higher fresh weight of flowers and yield per plant.

Among the silicon dioxide (SiO_2) nano fertilizers used at different concentrations, T_7{100 ppm (foliar application) and 200 ppm (soil application)} registered the highest values for plant characteristics (Table 1) like plant height (57.078 cm) with a number of branches of 11.333. The second highest value of plant height was T_8{100 ppm (foliar application),and 400 ppm (soil application)}- 50.011cm with branches of 9.667. The least values of plant height (44.02 cm) and number of branches (8.77) were observed in T_1 (control).

The increased plant height may be attributed to the role of silicon in elongating and strengthening plant roots resulting in increasing the ability to take up higher amount of nutrients from the soil solution (Ma and Yamaji, 2006). These results are in agreement with those of Kamenidou (2005) on *Zinnia elegans* who found that, potassium silicate drench treatments (100 and 200 mg/L Si) enhanced plant height more than control. Likewise, the results of Zhao *et al.,* (2013) on *Paeonia lactiflora* Pall. and Abdelkader *et al.,*(2016) on roselle (*Hibiscus sabdariffa* L.), Abo El-Enien *et al*., (2017) on citrus seedlings and Magouz (2017) on *Catharanthus roseus,* L. are in line with the findings of the present study.

Data presented showed that, stem girth or thickness was significantly increased when marigold plants were treated with silicon dioxide fertilizer as foliar and soil application. The obtained results show similarity to findings by Abdelkader *et al.,* (2016) on roselle *(Hibiscus sabdariffa* L.), Magouz (2017) on *Catharanthus roseus,* L., and Long *et al.,* (2018) on chive (*Allium schoenoprosum* L.) who found that, the application of silicon fertilizer could improve the stem thickness of the plant.

Several studies reported, improved growth effects of SiNPs on different plant crops such as common bean (*Phaseolus vulgaris*; Alsaeedi et al., 2017), cucumber (*Cucumis sativus*; Alsaeedi *et al.,* 2019), maize (Zea mays L.; Kaya *et al.,* 2006), wheat (*Triticum aestivum;* Gong *et al.,* 2003), and soybean (*Glycine max*; Hamayun *et al.,* 2010). Despite the positive effect of Si on plant development is well-documented in several plant crops belonging to monocots

(Mehrabanjoubani *et al.,* 2015) and dicots (Li *et al.,* 1989), most of the ornamental plants lack such investigation.

Flower characters (Table 2) like days taken to first flower bud appearance was found to be earlier (33.667 days) in T_7{100 ppm (foliar application), and 200 ppm (soil application), followed by T_8 {100 ppm (foliar application), 600 ppm (soil application)} - (34.222 days). The maximum days (41.778 days) for first flower bud appearance was noted in T_2 {200 ppm (foliar application)}.

Yield characters was recorded highest in T_7{100 ppm (foliar application), and 200 ppm (soil application)} for number of flowers per plant (21.333), flower stalk height (12.122 cm) and flower diameter (7.944 cm). The second highest values of the same characters were recorded in T_8{100 ppm (foliar application),400 ppm (soil application)}. Lowest yield characters was observed in T_{12} {200 ppm (foliar application), 600 ppm (soil application)} with the value of 15.889 for number of flowers, 8.811 cm for flower stalk length and 6.133 cm for flower diameter.

For ornamental plants, longer flowering periods and early first bud initiation are among the desired traits; in addition to the number of flowers, and diameter of flower. Plant has also several medical and herbal uses especially its lutein (yellow component); therefore, higher fresh and dry weights of flowers are of the importance. In the current study, all the flower traits and flowering period was positively and significantly increased upon the addition of SiO_2NPs. The combined application of SiO_2NPs as foliar and soil application exhibited the highest values for the traits mentioned above.

Silicon dioxide nano particle treatments as foliar application (100 ppm) and soil application (200 ppm) significantly increased number of flowers, flower diameter, flower weight compared with the control (no Si application).This could be attributed to the increase in the accumulated Si in leaves upon the application of higher SiO_2NPs concentration together by foliar and soil application. These results are in harmony with those of Abou-El-Ghait *et al.,* (2007) on *Helichrysum bracteatum*; Kamenidou *et al.,* (2009) on *Zinnia elegans*; Kamenidou *et al.* (2010) on gerbera (Gerbera hybrid L.), Zhao *et al.,* (2013) on Paeonia. In addition, Kamenidou (2005) found that the greatest flower diameter was obtained zinnia plants treated with Si as compared with untreated plants. Also, Kamenidou *et al.,* (2010) recorded that Gerbera produced thicker flower peduncles, increased flower diameter, increased height and flowered earlier when treated with silicon.

Conclusion

From the present study, it is recommended that combined application of silicon dioxide nanofertilizer (SiO_2) as foliar spray at 100 ppm and soil application at 200 ppm improved growth and yield of marigold.

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Table. 1 Effect of silicon dioxide nano fertilizer on growth parameters of marigold cv. Top Yeloow

Trt. No.	Treatments	Plant height (cm)	Stem Girth (cm)	Number of branches
T_1	Control (water spray)	44.022	1.367	8.778
T_2	Foliar application -100 ppm	49.144	1.622	9.889
T_3	Foliar application -200 ppm	47.133	1.611	9.556
T_4	Soil application - 200 ppm	46.844	1.333	9.556
T_5	Soil application - 400 ppm	45.367	1.500	9.444
T_6	Soil application - 600 ppm	46.133	1.533	9.333
T_7	Foliar application - 100 ppm +Soil application - 200 ppm	57.078	1.789	11.333
T_8	Foliar application -100 ppm + Soil application -400 ppm	50.011	1.7	10.667
T_9	Foliar application -100 ppm + Soil application - 600 ppm.	49.344	1.544	10
T_{10}	Foliar application 200ppm + Soil application -200 ppm.	47.989	1.589	9.444
T_{11}	Foliar application -200 ppm + Soil application- 400 ppm.	49.489	1.564	9.667
T_{12}	Foliar application -200 ppm + Soil application- 600 ppm	48.811	1.556	10.222
S. Ed		**1.914**	**0.104**	**0.541**
CD (P= 0.05)		**3.974**	**0.217**	**1.122**

Trt. No.	Treatments	Days taken for first flower bud appearance(Days)	Days taken for first flower opening (days)	Number of flowers per plant	Length of flower stalk (cm)	Flower diameter (cm)	Flower weight (g)	Flower yield (g)
T_1	Control (water spray)	41.111	48.000	16.000	8.078	6.444	7.800	124.800
T_2	Foliar application -100 ppm	41.667	47.667	18.444	8.089	6.411	10.860	200.301
T_3	Foliar application -200 ppm	41.778	48.000	18.222	7.722	7.167	11.600	211.375
T_4	Soil application - 200 ppm	38.000	45.889	17.556	7.622	6.811	9.250	162.393
T_5	Soil application - 400 ppm	39.444	45.889	17.778	8.367	7.367	10.390	184.713
T_6	Soil application - 600 ppm	36.444	42.667	17.778	7.278	7.756	10.710	190.402
T_7	Foliar application - 100 ppm +Soil application - 200 ppm	33.667	39.111	21.333	12.122	8.121	12.780	272.635
T_8	Foliar application -100 ppm + Soil application -400 ppm	34.222	41.444	19.778	11.100	7.78	12.230	241.884
T_9	Foliar application -100 ppm + Soil application - 600 ppm.	34.778	41.444	18.111	8.867	7.733	12.130	219.686
T_{10}	Foliar application 200ppm + Soil application -200 ppm.	38.000	444.444	16.778	8.133	7.711	11.860	198.987
T_{11}	Foliar application	40.222	46.444	14.867	8.167	6.811	11.350	169.080

	-200 ppm + Soil application-400 ppm.							
T_{12}	Foliar application -200 ppm + Soil application-600 ppm	41.667	48.000	15.889	8.811	6.133	11.010	174.937
S. Ed		**0.505**	**0.686**	**0.923**	**0.090**	**0.057**	**0.263**	**0.242**
CD (P= 0.05)		**1.049**	**1.425**	**1.917**	**0.188**	**0.119**	**0.553**	**0.228**