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Attributes of salicylic acid and humic acid on seed yield and quality in African marigold

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Abstract
A field experiment was conducted in *kharif* season of 2016-17 at Research Farm Horticulture Section, College of Agriculture Nagpur to evaluate effect of foliar application of salicylic acid and humic acid on quality and yield attributes of African marigold. The treatment comprised of different concentration of salicylic acid (50, 100, 150, 200 ppm), humic acid (250, 500, 750, 1000 ppm) and control (water spray) were applied as foliar sprays on 15th and 30th DAT. The treatments were replicated thrice in RBD. Among different concentrations of chemicals, salicylic acid 200 ppm recorded significantly maximum number of branches plant^{-1} (20.87), minimum days to 50 % flowering (62.00 days), number of flowers plant^{-1} (38.07), weight of dry flower (2.43 g), number of seeds flower^{-1} (197.61), seed yield hectare^{-1} (3.27 q), diameter of fully open flower (7.40 cm) and test weight (2.77 g) whereas minimum days to harvesting of flower for seed (34.00 days) were observed in salicylic acid 50 ppm and control.

Keywords: Salicylic acid, humic acid, African marigold, seed yield, quality

1. Introduction
Marigold (*Tagetes* spp.) is a common ornamental herbaceous annual plant. It is an important flower which is used for floral decorations, religious offering and also for making garland. It is popular flowering plant grown throughout the year. It has huge demand in market. Considering the demand of flowers in market, a quality seed production is need of a day and it is mainly depend on healthy growth of plant in different climatic conditions especially under biotic and abiotic stress. Biotic stress occurs as a result of damage to the plant by living organisms, such as bacteria, fungi, viruses, parasite, beneficial and harmful insects. Majority of plant diseases are caused by fungi. Abiotic stress is a negative impact of non-living organism in a specific environment. Such as intense sunlight, drought, wind and salinity may cause harm to the plant in the area affected. Abiotic stress is the most harmful factor concerning the growth and productivity of crop worldwide. Salicylic acid is phyto-harmone that play an important role in response to biotic stresses pathogenesis and also participate in the signaling of abiotic stress responses such as drought, high and low temperature, salinity, ozone, UV radiation and heavy metal. Similarly, humic acid helps to play an important role in nutrient uptake of plant, reduce fertilizer requirement & increase flower yield. It stimulates plant enzyme & hormones and also promotes antioxidant activity. It was observed that humic acid treatment in pot marigold (*Calendula officinalis.* L) Significantly increase dry weight, plant height, leaves and number of flowers. (Mohammadipour *et al.* 2012). Keeping in view the importance of salicylic acid & humic acid the present investigation has been undertaken.

2. Materials and methods
An experiment was conducted at the Research Farm of Horticulture Section, College of Agriculture, Nagpur during 2016-17. The experiment was laid in Randomized Block Design (RBD) with 9 treatments replicated thrice at spacing 45cm x 30cm with gross plot size 1.8mx 3.0m The treatments consisted viz., T_1- Control (water spray), T_2- Humic acid 250ppm, T_3- Humic acid 500ppm, T_4-Humic acid 750 ppm and T_5-Humic acid 1000 ppm, T_6- Salicylic acid 50ppm, T_7-Salicylic acid 100ppm, T_8- Salicylic acid 150ppm and T_9- Salicylic acid 200 ppm were applied as foliar spray on 15th and 30th days after transplanting. A recommended dose of FYM @ 25 t ha^{-1} and standard dose of NPK @ 100:50:25 kg ha^{-1} was applied through Urea, SSP and MOP. The basal dose of 50 kg N and full dose of P and K was applied at the time of transplanting; remaining dose 50 kg N was applied at one month after transplanting.

Observations were recorded on different parameters viz., number of branches, days to 50% flowering, number of flowers plant^{-1}, weight of dry flower, days to dry flower harvesting, number of seeds flower^{-1}, seed yield plot^{-1}, seed yield ha^{-1} and quality parameters, diameter of fully open flower and test weight during the course of investigation.

3. Results and discussion

3.1 Growth parameters

The data presented in Table 1 revealed that, different treatments showed significant differences with respect to number of branches. It was observed that maximum number of branches plant^{-1} in treatment salicylic acid 200 ppm (20.87) and found statistically at par with the treatments salicylic acid 150ppm and (19.80). However, minimum branches were recorded in the control treatment (15.87). The results obtained during this investigation are closely agreement with the finding of Kumar *et al.* (2015) [5]. The experiment was conducted on China Aster cv. Kamini where results revealed that increase in primary and secondary branches with application of salicylic acid 200 ppm.

Table 1: Growth, flowering, seed yield and quality as influence by foliar application of salicylic acid and humic acid.

Treatment	Branches plant^{-1}	Days to 50 % flowering (days)	Days to harvesting for seed from flower bud emergence (days)	Days to last harvesting for seed (days)	Number of flowers plant^{-1}	Weight of dry flower (g)	Number of seeds flower^{-1}	Seed yield plot^{-1} (kg)	Seed yield hectare^{-1} (q)	Diameter of fully open flower (cm)	Test weight (g)
T_1- Control (water spray)	**15.87**	**68.00**	**34.00**	**63.33**	**22.47**	**1.52**	**140.60**	**0.116**	**1.71**	**5.50**	**1.93**
T_2- Humic acid 250 ppm	**17.67**	**66.33**	**35.00**	**65.33**	**31.47**	**2.12**	**151.97**	**0.126**	**1.87**	**6.10**	**1.97**
T_3-Humic acid 500 ppm	**18.00**	**65.33**	**36.33**	**67.00**	**31.53**	**2.13**	**165.00**	**0.156**	**2.30**	**6.93**	**2.10**
T_4- Humic acid 750 ppm	**19.80**	**63.00**	**36.67**	**67.67**	**37.20**	**2.30**	**196.68**	**0.210**	**3.11**	**7.20**	**2.63**
T_5- Humic acid 1000 ppm	**18.93**	**64.67**	**39.33**	**70.33**	**32.00**	**2.05**	**175.28**	**0.174**	**2.57**	**7.10**	**2.53**
T_6- Salicylic acid 50 ppm	**17.93**	**65.67**	**34.00**	**67.00**	**33.53**	**2.12**	**151.72**	**0.145**	**2.15**	**6.80**	**2.07**
T_7- Salicylic acid 100 ppm	**18.00**	**63.33**	**35.67**	**67.33**	**33.80**	**2.17**	**165.42**	**0.165**	**2.44**	**7.07**	**2.27**
T_8- Salicylic acid 150 ppm	**19.00**	**63.00**	**36.67**	**67.67**	**35.80**	**2.37**	**173.59**	**0.190**	**2.81**	**7.17**	**2.53**
T_9- Salicylic acid 200 ppm	**20.87**	**62.00**	**37.33**	**68.33**	**38.07**	**2.43**	**197.61**	**0.221**	**3.27**	**7.40**	**2.77**
F test	**Sig.**	**Sig.**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE(m)±	**0.72**	**1.16**	**0.76**	**1.13**	**0.57**	**0.03**	**0.86**	**0.002**	**0.03**	**0.07**	**0.09**
CD at 5%	**2.18**	**3.52**	**2.31**	**3.41**	**1.74**	**0.11**	**2.58**	**0.007**	**0.10**	**0.21**	**0.28**

3.2 Flowering parameters

Significantly minimum days were required for 50% flowering when plants sprayed with salicylic acid at 200 ppm (62.00 days) and it was statistically at par with the treatments salicylic acid 150 ppm (63.00 days). However, significantly maximum days to 50% flowering (68.00 days) were noticed in the treatment control. Similar results were also reported by Yeluguri *et al.* (2015) with salicylic acid 200 ppm in marigold crop. Significant difference among the treatments in respect of days to harvesting of flowers for seed from flower bud emergence was recorded in African marigold. The treatments salicylic acid and control recorded significantly minimum period (34.00 days) and found to be at par with treatment humic acid 250 ppm (35.00 days) and salicylic acid 100 ppm (35.67 days) for harvesting of dry flowers for seed. Whereas, maximum period (39.33 days) were recorded in treatment humic acid 1000 ppm. Similar results were obtained by Khodakhah *et al.* (2014) in tuberose. Choudhary *et al.* (2016) in African marigold showed that increased duration of flower was recorded in salicylic acid 1 mM l^{-1}.

3.3 Yield parameters

The different treatments showed significant differences with respect to number of flowers plant^{-1}. The number of flowers plant^{-1} were noticed significantly maximum (38.07) with the treatment of salicylic acid at 200 ppm which was found to be at par with the treatment humic acid 750 ppm (37.20). While, minimum number of flowers plant^{-1} (22.47) were noted with the control treatment. The salicylic acid might have altered the biophysical properties of cell wall and also there is a synergistic effect of salicylic acid and auxin, which ultimately favored photosynthesis and translocation of assimilates into flower organ. The result obtained during investigation are closely in agreement with the finding of Kumar *et al.* (2015) [5]. The experiment conducted on China Aster where result revealed that, maximum number of flowers plant^{-1} with application of salicylic acid 200 ppm. In respect of weight of dry flower, significantly maximum weight of dry flower (2.43 g) was recorded with the treatment of salicylic acid at 200 ppm which was found to be at par with the treatment Salicilic acid 150 ppm (2.37g). Whereas, significantly minimum weight of dry flower (1.52 g) was noted with the control treatment. Similar results are in conformity with Gad El-Hak (2012) in pea. It was showed that pod weight increased in treatment salicylic acid 200 ppm and soil application of humic acid (85%) 1 g l^{-1}. The different treatments observed significant differences respect to number of seeds flowers^{-1}. The number of seeds flower^{-1} was significantly maximum with treatment salicylic acid 200ppm (197.61) which was at par with treatments humic acid 750 ppm (196.68). Whereas, minimum number of seeds flower^{-1} was noticed in the treatment control (140.60). Similar results reported by Gad El-Hak (2012) in pea that number of fresh seed pod^{-1} were increased by application of salicylic acid 200 ppm with humic acid 1 g l^{-1}.It has been observed that significantly highest seed yield hectare^{-1} was recorded under the treatment salicylic acid 200 ppm (3.27q) followed by treatment humic acid 750 ppm (3.11q). The lowest seed yield hectare^{-1} was recorded in control treatment (1.71q). The effect of salicylic acid on plant and seed yield might be due to accommodation of maximum number of flowers hectare^{-1} along with higher enlarged vegetative growth, photosynthetic pigments, minerals and some bio constituents which affect plant growth and in turn increased the seed yield plot^{-1} and hectare^{-1}. The above results

obtained during experiment are similar with Pavan Kumar *et al.* (2015) [5] who reported that foliar application of salicylic acid 200 ppm resulted in increased maximum seed yield plant^{-1} and hectare^{-1} in China Aster cv Kamini.

3.4 Quality parameters

The treatment Salicylic acid 200ppm had produced significantly the maximum diameter of fully opened flower (7.40cm) which was at par with the treatments Humic acid 750 ppm (7.20cm). Whereas, significantly minimum diameter of fully opened flower (5.50cm) was recorded under control treatment. Salicylic acid has positive effect on photosynthesis and carbohydrate in leaves and stem due to this reason flower size increased. The increase in flower diameter could be due to the synergism between salicylic acid and auxin. Similar results were obtained by Ram *et al.* (2012) who recorded increase in flower diameter with application of salicylic acid in gladiolus. Also, Abou El-Yazeid (2011) [1] recorded similar result in crop sweet paper with application of salicylic acid. The treatment salicylic acid 200ppm significantly recorded maximum test weight (2.77g) and it was found to be at par with the treatment humic acid 750 ppm (2.63g). Whereas, minimum test weight (1.93g) was recorded under the treatment control. Salicylic acid has positive effect on photosynthesis activity and carbohydrate in leaves and stem due to this reason seed quality and weight increased. Similar result were obtained by Kumar *et al.* (2015) [5] who recorded increase in 1000 seed weight with application of salicylic acid in china aster cv. Kamini. Also, Gad El-Hak *et al.* (2012) [3] recorded similar result in crop pea with application of salicylic acid with humic acid.

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