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Response of marigold cuttings to IBA and media for rooting and growth performance

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Abstract
An experiment was conducted to study the response of IBA and rooting media on rooting of cutting in African marigold cv. African Double Orange during the *kharif* season 2017-18 at Horticulture Section, College of Agriculture, Nagpur. The experiment was laid out in Factorial Completely Randomized Design with main factors viz.,50 ppm IBA, 100 ppm IBA, 150 ppm IBA and control and sub-factors, Sand 100%,Cocopeat + Perlite (3:1), Sand + FYM (1:1), Soil + FYM (2:1). Results of the investigation revealed that among different concentrations, IBA 100 ppm recorded significantly early sprouting of cuttings, maximum number of leaves, fresh and dry weight of shoot, final success percentage of rooted cuttings, length of roots and number of roots. Similarly, rooting media- Soil: FYM (2:1) found to be superior in respect of shoot and root parameters in rooted cuttings. However, minimum days to rooting of cuttings were observed in the treatment combination IBA 50 ppm with rooting media cocopeat: perlite (3:1).

Keywords: marigold, IBA, rooting media, cutting, growth

Introduction
Marigold (*Tagetes erecta* L.) is one of the commercially exploited flower crop having different flower colours, compactness, marketable size, easy culture and wide adaptability by which it gained the popularity amongst gardeners and flower dealers. However, due to its highly cross pollinated nature, true to type of flowers cannot be obtained naturally. Therefore, propagation techniques by cuttings may be applied to overcome this problem. The survival of cuttings usually depends upon the favorable factors like environment physiological conditions of parent plant, type of cutting, rooting medium and hormones. In sexually propagated marigold crop natural crossing is a source of varital deterioration due to introgation to gene from unrelated stock. Similarly production of genetically pure and good quality pedigree seed is an exacting task requiring high technical skill and comparatively heavy financial investment. Therefore, vegetative propagation is a form of asexual reproduction by which plants are true to type.

Materials and Methods
An experiment entitled "Response of marigold cuttings to IBA and media for rooting of cuttings and growth performance" was conducted at an experimental field of Horticulture Section, College of Agriculture, Nagpur during the *kharif*- 2017. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with main factors viz., 50 ppm IBA, 100 ppm IBA, 150 ppm IBA and control and sub-factors, Sand 100%, Cocopeat + Perlite (3:1), Sand + FYM (1:1), Soil + FYM (2:1) and three replications to observe the response of IBA and rooting media on rooted cutting. Treatment wise solutions were prepared and cuttings were dipped for 1 minute and transferred to the rooting media in the pro trays. Thirty cuttings per treatment were used in a pro-tray. Weekly observations were recorded for initiation of roots to find out the time required for rooting. Whereas, other observations on root and shoot were recorded 30 days after planting of cuttings. At the time of recording of observations, cutting were carefully uprooted and washed in running water to remove the media particles.

Results and Discussion
Effect of lBA on cuttings for shoot parameters
Days to sprouting of cuttings
The data presented in Table 1 revealed that different levels of IBA had significant effect on all

shoot and root pararmeters.
IBA 100 ppm recorded significantly minimum days to sprouting of cuttings (9.06 days) and found at par with IBA 150 ppm (9.11 days). The early sprouting of marigold cuttings might be due to the fact that external application of auxins promotes growth and produced more favourable conditions for sprouting. These findings are in agreement with the results of Singh *et al.* (2013) [13] in Night Queen (*Cestrum nocturnum* L).

Number of leaves cutting^{-1}
The data indicated that number of leaves per cutting was significantly maximum (7.1) were noticed with application of IBA 100 ppm at 25 days after planting of cuttings which was at par with application of IBA 50 ppm (6.88) and minimum number of leaves per cutting (5.22) was recorded in control. This might be due to vigorous root system and absorption of more nutrients along with moisture as compared to cuttings in all other treatments which in turn increased the more number of leaves. The results are in conformity with finding of Ullah *et al.* (2013) [14] in Marigold.

Fresh weight of shoot as influenced by lBA and rooting media
The data revealed that IBA 100 ppm was statistically superior in fresh weight of shoots (0.73 g) and found at par with IBA 50 ppm (0.70 g) and IBA 150 ppm (0.68 g). Maximum fresh weight of shoot might be due to early and fast cell division and cell enlargement with early and easy initiation of roots caused by auxin. The results are conformity findings of Ganjure *et al.* (2013) in chrysanthemum.

Dry weight of shoot
The data regarding dry weight of shoot influenced by 100 ppm IBA was found to be significantly superior for dry weight of shoots (0.152 g) followed by treatment IBA 150 ppm (0.140 g). The minimum dry weight of shoots was recorded in control treatment (0.130 g). Dry weight of shoot was highest may be due to contribution of early sprouting, number of leaves, length and diameter of of cuttings. Ganjure *et al.* (2013) supported in chryasnthemum and Wazir (2014) [15] in experiment camellia in bougainvillea.

Height of cutting
The result indicated that maximum height of cutting (13.66 cm) 25 days after planting of planting was significantly influenced by 100 ppm IBA which was at par with application of lBA 50 ppm (13.28 cm). However, minimum height of cutting was recorded in control (7.63 cm). Maximum height may be due to auxins stimulate elongation of roots of many species and activated shoot growth which might have resulted in elongation of stems and leaves through cell division accounting for more number of leaves and length of longest shoot. The results are in conformity with finding of Ullah *et al.* (2013) [14] in marigold.

Final success of rooting of cuttings
Result revealed that IBA 100 ppm recorded significantly maximum final rooting success of cuttings (89.37 %) over remaining treatments followed by IBA 150 ppm (80.78%). The minimum final success (66.12 %) of cuttings was observed in control treatment. Maximum final success of cutting might be due to development of effective root system and increase in number and length of roots per cutting as influenced by the up take of nutrients and water (Reddy *et al*., 2008) [11]. The survival of the sprouted cuttings might be directly linked to the formation of adventitious roots on cuttings.

Effect of lBA on cuttings for root parameters
Days to rooting
It was evident from Table 1 that IBA 100 ppm recorded statistically minimum days (9.10 days) for rooting over remaining treatments followed by IBA 150 ppm (9.78 days). Whereas, maximum days (10.30 days) required for rooting of cutting was observed in control treatment. The promotional effect of IBA 100 ppm on rooting of cuttings might be due to the fact that external application of auxins promoted growth and produced more favourable condition for rooting. (Hartman and Kester, 2002) [7].

Table 1: Rooting and growth parameters of marigold cuttings as influenced by IBA and rooting media

Treatments	Days to sprouts (days)	Number of leaves cutting^{-1}	Fresh weight of shoot (g)	Dry weight of shoot (g)	Height of cutting (cm)	Final success (%)	Days to rooting (days)	Root length (cm)	Number of roots cutting^{-1}
Factor A- IBA (G)									
G_1-Control	11.82	5.22	0.63	0.130	7.63	66.12	10.30	4.54	29.76
G_2-50 ppm	10.21	6.88	0.70	0.132	13.28	76.32	10.04	4.27	32.71
G_3-100 ppm	9.06	7.10	0.73	0.152	13.66	89.37	9.10	5.25	53.23
G_4-150 ppm	9.11	5.50	0.68	0.140	10.17	80.78	9.78	4.61	42.23
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E.(M) ±	0.18	0.13	0.02	0.002	0.17	1.15	0.06	0.10	0.57
C.D. at 5%	0.54	0.37	0.06	0.007	0.51	3.34	0.17	0.30	1.65
Factor B-Rooting media (M)									
M_1-Sand	10.22	5.51	0.65	0.132	9.91	75.19	10.19	4.35	39.26
M_2-Cocopeat: Perlite (3:1)	10.45	6.48	0.62	0.135	11.11	78.58	9.61	4.61	31.52
M_3 -Sand:FYM (1:1)	10.39	6.03	0.72	0.142	11.60	79.37	9.87	4.69	39.76
M_4-Soil:FYM (2:1)	9.14	6.67	0.76	0.145	12.13	79.45	9.55	5.03	41.4
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E.(M) ±	0.18	0.13	0.02	0.002	0.17	1.15	0.06	0.10	0.57
C.D. at 5%	0.54	0.37	0.06	0.007	0.51	3.34	0.17	0.30	1.65
Interaction AXB									
F test	Sig.	Sig.	Sig.	Sig.	Sig.	N.S.	Sig.	Sig.	Sig.
SE (m) ±	0.45	0.31	0.05	0.006	0.43	2.83	0.15	0.25	1.39
CD at 5%	1.32	0.92	0.15	0.017	1.25	-	0.43	0.73	4.04

Root length
The results revealed that maximum length of roots per cutting (5.25cm) was significantly influenced by IBA 100 ppm and followed by IBA 150 ppm (4.61 cm). Whereas, minimum length of roots per cutting (4.27 cm) was recorded in IBA 50 ppm. The maximum length may be due to early differentiation of cells and enhanced cell elongation caused by auxin. Auxins initiate synthesis of structural enzyme protein in the formation of adventitious roots. Thus, increasing the root length through the process of acidification. The results are in conformity with finding of Bhatt *et al.* (2012) [3] in marigold.

Number of roots cutting^{-1}
The result revealed that maximum number of roots per cutting (53.23) was significantly noticed in IBA 100 ppm and followed by IBA 150 ppm (42.23). Whereas, significantly minimum number of roots per cutting (29.76) was recorded in control. The maximum number of roots per cutting might be due to auxin with appropriate concentration induces early and better root initiation. Thus, the maximum number of roots were produced in those treatment which received appropriate concentration of auxin which initiate early and more root per cuttings. The results are conformity with finding of Bhatt *et al.* (2012) [3], Ullah *et al*. (2013) [14] in Marigold.

Effect of rooting media
The data presented in Table 1 revealed that days to sprouting of cuttings of African marigold was noticed significantly minimum (9.14 days) in rooting media soil and FYM (2:1) followed by sand 100% (10.22 days). The maximum days to sprouting of cuttings (10.45 days) were noticed in coco peat and perlite (3:1). The early sprouting of cuttings might be due to the fact that soil and FYM media is highly porus material and therefore it absorbed the large volume of water. The findings are agreement with the result of Baghel and Saraswat (1989) [2] in pomegranate.

Number of leaves cutting^{-1}
The results revealed in Table 1 indicated that significantly maximum number of leaves per cutting (6.67) was noticed in rooting media soil: FYM which was at par with rooting media (3:1) cocopeat and perlite (6.48). Whereas, minimum number of leaves per cutting (5.51) were recorded in rooting media sand (100%). The maximum number of leaves were recorded in rooting media might be due to more availability of nutrients in rooting media which in turn increased the more number of leaves. The result are in conformity with the Baghel and Saraswat (1989) [2] in pomegranate.

Fresh weight of shoot
Maximum fresh weight of shoot per cutting (0.76 g) was recorded in treatment soil and FYM (2:1) and found at par with rooting media sand and FYM (1:1) and minimum fresh weight of shoot per cutting (0.62 g) was recorded in rooting media coco peat and perlite (3:1).The rooting media soil and FYM (2:1) observed maximum fresh weight of shoot per cutting in African marigold might be due to better aeration and drainage condition and water maintenance capability (Khayyat *et al*., 2007) [10] in pothos.

Dry weight of shoot
Significantly, maximum dry weight of shoot per cutting (0.145 g) was recorded in soil and FYM (2:1) and found at par with Sand and FYM (1:1) (0.142 g) and minimum dry weight of shoot per cutting (0.132 g) was recorded in rooting media sand. This might be due to cuttings grown in a mixture of soil and FYM could be attributed to higher degree of fertility and water retaining capacity (Biswar and Mukherjee, 2009) [4]. The results are in line with the findings of Deb *et al*. (2009) [5] in lemon.

Height of cutting
The data presented in Table 1 revealed that 25 days after transplanting of cuttings significantly maximum height of cutting (12.13 cm) was noticed in rooting media of soil and FYM (2:1) followed by rooting media sand and FYM (11.60). However, minimum height of cutting (9.91 cm) was recorded in rooting media sand. Maximum height of cutting was recorded in rooting media soil and FYM (2:1) might be due to more availability of nutrient in rooting media which in turn increased the more height of cutting. The results are in conformity with findings of Baghel and Saraswat (1989) [2] in pomegranate.

Final rooting success
The data regarding final success of cuttings (79.45 %) was recorded in treatment Soil and FYM and found at par with rooting media Sand and FYM. Minimum final success was recorded in rooting media Sand (75.19 %). Maximum survival percentage of cutting might be due to sufficient aeration in media which is necessary for the gaseous exchange between the soil and atmosphere to remove CO_2 released by roots and microorganisms in the soil to external atmosphere and supply of O_2 from the external atmosphere to the growing roots leading to better respiration and survival of plants (Jeyaseeli and Paul Raj, 2010) [9].

Days to rooting
The results revealed that minimum days to rooting of cuttings (9.55 days) was recorded in soil and FYM and found significantly superior over other treatments. The treatment coco peat and perlite was found at par (9.61 days). Whereas, the maximum days to rooting of cuttings (10.19 days) was noticed in 100% sand. The minimum days to rooting might be due to highly porous material and therefore it absorbed the required volume of water for rooting. The results are in conformity with finding of Baghel and Saraswat (1989) [2] in pomegranate.

Root length
The length of roots per cutting was found to be significantly maximum (5.03 cm) was noticed in rooting media soil and FYM which was at par with sand and FYM (4.69 cm). Significantly, minimum length of roots per cutting (4.35 cm) was recorded in rooting medium sand. The maximum length of roots per cutting was recorded in rooting media soil and FYM might be due to more availability of nutrient in rooting media which in turn increased the length of root. Baghel and Saraswat (1989) [2] noticed in pomegranate.

Number of roots cutting^{-1}
The data from Table 1 indicated that, the number of leaves per cuttings was maximum number per cutting (41.4) in rooting media soil and FYM (2:1) followed by sand (100%) (40.18). Minimum number of roots per cutting (39.26) was recorded in media, coco peat and perlite (3:1). The maximum number of roots per cutting might be due to cuttings grown in a mixture of soil and FYM could be attributed to higher degree of fertility and water retention capacity (Biswar and Mukherjee,

2009) [4]. The results are conformity with finding of Baghel and Saraswat (1989) [2] in pomegranate.

Interaction effect as influenced by IBA and rooting media on shoot parameters

Days to sprouting of cuttings

Interaction effect on different levels of lBA and rooting media were found to be significant for shoot and root parameters except final rooting success percentage of cuttings. The data presented in Table 1 revealed that minimum days required for sprouting of cuttings (8.08 days) was recorded in treatment combination IBA 50 ppm and soil: FYM and found at par with IBA 150 ppm and sand (8.40 days). Whereas, maximum days required for sprouting of cuttings (12.66 days) was recorded in treatment combination control with sand.

Number of leaves cutting^{-1}

The maximum number of leaves per cutting (8.73) was recorded in treatment combination IBA 100 ppm and soil: FYM (2:1) and found at par with IBA 50 ppm and soil: FYM (7.60). The minimum number of leaves per cutting (5.07) was recorded in treatment combination control and sand. The maximum number of leaves per cutting might be due to mixture of IBA and soil: FYM which provides suitable condition to increase number of leaves.

Fresh weight of shoot

Significantly maximum on fresh weight of shoots (0.86 g) per cutting was recorded in treatment combination IBA 100 ppm and soil: FYM (2:1) and found at par with IBA 100 ppm with sand: FYM (1:1). The minimum fresh weight of shoots per cutting (0.56 g) was recorded in treatment combination of IBA 150 ppm and cocopeat: perlite (3:1).The maximum fresh weight of shoots per cutting was recorded in treatment combination IBA 100 ppm and soil: FYM (2:1) might be due to height of cutting, number of leaves and diameter of cutting as influenced by auxin and media. The aeration, drainage and nutrient retention for new root system may resulted to increase fresh weight of shoot.

Dry weight of shoot

The treatment combination IBA 100 ppm and soil: FYM (2:1) recorded significantly maximum dry weight of shoots per cutting (0.180 g) and found at par with IBA 100 ppm and sand: FYM (1:1) (0.150 g). The minimum dry weight of shoots per cutting (0.120 g) was recorded in treatment combination of control with sand. The maximum dry weight of shoots per cutting might be due to auxins which activated shoot growth and resulted in elongation of stems and leaves through cell division accounting for higher dry weight of shoot (Abraham, 1996) [1] and cuttings grown in a mixture of soil and FYM could be attributed to higher degree of fertility and water retaining capacity (Biswar and Mukherjee, 2009) [4]. The results are in line with the findings of Khayyat *et al*. (2007) [10] in pothos, Deb *et al*. (2009) [5] in lemon.

Height of cutting

The treatment combination IBA 100 ppm with soil: FYM significantly attained maximum height of cuttings (16.40 cm) and found at par with IBA 100 ppm and sand: FYM (15.53 cm). Whereas, minimum height of cuttings (7.07cm) was recorded in treatment combination control and sand.

Final success

The data exhibited that an interaction effect of IBA and rooting media were found to be non significant.

Interaction effect as influenced by IBA and rooting media on root parameters

Days to rooting

The data exhibited that an interaction effect of IBA and rooting media were found to be significant for days to rooting of cutting, root length and number of roots per cuttings. Significantly, minimum days (8.00 days) required for rooting of cutting was recorded in treatment combination IBA 100 ppm and coco peat: perlite and found at par with IBA 150 ppm and soil: FYM (8.58 days). The maximum days required for rooting of cutting was recorded in treatment combination control with sand (10.63 days). The minimum days required for rooting of cuttings (8.00 days) was observed in treatment combination IBA 100 ppm with cocopeat and perlite might be due to coco peat has a high water holding capacity which helps in high absorption of water and nutrients (Rubasinghe *et al*., 2009) [12]. This results are conformity finding of Izadi *et al.* (2012) [8] in rose.

Root length and number of roots cutting^{-1}

Significantly, maximum length of roots per cutting (5.91 cm) and number of roots per cutting (56.27) were recorded in treatment combination IBA 100 ppm with soil and. The maximum length of roots and number of roots per cutting were recorded in treatment combination IBA 100 ppm with soil and FYM might be due to auxins which initiates synthesis of structural enzyme protein in the formation of adventitious roots whereas in soil: FYM more availability of nutrients which in turn increase the length of roots.

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