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Interactive effect of different levels of fertilizers and plant growth regulators on yield and economics of African marigold (*Tagetes erecta* L.)

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Abstract
The investigation was aimed to find out the interactive effect of different levels of fertilizers and plant growth regulators on yield and economics of African marigold (*Tagetes erecta* L.) cv. 'Pusa Narangi Gainda'. The experiment comprised three levels of fertilizers (100% RDF, 80% RDF and 60% RDF) and five different concentrations of plant growth regulators (water spray, 25 ppm GA_3, 50 ppm GA_3, 1 ppm Triacontanol and 2 ppm Triacontanol) was laid out in a Randomized Block Design with factorial concept and three replications. Results revealed that yield attributes such as fresh weight of single flower (6.06 g), flower diameter (6.25 cm), number of flowers per plant (64.86), flower yield per plant (318.26 g), per plot (2.79 kg) and per hectare (114.76 q) were found maximum with 100% RDF. Among plant growth regulators, two times application (30 and 60 DAT) of 50 ppm GA_3 resulted in maximum fresh weight of individual flower (6.21 g), flower diameter (6.49 cm), number of flowers per plant (67.62), flower yield per plant (314.90 g), per plot (2.78 kg) and per hectare (114.49 q). The interaction between 100% RDF and 50 ppm GA_3 was found superior with respect to fresh weight of single flower (6.59 g), number of flowers per plant (73.23), flower yield per plant (377.30 g), per plot (3.31 kg) and per hectare (136.35 q) as well as benefit cost ratio (1:1.85). It can be concluded that 100% RDF with two time foliar application (30 and 60 DAT) of 50 ppm GA_3 gives higher yield and economic benefits in African marigold.

Keywords: African marigold, fertilizers, plant growth regulators, yield and economics

Introduction

In Gujarat, marigold occupies the most prominent place among all the flower crops. It is also state flower of Gujarat. Marigold has become one of the most popular flower crops because of its easy cultivation, wide adaptability to various soil and climatic conditions, long flowering duration, attractive flower colour with excellent keeping quality as well as easy transportation.

Marigold has great demand for loose flowers, garden display, garlands and decorative purposes at various social and religious functions. Marigold can be cultivated more or less throughout the year and hence commonly always available in market. The petals of African marigold are a good source of carotenoid specially lutein which is used as a natural pigment for textile coloration, colouring agent for food in confectionaries and an additive in poultry feed to intensify the colouration in egg yolk (Kammeswari *et al.*, 2011) [3]. The uses of marigold are many folds and it is often referred to as "versatile crop with golden harvest".

Marigold crop when grown in soil without fertilization usually suffers from nutrients deficiency and the application of fertilizers becomes an essential tool to boost up the yield. Improper nutrition leads to nutrient imbalance in plants and is a major factor contributing to lower yield. Under normal agro-climatic condition, the deficiencies of major nutrients *viz.*, nitrogen, phosphorus and potassium are common and cause serious problems in flowers production. Nutrition plays an important role in growth and yield of flowers. There is great demand of marigold throughout the year, especially during festive season. To fulfill the ever-increasing demand, it is necessary to increase its production through improved production technologies. Nitrogen is an essential element required by the plants for growth and development. An adequate supply of nitrogen is associated with vigorous vegetative growth and deep green colour of leaves. Nitrogen plays vital role in the synthesis of chlorophyll as well as amino acids, which contribute to the building units of protein and thereby, growth of plants. A good supply of phosphorus is associated with increased root growth and early maturity of crop besides disease resistance in plants. Application of phosphorus not only increases the crop yield but also improves the quality (Sharma, 2018) [12]. Potassium enhances the translocation of photosynthates and regulates the opening and closing of stomatas so, it is also major essential element for plant growth and flower yield of marigold.

Plant growth regulators consist of a large group of naturally occurring or synthetically produced organic chemicals and considered as helping tool in the modern production system of ornamentals.

These substances modify the plant physiological processes within the plant which ultimately affects growth, yield and quality (Vaghasia and Polara, 2015) [14]. For the production of economical yield of better-quality marigold flowers, it is necessary to adopt a proper agro technique by applying important nutrients in requisite quantity and special horticultural practices. Gibberellins (GA_3) play an important role in growth and flowering of ornamental plants. Foliar application of gibberellic acid enhances vegetative attributes along with flower initiation (Kumar *et al.*, 2003) [5]. Triacontanol (TRIA) is a natural plant growth regulator found in epicuticular waxes (Naeem *et al*., 2012) [8]. Triacontanol increase cell division rates, which produces large root and shoot mass, improve protein synthesis, promote flowering and earlier crop maturity (Naeem *et al*., 2012) [8]. Both GA_3 and Triacontanol outstandingly claim to promote growth and yield of certain crops. Thus, determining to the large scale cultivation and demand of marigold, this study was conducted to find out the interactive effect of different levels of fertilizers and plant growth regulators on yield and economics of African marigold.

Materials and Methods

The field experiment was conducted during 2019-20 at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Mehsana, Gujarat. Seeds of African marigold cv. 'Pusa Narangi Gainda' were sown on the raised beds and healthy and uniform seedlings were transplanted at a spacing of 60 cm x 45 cm on flat beds of 3.0 m × 2.25 m size after one month of sowing. There were fifteen treatment combinations with three levels of RDF *i.e.* 100%, 80% and 60% and five PGRs treatments *i.e.* water spray, 25 ppm GA_3, 50 ppm GA_3, 1 ppm triacontanol and 2 ppm triacontanol. The well decomposed FYM (15 t/ha) and recommended dose of chemical fertilizers at the rate of 250 kg N, 100 kg P_2O_5 and 100 kg K_2O per hectare were applied as per the treatment. Foliar application of plant growth regulators was done at 30 and 60 days after transplanting. The experiment was laid out in a Randomized Block Design with factorial concept and replicated thrice in open field condition. Observations on different yield parameters were recorded and analyzed statistically. Net return (Barghash *et al.*, 2014) [1] and benefit: cost ratio (Jat *et al.*, 2017) [2] were calculated by using the formulas given below.

Net returns (₹/ha) = Gross returns (₹/ha) − Total cost of cultivation (₹/ha)

$$\text{Benefit Cost ratio} = \frac{\text{Net returns (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

Results and discussion

Yield characters

The yield characteristics of African marigold *viz.* number of flowers per plant, flower yield per plant, per plot and per hectare were significantly influenced by various treatments (Table 1-3). Among the various fertilizer treatments, maximum fresh weight of flower (6.06 g), flower diameter (6.25 cm), number of flowers per plant (64.86), flower yield per plant (318.26 g), per plot (2.79 kg) and per hectare (114.76 q) was recorded in 100% RDF. Among the plant growth regulators, significantly maximum fresh weight of flower (6.21 g), flower diameter (6.49 cm), number of flowers per plant (67.62), flower yield per plant (314.90 g), per plot (2.78 kg) and per hectare (114.49 q) was recorded with application of 50 ppm GA_3. The interaction effect between fertilizers and plant growth regulators was also found significant for yield characters except for flower diameter. The maximum fresh weight of flower (6.59 g), number of flowers per plant (73.23), flower yield per plant (377.30 g), per plot (3.31 kg) and per hectare (136.35 q) was recorded with interaction of 100% RDF and two times foliar application of 50 ppm GA_3. The fresh weight of flower and yield was significantly influenced by fertilizers, which might have accelerated the photosynthetic activities of plants and thus more assimilates have been available to the flowers resulting in increased vegetative growth, flower weight and diameter therefore more number of flowers per plant and per hectare. Potassium increases carbon exchange and enhances carbohydrate movement which consequently stimulates weight of flower (Senapati, 2018) [11]. These results corroborate with the findings of Saravanan and Kumar (2016) [10], Singh and Vikram (2016) [13] and Palekar *et al.* (2018) [9] in African marigold. Foliar application of GA_3 has produced large number of laterals at early stage of growth which had sufficient time to accumulate carbohydrate for proper flower bud differentiation due to enhanced reproductive efficiency and diversification of photosynthates towards the flowers that resulted in more accumulation of metabolites and production of large sized flowers as well as flower yield. Another possible reason may be that inorganic fertilizers assure quick availability of essential nutrients and growth regulators increase cell elongation. These results corroborate the earlier findings of Kumar *et al.* (2010) [7], Kumar *et al.* (2016) [6] and Khangjarakpam *et al.* (2019) [4] in African marigold.

Economics

Influence of application of different levels of fertilizers and plant growth regulators on net return and benefit cost ratio in African marigold are presented in Table 4. The results revealed that among the fifteen-treatment combination, 100% RDF and 50 ppm GA_3 recorded maximum gross return of ₹ 272702 per ha, net return of ₹ 177035 per ha and benefit cost ratio 1:1.85. This might be due to the fact that an application of full dose of RDF and 50 ppm GA_3 helped in achieving significant flower yield as well as obtained maximum gross and net monetary returns as compared to other interaction treatments in African marigold.

Conclusion

On the basis of the results of the present investigation, it could be concluded that application of 100% RDF (NPK 250:100:100 kg/ha) along with two times foliar application (30 and 60 DAT) of 50 ppm GA_3 is beneficial for obtaining good flower yield with higher net returns and B:C ratio in African marigold.

Table 1: Effect of different levels of fertilizers and plant growth regulators on fresh weight of single flower (g) and flower diameter (cm)

Plant growth regulators (G) (ppm)	Fresh weight of single flower (g)				Flower diameter (cm)			
	Levels of fertilizers (F)			Mean	Levels of fertilizers (F)			Mean
	f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF		f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF	
g_0 - Water spray	5.18	5.02	4.92	5.04	5.20	5.03	4.90	5.04
g_1 - GA_3 25 ppm	6.07	5.89	5.64	5.87	6.30	6.03	5.40	5.91
g_2 - GA_3 50 ppm	6.59	6.38	5.65	6.21	7.07	6.80	5.59	6.49
g_3 - Triacontanol 1.0 ppm	6.10	5.80	5.04	5.65	5.84	5.67	5.00	5.50
g_4 - Triacontanol 2.0 ppm	6.38	6.21	5.09	5.89	6.87	6.37	5.20	6.14
Mean	6.06	5.86	5.27		6.25	5.98	5.22	
	F	G	Interaction (F x G)		F	G	Interaction (F x G)	
S.Em.±	0.07	0.09	0.16		0.09	0.11	0.20	
C.D. at 5 %	0.21	0.27	0.46		0.25	0.33	NS	

* NS- Non significant

Table 2: Effect of different levels of fertilizers and plant growth regulators on number of flowers per plant and flower yield per plant (g)

Plant growth regulators (G) (ppm)	Number of flowers per plant				Flower yield per plant (g)			
	Levels of fertilizers (F)			Mean	Levels of fertilizers (F)			Mean
	f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF		f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF	
g_0 - Water spray	61.11	56.55	50.56	56.07	293.90	246.41	224.10	254.80
g_1 - GA_3 25 ppm	64.21	60.17	58.53	60.97	319.11	288.07	226.82	278.00
g_2 - GA_3 50 ppm	73.23	68.82	60.80	67.62	377.30	301.96	265.42	314.90
g_3 - Triacontanol 1.0 ppm	61.02	60.33	59.60	60.31	297.82	283.64	240.08	273.85
g_4 - Triacontanol 2.0 ppm	64.72	62.07	60.52	62.44	303.17	295.09	287.36	295.21
Mean	64.86	61.59	58.00		318.26	283.04	248.76	
	F	G	Interaction (F x G)		F	G	Interaction (F x G)	
S.Em.±	0.66	0.85	1.47		5.14	6.63	11.49	
C.D. at 5 %	1.90	2.46	4.26		14.88	19.21	33.28	

Table 3: Effect of different levels of fertilizers and plant growth regulators on flower yield per plot (kg) and per hectare (q)

Plant growth regulators (G) (ppm)	Flower yield per plot (kg)				Flower yield per hectare (q)			
	Levels of fertilizers (F)			Mean	Levels of fertilizers (F)			Mean
	f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF		f_1 - 100% RDF	f_2 - 80% RDF	f_3 - 60% RDF	
g_0 - Water spray	2.60	2.12	1.90	2.20	106.86	87.11	78.19	90.72
g_1 - GA_3 25 ppm	2.73	2.52	2.00	2.42	112.48	103.57	82.30	99.45
g_2 - GA_3 50 ppm	3.31	2.74	2.29	2.78	136.35	112.89	94.24	114.49
g_3 - Triacontanol 1.0 ppm	2.63	2.48	2.04	2.39	108.37	102.19	83.95	98.17
g_4 - Triacontanol 2.0 ppm	2.67	2.58	2.51	2.58	109.74	106.17	103.16	106.36
Mean	2.79	2.49	2.15		114.76	102.39	88.37	
	F	G	Interaction (F x G)		F	G	Interaction (F x G)	
S.Em.±	0.05	0.06	0.10		1.88	2.42	4.20	
C.D. at 5 %	0.13	0.17	0.30		5.44	7.02	12.16	

Table 4: Interaction effect of different levels of fertilizers and plant growth regulators on economics and benefit cost ratio

Treatment combinations	Gross returns (₹/ha)	Total cost (₹/ha)	Net returns (₹/ha)	Benefit Cost Ratio
$f_1 g_0$	213717	88427	125290	1.42
$f_1 g_1$	224966	92047	132919	1.44
$f_1 g_2$	272702	95667	177035	1.85
$f_1 g_3$	216735	88977	127758	1.44
$f_1 g_4$	219479	89527	129952	1.45
$f_2 g_0$	174211	86385	87826	1.02
$f_2 g_1$	207133	90005	117128	1.30
$f_2 g_2$	225789	93625	132164	1.41
$f_2 g_3$	204390	86935	117455	1.35
$f_2 g_4$	212346	87485	124861	1.43
$f_3 g_0$	156379	84344	72035	0.85
$f_3 g_1$	164609	87964	76645	0.87
$f_3 g_2$	188477	91584	96893	1.06
$f_3 g_3$	167901	84894	83007	0.98
$f_3 g_4$	206310	85444	120866	1.41

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