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Yield and economics of marigold (*Tagetes erecta* L.) as influenced by spacing and fertigation under protected conditions

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Abstract
A field experiment comprising of six treatment combinations with spacing (60 cm x 45 cm) (60 cm x 60 cm) and water soluble fertilizers (WSF) as a nutrient source, three levels (80, 100 and 120% recommended dosage of fertilizers) and was conducted at department of horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru during 2017-2018. The yield parameters of marigold cv. Supreme Yellow in terms of number of flowers per plant(30.80), number of flowers per unit area (450.50), single flower weight (6.20 g), and weight of 30 flowers (163.22 g), yield of flowers per plant (91.58 g), yield of flower per unit area (3.40 kg), yield of flowers per hectare (11.30 t) diameter of flower (5.74 cm) and cost benefit ratio (1:1.50) increased significantly with wider spacing at (60 cm x 60 cm) and water soluble fertilizers at 100 percent recommended dosage of fertilizers supplied through fertigation at fifteen days intervals from the study. It is evident that maximum growth parameters in marigold could be obtained by application of water soluble fertilizers at 100 percent of RDF through fertigation.

Keywords: Marigold, spacing, fertigation, yield

Introduction
Marigold is one of the most important commercially grown loose flower crops in India. It is used as loose flower or to make garlands, which are extensively used in the religious and social functions. Marigold is broadly classified into two groups, *Viz*., African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) African marigold (*Tagetes erecta* L.) is a seasonal flowering plant which belonging to the family Asteraceae and is a native of South and Central Americas, especially Mexico. It can be used in landscaping and can also be used as bedding or potted plant. The petals of the flowers serve as a major source of Carotenoids and leaves are effective in controlling root-knot nematodes. Hence it is being grown for flowers, in addition to its medicinal value compared to ornamental plants like lilies.
In supplement to all the above applications, carotene pigments especially, lutein, a constituent of xanthophyll, from marigold flowers are extracted and plants are commercially used to manufacture poultry feed for increasing the yellow colour of yolk of eggs (Bird, 1996) [2].
Spacing plays an important role in growth and flowering of the crop. It influences the Environmental conditions. Proper spacing helps in the availability of more nutrients, aeration and light intensity by which the crop can grow properly in terms of quality and quantity.
The advantages of fertigation are that the required nutrients can be applied uniformly to each and every plant even on daily basis, thereby creating an ideal and optimum environment for the plants to absorb the required nutrient so as to reduce wastage and increase the yield substantially.

Material and methods
The experiment was conducted at the department of horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru during 2017-2018. The soil of the experimental area was red sandy loam soil having a p^H of 6.8 the experiment consisting of two levels of spacing (60 cm x 45 cm) and (60 cm x 60 cm) and three levels of fertilizers 80, 100 and 120% recommended dosage of fertilizers (225: 60: 60 kg NPK ha^{-1}) was laid out in randomized complete block design and replicated four. There were total six treatments as given below.

T_1: 60 cm x 45 cm with 80 percent of Recommended Dosage of Fertilizers
T_2: 60 cm x 45 cm with 100 percent of Recommended Dosage of Fertilizers
T_3: 60 cm x 45 cm with 120 percent of Recommended Dosage of Fertilizers
T_4: 60 cm x 60 cm with 80 percent of Recommended Dosage of Fertilizers
T_5: 60 cm x 60 cm with 100 percent of Recommended Dosage of Fertilizers
T_6: 60 cm x 60 cm with 120 percent of Recommended Dosage of Fertilizers

The single plot size 3x3 m. and number of plants/ unit area is 10 plants, and FYM 25 t ha^{-1} were applied. Fertigation treatments received fertilizers at 15 days intervals from date of transplanting till harvesting.
Weeding and plant protection measures were taken up when required. From each treatment 8 plants were selected at random for recording yield characters, *viz*, number of flowers per plant, number of flowers per unit area, single flower weight, weight of 30 flowers, yield of flowers per plant, yield of flower per unit area, yield of flowers per hectare, diameter of flower and cost economics. And the flowers were harvested as and when flowers attained full bloom stage.

Results and discussion
From the data presented in Table 1, flower characteristics such as number of flowers per plant (33.18), number of flowers per unit area (485.50) single flower weight (6.73 g) and weight of 30 flowers and (180.45 g) were found to be significantly higher with T_5 (60 cm x 60 cm and 100 percent RDF) supplied through fertigation The results indicated that application of medium level of recommended dosage of fertilizers with wider spacing increased number of flowers per plant, per unit area, individual flower weight and weight of thirty flowers. however, higher level fertigation with closer spacing reduced the more number of flowers per pant, and per unit area.
Number of marigold flowers per plant and weight of marigold flowers depend on number of branches, spread of plant in different directions, photosynthates accumulated in the plant system which altogether are influenced by spacing, levels of fertigations, nutrient availability in the soil and nutrient uptake by the marigold plant. Significantly higher number of marigold flowers per plant and per unit area, weight of single and 30 marigold flowers associated with wider spacing and medium level of recommended dosage of fertilizers could be due to the positive effect of the factors mentioned as above. Similar findings were obtained by (Tamara *et al.* 2010) [3] in china aster

Table 1: Yield parameters as influenced by levels of spacing and fertigation in marigold Cv. Supreme Yellow under protected conditions

Treatment	Number of flower / plant	Number of flowers / unit area	Single flower weight (g)	Weight of 30 flowers (g)	Yield of flower / plant (g)	Yield of flower / unit area (kg)	Yield of flower hectare (t)	Diameter of flower (cm)
T_1 : 60 cm x 45 cm with 80 percent of RDF	29.95	420.5	5.30	162.13	79.64	2.81	9.30	5.33
T_2 : 60 cm x 45 cm with 100 percent of RDF	31.44	441.75	5.76	169.38	99.30	3.20	10.66	6.00
T_3 : 60 cm x 45 cm with 120 percent of RDF	31.80	447.00	5.47	170.93	102.17	3.24	10.79	5.49
T_4 : 60 cm x 60 cm with 80 percent of RDF	30.06	452.25	5.39	175.94	76.51	3.40	11.30	5.48
T_5 : 60 cm x 60 cm with 100 percent of RDF	33.18	485.50	6.73	180.45	119.60	3.80	12.66	6.11
T_6 : 60 cm x 60 cm with 120 percent of RDF	32.56	461.75	6.28	178.90	111.16	3.66	12.19	5.79
Mean	31.58	451.45	5.80	172.95	98.06	3.35	11.15	5.71
F-test	*	*	*	*	*	*	*	*
S.Em±	0.55	7.11	1.59	2.06	4.43	0.22	0.05	0.18
CD@ 5%	1.66	21.30	0.53	6.18	13.27	0.67	0.07	0.54

From the data presented in Table 1, yield of flowers per plant (119.60g), yield of flower per unit area (3.80 kg), yield of flowers per hectare (12.66 t), and diameter of flower (6.11 cm). were found to be significantly higher with T_5 (60 cm x 60 cm and 100 percent RDF) supplied through fertigation. Wider spacing and medium level of recommended dosage of fertilizers has significantly resulted increased yield of flowers per plant, per unit area and per hectare.
Ultimately, yield is depending on so many factors, more precisely, on vegetative traits and reproductive traits. Yield is a combination of influence of so many extrinsic and intrinsic factors, it could be due to the genetic make up of the plant, however, certainly there will be influence of factors including the environment imposed on the plant during the period of growth of the crop.
Marigold crop grown under protected conditions in this experiment was under the major influence of levels of spacing and fertigation. This might be due to sufficient availability of nutrients in the greenhouse media and sunlight per unit area for photosynthesis, which might have led to better growth and uptake of nutrients under wider spacing. resulting in more number of branches per plant, better spread of plant, more number of flowers per plant, weight of marigold flowers per plant and altogether for obtaining significantly higher yield of marigold flowers per plant, per unit area and per hectare. This may be due to early breakeven time with respect to apical dominance, followed by uptake of nutrients during reproductive phase of plant as evidenced by plant analysis. Further, root system proportionate to the shoot system (height and spread of marigold plant) triggering the root activity might have resulted in the accumulation of carbohydrates and helped in increasing the diameter of marigold flower. The results were in conformity with (Belokar *et al*. 1992) who also have obtained similar data.

Economics
From the data presented in Table 2 Highest total yield (12.66 t ha^{-1}), highest gross returns (Rs. 4,43,100 /-) lower cost of cultivation (Rs. 2,38,622 /-), highest net returns (Rs. 2,04,478 /-) and lowest cost : benefit ratio (1:1.85) were registered with T_5 (60 cm x 60 cm with 100 percent of RDF).
Vara Prasad Rao (2005) [4] who worked out the economics of production of cut flowers grown in polyhouse in Sindhudurg and Ratnagiri districts of Maharashtra state wherein it was indicated that the profitability of gerbera after deducting subsidy for polyhouse from the total cost of production was Rs. 3,15,366 with gross returns of Rs. 4,03,200 and net return of Rs. 87,834. The cost-economics were in line with the output- input.

Table 2: Cost of cultivation of marigold grown under protected conditions

Treatment	Total yield (t ha^{-1})	Gross Return (Rs.)	Total cost of Cultivation (Rs.)	Net Returns (Rs.)	Cost: Benefit
T_1 : 60 cm x 45cm with 80 Percent of RDF	9.30	3,25,500	2,59,808	65,692	1:1.25
T_2 : 60 cm x 45cm with 100 Percent of RDF	10.66	3,73,100	2,66,288	1,06,812	1:1.40
T_3 : 60 cm x 45 cm with 120 Percent of RDF	10.79	3,77,650	2,72,762	1,04,888	1:1.38
T_4 : 60 cm x 60 cm with 80 Percent of RDF	11.30	3,955,00	2,32,142	1,63,358	1:1.70
T_5 : 60 cm x 60 cm with 100 Percent of RDF	12.66	4,43,100	2,38,622	2,04,478	1:1.85
T_6 : 60 cm x 60 cm with 120 Percent of RDF	12.19	4,26,650	2,45,096	1,81,554	1:1.74

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