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Effect of integrated nutrient management on flower yield ad quality of African marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gainda

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Abstract
The present investigation was carried out with aim to find out the effect of integrated nutrient management on flower yield and quality of African marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gainda at Department of Horticulture, University of Agricultural Sciences, Bengaluru, during *kharif 2*013-2014. The study consist of organic manures (FYM, Biofertilizers), recommended inorganic fertilizer (225:60:60 NPK/ha) and Micro nutrient foliar spray (Arka Microbial Consortium). The combined application 100per cent RDF + FYM + Arka Microbial Consortium+ VAM + Micro nutrient foliar spray (T_8) showed the significant influence on the yield parameters includes number of flowers per plant (47.63), number of flowers per m^2 (95.26), flower weight (9.92g), flower diameter (6.13cm) and total flower yield (9.60 t/ha) followed by T_9 (75 % RDF + FYM + Arka Microbial Consortium+ VAM + Micro nutrient foliar spray).. The quality attributes includes Xanthophyll (8.30 g/ kg) and shelf life of flowers were enhanced up to 9.70 days over control also recorded in the same treatment (T_8). The study concludes that significant influence of combined application of organic and inorganic fertilizers on African marigold to enhance the flowering yield and their characters.

Keywords: *Tagetes erecta*, flower yield, quality, organic manures and bio-fertilizer

Introduction
Marigold (*Tagetes erecta* L.) an important loose flower in India which occupies a prominent place in ornamental horticulture, and commercially exploited flower crop belongs to the family Asteraceae. It is grown as an annual in an herbaceous border and an ideal plants as filler for newly planted shrubberies to provide colour and spaces. However, the yield and quality of the flowers are very marginal in commercial cultivation where application of inorganic and organic fertilizers followed either alone or in combination. The use of organic manures and bio-fertilizers along with the balanced use of chemical fertilizers is known to improve physico-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers. It is a carrier based microbial product which contains N-fixing, P- solubilizing and plant growth promoting microbes. It will considerably reduce the cost of cultivation besides the synergistic effects of combined microbes. Hence it is wise to go for integrated approach system which includes fertilizers, farm yard manures, microbial Consortium, VAM, Micro nutrient foliar spray. These are less expensive and do not require non-renewable source of energy during their production. Integrated nutrient management in marigold is comparatively a new aspect of research (Singh, 2006) [5].

Materials and Methods
The present investigation was carried out at the Department of Horticulture, University of Agricultural Sciences, Bengaluru during the year of 2014-2015. The study consists of total nine treatments with three replications. The cultural operations throughout the cropping period were followed according to the Package of Practice as recommendation by UAS, Bengaluru. The soil at the experimental site comprised of red sandy loam with of P^H of 5.86 and the electrical conductivity (EC) was 0.211 dSm^{-1}.The soil had a good water holding capacity. Well decomposed FYM @ 20 tonnes per hectare was applied at the time of land preparation. The recommended dose of 225:60:60kg NPK /ha was applied in the form of urea, single super phosphate and muriate of potash, respectively.

Bio-fertilizer like VAM (675 gm/ha), Arka microbial consortium (12.5 kg/ ha) and Micro nutrient foliar spray (2.5 kg/ha) were applied to the seedlings immediately after transplanting. After second week of transplanting, 50 per cent N_2 and full dose of P_2O_5 and K_2O were applied in a circular band about 10 cm around each plant at a depth of 3 to 4cm and remaining 50 per cent 'N_2' was applied at 30 days after transplanting as a top dressing.

Experimental Results

The data recorded during the course of investigation are statistically analyzed and present hereunder. It envisages that yield and quality attributes are significantly affected due to the integrated application of nutrients. Flower production in terms of number of flowers produced per plant, per m^2 and per plot varied significantly and depicted in Table 1.

Number of flowers/plant, number of flower per m^2, number of flowers per plot and flower yield (ton / ha) were significantly higher (47.63, 95.26, 571.56 and 9.60 ton/ ha^{-1}, respectively) in T_8 (RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray) and it was on par with T_9 and T_6 (75 % RDF + FYM + Arka Microbial Consortium+ VAM + Micro nutrient foliar spray and 75 % RDF + FYM + VAM respectively) over remaining treatments which comprised the application of bio-fertilizers, organic manures along with inorganic fertilizers. Significantly minimum was noticed in (38.80, 77.60, 465.60 and 7.00 ton/ha^{-1}, respectively) control (T_1).

The increase in number of flowers may be due to possible role of Arka Microbial Consortium (*Azospirillum* PSB along plant growth promoting substances). Through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, higher plant height, plant spread in north-south and east- west direction. More photosynthesis enhanced food accumulation which might have resulted in better plant growth and subsequently number of flowers/plant, number of flower per m^2, number of flowers per plot and hence, more flower yield ton per ha. Flower harvest 1st, 2nd and 3rd picking of flowers more and 4th picking of flower because heavy rainfall due to the reducing in flower yield and seed yield. Besides this, increase in flower yield may be attributed to increased availability of phosphorous and its greater uptake (Kundu and Gaur, 1980) [2]. Vermicompost, being the source of macro and micro nutrients like Fe and Zn, enzymes, growth hormones and beneficial effects of micro-flora might have played a secondary role in increasing the flower yield.

It is evident from the date presented Table 2 that individual flower weight, flower diameter and total flower yield differed significantly due to the treatments of integrated nutrient management. The higher flower yield is a manifestation of other yield contributing characters *viz.,* Flower diameter (6.13 cm), individual flower weight (9.92 g), fresh weight of ten flowers (98.60 g). The treatment T_8 recorded maximum individual flower weight **(**9.92 g)**,** however it was on par with T_9 (9.88 g) and which was significantly superior over all other treatments control (8.43 g). The treatment T_8 recorded maximum individual fresh flower weight (98.60 g), however it was at par with T_9 (98.14 g) and which was significantly superior over all other treatments control (84.67 g). The treatment T_8 recorded maximum dry weight of ten flowers (13.00 g), however it was on par with T_9 (13.00) and which was significantly superior over all other treatments control (10.00 g). Hence, the increase in individual flower, fresh flower, dry flower weight and flower diameter in those treatments might be due to the effect of balanced nutrition supplied through the combined application of Arka Microbial Consortium, FYM and Micro nutrient foliar spray and along with 100 per cent RDF. Thus, the higher flower yield per hectare was obtained in treatment T_8. However, it was on par with T_9 Similar findings were obtained by (Rajanna, 2001) [4] in China aster.

A perusal of data presented in Table 3 reveals that quality parameters are varied significantly due to the integrated application of nutrients.

The difference in the seed yield (g) per plot due to the influence of different sources of nutrients. The treatment T_8 (RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray) recorded significantly higher seed yield (225.0 g) and it was on par with T_9 and T_6 (222.5 g and 220.0 g respectively). However, Seed yield per plot (g) in T_8 treatment may be due to maximum number of branches per plant, number of flowers per plant and 1000 seed weight which ultimately increased the seed yield and also might be attributed to the higher availability of plant nutrients through mineralization and release of growth promoting hormones, etc., from vermicompost application. Similar results were reported by jasmine, Narayanagowda (2003) [7] in gerbera, Munikrishnappa *et al.*, (2004) [6] in tuberose and Arindam *et al.,* (2004) [9] in potato.

Marigold flower production is governed by the extent to which the applied nutrients are translocated to the floral parts to obtain higher yield of flowers and ultimately xanthophyll yield. It was indicated that Xanthophyll ($C_{40}H_{56}O_2$) was the highest in T_8 (8.3 g/kg) which was to be found on par with T_9 (8.2 g/kg), T_6 (8.0 g/kg), and T_2 (7.8 g/kg).The lowest was recorded in control (5.2 g/kg).

In the present study xanthophyll content was observed to be maximum in T_8 which received RDF, FYM, Arka Microbial Consortium, VAM and Micro nutrient foliar spray. It might be due to the combined effect of inorganic and organic source of nutrients. It is a carrier based microbial product which contains N-fixing, P- solubilizing and plant growth promoting microbes. It will considerably reduce the cost of cultivation besides the synergistic effects of combined microbes. It has been reported that poultry manure helps in improving organic carbon (a constituent of xanthophylls) as well as macro and micro nutrients. In addition to C, N, P and K, it contains micro nutrients like zinc, copper, iron, and manganese which also improved xanthophylls content. Presence of iron would enhance the functioning of photosystem, ultimately increasing chlorophyll content in leaves and xanthophylls in flowers (Balakrishna *et al.* 2007) [8].

There was significant difference in shelf life of flowers as influenced by different treatments. The maximum shelf life (9.70 days.) of flowers was recorded in T_8 (RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray), however it was on par with T_9 (75 % RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray) (9.54 days).Which might be due to the higher retention of water in the cells of flowers and lower desiccation, whereas, in control (RDF + FYM) lesser shelf life (4.70 days) was noticed in room condition. Similar beneficial effects of bio-fertilizers and vermicompost on shelf life have been reported by Anuradha *et al.,* (1990) [1] and Mashaldi, (2000) [3] in marigold.

Table 1: Individual flower weight, fresh weight of ten flowers dry weight of ten flowers and flower diameter as influenced by integrated nutrient management in African marigold cv. Pusa Basanti Gainda

Treatments	Individual flower weight (g)	Fresh weight of ten flowers (g)	Flower diameter (cm)	Total Flower yield (ton/ha)
T_1- RDF + FYM (Control)	8.43	84.67	5.28	7.00
T_2- RDF +FYM + Arka Microbial Consortium	8.71	89.07	5.31	7.70
T_3- RDF + FYM + VAM	8.77	91.40	5.46	7.80
T_4- RDF+FYM+ Arka Microbial Consortium +VAM	9.00	88.60	5.45	7.40
T_5- 75% RDF +FYM+ Arka Microbial Consortium	9.15	91.53	5.47	8.40
T_6-75% RDF +FYM+ VAM	9.80	97.98	5.56	8.40
T_7-75% RDF+ FYM+ Arka Microbial Consortium + VAM	8.95	90.00	5.43	8.30
T_8- RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray	9.92	98.60	6.13	9.60
T_9-75% RDF+ FYM+ Arka Microbial Consortium + VAM + Micro nutrient foliar spray	9.88	98.14	6.10	9.57
Mean	9.17	92.22	5.57	82.45
S.Em±	0.01	0.17	0.01	31.04
CD (0.05)	0.04*	0.51*	0.03*	93.06*

RDF- Recommended Dose of Fertilizer (225:60:60 kg NPK/ ha)
VAM - 675 g/ ha
FYM - 20 tons/ ha
Micronutrient foliar spray – 2.5kg/ha
Arka Microbial Consortium- 12.5kg/ ha
* Significant

Table 2: Number of flower per m^2, number of flowers/plant, number of flowers /plot and flower yield as influenced by Integrated Nutrient Management in African marigold cv. Pusa Basanti Gainda

Treatments	Number of flowers/plant	Number of flower per m^2	Number of flowers /plot
T_1- RDF + FYM (Control)	38.80	77.60	465.60
T_2- RDF +FYM + Arka Microbial Consortium	41.56	83.12	498.72
T_3- RDF + FYM + VAM	44.42	88.84	533.04
T_4- RDF+ FYM+ Arka Microbial Consortium +VAM	43.10	86.20	517.20
T_5- 75% RDF +FYM+ Arka Microbial Consortium	44.80	89.60	537.60
T_6-75% RDF +FYM+ VAM	44.95	89.90	539.40
T_7-75% RDF+ FYM+ Arka Microbial Consortium + VAM	40.48	80.96	485.76
T_8- RDF + FYM + Arka Microbial Consortium+ VAM + Micro nutrient foliar spray	47.63	95.26	571.56
T_9-75% RDF+ FYM+ Arka Microbial Consortium + VAM + Micro nutrient foliar spray	47.50	95.00	570.00
Mean	43.69	87.37	524.32
S.Em	0.10	0.21	1.25
CD (0.05)	0.31*	0.63*	3.75*

* Significant @ 0.05%
RDF- Recommended Dose of Fertilizer (225:60:60 kg NPK/ ha)
VAM - 675 g/ ha
FYM - 20 tons/ ha
Micronutrient foliar spray – 2.5kg/ha
Arka Microbial Consortium- 12.5kg/ ha

Table 3: Thousand seed weight and seed yield per plot (g), xanthophyll yield (g/kg) and shelf life (days) as influenced by Integrated Nutrient Management in African marigold cv. Pusa Basanti Gainda

Treatments	1000 Seed weight (g)	Seed yield per plot (g)	Xanthophyll yield (g/kg)	Shelf life (days)
T_1- RDF + FYM (Control)	2.00	150.00	5.2	4.70
T_2- RDF +FYM + Arka Microbial Consortium	2.20	165.00	7.8	5.70
T_3- RDF + FYM + VAM	2.60	195.00	7.1	6.00
T_4- RDF+FYM+ Arka Microbial Consortium +VAM	2.50	187.50	6.9	6.30
T_5- 75% RDF +FYM+ Arka Microbial Consortium	2.70	202.50	7.5	6.30
T_6-75% RDF +FYM+ VAM	2.80	220.00	8.0	9.00
T_7-75% RDF+ FYM+ Arka Microbial Consortium + VAM	2.10	157.50	6.2	6.30
T_8- RDF + FYM + Arka Microbial Consortium + VAM + Micro nutrient foliar spray	3.00	225.00	8.3	9.70
T_9-75% RDF+ FYM+ Arka Microbial Consortium + VAM + Micro nutrient foliar spray	2.90	222.50	8.2	9.54
Mean	2.53	191.6	7.24	7.06
S.Em±	0.01	0.99	0.03	0.06
CD (0.05)	0.03*	2.98*	0.10*	0.19*

* Significant @ 0.05%
RDF- Recommended Dose of Fertilizer (225:60:60 kg NPK/ ha)
VAM - 675 g/ ha
FYM - 20 tons/ ha
Micronutrient foliar spray – 2.5kg/ha
Arka Microbial Consortium- 12.5kg/ ha

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