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Standardization of spacing and fertigation in marigold genotypes for northern dry zone of Karnataka

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Abstract
The present investigation was aimed to evaluate and commercialize different African marigold (*Tagetes erecta* L.) genotypes for UKP command area of Karnataka. The study was also aimed to standardize optimum spacing and fertigation levels for promising genotypes during *kharif* and *summer* seasons 2015-18 at College of Agriculture, Bheemarayanagudi of Shahapur taluk, Yadgir district. Among the fertigation schedules, providing 100 per cent water soluble fertilizers (125:60:60 NPK kg ha^{-1}) resulted in significantly higher flower yield (38.21 t and 34.24 t ha^{-1}), higher flower diameter (7.01 and 6.43cm), more duration of flowering (123.11 and 112.88 days) and gave higher benefit cost ratio as compared to other treatment combinations during *kharif* and *summer* season respectively.

Keywords: Marigold, water soluble fertilizers, fertigation, growth, yield

Introduction
Tagetes erectalis suitable for dry land and requires low maintenance. In Karnataka marigold is grown in all through the year. Successful production of marigold depends upon many factors like soil fertility, irrigation, plant density, plant protection measures *etc*., but manurial schedule and spacing plays a major role in crop production. Marigold is not popular in Northern dry zone of Karnataka and is slowly picking up due to ease of production.

Planting geometry or spacing plays an important role on growth and flowering of the plant by creating congenial environment condition. Optimum spacing for marigold crop helps in availability of nutrients, aeration and light requirement by which crop can express its genetic potential in terms of quantity and enhanced quality. Proper combination of fertilizers plays vital a role in growth and production of crops. Among essential nutrients, nitrogen, phosphorus and potassium are most important and are required in sufficient quantities to attain better plant growth and flowering.

Spacing and nutritional management in marigold crop is one of the important factor that can manifest the performance of the crop. But there is lack of know how regarding its optimum spacing and nutrient levels through fertigation for Northern dry zone of Karnataka.

Manual schedule of nitrogen, phosphorous and potash fertilizers plays a major role in successful production of marigold. Nitrogen applied as fertilizer is the main sources used to meet the nitrogen requirements of plant growth. When used properly, at the correct application rates and at the right time, nitrogen contributes in promoting optimal growth. Excessive N fertilization has an adverse effect making leaves a darker green and delaying flowering. Phosphorus is also an important elements for plant growth and yield. Lack of phosphorus nutrition resulted in a low basal root fresh weight and a shorter stem length.

Fertigation is a method of fertilization in which nutrients along with water are applied directly to the root zone of the plant in small but required quantities through the drippers. Drip fertigation has the potential to improve crop quality, yield thereby enhancing productivity. Fertigation allows nutrient placement directly into the plant root zone during critical periods in required dose (Singandhupe *et al*., 2003) [18]. The main advantages of fertigation over surface irrigation combined with broadcast fertilization are precise control over amount and concentration of nutrients as per plant requirement, reduced fluctuations of nutrient concentration in the root zone, enhanced fertilizer use efficiency and fertilizer saving, reduced nutrient leaching, saving of time, labour and cost of application and uniformity in application.

Through method of drip fertigation, fertilizer requirement can be reduced by 15-25 percent without affecting the yield (Hongal and Nooli, 2007) [7]. Adequate supply of water and nutrients results in higher water and nutrient use efficiency, better production control, and avoidance of stress situations. Irrigation management may significantly affect plant response and water consumption (Raviv and Blom, 2001) [17]. Thus it is imperative to standardize optimum quantity of nutrients and spacing which may enable marigold growers to obtained higher yield and income.

In the era of declining resources there is need to standardize precision farming technologies for farmers with the aim to fertigation level and water foot print per unit of crop produce. Therefore, the present study aimed to examine the suitable effect of fertigation, irrigation and on the productivity of marigold.

Materials and Methods

The present investigation on "Evaluation and commercialization of African marigold (*Tagetes erecta* L.) genotype for UKP command area of Karnataka" was carried out for four seasons (two season varietal evaluation and two season standardizing agro techniques) *viz*., *kharif* (2015) and *Summer* (2016) at College of Agriculture, Bheemarayanagudi, (University of Agricultural Sciences, Raichur), Shahapur taluk, Yadgir district and two season *viz*., *Kharif* (2016) and *Summer* (2017) in farmer's field at Chamanala village, of Shahapur taluk, Yadgir district.

The experiment was conducted in College block at College of Agriculture, Bheemarayanagudi, University of Agricultural Sciences, Raichur, The experiment was laid out in Split-Split Plot Design Comprising ninety-six treatments with three replications. The treatments details presented in Table-1 (Genotypes used in the experimentation). The Gross Plot size about 4.8m (8rows) × 4.5m (10plants) = 21.6sqm Followed by Net plot size 2.4 × 2.7m = 6.48sqm (24 plants). The *Kharif* season July to December 2016 and *summer* season: February to July 2017. The experiment was laid out in split-split plot design with three replications.

The entire experimental land was divided and raised beds were prepared measuring 18m × 0.9m (16.2m^2) at a height of 15cm and spaced at 30cm between the beds. Twenty five days old healthy and uniform seedlings were transplanted in the main field in double row system of planting at four leaf stage with a spacing of 60cm between the rows and 30cm between the plants was adapted to accommodate about 120 plants per bed (16.2m^2) during evening hours. Light irrigation was given after transplanting for better establishment of seedlings in the main field. Water soluble fertilizers and straight fertilizers were applied as per the treatment combinations. Fertigation was given twice a week as per the plant growth stage. Gap filling was done ten days after transplanting to maintain 100 per cent plant population in all the plots. Observations were recorded on growth, flowering and yield under different treatments. The data collected were subjected to statistical analysis as per Panse and Sukhatme (1978) [15].

Results and Discussion

The interaction between varieties, spacing and fertigation was found significant. The treatment $V_2S_1F_4$ (Arka Bangara-2, 45 × 45cm, 125:60:60kg WSF NPK/ha) recorded highest plant height of 120.44 and 113.80cm at 90 DAP respectively, which was on par with the treatment combination $V_1S_1F_4$ are 116.08 cm in *Kharif* season and in *Summer* season $V_2S_3F_4$ (107.71 cm) at 90 DAP respectively (Fig. 1). This might be due to the synergetic interactions between three factors. Increased plant height it might be due to the fact that frequent irrigation cum fertilization maintained at the root zone with well aerated condition and adequate soil moisture content that did not fluctuate between wet and dry extremes (Patil and Janawade, 1999) [13]. Under fertigation, frequent application of fertilizers at optimum intervals, increases the available nutrient status in the root zone thus increasing the uptake of nutrients. Sufficient supply of nutrients might have shown stimulatory action, in terms of cell elongation and thus resulting in increased plant height. The present findings are in accordance with those of Banker and Mukhyopadhyay (1990) [2] in tuberose and Wang and Rose (1999) [21] in Rhododendron.

The interaction effect of varieties, spacing and fertigation levels had significant effect on Number of secondary branches in marigold at 30, 60 and at harvest stage (Fig. 2). The treatment combination ($V_2S_4F_4$-Arka Bangara-2, 90 × 60cm, 125:60:60kg WSF NPK/ha) showed highest number of secondary branches (95.73 and $V_2S_2F_4$ 66.60 at 90 DAP), which was on par with the treatment $V_1S_4F_4$ (Arka Agni, 90 × 60cm, 125:60:60kg WSF NPK/ha)are 85.52 and 59.33 at 90 DAP. Whereas, least number of secondary branches was registered in treatment combination $V_1S_1F_2$ and $V_1S_1F_1$ (40.60 and 41.93 at 90 DAP respectively). The varieties under assessment had shown different performance in production of secondary branches per plant. The cv. Arka Bangara-2 produced more number of secondary branches per plant than cv. Arka Agni because of genetic potential some variety is prolific in producing secondary branches. Koli (2015) [10] and Rajababu (2017) [16] also reported variation in formation of secondary branches in different varieties of marigold.

The interaction effect between varieties × spacing × fertigation levels had significant effect on flower diameter in marigold (Tab.1). The treatment combination $V_2S_4F_4$ (Arka Bangara-2, 90 × 60cm, 125:60:60kg WSF NPK/ha) recorded highest flower diameter (7.01 and 6.43 cm) which was on par with treatment ($V_1S_2F_4$- Arka Agni, 60 × 45cm, 125:60:60kg WSF NPK/ha)was 6.72 cm in *Kharif* whereas in *Summer* treatment $V_1S_4F_4$-Arka Agni, 90 × 60cm, 125:60:60kg WSF NPK/ha)flower diameter was 6.03cm and minimum was observed in $V_1S_1F_1$ (3.86 and 3.80cm). Interaction due to varieties, spacing and NPK levels had significant influence on flower diameter, disc diameter and corolla length. Similar results were reported found by Hugar (1997) [8] in gaillrdia and Munikrishnappa (2011) [12] in China aster and also pointed out that fertigation of RDF at every irrigation (two-day intervals) up to 105 days resulted in significant in higher yield in gerbera. Obviously, the diameter of flower is contributed by number of petals, petal length and width of flower. The results of the present study are in line with the above finding, since the maximum availability of potassium through WSF and potassium nitrate for flower growth in the growing soil might be one of the reasons for the production of flowers with better size. This is well supported Jadhav (2007) [9] in anthurium.

The interactions effect between varieties × spacing × fertigation levels showed that, the treatment combination $V_2S_4F_4$ showed higher duration of flowering (123.11 and 112.88 days), which was followed $V_1S_4F_4$ (118.57 and 102.57 days), it was at par with $V_2S_4F_3$ (114.85 days) and $V_2S_2F_3$ (114.51 and 102.17 days) respectively. Whereas lowest duration of flowering was observed in treatment $V_1S_2F_2$ (61.02 days) $V_1S_1F_1$ (61.86 days) presented in (Tab.1). This may be due to varietal superiority and enhanced macronutrient availability in 100% water soluble fertigation

and modification in their expression due to environmental conditions *viz*. high temperature and low humidity and less rainy days during crop period might be the possible causes of observed variation. Similar findings (Geetha, 2004) [6] in rose and (Jadhav, 2007) [9] in anthurium.

The interactions effect between varieties × spacing × fertigation levels showed that the treatment combination $V_2S_2F_3$ showed higher shelf life (7.80 and 7.53 days), which was on par with treatment $V_2S_4F_3$ (7.77 and 6.97 days) whereas lowest shelf life of flowers was observed in treatment $V_1S_1F_1$ (4.07 and 3.87days) in the next order treatment combination $V_1S_1F_2$ (4.08 and 3.90 days) (Tab.1). This might be due to increased uptake of primary and secondary nutrients. Similar result was reported earlier by Qasim *et al.* (2008) [20] in rose. The increased uptake of N caused the increased accumulation of leaf sugars which in turn extending the shelf life period and the increased uptake of potash might have supplied an increased level of carrier ions for cytokinin transport (Muhilarasi, 2008 in chrysanthemum) [11]. Cytokinin being a hormone with antimicrobial and anti-senescence activities might have delayed the processes associated with senescence, leading to extended shelf life of these flowers. Further, increased levels of N, P, K and micronutrients uptake might have decreased the water loss and helped in maintaining the water potential in a constant state which in turn might have maintained the turgidity (Jadhav, 2007) [9] in anthurium.

The interaction between varieties × sprays × fertigation levels has shown significant differences among the treatment (Fig. 3). The treatment ($V_2S_4F_4$) recorded maximum flower yield of 2933 g, 45.46 t and 1953 g and 40.47 t per plant and per hectare respectively, Whereas, minimum number of flowers were registered in the treatment $V_1S_1F_2$ (441g, 16.28t and 382g and 14.99t) per plant and per hectare during *Kharif* and *Summer* season respectively.

Higher frequency irrigation created favourable soil water environment for crop growth and resulted in higher yield. It may be stated that the yield increased as a result of keeping the soil water content at required level similar results observed in Tsirogiannis *et al.* (2010) [19] in gerbera and Aydinsakir *et al.* (2011) [1] in carnation. The application of water increase solubility and degree of ionization of nutrients in the soil resulting into increased availability of nutrients and improved lipid synthesis with optimum soil moisture supply. The supremacy of overall vegetative growth might have leads to the improve productivity flowers. Increase of yield due to application of irrigation was completely agreement in with Patil *et al.* (2008) [14] in tuberose, Bastug *et al.* (2006) [3] and Begum *et al.* (2007) [4] in gladiolus.

Table 1: Flower quality as influenced by interaction between varieties, spacing and fertigation levels during planting season in marigold genotypes

Interaction effect	Flower diameter (cm)			Flowering duration (days)			Shelf life (days)		
	Kharif	Summer	Mean	Kharif	Summer	Grand Mean	Kharif	Summer	mean
V x S x F									
$V_1S_1F_1$	3.86	3.80	3.82	63.65	61.86	62.75	4.07	3.87	3.97
$V_1S_1F_2$	3.93	4.05	4.00	65.87	63.61	64.73	4.08	3.90	4.38
$V_1S_1F_3$	4.36	4.56	4.38	65.70	64.70	65.20	4.53	4.23	3.99
$V_1S_1F_4$	4.87	4.96	5.00	64.58	64.70	64.64	4.97	4.77	4.87
$V_1S_2F_1$	4.13	4.53	4.18	66.47	64.19	65.33	4.53	4.17	4.35
$V_1S_2F_2$	4.73	4.75	4.36	61.02	58.35	59.69	4.93	4.93	4.93
$V_1S_2F_3$	6.08	5.61	4.35	78.11	71.47	74.79	6.28	5.33	5.81
$V_1S_2F_4$	6.72	6.00	4.52	76.80	76.03	76.42	4.77	4.43	4.60
$V_1S_3F_1$	3.90	3.90	4.48	72.89	73.38	73.14	5.47	4.97	5.22
$V_1S_3F_2$	4.03	4.03	4.62	72.07	68.77	70.42	4.63	4.53	4.58
$V_1S_3F_3$	3.97	4.30	5.10	65.97	68.57	67.27	4.67	4.33	4.50
$V_1S_3F_4$	3.93	4.97	5.80	72.97	70.12	71.55	5.47	5.07	5.27
$V_1S_4F_1$	3.90	3.84	4.47	77.00	72.00	74.50	5.33	5.13	5.23
$V_1S_4F_2$	4.43	4.43	4.95	71.13	71.47	71.30	5.47	5.40	5.44
$V_1S_4F_3$	5.91	5.21	5.17	105.18	96.87	101.03	5.93	5.60	5.77
$V_1S_4F_4$	6.35	6.03	6.19	118.57	102.57	110.57	5.47	5.27	5.37
$V_2S_1F_1$	5.13	5.03	4.58	79.44	79.44	79.44	5.03	5.73	5.38
V_2 S_1F_2	5.23	4.80	4.77	65.51	62.22	63.87	5.10	4.93	5.02
$V_2S_1F_3$	5.94	5.93	5.17	68.88	69.43	94.16	5.05	4.27	4.66
$V_2S_1F_4$	6.05	5.55	5.80	95.76	93.76	69.16	4.17	5.80	4.99
$V_2S_2F_1$	5.34	5.47	4.70	73.18	72.51	72.85	5.80	5.57	5.69
$V_2S_2F_2$	5.17	5.16	4.80	84.43	86.86	85.65	5.10	5.77	5.43
$V_2S_2F_3$	6.00	5.22	4.73	114.51	102.17	108.34	7.80	7.53	7.67
$V_2S_2F_4$	6.38	5.66	6.02	97.28	96.95	97.12	6.13	6.30	6.22
$V_2S_3F_1$	5.00	5.50	5.43	76.11	71.57	73.84	4.17	4.07	4.12
$V_2S_3F_2$	5.47	5.06	5.08	80.11	78.12	79.12	5.27	5.17	5.22
$V_1S_3F_3$	5.90	5.88	5.58	91.34	88.34	89.84	4.87	4.87	4.87
$V_2S_3F_4$	5.30	5.43	6.37	90.17	86.77	88.47	6.15	5.97	6.09
$V_2S_4F_1$	5.07	4.73	4.90	82.29	78.95	80.62	5.43	5.17	5.30
$V_2S_4F_2$	5.33	5.03	5.17	104.22	97.88	101.05	5.93	5.83	5.88
$V_2S_4F_3$	6.49	6.00	6.25	114.85	104.81	109.83	7.77	6.97	7.37
$V_2S_4F_4$	7.01	6.43	5.71	123.11	112.88	118.00	6.20	6.20	6.20
S.Em±	0.12	0.14	0.20	1.68	1.64	4.95	0.12	0.11	0.08
C.D (P=0.05)	0.29	0.44	NS	4.78	4.66	15.29	0.39	0.37	0.24

V1: Arka Agni **V2:** Arka Bangara-2
S1: 45 X 45 cm **F1:** Control (RDF-125:60:60 kg/ha)

S2:	60 x 45 cm	**F2:**	62.50:30:30 kg/ha (50% of RDF)
S3:	40 x 60 cm	**F3:**	93.75:45:45 kg/ha (75% of RDF)
S4:	90 x 60cm	**F_4:**	125:60:60 kg/ha (100% of RDF)

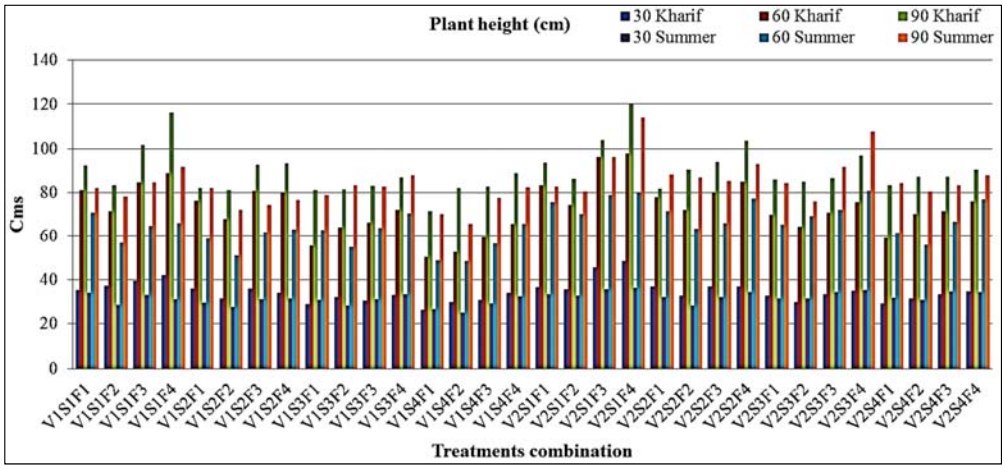

Fig 1: Plant height as influenced by interaction between varieties spacing and fertigation levels during planting season in marigold genotypes

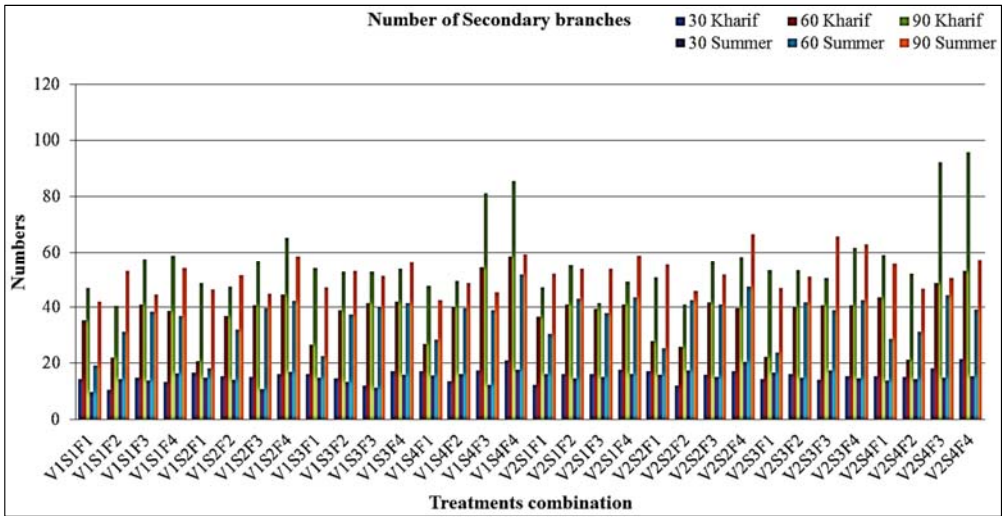

Fig 2: Number of secondary branches as influenced by interaction between varieties, spacing and fertigation levels during planting season in marigold genotypes.

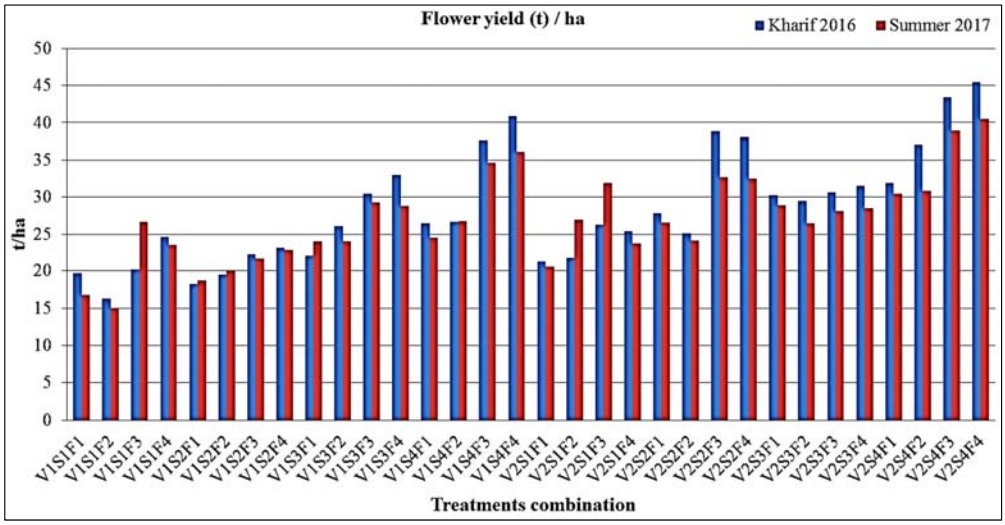

Fig 3: Yield characters per hectare as influenced by interaction between varieties, spacing and fertigation levels during different planting season in marigold genotypes

Conclusion

Among different spacing closer spacing of 45 x 45cm produced more plant height and wider spacing 90 x 60cm produced more number of primary and secondary branches, higher plant spread and minimum insect pest incidence and higher yield per plant and ha.

The treatment combination 125:60:60kg NPK per hectare 100% WSF (F_4) and F_3 (93.75:45:45kg NPK/ha 75% WSF) was produced higher flower yield, higher flower diameter, petal meal yield, xanthophyll content and more antioxidant and higher cost benefit ratio, whereas it was lowest S_1F_1- 45x 45cm, 125:60:60kg SF NPK/ha and S_1F_2-45 x 45cm, 125:60:60kg SF NPK/ha.

The wider spacing of 90x60 cm was found to be superior for the growth, yield and quality of marigold.

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