The Pharma Innovation Journal 2023; 12(10): 1866-1870

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 1866-1870

www.thepharmajournal.com
Received: 02-08-2023
Accepted: 10-09-2023

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Effect of different doses of chemical fertilizer with split application through fertigation on growth, flower yield and quality of African marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda

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Abstract
The experiment was carried out to entitled **"**Effect of different doses of chemical fertilizer with split application through fertigation on growth, flower yield and quality of African marigold (*Tagetes erecta* L.) Cv. Pusa Narangi Gainda" at experimental farm Madhadi Baug, Fruit Research Station, Department of Horticulture, College of Agriculture, J. A.U, Junagadh during during Rabi season 2018-19. Randomized Block Design with Factorial concept was laid out in experiment. Consisting's 2 factors with 3 replications. The treatment comprised of 4 different doses of chemical fertilizer like NPK @ 150:75:50 kg/ha (F_1), NPK @ 200:100:100 kg/ha (F_2), NPK @ 250:125:150 (F_3) and NPK @ 300:150:200 (F_4) with four different of split application *i.e.* control (S_1), 3 split 40, 80 and 120 DATP (S_2), 4 split at 30, 60, 90 and 120 DATP (S_3), 5 split at 24, 48, 72, 96 and 120 DATP (S_4). The results of investigation indicated the application of soluble chemical fertilizer NPK @ 150:75:50 kg/ha with 3 splits during 40, 80 and 120 DAP, through fertigation which improved growth and yield of flower with higher net realized.

Keywords: Dose of chemical fertilizer (NPK @ kg/ha), split application, marigold, Pusa Narangi Gainda

Introduction
African marigold (*Tagetes erecta* L.) belongs to the family Asteraceae is the most important conventionally exploited flower. Easy growing nature, wider adoptability in different soil & climatic condition and its habit of profuse flowering, short duration to produce marketable flowers, wide spectrum of attractive colors, shape, size and good keeping quality attracted the attention of producers and traders most. Marigold flowers are extensively used for making garlands, beautification, religious offerings, social functions and other purposes such as pigment and oil extraction and therapeutic uses. Apart from these uses, marigold is widely grown in gardens and pots for display purpose. It is a highly suitable bedding plant and also ideal for newly planted shrubberies to provide colour and to fill space. It has a great economic potential in loose flower trade make marigold popular. Traditionally marigold is grown as an intercrop in turmeric fields to check nematode population and also grown as trap crop in solanaceous vegetables (Raghava, 2000) [18]. Dry flower petals are used as food additives in poultry feed to increase the colour of egg yolk as well as broiler's skin pigmentation (Anuradha *et al.* 1988) [2] with increased concentration of vitamin-A (Hencken, 1992) [9]. The aromatic oil is also extracted from marigold flowers as "Tagetes oil" used in preparation of high-grade perfumes and pharmaceutical industries. Flower crops are very much responsive to fertilizer. It is highly capable of exhausting huge nutrients from native soil. So, it require higher amount of chemical fertilizer in balance proportion for ensuring maximum flower production. Fertigation is one such technique of applying nutrients through micro irrigation systems directly at the site of active root zone. Though a new concept in India, it has potential for more accurate and timely crop nutrition leading to increased yields, enhanced quality and early crop maturity. Fertigation also helps in reducing the wastage of nutrients through enhanced fertilizer use efficiency, besides providing flexibility in timing of fertilizer application in relation to crop demand based on physiological stages of growth (Papadopoulos, 1992) [16].

Depending upon soil type, agronomical practices and other factors, fertilizer can be vulnerable to loss denitrification, leaching, volatilization, surface runoff and soil erosion impose the costs that include lost productivity and negative environmental impact.

Split application can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Dividing total fertilizer into two or more treatments can help to enhance the nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Among the various factors responsible for high crop yield, supply of appropriate quantity of nutrients at appropriate time, plays a vital role in enhancing as a basal dose and top dressing the nutrients applied in the form of fertilizes are subjected to leaching, fixation and losses in the soil. Further, the nutrients traverse deeper to areas beyond the active root zone and become unavailable to the plants. In many cases, the effective utilization of nutrients by the plants is less than fifty percent of the fertilizer applied. The fertilizers required are supplied at the exact place and time of requirement. Thereby the cost of fertilizers is also saved and the environmental pollution problems due to excessive application of fertilizers are avoided.

Materials and Methods

The field experiment was carried out at Madhadi Baug, Fruit Research Station, Department of Horticulture, College of Agriculture, J.A.U, Junagadh during Rabi season 2018-19. Randomized Block Design with Factorial concept was laid out in experiment. Consisting's 2 factors with 3 replications. The treatment comprised 4 treatments of different doses of chemical fertilizer like NPK @ 150:75:50 kg/ha (F_1), NPK @ 200:100:100 kg/ha (F_2), NPK @ 250:125:150 (F_3) and NPK @ 300:150:200 (F_4) compression with four treatments of split application *i.e*. control (S_1), 3 split 40, 80 and 120 DAP (S_2), 4 split at 30, 60, 90 and 120 DAP (S_3), 5 split at 24, 48, 72, 96 and 120 DAP (S_4).

Treatment Details

Factor – A - Fertigation (NPK @ kg/ha) (Four levels)

1. F_1-150:75:50 NPK kg/ha
2. F_2-200:100:100 NPK kg/ha
3. F_3-250:125:150 NPK kg/ha
4. F_4-300:150:200 NPK kg/ha

Factor – B - Splits application (Four)

1. S_1- Control
2. S_2- 3 Split (at 40, 80 and 120 days)
3. S_3- 4 Split (at 30, 60, 90 and 120 days)
4. S_4- 5 Split (at 24, 48, 72, 96 and 120 days)

Results and discussion

Effect on Vegetative Growth Parameters

Effect of dose (NPK @ kg/ha)

The data showed that the application of different dose of chemical fertilizer had produced non-significant result on plant height (at 30, 60 DAT), number of main branches per plant (at 30, 60 and 90 DAT), stem diameter, of plant and significant effect on plant height (at 90 DAT). Where maximum plant height (44.62 cm) was obtained in treatment of NPK @ 150:75:50 kg/ha (F_1). Which was at par with treatment NPK @ 200:100:100 kg/ha (F_2). Likewise, lowest plant height (40.42 cm) was recorded with different dose of NPK @ 300:150:200 kg/ha (F_4) at 90 DAT. Under fertigation, uniform distribution of the nutrients, coupled with confinement in the root zone, might have increased the nutrient uptake thereby leading to higher synthesis of metabolites and their subsequent translocation resulting in enhanced vegetative growth. In case of lowest dose of NPK requirement of crop should be full field, additional dose of nitrogen fertilizer in higher dose was loss due to leaching and high pH in calcareous soil. Higher dose of Phosphorus was combined with Ca^{2+} and make insoluble calcium phosphate and unavailable to plant, while higher dose of potassium was not uptake by plant due to fix in clay mineral and some amount of leaching. Increased growth of plant in present study are in agreement with the results obtained by Acharya and Dashora (2004) [1], and Naik (2015) [14] in marigold; Dahiya *et al*. (2001) [5] in tuberose; Sujatha *et al*. (2002) [22] in gerbera and Hemanta *et al*. (2012) [8] in carnation.

Effect of split application

The data showed that in split application, the different was also found non-significant on vegetative parameters like plant height (at 30, 60 and 90 DAP) and stem diameter. But significant effect on number of main branches per plant at 30, 60 and 90 DAP. For split application, result was obtained significant and maximum number of main branches per plant (6.18) at 30 DAT was observed with an application of fertilizer in 4 split (S_3), but it was at par with 3 split (S_2). Significantly, lowest number of main branches per plant (5.66) at 30 days after planting was recorded with 5 split (S_4). Similarly for 60 days after planting, highest number of main branches per plant (12.19) was noted with a split (S_4), but it was at par with 3 split (S_2). Significantly, lowest number of main branches per plant (10.95) at 60 days after planting was recorded with control (S_1). Likewise, significantly highest number of main branches per plant (16.78) at 90 days after planting was observed with an application of fertilizer in 3 split (S_2), followed by 5 split (S_4). Lowest number of main branches per plant (15.79) at 90 days after planting was recorded with control (S_1). The above discussed vegetative growth parameters were superior in 3 split applications *i.e*., 40, 80 and 120 DAP (S_2) might be due to stage-based supply of nutrients in to the plants which resulted to improve nutrient use efficiency for better growth performance. The result was also supported by Sanghmitra (2015) [19] in marigold; Singh (2000) [21], Kakamani (2013) [11] and Sharma (2014) [20] in gladiolus; Kishore (2015) [12] in tuberose; Palai *et al*. (2002) [15] in rose; Jadhao *et al*. (2010) [10] in gerbera.

Interaction effect of different dose of chemical fertilizer and split application

The interaction effect between different dose of chemical fertilizer and split application and their possible combinations were found non-significant on different vegetative parameters.

Table 1: Effect of different dose of chemical fertilizer with split application through fertigation on growth parameters in marigold cv. Pusa Narangi Gainda

Treatments	Plant height (cm)			Number of main branches per plant			Stem diameter (cm)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	
Factor A – Dose (NPK @ kg/ha)							
F_1- 150:75:50	24.10	34.15	44.62	6.04	11.57	16.63	1.07
F_2- 200:100:100	23.72	33.93	42.19	5.79	11.12	15.95	1.04
F_3 -250:125:150	23.69	32.45	41.00	5.65	12.01	16.11	0.97
F_4- 300:150:200	23.25	33.02	40.42	6.10	11.76	15.69	1.06
S.Em. ±	0.42	0.65	0.95	0.14	0.23	0.26	0.04
C.D. at 5%	NS	NS	2.74	NS	NS	NS	NS
Factor B – Split application							
S_1- Control	23.48	33.70	41.25	5.69	10.95	15.79	1.03
S_2- 3 Split (at 40, 80 and 120 days)	23.91	34.34	43.65	6.05	12.00	16.78	1.11
S_3- 4 Split (at 30, 60, 90 and 120 days)	23.58	31.88	40.95	6.18	11.33	15.82	0.97
S_4- 5 Split (at 24, 48, 72, 96 and 120 days)	23.79	33.62	42.38	5.66	12.19	15.99	1.03
S.Em. ±	0.42	0.65	0.95	0.14	0.23	0.26	0.04
C.D. at 5%	NS	NS	NS	0.42	0.66	0.75	NS
Interaction (A X B)							
S.Em. ±	0.83	1.29	1.90	0.29	0.45	0.52	0.07
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
CV%	6.07	6.71	7.81	8.45	6.61	5.60	11.78

Effect on yield parameters

Effect of dose (NPK @ kg/ha)

The data revealed that application of different dose of chemical fertilizer had produced significant effect on yield parameters like number of flowers per plant, flower yield per plant, flower yield per plot and flower yield per hectare. Significantly maximum number of flowers per plant (38.64) was obtained in treatment of NPK @ 250:125:150 kg/ha (F_3) followed by NPK @ 150:75:50 kg/ha (F_1). Likewise, minimum number of flowers per plant (35.85) was recorded with different dose of NPK @ 300:150:200 kg/ha (F_4). Significantly maximum flower yield per plant (181.54 g) was obtained in treatment of NPK @ 150:75:50 kg/ha (F_1) followed by NPK @ 250:125:150 kg/ha (F_3). Likewise, minimum flower yield per plant (165.48 g) was recorded with different dose of NPK @ 200:100:100 kg/ha (F_2). Significantly maximum flower yield per plot (5.67 kg) was obtained in treatment of NPK @ 150:75:50 kg/ha (F_1). Likewise, minimum flowers yield per plot (5.07 kg) was recorded with different dose of NPK @ 200:100:100 kg/ha (F_2). Significantly maximum flower yield per hectare (11.68 t/ha) was obtained in treatment of NPK @ 150:75:50 kg/ha (F_1). Likewise, minimum flowers yield (10.44 t/ha) was recorded with different dose of NPK @ 200:100:100 kg/ha (F_2). Drip fertigation played a direct positive role in more flowering span, number of florets per spike, fresh weight, number of spikes per plant, per plot, spike and per hectare.

Effect of split application

In case of split application, the variation was also found significant effect on yield parameters like number of flowers per plant, flowers yield per plant, flower yield per plot, and per hectare. Significantly maximum number of flowers per plant (38.69) was recorded with an application of fertilizer in 3 split *i.e.* 40, 80 and 120 DAP (S_2), but it was at par with 5 split *i.e.* 24, 48, 72, 96 and 120 days (S_4). Whereas, 4 split i.e. 30, 60, 90 and 120 DAP (S_3), recorded significantly minimum number of flowers per plant (35.31). Significantly maximum flower yield per plant (180.71 g) was recorded with an application of fertilizer in 3 split i.e. 40, 80 and 120 DAP (S_2), but it was at par with 5 split *i.e.* 24, 48, 72, 96 and 120 days (S_4). Whereas, control (S_1) recorded significantly minimum flower yield per plant (165.04 g). Similar trends was also observed for split application maximum flower yield per plot (5.67 kg) was observed with an application of fertilizer in 3 split *i.e.* 40, 80 and 120 DAP (S_2), whereas, minimum flower yield per plot (5.05 kg) noted in control (S_1). Significantly maximum flower yield per hectare (11.68 t/ha) was recorded with an application of fertilizer in 3 split *i.e.* 40, 80 and 120 DAP (S_2). Whereas, significantly lowest flower yield per hectare (10.40 t/ha) control (S_1). These results were supported by Kurakula *et al.* (2017) [13] in marigold; Deo and Dubey (2005) [6] in gladiolus; Dahal *et al.* (2014) [4] in tuberose; Gurav *et al.* (2005) [7] and Chaudhary *et al.* (2016) [3] in rose; Patel and Chaudhari (2011) [17] in chrysanthemum.

Interaction effect of different dose of chemical fertilizer and split application

Interaction effect of the number of flowers per plant, flower yield per plant, flower yield per plot and flowers yield per hectare was also significantly influenced by treatment of different doses chemical fertilizer with split application and maximum flower yield was recorded with combined application of NPK @ 150:75:50 kg/ha with 3 splits *i.e.*, 40, 80 and 120 DAP (F_1S_2). Likewise, minimum number of flowers per plant found F_1S_3, minimum flower yield per plant and flower yield per plot were noted in F_2S_3 and flower yield per hectare was found in F_2S_1.

Table 2: Effect of different dose of chemical fertilizer with split application through fertigation on yield parameters in marigold cv. Pusa Narangi Gainda

Treatments	Number of flowers per plant	Flower yield per plant (g)	Flower yield per plot (kg)	Flower yield (t/ha)
Factor A – Dose (NPK @ kg/ha)				
F_1- 150:75:50	37.83	181.54	5.67	11.68
F_2- 200:100:100	35.96	165.48	5.07	10.44
F_3 -250:125:150	38.64	172.35	5.22	10.76
F_4- 300:150:200	35.85	170.34	5.25	10.82
S.Em. ±	0.65	2.59	0.08	0.17
C.D. at 5%	1.87	7.48	0.24	0.50
Factor B – Split application				
S_1 - Control	36.67	165.04	5.05	10.40
S_2 - 3 Split (at 40, 80 and 120 days)	38.69	180.71	5.67	11.68
S_3 - 4 Split (at 30, 60, 90 and 120 days)	35.31	169.02	5.17	10.64
S_4- 5 Split (at 24, 48, 72, 96 and 120 days)	37.62	174.93	5.32	10.96
S.Em.±	0.65	2.59	0.08	0.17
C.D. at 5%	1.87	7.48	0.24	0.50
Interaction (AX B)				
S.Em.±	1.30	5.18	0.17	0.35
C.D. at 5%	3.74	14.96	0.49	1.00
CV%	6.05	5.20	5.50	5.50

Table 3: Interaction effect of different dose of chemical fertilizer with split application through fertigation on yield parameters in marigold cv. Pusa Narangi Gainda

Treatment combination	Number of flower per plant	Flower yield per plant (g)	Flower yield per plot (kg)	Flower yield (t/ha)
F_1S_1	36.47	159.71	4.92	10.13
F_1S_2	42.49	212.00	7.00	14.42
F_1S_3	33.63	176.96	5.34	11.01
F_1S_4	38.74	177.49	5.41	11.14
F_2S_1	35.45	162.89	4.89	10.07
F_2S_2	38.38	169.37	5.24	10.79
F_2S_3	34.52	158.52	4.89	10.08
F_2S_4	35.50	171.13	5.25	10.81
F_3S_1	40.72	178.02	5.49	11.30
F_3S_2	36.99	165.00	5.02	10.35
F_3S_3	36.46	170.06	5.21	10.72
F_3S_4	40.38	176.31	5.17	10.65
F_4S_1	34.05	159.55	4.91	10.11
F_4S_2	36.90	176.49	5.41	11.15
F_4S_3	36.61	170.54	5.23	10.77
F_4S_4	35.85	174.79	5.46	11.25
S.Em. ±	1.30	5.18	0.17	0.35
C.D. at 5%	3.74	14.96	0.49	1.00
CV%	6.05	5.20	5.50	5.50

Conclusions

It has been concluded that the application of soluble chemical fertilizer NPK @ 150:75:50 kg/ha with 3 splits during 40, 80 and 120 DAP, through fertigation which improved growth and yield parameters of flower with higher net realization.

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