International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 1854-1857

Received: 17-09-2018
Accepted: 21-10-2018

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Nutrient content of African marigold (*Tagetes erecta* L.) as infuenced byirrigation, fertigation and mulching

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Abstract
A field experiment was conducted at ICAR-Indian Institute of Horticultural Research, Bengaluru during *kharif* 2016 to study the effect of fertigation, irrigation and mulching on nutrient content in African marigold. The results revealed that greater nitrogen, phosphorus and potassium content in plant when treated with irrigation at 1.0 Evapo-replinishment and fertigation with 100% recommended dose of fertilizers (RDF) and polyethylene mulching followed by 0.8 Evapo-replinishment and fertigation with 100% RDF and polyethylene mulching in three successive stages of pant growth. Similar observed in micronutrients (iron, manganese, zinc and copper) as well. There was an increase in nutrient content from vegetative stage to full bloom stage. Among the treatments, the minimum nutrient uptake was recorded in 0.6 ER and soil application of normal fertilizers @ 100% RDF without Mulching.

Keywords: Fertigation, irrigation, mulching, evapo-replinishment

Introduction
The African marigold (*Tagetes erecta* L.) is hardy flower crops grown throughout the India. It has got considerable choice among the gardeners and flower growers on account of its ease in cultivation, wide adaptability in varying soil and climatic conditions. Fertigation is the technique of applying nutrients along with irrigation water directly at the site of active root zone resulting in quality production. Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Nitrogen applied as fertilizer is the main sources used to meet the N requirements of plant growth (Konnerup and Brix, 2010) [8]. Drip irrigation is often preferred over other irrigation methods leads to high water-application efficiency on account of reduced losses via surface evaporation and deep percolation. Because of this high frequency of water application, salts concentration remain manageable in the root zone (Mantell *et al*. 1985) [4]. Mulching facilitates more retention of soil moisture, improves physical, biological and chemical properties of soil, as it adds nutrients to the soil and helps in control of temperature fluctuations ultimately enhances the growth and yield of crops (Nagalakshmi *et al*. 2002) [5].

Materials and Methods
The experiment was conducted during *kharif* season of 2016, at the Division of Floriculture and medicinal crops, ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru. The experiment laid out on split plot design by keeping Irrigation as a main plot *viz.,*1.0, 0.8 and 0.6 ER as a main plots and fertigation and mulching given as sub plot treatments *viz.,* fertigation of WSF @ 100% RDF with polyethylene mulching, fertigation of WSF @ 75% RDF with polyethylene mulching, fertigation of WSF @ 100% RDF without polyethylene mulching, fertigation of WSF @ 100% RDF without polyethylene mulching, soil application of normal fertilizers @ 100% RDF with polyethylene mulching and soil application of normal fertilizers @ 100% RDF without polyethylene mulching. Organic manure *i.e.,* farmyard manure (20 t) were applied in the pre marked rows as per the treatments five days earlier to transplanting. The recommended dose of fertilizers (NPK @ 100:75:75 kg ha^{-1}) was applied based on treatments (through fertigation) in the form of water soluble fertilizers (Urea, 19:19:19). The fertigation was given at weekly intervals twenty days after transplanting up to 70 days. Fertigation was given by using gutter spray. For direct soil application treatments Normal fertilizers like Urea, DAP and MOP (585, 1265 and 337 g, respectively) were applied at the time of bed preparation.

For nutrient analysis, the whole plant was collected from net plot at three stages of plant growth (30,60 and 90 days after transplanting), They were thoroughly washed with distilled water and oven dried for 72 hours at 60 ºC. Dried samples were finally ground and powdered in a grinder. And then this powder was used for analysis. The estimation of nitrogen was done by microkjeldahl's method (Piper, 1996) [9]. Phosphorus content in plant sample was determined by Vandomolybdate method (Jackson, 1973) [7]. Potash content of plant was estimated by Flame photometer (Jackson, 1973) [7]. The content of micronutrients (Fe, Mn, Zn and Cu) was determined by using Atomic Absorption Spectrophotometry (AAS), (Sarma *et al*. 1987) [11].

Results and Discussion

The plant nutrient content of N, P, K, Fe, Mn, Zn and Cu was increased significantly from vegetative stage to full bloom stage with the supply of respective levels of Irrigation, Fertigation and Mulching.

Among all macro and micro nutrients, irrigation with 1.0 ER recorded highest nutrient uptake in all three successive stages followed by 0.8ER. Similarly in the treatments with fertigation and mulching, fertigation of WSF @ 100% RDF with polyethylene mulching recorded highest nutrient uptake by plant followed by fertigation of 75% RDF with mulching.

Nitrogen Content

From the data presented on table 1, it is seen that different levels of irrigation, fertigation and mulching was influenced the nitrogen content in plants. The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better nitrogen content by plant 3.31, 2.42 and 1.69 ppm at 30, 60 and 90 days after transplanting respectively and followed by the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (2.27, 1.58 and 1.10 ppm)

Phosphorus Content

Different levels of irrigation, fertigation and mulching significantly influenced the phosphorus content by plants (table 1). The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded maximum phosphorus content by plant 0.61, 0.55 and 0.48 ppm at 30, 60 and 90 days after transplanting respectively and these values at par with the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (0.38, 0.30 and 0.26 ppm)

Potassium Content

Potassium content by plants was influenced significantly with different levels of irrigation, fertigation and mulching (table 1). The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better potassium content by plant 4.10, 3.00 and 2.40 ppm at 30, 60 and 90 days after transplanting respectively followed by the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (3.00, 2.00 and 1.30 ppm)

Iron Content

From the data presented on table 1, it is seen that different levels of irrigation, fertigation and mulching significantly influenced the Iron uptake by plants. The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better Iron content by plant 311.00, 259.00 and 232.00 ppm at 30,60 and 90 days after transplanting respectively followed by the treatment 0.8ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (194.00, 202.00 and 153.00 ppm)

Manganese Content

From the data presented on table 2, it is seen that different levels of irrigation, fertigation and mulching significantly influenced the Manganese content by plants. The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better Manganese content by plant 73.40, 45.10 and 45.00 ppm at 30, 60 and 90 days after transplanting respectively and these values at par with the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (50.20, 22.40 and 28.50 ppm).

Table 1: Effect of fertigation, irrigation and mulching on nitrogen, phosphorus, potassium and iron content (ppm) in African marigold

Treatment	Percent Nitrogen content			Percent Phosphorus content			Percent potassium content			Percent iron content		
	Vegetative stage	Blooming stage	Full bloom stage	Vegetative stage	Blooming stage	Full bloom stage	Vegetative stage	Blooming stage	Full bloom stage	Vegetative stage	Blooming stage	Full bloom stage
Irrigation												
I_1	3.05	2.11	1.44	0.51	0.46	0.41	3.71	2.75	2.03	275.16	244.02	209.16
I_2	3.03	2.10	1.42	0.51	0.46	0.41	3.58	2.31	2.01	270.83	240.83	208.50
I_3	2.75	1.89	1.28	0.46	0.39	0.34	3.45	2.11	1.70	253.50	220.83	189.33
$^{CD}0.05$	0.06	0.03	0.02	0.01	0.01	0.01	0.04	0.10	0.05	3.61	3.90	3.52
Fertigation and Mulching												
S_1	3.23	2.21	1.60	0.58	0.53	0.44	4.00	2.83	2.30	304.66	258.33	224.00
S_2	3.07	1.95	1.43	0.53	0.47	0.42	3.76	2.40	2.10	294.33	248.66	220.66
S_3	3.09	2.00	1.47	0.55	0.48	0.43	3.80	2.43	2.06	291.66	236.00	218.00
S_4	2.99	1.90	1.37	0.50	0.45	0.38	3.53	2.36	2.00	267.00	224.66	206.33
S_5	2.71	1.72	1.21	0.43	0.36	0.33	3.23	2.20	1.56	227.33	223.66	177.00
S_6	2.57	1.58	1.20	0.40	0.33	0.30	3.16	2.13	1.46	214.00	222.00	168.00
$^{CD}0.05$	0.03	0.03	0.02	0.01	0.01	0.01	0.05	0.03	0.04	4.99	2.10	3.16
Interactions												
I_1 X S_1	3.31	2.42	1.69	0.61	0.55	0.48	4.10	3.00	2.40	311.00	259.00	232.00

I_1 X S_2	3.16	2.20	1.48	0.55	0.50	0.45	3.70	2.80	2.20	297.00	254.00	224.00
I_1 X S_3	3.20	2.29	1.53	0.58	0.52	0.46	4.00	2.90	2.30	300.00	248.00	230.00
I_1 X S_4	3.10	2.10	1.41	0.52	0.48	0.42	3.70	2.80	2.10	271.00	232.00	210.00
I_1 X S_5	2.80	1.88	1.28	0.44	0.39	0.36	3.50	2.60	1.70	242.00	235.00	184.00
I_1 X S_6	2.74	1.80	1.26	0.41	0.34	0.33	3.30	2.40	1.50	230.00	236.00	175.00
I_2 X S_1	3.26	2.40	1.66	0.60	0.56	0.46	4.00	2.80	2.50	307.00	262.00	230.00
I_2 X S_2	3.20	2.18	1.49	0.55	0.50	0.46	3.80	2.30	2.20	296.00	255.00	226.00
I_2 X S_3	3.18	2.28	1.50	0.57	0.50	0.46	3.80	2.40	2.10	294.00	240.00	224.00
I_2 X S_4	3.10	2.11	1.41	0.52	0.49	0.40	3.50	2.30	2.10	270.00	230.00	208.00
I_2 X S_5	2.78	1.88	1.25	0.45	0.38	0.35	3.20	2.10	1.60	240.00	230.00	187.00
I_2 X S_6	2.70	1.76	1.24	0.42	0.35	0.33	3.20	2.00	1.60	218.00	228.00	176.00
I_3 X S_1	3.12	2.21	1.48	0.54	0.50	0.41	3.90	2.70	2.00	296.00	254.00	210.00
I_3 X S_2	2.86	1.96	1.32	0.50	0.43	0.37	3.80	2.10	1.90	290.00	237.00	212.00
I_3 X S_3	2.91	2.00	1.40	0.51	0.44	0.39	3.60	2.00	1.80	281.00	220.00	200.00
I_3 X S_4	2.78	1.90	1.30	0.46	0.40	0.35	3.40	2.00	1.80	260.00	212.00	201.00
I_3 X S_5	2.56	1.72	1.12	0.40	0.32	0.30	3.00	1.90	1.40	200.00	200.00	160.00
I_3 X S_6	2.27	1.58	1.10	0.38	0.30	0.26	3.00	2.00	1.30	194.00	202.00	153.00
$^{CD}0.05$	0.07	NS	0.03	0.02	0.02	0.02	0.08	0.08	0.08	8.92	4.22	5.92

S_1: Fertigation of WSF@ 100% RDF with Mulching
S_2: Fertigation of WSF @ 75% RDF with Mulching
S_3: Fertigation of WSF @ 100% RDF without Mulching
S_4: Fertigation of WSF @ 75% RDF without Mulching
S_5: Soil application of normal fertilizers @ 100% RDF with Mulching
S_6: Soil application of normal fertilizers @ 100% RDF without Mulching

Table 2: Effect of fertigation, irrigation and mulching on Manganese, zinc and copper content (ppm) in African marigold

Treatment	Percent manganese content			Percent zinc content			Percent copper content		
	Vegetative stage	Blooming stage	Full bloom stage	Vegetative stage	Blooming stage	Full bloom stage	Vegetative stage	Blooming stage	Full bloom stage
Irrigation									
I_1	66.76	33.76	39.31	47.03	39.56	30.78	23.71	19.76	16.88
I_2	65.03	34.08	38.05	44.05	38.85	29.53	22.48	19.18	16.13
I_3	58.83	29.86	34.11	36.61	33.81	27.16	17.80	15.71	13.88
$^{CD}0.05$	1.30	0.73	0.85	1.67	0.98	0.57	0.97	0.68	0.48
Fertigation and Mulching									
S_1	69.73	43.40	43.20	48.16	42.63	35.53	25.76	19.93	17.06
S_2	65.16	41.66	39.36	46.23	40.66	32.30	24.33	19.10	16.60
S_3	67.03	33.83	39.13	44.70	39.90	30.70	22.76	19.50	16.16
S_4	67.03	30.13	37.06	41.43	36.80	29.10	20.16	18.83	16.06
S_5	57.20	24.46	33.36	38.56	33.20	25.03	18.06	16.20	14.23
S_6	55.10	21.93	30.83	36.30	31.26	22.30	16.90	15.76	13.66
$^{CD}0.05$	0.80	1.15	0.59	1.63	0.60	0.63	0.48	0.24	0.18
Interactions									
I_1 X S_1	73.40	45.10	45.00	51.60	45.10	37.80	29.80	21.70	18.50
I_1 X S_2	70.50	42.40	41.90	48.90	42.80	33.20	27.50	20.30	18.00
I_1 X S_3	69.10	36.10	40.60	48.00	43.00	32.50	25.80	21.90	17.30
I_1 X S_4	70.00	32.30	38.20	49.10	39.00	31.10	21.30	20.30	17.20
I_1 X S_5	60.50	25.30	36.00	44.20	35.20	27.70	19.40	17.40	15.30
I_1 X S_6	57.10	21.40	34.20	40.40	32.30	22.40	18.50	17.00	15.00
I_2 X S_1	73.00	45.10	46.10	50.80	42.80	36.00	26.20	21.60	18.00
I_2 X S_2	65.00	44.00	40.20	49.20	43.00	33.40	25.50	20.00	17.20
I_2 X S_3	70.00	35.40	41.00	45.50	42.60	30.90	25.00	20.00	16.60
I_2 X S_4	68.10	32.00	38.00	41.00	38.90	29.80	22.00	20.20	16.60
I_2 X S_5	56.10	26.00	33.20	41.20	34.30	24.10	19.00	17.00	14.50
I_2 X S_6	58.00	22.00	29.80	36.60	31.50	23.00	17.20	16.30	13.90
I_3 X S_1	62.80	40.00	38.50	42.10	40.00	32.80	21.30	16.50	14.70
I_3 X S_2	60.00	38.60	36.00	40.60	36.20	30.30	20.00	17.00	14.60
I_3 X S_3	62.00	30.00	35.80	40.60	34.10	28.70	17.50	16.60	14.60
I_3 X S_4	63.00	26.10	35.00	34.20	32.50	26.40	17.20	16.00	14.40
I_3 X S_5	55.00	22.10	30.90	30.30	30.10	23.30	15.80	14.20	12.90
I_3 X S_6	50.20	22.40	28.50	31.90	30.00	21.50	15.00	14.00	12.10
$^{CD}0.05$	1.57	2.06	1.15	1.35	1.18	1.16	0.98	0.52	0.38

S_1: Fertigation of WSF@ 100% RDF with Mulching
S_2: Fertigation of WSF @ 75% RDF with Mulching
S_3: Fertigation of WSF @ 100% RDF without Mulching
S_4: Fertigation of WSF @ 75% RDF without Mulching
S_5: Soil application of normal fertilizers @ 100% RDF with Mulching
S_6: Soil application of normal fertilizers @ 100% RDF without Mulching

Zinc Content

Zinc content by plants was influenced significantly by different levels of irrigation, fertigation and mulching (table 2). The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better Zinc content by plant. 51.60, 45.10 and 37.80 ppm at 30,60 and 90 days after transplanting respectively followed by the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (31.90, 30.00 and 21.50 ppm)

Copper Content

Different levels of irrigation, fertigation and mulching significantly influenced the copper content by plants (table 2). The interaction study revealed that the irrigation treatment 1.0 ER with fertigation of WSF @ 100% RDF with polyethylene mulching recorded better copper content by plant. 29.80, 21.70 and 18.50 ppm at 30, 60 and 90 days after transplanting respectively followed by the treatment 0.8 ER+ fertigation with WSF @ 100% RDF and mulching. Minimum nutrient content was recorded in 0.6 ER + Soil application of normal fertilizers @ 100% RDF without Mulching (15.00, 14.00 and 12.10 ppm)

Discussion

The higher nutrient content in plant samples under the drip irrigated treatments might be due to frequent application of irrigation and required quantity of fertilizers through drip, in which the nutrients were effectively utilized. Besides, nutrients were in direct contact with the root system with negligible loss of nutrients beyond the deeper depth of the soil profile. Enhanced solubilisation and increased extractability of micronutrients may also account for its increased micronutrient content. Increased nutrient content in different plant parts could be due to the higher availability in the root zone, uptake and accumulation of nitrogen, which may take place gradually with the advancement of crop growth phase. Similar findings were also reported by Colla *et al.* (2001) [2] and Girish (2006) [3] in Heliconia, Singh *et al.* 2015 [1] in carnation, Polara *et al.* 2014 [10] in marigold, Shalini *et al*. 2015 [6].

Conclusion

The findings of the present investigation revealed that nutrient content of marigold was significantly influenced with fertigation, irrigation and mulching treatments. Greater nutrient content of plant obtained with interaction of Irrigation at 1.0 Evaporation Replenishment (ER), Fertigation with water soluble fertilizers @100 % RDF and polyethylene mulching and it was at par with irrigation level of 0.8 Evaporation Replenishment and fertigation of WSF @ 100% RDF with polyethylene mulching.

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