Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 3787-3796

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-7 pp. 3787-3796
Journal homepage: http://www.ijcmas.com

Original Research Article

Yield and Nutrient Uptake of Hybrid Maize as Influenced by Different Fertigation Intervals, Duration and Fertilizer Levels in Southern Dry Zone of Karnataka

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Keywords

Drip irrigation, fertigation interval, Kernel yield, Harvest index, nutrient uptake

ABSTRACT

A study was undertaken at Zonal Agricultural Research Station, V.C. Farm, Mandya which comes under Southern Dry zone of Karnataka during *Kharif*-2015 and *Kharif*-2016 to investigate the effect of drip fertigation on nutrient uptake and yield of drip irrigated hybrid maize (*Zea mays* L.). The experiment was laid out in a Randomized Complete Block Design using factorial concept involving different fertigation intervals and duration with varied levels of fertilizers and replicated thrice. The results revealed that application of 125 per cent of recommended nitrogen and potassium through drip fertigation with four or eight days interval with fertigation duration of 25 % at 0-30 DAS + 50 % at 31-50 DAS + 25 % at 51-80 DAS resulted in higher kernel yield (86.85 q ha^{-1}) and stover yield (103.73 q ha^{-1}). Whereas, drip fertigation of 75 % of recommended nitrogen and potassium with the same fertigation duration was found on par with 100 % recommended NPK application under surface irrigation method (69.34, 79.80 q ha^{-1} and 68.81, 79,20 q ha^{-1}, respectively). The higher NPK uptake (238.56, 111.41 and 185.37 kg ha^{-1}, respectively) was found with the above fertigation treatment than control (158.33, 55.17 and 123.00 kg ha^{-1}, respectively) when compared to surface irrigation method.

Introduction

Maize is one of the most versatile crops across the world where it was grown throughout the year one or the other place. In India, about 25 per cent of the maize produced is used for human consumption, 49 per cent in poultry and 12 per cent as cattle feed and 12 per cent in food processing industries mainly as starch and one per cent each in brewery and seed (Jat *et al.*, 2009). In India, it is cultivated in an area of 9.4 million hectare with a production 22.27 million tonnes. However, the productivity is 2.5 t ha^{-1} which is much lower than the global average. Karnataka being major maize producing state alone contributes 16.5 per cent of the total maize production with an area of 1.3 million hectare and production of 4.0 million tonnes (Anon., 2016) with a productivity of 2883 kg ha^{-1}. In present day scenario, maize is replacing many other traditional crops in the state. Being most exhaustive crop maize extracts more nutrients and also responds well to the irrigation as it's one of the crops with higher yield potential. Since water and nutrients are the critical inputs for agriculture their better management and effective utilization is very much essential for successful crop production and is also a serious challenge to future food security and environmental sustainability. So, in this regard drip irrigation and fertigation practices are proven better for efficient nutrient and water management in many commercial crops and also field crops including sugarcane, rice, cotton etc. due to the direct application of water and nutrients in the vicinity of root zone.

Fertigation with drip irrigation practice is gaining higher momentum in present day crop production. Because water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network, the irrigation efficiency does not exceed 40%. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. The need of the hour is, therefore, to maximize the production per unit of water and nutrients as well. Therefore, while giving fertigation, it is very important to consider how much fertilizer to be given and when to give the fertigation and also the crop stage and its nutrient demand, thereby one can achieve higher water and nutrient efficiency in addition to higher yield and economic returns. With this background present study was undertaken to know the effect of different fertigation treatments including different fertigation durations, intervals and fertilizer levels on yield and nutrient uptake of hybrid maize in Southern dry zone of Karnataka.

Materials and Methods

A Field experiment was conducted during *Kharif* -2015 and *Kharif*- 2016 at Zonal Agricultural Research Station, V.C. Farm, Mandya, Southern Dry Zone (Zone-6) of Karnataka. The soil in the experimental site was sandy loam with low organic carbon content. The initial nitrogen, phosphorus and potassium status of the soil were 248.4, 32.50 and 189.3 kg per ha, respectively. The soil pH was 6.9 with an EC of 0.32 dSm^{-1}. The hybrid maize Nithyashree was used in study. The field experiment was laid out in a Randomized Complete Block Design with three replications using factorial concept involving different fertigation intervals of once in 4 days (I_1) and 8 days interval (I_2) with fertigation duration as D_1: 25% RDF (from sowing to 30 DAS) + 50% RDF (31 to 50 DAS) + 25% RDF (51 to 80 DAS) and D_2: 50% RDF (from sowing to 30 DAS) + 25% RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS) with varied levels of fertilizers *i.e.* 75 % (F_1), 100 % (F_2) and 125 % (F_3) of recommended NPK. Phosphorus was applied as basal dose through soil applications. In the control treatment the recommended package of practices with surface irrigation and soil application of (50 % N and 100 % PK basally with one top dress at 40 DAS) of fertilizer was followed. The drip line was passed in between paired row.

This system included pump, filter units, fertigation tank, ventury, main line and sub line with control valves for each plots to regulate the fertigation frequency and duration. The calculated quantity of phosphorus was applied to all the treatments through single super phosphate by soil application basally, whereas, nitrogen and potassium were supplied through drip fertigation starting from 6^{th} days after sowing as per the treatments using water soluble urea and muriate of potash, respectively. Drip irrigation was given once in two days and fertigation was as per the treatments. The observations of the crop yield and nutrient uptake was recorded and the data was subjected to statistical analysis.

Results and Discussion

Kernel and stover yield of maize

The pooled data of kernel and stover yield of maize as influenced by various fertigation treatments was discussed in this section (Table 1). The fertigation interval under the study did not influence the yield of maize significantly. However, comparatively higher values were observed with four days fertigation interval compared to eight days interval.

Among fertigation durations, significantly higher kernel (80.32 q ha^{-1}) and stover yield (95.12 q ha^{-1}) were recorded in the treatment with fertigation duration given as 25 per cent RDF from sowing to 30 DAS + 50 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS compared to fertigation duration of 50 per cent RDF from sowing to 30 DAS + 25 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS (76.57 and 90.49 q ha^{-1}, respectively).

Further, application of 125 per cent RDF recorded higher kernel and stover yield (84.41 and 103.4 q ha^{-1}, respectively) followed by 100 per cent RDF (77.56 and 95.85 q ha^{-1}, respectively) and the lower values were observed with the application of 75 per cent RDF (73.37 and 84.88 q ha^{-1}, respectively).

The interaction between fertigation interval and fertigation duration as well as fertigation interval and fertilizer levels found no significant with respect to the yield of maize. Wherein the interaction of fertigation duration and fertilizer levels had significantly influenced the yield of maize and higher kernel and stover yield were observed with application of 125 per cent RDF fertigated with the duration of 25 per cent RDF from sowing to 30 DAS + 50 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS (86.18 and 103.82 q ha^{-1}, respectively) and lowest parameters were realized with the application of 75 per cent of RDF fertigated as 50 per cent RDF from sowing to 30 DAS + 25 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS (69.52 and 78.27 q ha^{-1}, respectively).

The interaction of fertigation interval, duration and fertilizer levels together influenced the yield of maize and found significantly superior over the control. Among those, higher kernel (86.85 q ha^{-1}) and stover yield (103.73 q ha^{-1}) were noticed with the interaction comprised of 125 per cent RDF fertigated once in four days as 25 per cent RDF from sowing to 30 DAS + 50 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS which was on par with treatment comprised of 125 per cent RDF fertigated once in eight days as 25 per cent RDF from sowing to 30 DAS + 50 per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS (85.52 and 102.23 q ha^{-1}, respectively).

However, the lowest values were recorded in the control with the surface irrigation soil application of fertilizers (68.81 and 79.2 q ha^{-1}, respectively) and found to be on par with application of 75 per cent RDF fertigated once in eight days as 50 per cent RDF from sowing to 30 DAS + 25per cent from 31 to 50 DAS + 25 per cent from 51 to 80 DAS (69.34 and 79.80 q ha^{-1}, respectively) which further reflected on harvest index of the crop (Table 1).

The kernel and stover yield of maize differed significantly under drip fertigation. Since the economic yield is a part of total biological yield, accumulation of total dry matter with better growth and development of crop helps in enhancement of economical yield of crop.

Table.1 Yield of maize as influenced by fertigation interval, duration and fertilizer levels

Treatments	Kernel yield (q ha^{-1})			Stover yield (q ha^{-1})			Harvest index		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Fertigation intervals									
I_1	79.26	78.20	78.73	98.17	94.06	96.11	0.45	0.45	0.45
I_2	78.81	77.50	78.16	95.06	91.55	93.31	0.45	0.46	0.46
SEm±	0.84	0.84	0.58	1.45	1.52	1.00	0.004	0.004	0.004
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation durations									
D_1	81.04	79.60	80.32	99.23	95.12	97.18	0.45	0.46	0.45
D_2	77.04	76.11	76.57	94.00	90.49	92.24	0.45	0.46	0.45
SEm±	0.84	0.84	0.58	1.45	1.52	1.00	0.004	0.004	0.004
CD (p=0.05)	2.45	2.47	1.65	4.24	4.46	2.83	NS	NS	NS
Fertilizer levels									
F_1	72.95	73.78	73.37	86.68	83.08	84.88	0.46	0.47	0.46
F_2	78.27	76.85	77.56	97.60	94.10	95.85	0.45	0.45	0.45
F_3	85.89	82.93	84.41	105.57	101.24	103.40	0.45	0.45	0.45
SEm±	1.02	1.03	0.71	1.77	1.86	1.22	0.005	0.005	0.005
CD (p=0.05)	3.01	3.03	2.02	5.20	5.46	3.47	NS	NS	NS
Interactions									
IXD									
SEm±	1.18	1.19	0.82	2.05	2.15	1.41	0.005	0.006	0.004
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
IXF									
SEm±	1.45	1.46	1.00	2.51	2.63	1.73	0.005	0.008	0.005
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
DXF									
D_1F_1	76.74	77.69	77.21	93.33	89.66	91.49	0.45	0.46	0.46
D_1F_2	78.18	76.94	77.56	98.81	95.31	97.06	0.44	0.45	0.44
D_1F_3	88.20	84.17	86.18	105.58	102.07	103.82	0.46	0.46	0.46
D_2F_1	69.17	69.87	69.52	80.03	76.51	78.27	0.46	0.48	0.47
D_2F_2	78.36	76.76	77.56	96.39	92.89	94.64	0.45	0.45	0.45
D_2F_3	83.57	81.70	82.64	105.57	100.40	102.98	0.44	0.44	0.44
SEm±	1.45	1.46	1.00	2.51	2.63	1.73	0.007	0.008	0.005
CD (p=0.05)	4.25	4.28	2.85	7.35	7.73	4.90	NS	NS	NS
IXDXF									
$I_1D_1F_1$	76.76	77.17	76.97	99.71	95.88	97.79	0.43	0.45	0.44
$I_1D_1F_2$	78.75	77.43	78.09	101.84	98.34	100.09	0.44	0.44	0.44
$I_1D_1F_3$	88.69	85.01	86.85	107.15	100.32	103.73	0.45	0.46	0.46
$I_1D_2F_1$	69.30	70.09	69.69	78.49	74.99	76.74	0.47	0.48	0.48
$I_1D_2F_2$	77.95	76.57	77.26	98.78	95.28	97.03	0.44	0.45	0.44
$I_1D_2F_3$	84.13	82.96	83.54	103.05	99.55	101.30	0.45	0.45	0.45
$I_2D_1F_1$	76.72	78.21	77.46	86.94	83.44	85.19	0.47	0.48	0.48
$I_2D_1F_2$	77.61	76.45	77.03	95.79	92.28	94.03	0.45	0.45	0.45
$I_2D_1F_3$	87.71	83.33	85.52	103.98	100.48	102.23	0.46	0.45	0.46
$I_2D_2F_1$	69.04	69.65	69.34	81.57	78.03	79.80	0.46	0.47	0.46
$I_2D_2F_2$	78.78	76.95	77.86	93.99	90.49	92.24	0.46	0.46	0.46
$I_2D_2F_3$	83.01	80.44	81.73	104.10	101.60	102.85	0.43	0.43	0.43
Control	68.11	69.51	68.81	81.45	76.94	79.20	0.46	0.47	0.46
SEm±	1.99	2.09	1.42	3.40	3.59	2.44	0.009	0.01	0.007
CD (p=0.05)	5.82	6.11	4.03	9.92	10.49	6.93	NS	NS	NS

Note: I_1: Fertigation once in 4 days, **I_2**: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
F_1: 75 % RDF, **F_2:** 100 % RDF, **F_3:** 125 % RDF
Control: Surface irrigation with soil application of RDF (NPK at150:75:40 kg ha^{-1})

Table.2 Correlation and regression equation for growth and yield components with yield as influenced by fertigation interval, duration and fertilizer levels

Sl. No.	Parameters	Correlation co-efficient (r)	Regression equation Y{Kernel yield (kg ha^{-1})}	R^2
Between yield vs growth components				
1.	Plant height at harvest (cm)	0.87**	Y = 0.5991X - 30.92	0.7554
2.	Number of leaves	0.77**	Y = 7.1879X - 10.43	0.6002
3.	Leaf area at harvest (cm^2 plant^{-1})	0.86**	Y = 0.0072X + 29.782	0.7471
4.	Total dry matter production (g plant^{-1})	0.87**	Y = 0.2587X + 1.775	0.7605
Between yield vs yield components				
1.	Cob length (cm)	0.84**	Y = 3.8598X - 8.5238	0.7026
2.	Kernel rows cob^{-1}	0.83**	Y = 6.4482X - 17.328	0.6828
3.	Kernel weight cob^{-1} (g)	0.95**	Y = 0.4494X + 16.824	0.9003
4.	100 kernel weight (g)	0.87**	Y= 4.5412X - 68.695	0.7556

Note: The independent variable X refers to the parameters listed in serial number,
Y is dependent variable kernel yield in kg ha^{-1}. **Correlation is significant at p = 0.01

Table.3 Nitrogen uptake by maize as influenced by fertigation interval, Duration and fertilizer levels

Treatments	Kernel (kg N ha^{-1})			Stover (kg N ha^{-1})			Total (kg N ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Fertigation intervals									
I_1	125.30	129.62	127.46	69.44	72.46	70.95	194.73	202.08	198.41
I_2	130.72	133.46	132.09	68.22	70.86	69.54	198.94	204.33	201.63
SEm±	1.95	1.99	2.35	0.96	1.19	0.93	2.40	2.25	1.79
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation durations									
D_1	130.89	134.48	132.69	70.78	73.53	72.16	201.67	208.02	204.84
D_2	125.13	128.60	126.87	66.87	69.79	68.33	192.00	198.39	195.20
SEm±	1.95	1.99	1.35	0.96	1.19	0.73	2.40	2.25	1.59
CD (p=0.05)	5.73	5.85	3.84	2.80	3.48	2.07	7.04	6.59	4.52
Fertilizer levels									
F_1	111.30	117.19	114.25	63.31	64.51	63.91	174.62	181.70	178.16
F_2	124.02	125.61	124.82	68.72	72.50	70.61	192.74	198.11	195.43
F_3	148.70	151.83	150.27	74.44	77.97	76.21	223.15	229.80	226.47
SEm±	2.39	2.44	1.66	1.17	1.45	0.89	2.94	2.75	1.95
CD (p=0.05)	7.01	7.16	4.71	3.43	4.26	2.54	8.62	8.08	5.53
Interactions									
IXD									
SEm±	2.76	2.82	1.91	1.35	1.68	1.03	3.39	3.18	2.25
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
IXF									
SEm±	3.38	3.45	2.34	1.66	2.05	1.26	4.16	3.89	2.76
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
DXF									
D_1F_1	109.31	114.46	111.88	67.78	69.79	68.78	177.09	184.24	180.67
D_1F_2	125.78	127.65	126.71	69.76	73.31	71.53	195.53	200.96	198.25
D_1F_3	157.57	161.35	159.46	74.81	77.51	76.16	232.38	238.86	235.62
D_2F_1	113.29	119.92	116.61	58.85	59.23	59.04	172.15	179.15	175.65
D_2F_2	122.26	123.58	122.92	67.68	71.69	69.69	189.94	195.27	192.61
D_2F_3	139.83	142.32	141.07	74.08	78.44	76.26	213.91	220.75	217.33
SEm±	3.38	3.45	2.34	1.66	2.05	1.26	4.16	3.89	2.76
CD (p=0.05)	9.92	10.13	6.65	4.86	6.03	3.59	NS	NS	7.83
IXDXF									
$I_1D_1F_1$	112.37	116.65	114.51	68.45	74.78	71.62	180.82	191.43	186.13
$I_1D_1F_2$	121.46	123.27	122.36	70.86	74.01	72.43	192.31	197.27	194.79
$I_1D_1F_3$	158.52	162.84	160.68	76.82	78.93	77.88	235.34	241.77	238.56
$I_1D_2F_1$	109.49	117.66	113.57	58.98	56.82	57.90	168.47	174.49	171.48
$I_1D_2F_2$	113.76	115.62	114.69	71.14	75.29	73.21	184.89	190.91	187.90
$I_1D_2F_3$	136.20	141.69	138.95	70.35	74.93	72.64	206.55	216.62	211.59
$I_2D_1F_1$	117.10	122.17	119.64	67.10	64.80	65.95	173.36	177.06	175.21
$I_2D_1F_2$	130.10	132.03	131.07	68.66	72.61	70.63	198.76	204.64	201.70
$I_2D_1F_3$	156.63	159.85	158.24	72.79	76.08	74.44	229.42	235.94	232.68
$I_2D_2F_1$	106.26	112.26	109.26	58.72	61.64	60.18	175.83	183.81	179.82
$I_2D_2F_2$	130.76	131.54	131.15	64.23	68.10	66.16	194.99	199.64	197.31
$I_2D_2F_3$	143.46	142.94	143.20	77.81	81.95	79.88	221.27	224.89	223.08
Control	98.77	104.26	101.51	55.65	57.98	56.82	154.42	162.24	158.33
SEm±	4.59	4.82	3.31	2.26	2.82	1.79	5.66	5.51	3.90
CD (p=0.05)	13.40	14.07	9.41	6.59	8.22	5.07	16.52	16.09	11.07

Note: I_1: Fertigation once in 4 days, **I_2**: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
F_1: 75 % RDF, **F_2:** 100 % RDF, **F_3:** 125 % RDF
Control: Surface irrigation with soil application of RDF (NPK at150:75:40 kg ha^{-1})

Table.4 Phosphorus uptake by maize as influenced by fertigation interval, Duration and fertilizer levels

Treatments	Kernel (kg P_2O_5 ha^{-1})			Stover (kg P_2O_5 ha^{-1})			Total (kg P_2O_5 ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Fertigation intervals									
I_1	51.76	53.46	50.87	30.97	26.95	28.96	82.73	76.93	79.83
I_2	49.56	52.15	52.59	29.75	25.87	27.81	79.31	81.49	80.40
SEm±	1.18	1.88	1.06	0.99	1.00	0.86	1.48	2.35	1.32
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation durations									
D_1	53.25	49.98	53.36	32.82	28.75	30.79	86.08	82.20	84.14
D_2	48.07	55.62	50.11	27.89	24.07	25.98	75.96	76.22	76.09
SEm±	1.18	1.88	1.06	0.99	1.00	0.66	1.48	2.35	1.32
CD (p=0.05)	3.47	5.52	3.00	2.90	2.94	1.89	4.34	NS	3.74
Fertilizer levels									
F_1	40.06	43.31	41.69	23.04	19.63	21.34	63.10	62.95	63.02
F_2	49.64	49.53	49.59	28.84	24.82	26.83	78.48	74.35	76.41
F_3	62.28	65.56	63.92	39.20	34.78	36.99	101.48	100.34	100.91
SEm±	1.45	2.31	1.29	1.21	1.23	0.81	1.81	2.88	1.61
CD (p=0.05)	4.25	6.76	3.68	3.56	3.60	2.31	5.32	8.46	4.58
Interactions									
IXD									
SEm±	1.67	2.66	1.49	1.40	1.42	0.94	2.09	3.33	1.86
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
IXF									
SEm±	2.05	3.66	1.83	1.72	1.74	1.15	2.56	4.08	2.28
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
DXF									
D_1F_1	41.96	37.54	39.75	22.90	19.13	21.01	64.86	56.67	60.76
D_1F_2	49.83	51.47	50.65	33.07	28.99	31.03	82.90	80.46	81.68
D_1F_3	67.97	71.35	69.66	42.50	38.13	40.31	110.47	109.48	109.98
D_2F_1	38.16	49.08	43.62	23.18	20.14	21.66	61.33	69.22	65.28
D_2F_2	49.46	47.59	48.52	24.60	20.65	22.62	74.06	68.23	71.15
D_2F_3	56.59	59.77	58.18	35.89	31.43	33.66	92.49	91.20	91.84
SEm±	2.05	3.26	1.83	1.72	1.74	1.15	2.56	4.08	2.28
CD (p=0.05)	6.00	9.56	5.20	5.03	5.09	3.27	7.52	11.96	6.48
IXDXF									
$I_1D_1F_1$	43.11	40.25	41.68	23.63	19.51	21.57	66.74	59.75	63.25
$I_1D_1F_2$	55.71	46.61	51.16	35.56	31.31	33.44	91.28	77.91	84.59
$I_1D_1F_3$	68.94	70.69	69.82	43.78	39.40	41.59	112.72	110.09	111.41
$I_1D_2F_1$	38.07	44.94	41.51	23.29	20.34	21.82	61.36	65.28	63.32
$I_1D_2F_2$	51.22	39.82	45.52	24.04	19.95	22.00	75.26	59.77	67.52
$I_1D_2F_3$	55.44	56.24	55.84	38.06	33.74	35.90	93.50	89.97	91.74
$I_2D_1F_1$	40.81	34.83	37.82	22.17	18.75	20.46	62.98	53.58	58.28
$I_2D_1F_2$	43.95	56.34	50.14	30.58	26.67	28.62	74.53	83.01	78.77
$I_2D_1F_3$	67.00	72.01	69.51	41.22	36.85	39.04	108.22	108.87	108.55
$I_2D_2F_1$	38.24	53.22	45.73	23.06	19.95	21.50	61.30	73.17	67.24
$I_2D_2F_2$	47.70	55.36	51.53	25.16	21.34	23.25	72.85	76.70	74.78
$I_2D_2F_3$	57.75	63.30	60.53	33.73	29.12	31.42	91.48	92.42	91.95
Control	32.01	35.45	33.73	22.97	19.91	21.44	54.98	55.36	55.17
SEm±	2.79	4.42	2.59	2.33	2.37	1.63	3.48	5.53	3.22
CD (p=0.05)	8.14	12.90	7.36	6.81	6.90	4.62	10.14	16.14	9.16

Note: I_1: Fertigation once in 4 days, **I_2**: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
F_1: 75 % RDF, **F_2:** 100 % RDF, **F_3:** 125 % RDF
Control: Surface irrigation with soil application of RDF (NPK at150:75:40 kg ha^{-1})

Table.5 Potassium uptake by maize as influenced by fertigation interval, Duration and fertilizer levels

Treatments	Kernel (kg K_2O ha^{-1})			Stover (kg K_2O ha^{-1})			Total (kg K_2O ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Fertigation intervals									
I_1	53.65	54.12	53.89	112.09	95.97	104.03	165.74	150.10	157.92
I_2	52.55	52.76	52.66	111.95	93.75	102.85	164.50	146.52	155.51
SEm±	0.63	0.59	0.43	1.99	1.56	1.20	2.01	1.80	1.29
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation durations									
D_1	54.40	54.78	54.59	116.93	97.32	107.12	171.33	152.10	161.71
D_2	51.80	52.10	51.95	107.11	92.41	99.76	158.91	144.51	151.71
SEm±	0.63	0.59	0.43	1.99	1.56	1.20	2.01	1.80	1.29
CD (p=0.05)	1.84	1.73	1.22	5.85	4.57	3.40	5.91	5.29	3.67
Fertilizer levels									
F_1	48.83	50.34	49.58	93.40	85.28	89.34	142.23	135.62	138.93
F_2	52.09	52.50	52.30	108.05	96.03	102.04	160.14	148.53	154.33
F_3	58.38	57.48	57.93	134.61	103.28	118.94	192.99	160.77	176.88
SEm±	0.77	0.72	0.53	2.44	1.91	1.47	2.47	2.21	1.58
CD (p=0.05)	2.25	2.12	1.50	7.17	5.59	4.17	7.23	6.47	4.50
Interactions									
IXD									
SEm±	0.89	0.83	0.61	2.82	2.20	1.69	2.85	2.55	1.83
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
IXF									
SEm±	1.09	1.02	0.75	3.46	2.27	2.09	3.49	3.12	2.24
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
DXF									
D_1F_1	51.73	53.18	52.45	93.83	92.20	93.02	145.56	145.38	145.47
D_1F_2	52.22	52.51	52.37	112.74	97.13	104.94	164.97	149.64	157.31
D_1F_3	59.24	58.66	58.95	144.23	102.61	123.42	203.47	161.26	182.37
D_2F_1	45.92	47.51	46.71	92.98	78.36	85.67	138.90	125.87	132.38
D_2F_2	51.96	52.49	52.23	103.35	94.92	99.13	155.31	147.41	151.36
D_2F_3	57.52	56.31	56.92	124.99	103.95	114.47	182.51	160.27	171.39
SEm±	1.09	1.02	0.75	3.46	2.70	2.07	3.49	3.12	2.24
CD (p=0.05)	3.18	3.00	2.12	10.13	7.91	5.89	NS	9.16	6.36
IXDXF									
$I_1D_1F_1$	52.21	54.12	53.16	100.38	98.75	99.57	152.59	152.87	152.73
$I_1D_1F_2$	52.49	52.25	52.37	112.87	98.59	105.73	165.36	150.84	158.10
$I_1D_1F_3$	60.89	60.15	60.52	145.68	104.01	124.85	206.58	164.16	185.37
$I_1D_2F_1$	45.51	47.49	46.50	90.64	75.57	83.11	136.15	123.06	129.61
$I_1D_2F_2$	52.48	53.11	52.80	104.79	99.11	101.95	157.27	152.22	154.75
$I_1D_2F_3$	58.32	57.60	57.96	118.18	99.81	109.00	176.50	157.41	166.96
$I_2D_1F_1$	51.25	52.24	51.75	87.27	85.66	86.47	138.53	137.90	138.21
$I_2D_1F_2$	51.96	52.77	52.36	112.62	95.68	104.15	164.58	148.45	156.51
$I_2D_1F_3$	57.58	57.16	57.37	142.78	101.20	121.99	200.36	158.37	179.36
$I_2D_2F_1$	46.33	47.52	46.93	95.32	81.15	88.23	141.65	128.67	135.16
$I_2D_2F_2$	51.44	51.87	51.66	101.92	90.72	96.32	153.36	142.59	147.98
$I_2D_2F_3$	56.73	55.02	55.88	131.79	108.10	119.94	188.52	163.12	175.82
Control	44.51	46.90	45.71	77.37	77.22	77.30	121.89	124.12	123.00
SEm±	1.50	1.51	1.06	4.68	3.69	2.93	4.75	4.38	3.17
CD (p=0.05)	4.39	4.42	3.00	13.67	10.78	8.33	13.86	12.78	9.00

Note: I_1: Fertigation once in 4 days, I_2: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 DAS to 50 DAS) + 25 % RDF (51 DAS to 80 DAS)
F_1: 75 % RDF, **F_2:** 100 % RDF, **F_3:** 125 % RDF
Control: Surface irrigation with soil application of RDF (NPK at150:75:40 kg ha^{-1})

Assessment of maize yield in different treatments indicated that significantly higher kernel and stover yield was observed with drip fertigation with higher dose of nutrient application and nutrient supply coinciding the crop requirement which could be correlated to improved growth parameters (Table 2) such as higher plant height (r=0.87), number of leaves (r=0.77) and leaf area (r=0.86) and yield parameters viz., cob length (r=0.84), kernel rows cob^{-1} (r=0.83), kernel weight cob^{-1} (r=0.95) and 100 kernel weight (r=0.87). Lower kernel and stover yield was observed with surface irrigation.

Frequent split application of fertilizers in drip irrigation coinciding with the actual crop nutrient demand and supplied more nutrients at peak time without any nutrient stress which might have resulted in higher yield of maize. Scheduling fertigation once in four or eight days might not differ but matched with crop demand. In surface irrigation method, initial application of nutrient as basal was more which might allow leaching away of nutrients from the root zone (Ibrahim *et al.,* 2016). These results are in accordance with the studies of Rajput and Patel (2006) wherein yield of onion was not significantly affected in daily, alternate day and weekly fertigation intervals. Moreover, there was increased solubility and availability of nutrients to the root zone in case of fertigation and least or no loss of fertilizers might have taken place as they are supplied in small doses in regular scheduled fertigation (Anusha, 2015). Richa Khanna (2013) documented that 75 per cent recommended fertilizer in drip fertigation recorded on par yield with application of 100 per cent recommended fertilizer through soil application (focused more fertilizer application as basal dose with one top dress) in maize and similar findings were observed by Rekha (2014) in rice and Gururaj (2016) in sugarcane.

Nutrient uptake by maize

The uptake of nutrients by maize was significantly influenced by drip fertigation as indicated in Table 3, 4 and 5. The fertigation interval did not varied significantly with respect to nutrient uptake by maize in grain, stover and total uptake as well. However, comparatively higher nutrient uptake was observed with four days fertigation interval compared to eight days interval. The pooled data was discussed below with respect to total nitrogen, phosphorous and potassium uptake.

Among different treatments the fertigation duration comprised of 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher nitrogen, phosphorous and potassium uptake (204.84, 84.14 and 161.71 kg ha^{-1}, respectively). Application of 125 per cent RDF recorded significantly higher nitrogen, phosphorous and potassium uptake (226.47, 100.91 and 176.88 kg ha^{-1}, respectively) followed by 100 per cent (195.43, 76.41 and 154.33 kg ha^{-1}, respectively) and 75 per cent RDF application (178.16, 63.02 and 138.93 kg ha^{-1}, respectively). In the interaction effect, application of 125 per cent RDF at four days interval with fertigation duration comprised of 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher NPK uptake (238.56, 111.41 and 185.37 kg ha^{-1}, respectively) than control (158.33, 55.17 and 123.00 kg ha^{-1}, respectively) and found superior over other interactions.

Higher kernel yield related to higher photosynthetic efficiency of crop was attributed to higher nutrient uptake and assimilation in source and translocation to the sink. Nitrogen is a constituent of chlorophyll, proteins, enzymes, hormones, vitamins *etc*. Phosphorus is a constituent of sugars, phosphates, nucleotides, nucleic acids. Potassium is most important cation not only with regard to its content in plant tissue but also its role in physiological and biochemical functions in imparting drought tolerance in plants (Pushpa *et al.,* 2007). Higher N, P and K uptake with fertigation duration coinciding maximum supply at grand growth period with four or eight days drip fertigation frequency and also application of 125 per cent RDF through drip fertigation would have contributed to higher dry matter production and yield. This might be due to higher soil moisture content which facilitated the nutrients to bring into soil solution in drip fertigation than surface irrigation.

Further it influenced the better availability of nutrients and water in root zone as a result of frequent fertigation which in turn resulted in better uptake by crop and might have reduced leaching of nutrients in drip fertigation as compared to soil application of fertilizer with surface irrigation. Similar results were also reported by Veeraputhiran and Chinnusamy (2005) in cotton; Hebbar *et al.,* (2004) in tomato; Raina *et al.,* (2011) in apricot and Rekha (2014) in aerobic rice. Decrease in total NPK uptake observed under surface irrigation with soil application of fertilizers was due to reduced moisture level which might have reduced nitrate reductase activity, nitrification and P diffusion through the soil to root surface (Pushpa *et al.,* 2007b).

Present investigation suggest that application of fertilizers through fertigation in four or eight days interval matching the crop demand such that it should be available as per crop demand for realizing higher yield and to harness the yield potential of hybrid maize than the traditional method of water and nutrient application where it may undergo more losses than the crop uptake.

Acknowledgement

I acknowledge the government of Karnataka and Zonal Agricultural Research Station, V. C. Farm, Mandya, University of Agricultural Sciences, Bengaluru for providing financial assistance and other facilities for conducting the research work under RKVY project on “Precision farming technique in maize”.

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