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Response of hybrid maize (*Zea mays* L.) to precision water and nutrient management through drip system

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Abstract
To study the synergistic effect of water and nutrients applied precisely through drip fertigation a study was conducted at UAS, Bangalore in *Kharif* season of 2012. The experimental results indicated that maize crop responded very well to precised application of nutrients and water. The observations taken on growth parameters indicated that treatments provided with drip fertigation with 125 per cent RDF through water soluble fertilizers recorded maximum plant height at harvest, highest leaf index at 90 days after sowing and maximum dry matter accumulation in cobs and in total plant at harvest. A reduction in fertilizer dose to 75 per cent of RDF through water soluble fertilizers resulted in statistically comparable values of above mentioned characters as that of 125 per cent RDF. This clearly indicates the benefits of precision farming in resource savings. The yield data also revealed that though maximum yield was obtained with drip fertigation with 125 per cent RDF through water soluble fertilizers, but it was statistically at par with drip fertigation with 100 per cent RDF through water soluble fertilizers. Further, the later was again found to be at par with drip fertigation with 75 per cent RDF through water soluble fertilizers.

Keywords: Maize, drip fertigation, water soluble fertilizers, normal fertilizers, plant height, leaf area index, dry matter accumulation, yield

1. Introduction
Globally maize is an important cereal crop. Its special features like higher dry matter production and good adaptability to both rainfed and irrigated systems have favored the expansion of area under its cultivation. In India, it occupies an area of 8.7 million hectares with a production of 21.8 million tones (Mahajan, 2017) [8]. Maize being a heavy feeder of nutrients requires higher doses of nutrients and being sensitive to moisture, it requires proper management of irrigation water. Therefore, in crops like maize technological innovations are to be exploited to achieve the twin objective of higher productivity and better water and nutrient use efficiencies. To accomplish the target of achieving precision management of these costly and scarce inputs, drip fertigation seems to be a possible solution. It offers several advantages like efficient use of water and nutrients, reduced water quality hazards, opportunity for use of degraded water and greater uniformity of applied water. Apart from above mentioned soil and water issues, it provides other advantages like improved plant health, better weed control, proper management of pesticides and fertilizers, improved double cropping opportunities etc. (Lamm, 2002) [7].

Materials and Methods
In order to see the response of maize crop towards precised management of nutrients and water, a field experiment was carried out during *kharif*, 2012 at ZARS, University of Agricultural Sciences Bangalore, India. Bangalore is situated between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above MSL. The soil of the experimental site was sandy clay loam soil with a pH of 5.56 (Jackson, 1973) [6]. At the beginning of the experiment the experimental site had, 0.56 % organic carbon (Walkley and Black, 1934) [13], 362.49 kg/ha available N (Subbiah and Asija, 1956) [12], 62.33 kg/ha available P (Oleson *et al*., 1954) and 273.20 kg/ ha available K (Black, 1971) [1]. During the crop growth period a total rainfall of 354.70 mm was received, whereas the normal average rainfall of that season is about 582.30 The experiment consisted of 10 treatments with 3 replications and it was laid out in Randomized Complete Block Design. The treatments were: T_1- surface irrigation with soil

application of 100% RDF (Normal Fertilizers: NF), T_2- Drip irrigation with soil application of 100% RDF (NF), T_3 -Drip fertigation with 50 % RDF (NF), T_4 -Drip fertigation with 75 % RDF (NF), T_5 -Drip fertigation with 100 % RDF (NF), T_6 -Drip fertigation with 125 % RDF (NF), T_7 -drip fertigation with 50 % RDF (Water Soluble Fertilizers: WSF), T_8 -Drip fertigation with 75 % RDF (WSF), T_9 - Drip fertigation with 100 % RDF (WSF), T_{10} -Drip fertigation with 125 % RDF (WSF).

The crop was sown on 17th August 2012, and the spacing used was 60 × 20 cm. Seeds of hybrid maize 'NAH 1137' were used in the experiment. In treatments T_1 and T_2 fertilizers were applied as per package of practices *i.e.* 50 % of nitrogen along with entire dose of phosphorus and potassium as basal dose and remaining 50 % nitrogen was applied in two equal splits i.e. at 25 DAS and 45 DAS (Recommended dose of fertilizer for particular area was 150:75:40 kg N, P_2O_5 and K_2O, ha^{-1}). In rest of the treatments whole amount of fertilizer was divided in to 8 equal splits and was applied along with irrigation water through drip system. Normal fertilizers used were: Urea, Diammonium Phosphate, Single Super Phosphate and water soluble fertilizers used were: Calcium Nitrate, 19:19:19 and 12:61:0. In order to prevent micronutrient deficiency, Zinc Sulfate @ 10 kg ha^{-1} was applied uniformly to all the treatments.

After sowing two general irrigations of 3 cm each were applied to all treatments and drip irrigation was started on 16th DAS. Water through drip system was provided at an interval of 2-3 days on the basis of Cumulative Pan Evaporation values. The discharge rate through drip emitters was 2 lph and emitters were situated at a spacing of 30 cm. Fertigation treatments were also imposed on same day and whole amount of fertilizer was divided into 8 equal splits and they were given to crop at an interval of every 8 days through drip. The irrigation to T_1 was provided on the basis of visual observations and critical stage approach.

The crop remained weed free (Atrazine was applied @ 1 kg *a.i.* / ha as pre emergence) and did not show incidence of any disease. Earthing up was done at 45 DAS to ensure protection against lodging. Harvesting was done on 16th December 2012. For data collection five plants were selected from every plot and they were tagged and all the observations were recorded using the same plants. The data were analyzed using analysis of variance (ANOVA) technique as applicable for Randomized Complete Block Design (Rangaswamy, 2006) [11]. The results were interpreted on the basis of F- test and critical difference at 5% was used for calculating the significant difference between the means of two treatments (Gomez and Gomez, 1984) [3].

Results and Discussion

The observations made on plant height revealed that, the plant height differed significantly due to effect of different treatments (Table 1). At harvest stage, though the tallest plants were observed in T10, but it was found to be at par with T4, T5, T6, T8 and T9. A reduced RDF to the tune of 75 per cent recorded statistically comparable plant height as compared to 125 per cent of RDF and this may be attributed to the reason that, with drip fertigation water and nutrients are precisely applied to the root zone and more concentration of these inputs are present near to plants, so the plants were able to utilize them with higher efficiency. Further, it is cleared from the observations that, T10 recorded significantly higher plant height as compared to T1 i.e. surface irrigation, which is attributed to the reason that in surface irrigation system there are higher losses of nutrients and water due to various reasons, but in drip irrigation systems nutrients are present in the root zone, so they are subjected to less losses. Similar findings in terms of nutrient and water saving through drip fertigation were also reported by Ponnuswamy and Santhy (2008) and Fanish *et al*. (2011) [10, 2].

Leaf Area Index is an important parameter of plant growth. The higher leaf area index indicates the better photosynthetic activity and thus, better crop performance. Data on leaf area index at 90 DAS, inferred that, T10 recorded significantly highest LAI as compared to all other treatments. This can be linked to the fact that higher doses of fertilizers above the recommended one produced more vegetative growth. Similar increase in vegetative growth due to higher uptake of nutrients and water was also reported by Hassan *et al*. (2010) and Yadav *et al*. (2012) [5, 14]. Further, it was observed that, T9 and T8 were also statistically at par with each other, that is again because of the reason that, precised application of agricultural resources can result in their saving.

At harvesting stage, treatment T10, being at par with T6, T8 and T9 recorded significantly highest dry matter accumulation in cobs. Further, it was observed that T6 and T5 were also statistically at par. This also indicates that when water soluble fertilizers were applied, 75 per cent of RDF produced comparable dry matter accumulation in cobs as that of 125 per cent of RDF. Similarly, the significantly highest total dry matter accumulation was observed with T10 and it was statistically at par with T8 and T9. Further, T6 was found to produce statistically comparable total dry matter accumulation as that of T5.

The yield data obtained from the above experiment showed that, though T10 produced highest grain yield of maize, but the yield was statistically comparable toT9 and T6. Further, it was observed that, T9 was statistically at par with T8 and T6 was statistically at par with T5. This clearly indicates that drip fertigation resulted in nutrient savings and use of drip fertigation produced higher yield per unit of nutrients applied. These results are in confirmation to the results obtained by Hamdy *et al*. (1993) [4], where they obtained more or less equal corn yield by application of 140 kg N/ha through drip fertigation as compared to application of 210 kg N/ha through drip fertigation.

Table 1: Effect of precision water and nutrient management on plant height, number of leaves and leaf area index (LAI) of maize.

Treatments	Plant Height (cm)		Number of Leaves		Leaf Area Index	
	90 DAS	Harvest	60 DAS	90 DAS	60 DAS	90 DAS
T_1: Surface irrigation with soil application -100 % RDF (NF)	172.47	174.63	11.13	14.20	2.67	3.58
T_2: Drip irrigation with soil application- 100 % RDF (NF)	173.97	175.63	12.20	15.00	2.78	3.73
T_3: Drip fertigation - 50 % RDF (NF)	168.73	170.80	11.60	14.47	2.62	2.90
T_4: Drip fertigation- 75 % RDF (NF)	180.93	182.87	12.13	14.60	3.10	3.50
T_5: Drip fertigation -100 % RDF (NF)	188.54	197.03	12.87	15.33	3.45	3.74
T_6: Drip fertigation -125 % RDF (NF)	193.17	195.07	13.13	15.60	3.56	4.00
T_7: Drip fertigation - 50 % RDF (WSF)	165.57	166.87	11.40	14.73	2.89	3.39

T_8: Drip fertigation - 75 % RDF (WSF)	188.13	189.17	13.00	15.40	3.60	4.21
T_9: Drip fertigation - 100 % RDF (WSF)	186.67	193.23	12.80	15.27	3.64	4.26
T_{10}: Drip fertigation - 125 % RDF (WSF)	199.73	200.03	13.73	15.87	4.05	4.54
S.Em ±	**4.94**	**6.26**	**0.23**	**0.15**	**0.15**	**0.06**
C.D. at 5 %	**14.69**	**18.59**	**0.68**	**0.44**	**0.44**	**0.18**

*Note: DAS: Days After Sowing; NF: Normal Fertilizer; RDF: Recommended Dose of Fertilizer (150:75:40 kg N: P2O5: K2O/ha); WSF: Water Soluble Fertilizer; Interval of fertigation: Eight equal splits at one week interval.

Table 2: Effect of precision water and nutrient management on dry matter accumulation in maize.

Treatments	**Dry matter accumulation in cobs (g/plant) at harvest**	**Total Dry Matter Accumulation**			**Grain Yield (t/ha)**
		60 DAS	**90 DAS**	**Harvest**	
T_1: Surface irrigation with soil application -100 % RDF (NF)	164.54	164.91	305.64	334.87	7.94
T_2: Drip irrigation with soil application- 100 % RDF (NF)	168.58	173.78	315.27	340.15	9.16
T_3: Drip fertigation - 50 % RDF (NF)	132.78	149.32	277.99	293.22	7.07
T_4: Drip fertigation- 75 % RDF (NF)	169.25	183.72	314.13	345.69	9.00
T_5: Drip fertigation -100 % RDF (NF)	181.64	194.45	334.07	376.51	10.62
T_6: Drip fertigation -125 % RDF (NF)	188.56	201.39	349.89	390.01	10.87
T_7: Drip fertigation - 50 % RDF (WSF)	131.97	152.85	303.25	308.41	8.63
T_8: Drip fertigation - 75 % RDF (WSF)	194.05	206.11	364.05	410.66	10.33
T_9: Drip fertigation - 100 % RDF (WSF)	195.56	212.53	372.16	418.06	11.29
T_{10}: Drip fertigation - 125 % RDF (WSF)	198.53	229.40	378.53	426.26	11.86
S.Em ±	**4.64**	**5.01**	**5.66**	**5.52**	**0.38**
C.D. at 5 %	**13.78**	**14.88**	**16.83**	**16.41**	**1.12**

*Note: DAS: Days after Sowing; NF: Normal Fertilizer; RDF: Recommended Dose of Fertilizer (150:75:40 kg N: P2O5: K2O/ha); WSF: Water Soluble Fertilizer; Interval of fertigation: Eight equal splits at one week interval.

Conclusion

The study inferred that drip irrigation can be successfully used for growing hybrid maize, as the maize crop responded very well to water and nutrient applied through drip fertigation and also provided the benefits of nutrient saving.

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