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Research Article

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Yield, nutrient and water use efficiency and economics of maize as influenced by levels of irrigation and fertigation

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Summary

A field experiment was conducted during *Kharif* 2015 at Zonal Agricultural Research Station, V.C. Farm, Mandya, Southern Dry Zone of Karnataka to study the growth and yield of maize as influenced by drip fertigation. The experiment was laid out in Randomized Complete Block Design with three replications and eleven treatments comprising two levels of irrigation and four levels of fertilizers, absolute control, package of practice and paired row of spacing 45 x 75 cm. Irrigation @ 100% cumulative pan evaporation + drip fertigation 125% recommended dose fertilizer was found higher kernel yield (7763 kg ha^{-1}) and stover yield (8159 kg ha^{-1}). Higher nitrogen, phosphorus and potassium use efficiency was recorded in irrigation @ 100% cumulative pan evaporation + drip fertigation 75% recommended dose fertilizer (65, 131 and 245 kg kg^{-1}, respectively). Significantly higher water use efficiency was found in irrigation @75% cumulative pan evaporation+ drip fertigation 125% recommended dose of fertilizer (132.17 kg ha cm^{-1}) over University of Agricultural Sciences- package (74.18 kg ha cm^{-1}). Higher cost of cultivation was recorded in irrigation @100% cumulative pan evaporation + drip fertigation 125% recommended doses fertilizer (Rs.37089 ha^{-1}) followed by irrigation @100% cumulative pan evaporation + drip fertigation 100% recommended dose fertilizer (Rs. 35379 ha^{-1}).

Key words : Drip fertigation, Water use efficiency, Nutrient use efficiency

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Introduction

Maize (*Zea mays* L.) is becoming very popular cereal crop in India, because of the increasing market price and high production potential of hybrids in both irrigated as well as rainfed conditions. In India, about 50 to 55 per cent of the total maize production is consumed as food, 30 to 35 per cent goes for poultry, piggery and fish meal industry and 10 to 12 per cent to wet milling industry (Arun Kumar *et al*., 2007). It occupies an area of 9.4 m ha in India with a production of 23 m t. (Anonymous, 2014). In Karnataka maize is growing in an area of 1.28 m.ha with a productivity of 3018 kg ha^{-1} (Anonymous, 2012). For increasing the profitability of maize, farmers are cultivating the crop intensively with the large use of chemical fertilizers, pesticides, weedicides, etc. Maize crop has better yield response to chemical or inorganic fertilizers. Hence, heavy doses of these fertilizers are applied. Though these practices help in temporary increasing of crop production; deterioration of natural resources (*viz*. land, water and air) is also another side of such high input intensive cultivation. Over reliance on use of chemical fertilizers has been associated with decline in soil physical and chemical properties and crop yield (Paul Hepperly *et al.*, 2009).

Improper management of water has contributed extensively to the current water scarcity and pollution problems in many parts of the world and also a serious challenge to future food security and environmental safety. This issue requires an integrated approach to soil-water-plant nutrient management at the plant-rooting zone. One of these technologies is fertigation, which is the direct application of water and nutrients to plants through a drip irrigation system. Keeping in this view an experiment was conducted to study the growth and yield of maize as influenced by drip fertigation.

Resource and Research Methods

A field experiment was conducted during *Kharif* 2015 at Zonal Agricultural Research Station, V.C. Farm, Mandya, Southern Dry Zone (Zone – 6) of Karnataka. The experimental site is located between 12º 51' and Latitude and 77º 35' E Longitude at an altitude of 930 m above mean sea level (MSL). The soil was sandy loam with organic carbon content of 4.1 g kg^{-1}. The initial nitrogen, phosphorus and potassium status of the soil were 250.30, 26.50 and 175.69 kg per ha, respectively. The soil pH was 6.5 with an EC of 0.32 dSm^{-1}. The experiment was laid out in Randomized Complete Block Design with eleven treatments and three replications.

The drip line was passed in between paired row, which includes 18 emitters in each row at a distance of 30 cm with a total of 180 emitters per plot. This system included pump, filter units, fertigation tank, ventury, main line and sub line for each replication and a lateral for each plot. The calculated quantity of phosphorus was applied to all the treatments through single super phosphate by soil application, whereas nitrogen and potassium were supplied through drip in equal splits (starting from 12^{th} day after sowing upto silking stage) using water soluble urea and muriate of potash, respectively. The quantity of water to be irrigated was calculated based on daily pan evaporation and irrigated four days once and water use was recordedand water use efficiency (WUE) was worked out from the yield of maize and the amount of water used and expressed in kg $ha\text{-}cm^{-1}$.

$$\text{WUE} = \frac{\text{Kernel yield (kg ha}^{-1})}{\text{Quantity of total water applied (cm)}}$$

Kernel and stover yield was recorded and nutrient use efficiency (NUE) was computed and economics was worked out using the price of inputs that were prevailing at the time of their use. Net return ha^{-1} was calculated by deducting the cost of cultivation from gross income ha^{-1}.

$$\text{NUE} = \frac{\text{Kernel yield (kg ha}^{-1})}{\text{Nutrient applied (kg ha}^{-1})}$$

Research Findings and Discussion

The economic yield is a fraction of the total biological yield of the crop (Donald, 1962). Total dry matter production may reflect on the economic yield in view of the fact that, vegetative part of the plant serves as the source and the kernels as sink. Accumulation of dry matter (resultant of leaf area duration and crop growth rate during the crop cycle) and its distribution to yield attributes during reproductive stage (translocation from source to sink) determines the yield of a crop.

Irrigation @ 100% CPE + DF 125% RDF was found higher kernel yield (7763 kg ha^{-1}) this might be due to more cob weight (160.16 g), higher cob length (16.12 cm), more rows per cob (17.56) and higher kernels per cob (527.65) and lowest yield was recorded in absolute control (1531 kg ha^{-1}) (Table 1). Application of water in accordance with plant need (100% CPE) to the root zone with required quantity and irrigation intervals through drip in combination with water soluble fertilizers favored higher uptake of nutrients which contributed better growth and yield parameters and yield of maize.The similar trend was also observed instover yield. This higher yield parameter due to sufficient supply of nutrients to the root zone of the crop and less moisture stress leads better transfer of photosynthates from source to the sink (Abd El-Rahman 2009) and Khanna (2013).

Kernel yield recorded with irrigation @ 100% CPE + DF 100% RDF (7619 kg ha^{-1}) was found at par with the T_8, but significantly over paired row (RDF+ FYM+ $ZnSO_4$ soil application) (5902 kg ha^{-1}) and UAS package (spacing 30/60 +RDF+FYM+ $ZnSO_4$) (5649 kg ha^{-1}) treatments. The growth parameters *viz*., plant height, number of leaves and leaf area were found higher in treatments, received fertilizers than absolute control resulted in production of higher photosynthates, that contributes for higher yield. Balanced and optimum dose of macro and micronutrients, which might have improved soil condition, root proliferation and source to sink relationship (Arun Kumar *et al.*, 2007).

Nutrient use efficiency :

Higher nitrogen use efficiency (65 kg kg^{-1}) was recorded in T_{10} (irrigation @ 100% CPE + DF 75% RDF) treatment followed by T_{11} (irrigation @ 100% CPE + DF 50% RDF) (55 kg kg^{-1}). The least nitrogen use efficiency (38 kg kg^{-1}) was recorded in (T_3) UAS Package (spacing 30/60 + RDF + FYM + $ZnSO_4$). Phosphorus use efficiency varied significantly with different levels of irrigation and drip fertigation in maize. Irrigation @100% CPE + DF 75% RDF registered significantly higher phosphorus use efficiency of 131 kg kg^{-1} as compared to irrigation @100% CPE + DF 125 % RDF (83 kg kg^{-1}). Irrigation @100% CPE + DF 75% RDF recorded higher potassium use efficiency of 245 kg kg^{-1} followed by irrigation @100% CPE + DF 50% RDF (205 kg kg^{-1}) whereas lower was recorded in T_3:

Table 1: Kernel and stover yield of maize as influenced by levels of irrigation and drip fertigation

Treatments	Yield (kg ha^{-1})	
	Kernel	Stover
T_1: Absolute control	1531	1627
T_2: Paired row	5902	6125
T_3: UAS Package	5649	5824
T_4: I @ 75% CPE + DF 12 % RDF	7383	7792
T_5: I @ 75% CPE + DF 100% RDF	7278	7521
T_6: I @ 75% CPE + DF 75% RDF	5839	6015
T_7: I @ 75% CPE + DF 50% RDF	3863	4158
T_8: I @ 100% CPE + DF 125% RDF	7763	8159
T_9: I @ 100% CPE + DF 100% RDF	7619	7938
T_{10}: I @ 100% CPE + DF 75% RDF	7351	7650
T_{11}: I @ 100% CPE + DF 50% RDF	4104	4427
S.E.±	247.5	213.6
C.D. (P=0.05)	751.3	656.4

Note: CPE: Cumulative pan evaporation I: Irrigation DF: Drip fertigation RDF: Recommended dose of fertilizers DAS: Days after sowing, UAS: University of Agricultural Sciences

Table 2 : Nutrient use efficiency in maize as influenced by levels of irrigation and fertigation

Treatments	Nutrient use efficiency (kg kg^{-1})		
	N	P	K
T_1: Absolute control	-	-	-
T_2: Paired row	39	79	148
T_3: UAS Package	38	75	141
T_4: I @ 75% CPE + DF 125 % RDF	40	79	148
T_5: I @ 75% CPE + DF 100% RDF	49	97	182
T_6: I @ 75% CPE + DF 75% RDF	52	104	195
T_7: I @ 75% CPE + DF 50% RDF	51	103	193
T_8: I @ 100% CPE + DF 125 % RDF	41	83	155
T_9: I @ 100% CPE + DF 100% RDF	51	102	190
T_{10}: I @ 100% CPE + DF 75% RDF	65	131	245
T_{11}: I @ 100% CPE + DF 50% RDF	55	110	205
S.E.±	2	4	7
C.D. (P=0.05)	6	11	19

Note: CPE: Cumulative pan evaporation DF: Drip fertigation RDF: Recommended dose of fertilizers UAS: University of Agricultural Sciences

UAS Package (spacing 30/60 +RDF+FYM+ $ZnSO_4$) (141 kg kg^{-1}) (Table 2). This might be attributed to better availability of moisture and nutrients throughout the crop growth stages in drip fertigation system leading to better uptake of nutrients, production of higher dry matter and in turn economic yield. These findings are in conformity with the findings of Gururaj (2013), he also reported that the apparent N recovery percentage was higher at the lowest N level and decreased with increasing N levels. Nutrient use efficiency in fertigation increases as a result of controlled and regular application of fertilizer.

Nutrient may be used very effectively when applied continuously through the irrigation system at rates not exceeding the requirements of the plants. Drip fertigation with water-soluble fertilizers resulted in higher nutrient use efficiency compared to surface application of fertilizer with drip irrigation (Suganya *et al*., 2007).

Water use and water use efficiency :

Lowest irrigation water was applied with irrigation @75% CPE (558.61 mm) followed by irrigation @100% CPE and highest amount of irrigation water (761.52 mm) used in conventional method of irrigation.

The data pertaining to the water use and water use efficiency by maize as influenced by the different levels of irrigation and drip fertigation are presented in Table 3. Water use efficiency varied significantly due to different methods of irrigation and drip fertigation in

Table 3 : Water use and water use efficiency of maize as influenced by levels of irrigation and fertigation

Treatments	Water use (cm)	WUE (kg ha-cm^{-1})
T_1: Absolute control	761.52	20.10
T_2: Paired row	761.52	77.50
T_3: UAS Package	761.52	74.18
T_4: I @ 75% CPE + DF 125 % RDF	558.61	132.17
T_5: I @ 75% CPE + DF 100% RDF	558.61	130.29
T_6: I @ 75% CPE + DF 75% RDF	558.61	104.53
T_7: I @ 75% CPE + DF 50% RDF	558.61	69.15
T_8: I @ 100% CPE + DF 125 % RDF	611.57	126.93
T_9: I @ 100% CPE + DF 100% RDF	611.57	124.58
T_{10}: I @ 100% CPE + DF 75% RDF	611.57	120.19
T_{11}: I @ 100% CPE + DF 50% RDF	611.57	67.11
S.E.±	NA	4
C.D. (P=0.05)		13

Note: CPE: Cumulative pan evaporation DF: Drip fertigation RDF: Recommended dose of fertilizers DAS: Days after sowing
UAS: University of Agricultural Sciences

Table 4 : Economics of maize as influenced by levels of irrigation and fertigation

Treatments	Gross returns ($Rs.ha^{-1}$)	Cost of cultivation ($Rs.ha^{-1}$)	Net returns ($Rs.ha^{-1}$)	B:C
T_1: Absolute control	20716	18914	7802	0.41
T_2: Paired row	79788	36910	42878	1.16
T_3: UAS Package	76349	36910	39439	1.06
T_4: I @ 75% CPE + DF 125 % RDF	99875	37089	62786	1.69
T_5: I @ 75% CPE + DF 100% RDF	98374	35379	62995	1.78
T_6: I @ 75% CPE + DF 75% RDF	78914	33657	45257	1.34
T_7: I @ 75% CPE + DF 50% RDF	52298	31922	20376	0.63
T_8: I @ 100% CPE + DF 125 % RDF	104998	37089	67909	1.83
T_9: I @ 100% CPE + DF 100% RDF	103016	35379	67637	1.91
T_{10}: I @ 100% CPE + DF 75% RDF	99388	33657	65731	1.95
T_{11}: I @ 100% CPE + DF 50% RDF	55565	31922	23643	0.74

Note: CPE: Cumulative pan evaporation DF: Drip fertigation RDF: Recommended dose of fertilizers UAS: University of Agricultural Sciences maize. Significantly higher water use efficiency was found in T_4: irrigation @ 75% CPE + DF 125 % RDF (132.17 kg ha cm^{-1}) over T_3: UAS Package (spacing 30/ 60 +RDF+FYM+ $ZnSO_4$) (74.18 kg ha cm^{-1}). Lowest was recorded in T_1: absolute control (20.10 kg ha cm^{-1}). This might be attributed to higher yield levels due to higher uptake of nutrients by crop as a result of timely and frequent supplementation of water and nutrient to root zone leading to the decrease in leaching and volatilization losses of nitrogen. These results are in accordance with findings of Vijaykumar (2009); Anitta *et al*. (2011); Sundrapandiyan (2012) and Fanish and Muthukrishnan (2013).

The increase in water use efficiency in all drip-irrigated treatments was mainly due to considerable saving of irrigation water, greater increase in yield of crop and higher nutrient use efficiency (Pushpa *et al.*, 2010). These studies reveal that supplying water to soil and nearer to the plant without much loss of water resulting in higher water use efficiency.

The higher WUE with drip system was attributed to reduced water loss and efficient water use by the plants (Goldberg *et al*., 1976). Similarly, (Pushpa *et al.*, 2010) reported that drip irrigation had highest irrigation efficiency of 84 per cent compared to 37 per cent with surface irrigation. Favourable effect of drip irrigation as in many studies are maintenance of constant soil moisture potential without causing severe aeration problems (Halevy *et al*., 1973 and Bucks *et al*., 1981). Narayanamoorthy (2006) has mentioned that water saving and the water-use efficiency of different crops are significantly higher under drip irrigation than conventional irrigation. Kaushal Arun *et al*. (2012) reported that the adoption of drip irrigation increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation.

Economics :

Different levels drip fertigation treatments showed variation in cost of cultivation, gross returns, net returns and B:C which are presented in Table 4.

Higher cost of cultivation was recorded in irrigation @100% CPE + DF 125 % RDF (Rs.37089 ha^{-1}) followed by irrigation @100% CPE + DF 100% RDF (Rs. 35379 ha^{-1}). However, the cost of cultivation found least under conventional method - flooded condition (Rs. 12914 ha^{-1}). Gross returns also recorded highest in @100% CPE + DF 125 % RDF (Rs.104998 ha^{-1}) followed by irrigation @100% CPE + DF 100% RDF (Rs. 103016 ha^{-1}). However, the gross returns was found least under conventional method - flooded condition (Rs.20716 ha^{-1}).

Net returns registered highest in 100% CPE + DF 125 % RDF (Rs.67909 ha^{-1}) followed by irrigation @100%CPE+DF 100% RDF (Rs.67637 ha^{-1}). However, net returns found least under conventional method - flooded condition (Rs.7802 ha^{-1}).

Highest B:C of 1.95 was recorded in 100% CPE + DF 75% RDF followed by 1.91 of 100% CPE + DF 100% RDF and least was registered in conventional method (0.63)

Literature Cited

Abd El-Rahman, G. (2009). Water use efficiency of wheat under drip irrigation systems at Al- Maghara area, North Sinai, Egypt. *American-Eurasian J. Agric. Environ. Sci.,* **5** (5) : 664-670.

Anitta, F., Muthukrishnan, P. and Prem Sekar, S. (2011). Effect of drip fertigation in maize based intercropping system. *Crop Res.,* **42**: 69-72.

Arun Kumar, M.A., Gali, S.K. and Hebsur, S. (2007). Effect of different levels of NPK on growth and yield parameters of sweet corn. *Karnataka J. Agric. Sci*., **20**(1): 41-43.

Bucks, D.A., Nakayama, F.S. and Warrick, A. (1981). Principles of trickle (drip) irrigation. In: A*dvances in irrigation.* Academic Press Inc. New York. pp. 220-299.

Donald, C.M. (1962). In search of yield. *J. Australia Inst. Agric. Sci.,* **28**: 194-198.

Fanish, A.S. and Muthukrishnan, P. (2013). Nutrient distribution under drip fertigation systems. *World J. Agril Sci.,* **9** (3) : 277-283.

Goldberg, D., Garnat, B. and Rimon, L. (1976). *Drip irrigation principles design and Agricultural Practices*. Drip Irrig. Sci. Publ. Israel, pp. 295.

Gururaj, K. (2013). Optimization of water and nutrient requirement through drip fertigation in Aerobic rice. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bangalore, KARNATAKA (INDIA) .

Halevy, I., Boaz, M., Zohar, Y., Shani, M. and Dan, M. (1973). In trickle irrigation, FAO, *Irrig. Drain.*, **14** : 75-117.

Kaushal Arun, A.R., Patole, Rahul and Singh, K.G. (2012). Drip irrigation in sugarcane*:* A review, *Agri Rev.*, **33**:211–219.

Khanna, Richa (2013). Effect of precision nutrient and water management with different sources and levels of fertilizers on maize production. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bengaluru, KARNATAKA (INDIA).

Narayanamoorthy, A. (2006). Efficiency of irrigation: A case of drip irrigation. *Occasional Paper No. 45*, National Bank for Agriculture and Rural Development, Mumbai.38pp.

Paul Hepperly, Lotter, D., Ziegler Ulsh, C., Seidel, R. and Reider, C. (2009). Compost, manure and synthetic fertilizer influences on crop yields, soil properties, nitrate leaching and crop nutrient content. *Compost Sci.,* **17**(3): 80-85.

Pushpa, K. Devakumar, N. and Krishna Murthy, R.(2010). Water Use Efficiency of Rice Genotypes as Influenced by Methods of Irrigation and Nitrogen Sources, *31 Indian Geographers meet and International Conference on Environment, Agriculture and Food Security in India*, February 19-21, 2010 held at P.G. Department of Geography, Bangalore University, Bangalore (KARNATAKA) INDIA.

Suganya, S., Anitha, A. and Appavu, K. (2007). Moisture and nutrient distribution system under drip fertigation systems. In: Third international ground water conference on Water, environment and agriculture-present problems and future challenge. *Adv. Pl. Sci.,* pp. 512-520.

Sundrapandiyan, R. (2012). Study on the effect of dripbiogation on the productivity of aerobic rice, M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, T. N. (INDIA).

Vijaykumar, P. (2009). Optimization of water and nutrient requirement for yield maximization in hybrid rice under drip fertigation system. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, T.N. (INDIA) .

Webliography

Anonymous (2012). *Directorate of economics and statistics,* Department of Agriculture and Cooperation. *http:// eands.dacnet.nic.in/At_A_Glance2011/4.11(a).*

Anonymous (2014). Area, production and productivity of major cereals in India. *www.indiastat.com*.