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Effect of drip irrigation regimes on growth, yield and economics of maize (*Zea mays*) genotypes

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ABSTRACT

A field experiment was conducted during summer 2018 and 2019 to study the performance of maize (*Zea mays* L.) genotypes under drip and furrow irrigation regimes at the Main Agriculture Research Station, University of Agricultural Sciences, Dharwad, Karnataka. The experiment was laid out in strip plot design with 3 replications. Treatments included 4 irrigation levels (drip irrigation at 0.6 ETc, 0.8 ETc and 1.0 ETc and furrow irrigation at 0.8 IW/CPE ratio) and 4 maize genotypes. The data indicated that, furrow irrigation at 0.8 IW/CPE ratio and drip irrigation at 1.0 ETc recorded significantly higher and on par growth and yield parameters, grain yield (75.8 q/ha and 71.4 q/ha, respectively) and economic returns. Drip irrigation at 1.0 ETc consumed 28.6% less water but recorded significantly higher water productivity over furrow irrigation. Among the genotypes, NK-6240 found superior over rest of the genotypes. The combination of furrow irrigation with NK-6240 recorded significantly higher growth and yield attributes as well as grain yield and economics over rest of the combinations. However, this treatment remained statistically non-significant with drip irrigation at 1.0 ETc with NK-6240 and furrow irrigation with CP-818.

Keywords: Crop evapotranspiration (ETc), Furrow irrigation, IW/CPE ratio, Water productivity

Water is the most important and critical input for sustainable crop production under both irrigated and rainfed agro-ecosystem. Out of 17 sustainable development goals of the global community, seven goals are highly related to the effective utilization and conservation of water resources. Thereby; signifying the role of water management and enhancing water productivity in achieving responsible consumption and production to build a poverty-free, hunger-free, sustainable and healthy society. Today, irrigation is consuming 70% of fresh water on earth (Pathak *et al.* 2014). Hence, it has the greatest potential for solving the problem of global water scarcity. Therefore, efficient use of water is the need of the hour to meet our food security along with higher water productivity.

Maize (*Zea mays* L.) is the most versatile crop having wider adaptability under varied agro-climatic conditions. In India, it occupied an area of 9.47 million hectare (Mha) with production of 28.72 million tonnes (Mt) and the productivity of 3,032 kg/ha, which is less than the world's productivity (5,923 kg/ha). Out of which 34.4% area is under irrigation (Anonyous 2018). Conventionally, maize is a furrow irrigated crop and very sensitive to both drought and water logging, hence it calls for an effective on-farm management of water in field through micro-irrigation to boost crop and water productivity.

Drip irrigation is a proven technology to reduce the water conveying and application losses. Further, Government of India is also promoting the farmers to adopt micro-irrigation through PMKSY with a motto of 'more crop per drop' and '*har khet ko paani*'. Apart from this, suitable genotype having efficient rooting pattern is more important to enhance water productivity. Now a day, hybrid varieties of maize with different durations are available, but their performance is varying in different soil-plant-climate management complex (Adamu *et al.* 2014). Therefore, hypothesis of the present study was 'whether different drip irrigation levels and genotypes will significantly influence growth, yield and water productivity of maize or not?' and objective of the study was to examine judicious use of irrigation water coupled with suitable water use efficient genotype in order to enhance crop growth, production and water productivity.

MATERIALS AND METHODS

The experiment was conducted at Main Agriculture Research Station (MARS), University of Agricultural Sciences, Dharwad (Karnataka) under irrigated condition

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Table 1 Total amount of water used by maize crop under different irrigation regimes

Treatment	No. of irrigation		Water provided through irrigation (cm)		Effective rainfall (cm)		Evaporation (cm)		Total water used (cm)		Mean wetting zone diameter (cm)	
	2018	2019	2018	2018	2018	2019	2018	2019	2018	2019	2018	2019
I_1= 0.6 ETc	14	15	203.7	248.2	183.1	38.6	799.1	877.8	386.8	286.9	33.4	35.1
I_2= 0.8 ETc	14	15	247.6	299.0	183.1	38.6	799.1	877.8	430.7	337.6	40.3	41.8
I_3= 1.0 ETc	14	15	291.5	349.7	183.1	38.6	799.1	877.8	474.6	475.8	44.6	44.0
I_4=0.8 IW/CPE	8	10	490.0	620.0	183.1	38.6	799.1	877.8	673.1	658.6	Entire soil surface was wetted	

during summer 2018 and 2019. During the crop growth period (January to May), total rainfall received was 447.1 mm during 2018 and 92.4 mm during 2019. The soil of the experimental site was clay with neutral to slight alkaline in reaction (7.75 *p*H), normal EC (0.23 dS/m), low organic carbon (0.45%), medium available nitrogen (243 kg/ha), available phosphorus (32.2 kg/ha) and available potassium (385.5 kg/ha). The experiment was laid out in strip plot design involving 16 treatment combinations replicated thrice. The treatments included 4 irrigation levels, viz. drip irrigation at 0.6 ETc (I_1), 0.8 ETc (I_2) and 1.0 ETc (I_3) and furrow irrigation at 0.8 IW/CPE ratio (I_4) and 4 maize genotypes namely NK-6240 (G_1), Pinnacle (G_2), CP-818 (G_3) and RCRMH-2 (G_4) (Table 1).

The selected bold and healthy seeds of all 4 maize genotypes were sown manually in summer @22.5 kg/ha at a spacing of 60 cm × 20 cm. FYM @10 t/ha was applied uniformly and incorporated into the soil before 10 days of sowing. N, P_2O_5 and K_2O were applied @150:65:65 kg/ha. Initially, 3 common 3 cm sprinkler irrigations were given at 5 to 6 days interval for uniform germination and establishment of maize. Twenty days after sowing, irrigation was scheduled according to the treatments. The dripper laterals (16 mm) and emitters (3.2 litre/h discharge) were laid at a spacing of 0.60 m × 0.3 m. Control valves were fixed on all laterals to facilitate controlling the water flow as per the treatments in the system. Drip irrigation scheduling at 5 days interval was based on crop evapotranspiration (ETc) and the ET_C was calculated in two steps, first potential evapotranspiration (ET_O; mm) was estimated using Penman-Montieth method (equation 1).

$$ET_O = E_p \times K_p \tag{1}$$

where, E_P, daily pan evaporation (mm); K_P, pan-coefficient (0.75).

The daily pan evaporation data was recorded by Class A open pan evaporimeter from Agromet observatory of MARS, Dharwad. The average daily evaporation during crop growth season (from 1st fortnight of February to 1st fortnight of June) was 6.74 mm and 7.42 mm during 2018 and 2019, respectively. Further, ET_C (equation 2) was calculated using ET_O and crop coefficients as given by Allen *et al.* (1998):

$$ET_C = E_O \times K_C \tag{2}$$

where, K_C, crop coefficient for maize.

Crop coefficient values used during maize growth period are as follows:

Crop growth stage	Duration (days)	Crop coefficient (Kc)
Seedling stage	20	0.40
Vegetative stage	35	0.80
Reproductive stage	40	1.15
Maturity stage	30	0.70

The application rate of the drip system/total water applied and duration of irrigation were done based on wetted area concept (Sampathkumar *et al.* 2012).

$$\text{Total water applied (mm)} = \text{Crop evapotranspiration (mm)} \times \text{wetting area percentage (80\%)}$$

$$\text{Duration of irrigation (minutes)} = \frac{\text{Total water applied (1)}}{\text{No. of emitters} \times \text{emitter dischage (1 per hr)}} \times 60$$

Further, 5 plants were selected randomly from net plot and tagged with label for taking various observations on growth and yield components. The experimental data were compiled and subjected to statistical analysis by adopting Fischer's method of analysis of variance with critical difference values at 0.05 level of significance (Gomez and Gomez 1984). The mean value of main plot, sub plot and interactions were separately subjected to Duncan Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom in MSTAT software. Correlation analysis were one by using OPSTAT package.

RESULTS AND DISCUSSION

Growth and yield performance

Effect of irrigation regimes: The two years pooled data revealed that, growth and yield parameters of maize differed significantly due to irrigation levels (Table 2 and Fig 1). Furrow irrigation at 0.8 IW/CPE ratio and drip irrigation at 1.0 ETc recorded significantly higher and on par growth parameters like plant height, dry matter production, leaf area and stem girth when compared to other levels of irrigation. Further, the same treatments recorded significantly higher number of grains, cob diameters, cob weight, grain weight and grain yield. Higher growth parameters were mainly due to better availability of soil moisture coupled with improved nutrient uptake which might have favoured cell elongation and division leading to higher growth of maize. Further, yield is eventually a result of crop growth. Higher growth attributes might have resulted in higher photosynthesis, carbon assimilation and carbohydrate reserves in the plant which helped in development of higher number of reproductive parts and larger sized sink i.e. size of the cob. Contrarily, the lowest growth parameters, yield parameters and grain yield (38.8 q/ha) were recorded in drip irrigation at 0.6 ETc. This is mainly because of insufficient soil moisture regime leading to root stress might have led to shorter plants, lower number of leaves and leaf area and hence lower reproductive parts and yield. These results are in conformity with the findings of Ramdas (2018) and Roja *et al.* (2019).

Effect of maize genotypes: Among the 4 genotypes, NK-6240 recorded significantly higher growth parameters, yield parameters and grain yield (66.4 q/ha) when compared to rest of the genotypes tested. However, lowest growth parameters, yield parameters and yield were found with Pinnacle (Table 2). Significantly superior growth and yield of NK-6240 was mainly due to its genotypic superiority for growth and yield parameters, which is particularly related to differences in the inherent genetic potential of the genotypes themselves to acquire water and nutrient from the crop root zone. Genetic variability of maize genotypes was also reported by Majid *et al.* (2017).

Interaction effect of irrigation regimes and genotypes: Combined effect of irrigation levels and genotypes had significant effect on growth and yield performance of maize crop (Table 2 and Fig 1). The treatment I_4G_1 produced significantly tallest plants, higher dry matter and leaf area. However, the plant height of all 4 genotypes under both furrow and drip irrigation (1.0 ETc) found no significant

Table 2 Effect of irrigation regimes and genotypes on growth and yield parameter, and yield of maize

Treatment	Growth parameters				Yield parameters and yield				
	Plant height (cm)	TDMP (g/ plant)	Leaf area (cm^2)	Stem girth (cm)	Cob dia (cm)	Number of grains per cob	Cob weight (g/cob)	Grain weight/ plant (g)	Grain yield (q/ha)
Irrigation level (I)									
I_1	131.1^{b}	134.4^{c}	45.32^{b}	7.29^{c}	3.57^{c}	292.3^{c}	107.7^{c}	78.4^{d}	38.8^{c}
I_2	140.4^{b}	155.4^{b}	49.53^{b}	7.80^{b}	4.17^{b}	396.9^{b}	132.0^{b}	99.0^{c}	54.4^{b}
I_3	151.5^{a}	220.1^{a}	59.50^{a}	8.24^{a}	4.54^{a}	509.0^{a}	168.0^{a}	135.5^{b}	71.4^{a}
I_4	154.8^{a}	231.6^{a}	62.89^{a}	8.48^{a}	4.85^{a}	541.0^{a}	178.8^{a}	147.4^{a}	75.8^{a}
Maize genotype (G)									
G_1	151.3^{a}	192.8^{a}	57.68^{a}	8.23^{a}	4.41^{a}	429.6^{b}	152.1^{a}	123.7^{a}	66.4^{a}
G_2	138.4^{c}	179.1^{c}	51.29^{d}	7.56^{b}	4.49^{a}	492.8^{a}	139.7^{c}	106.1^{c}	55.1^{d}
G_3	145.5^{b}	186.5^{b}	55.39^{b}	7.73^{b}	4.14^{b}	418.0^{b}	148.2^{ab}	116.7^{b}	60.8^{b}
G_4	142.7^{bc}	183.2^{b}	52.90^{c}	8.29^{a}	4.09^{b}	398.8^{c}	146.5^{b}	113.8^{b}	58.1^{c}
Interaction (I × G)									
I_1G_1	$139.6^{c\text{-}f}$	132.2^{ij}	47.64^{de}	$7.80^{b\text{-}d}$	$3.81^{e\text{-}g}$	287.9^{g}	107.7^{j}	80.1^{j}	$41.7h^{i}$
I_1G_2	125.1^{f}	126.4^{j}	41.62^{e}	6.99^{ef}	3.54^{fg}	339.5^{f}	96.2^{k}	68.3^{k}	32.0^{j}
I_1G_3	131.4^{ef}	136.2^{hi}	46.05^{de}	6.66^{f}	3.48^{g}	272.9^{g}	109.3^{ij}	79.2^{j}	39.5^{i}
I_1G_4	128.4^{f}	142.9^{gh}	45.98^{de}	$7.71^{c\text{-}e}$	3.47^{g}	269.0^{g}	117.6^{hi}	85.8^{ij}	41.9^{hi}
I_2G_1	$148.9^{a\text{-}d}$	164.6^{e}	52.17^{cd}	$8.02^{a\text{-}d}$	$4.30^{c\text{-}e}$	408.8^{e}	145.4^{e}	112.5^{f}	65.1^{f}
I_2G_2	$132.6^{d\text{-}f}$	148.2^{fg}	47.71^{de}	$7.39^{d\text{-}f}$	$4.51^{b\text{-}d}$	439.9^{d}	121.7^{gh}	89.6^{hi}	46.1^{fh}
I_2G_3	$139.7^{c\text{-}f}$	155.8^{f}	51.93^{cd}	$7.72^{c\text{-}e}$	$4.02^{d\text{-}f}$	385.8^{e}	131.7^{f}	98.5^{g}	54.3^{g}
I_2G_4	$140.4^{b\text{-}f}$	153.2^{f}	46.33^{de}	$8.07^{a\text{-}d}$	$3.86^{e\text{-}g}$	353.1^{f}	129.3^{fg}	95.5^{gh}	52.2^{g}
I_3G_1	156.5^{ab}	231.5^{b}	64.44^{ab}	$8.54^{a\text{-}c}$	4.58^{bc}	491.5^{c}	175.5^{bc}	148.5^{ab}	77.9^{ab}
I_3G_2	$146.3^{a\text{-}e}$	215.0^{d}	56.35^{bc}	$7.75^{b\text{-}d}$	$4.73^{a\text{-}c}$	585.4^{a}	165.5^{d}	128.4^{e}	$68.5^{d\text{-}f}$
I_3G_3	$153.5^{a\text{-}c}$	220.8^{cd}	$59.89^{a\text{-}c}$	$8.03^{a\text{-}d}$	$4.48^{b\text{-}d}$	496.3^{c}	167.1^{cd}	135.0^{de}	$72.0^{b\text{-}e}$
I_3G_4	$149.8^{a\text{-}c}$	213.2^{d}	57.34^{bc}	8.64^{ab}	4.36^{cd}	462.6^{d}	163.9^{d}	129.9^{e}	67.1^{ef}
I_4G_1	160.2^{a}	242.8^{a}	66.47^{a}	8.55^{ab}	4.97^{ab}	530.5^{b}	179.7^{ab}	153.8^{a}	80.8^{a}
I_4G_2	$149.7^{a\text{-}c}$	226.7^{bc}	$59.48^{a\text{-}c}$	$8.10^{a\text{-}d}$	5.20^{a}	606.2^{a}	175.2^{bc}	138.0^{cd}	$73.8^{b\text{-}d}$
I_4G_3	157.2^{a}	233.2^{b}	63.68^{ab}	$8.50^{a\text{-}c}$	4.57^{bc}	516.9^{bc}	184.7^{a}	154.1^{a}	$77.4^{a\text{-}c}$
I_4G_4	$152.1^{a\text{-}c}$	223.6^{c}	61.96^{ab}	8.76^{a}	4.66^{bc}	510.5^{bc}	175.4^{bc}	143.8^{bc}	$71.4^{c\text{-}e}$

Treatment details are given under Materials and Methods.

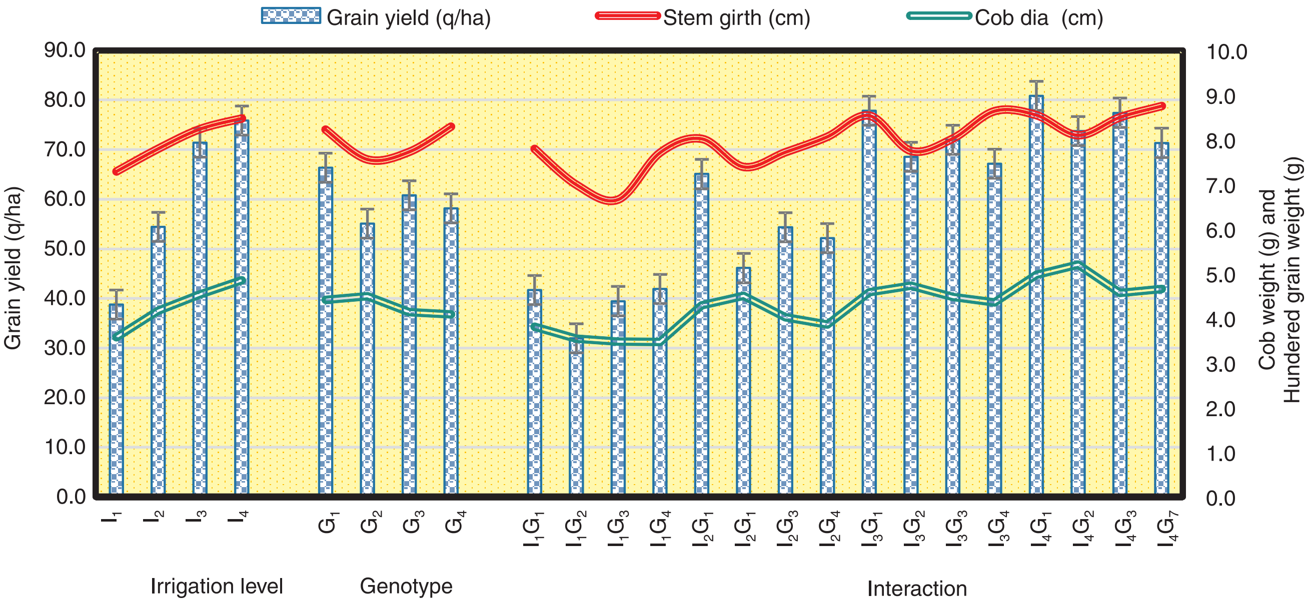

Fig 1 Effect of irrigation regimes and genotypes on stem girth, cob diameters and grain yield of maize.

difference. Similarly, highest number of green leaves was recorded with I_4G_3 and found on par with I_3G_3, I_3G_1, I_4G_1, I_4G_4, I_4G_2 and I_3G_4. Further, significantly superior leaf area was recorded with I_4G_1, I_3G_1, I_4G_3, I_4G_4, I_3G_3 and I_4G_2 when compared to rest of the treatments. Whereas, lowest plant height, number of green leaves and leaf area were recorded with I_1G_2. The improved vegetative growth with above mentioned superior genotypes under both furrow irrigations (0.8 IW/CPE) ratio and drip irrigation (1.0 ETc) might be due to proper balance of air and moisture in crop root zone, which might have created favorable conditions for genetically superior genotypes to enhance nutrients uptake, photosynthesis and metabolites translocation which ultimately accelerated the rate of vegetative growth. These results are in harmony with findings of Adamu *et al.* (2014) and Ben *et al.* (2019).

The interaction of irrigation levels and genotypes significantly influenced grain yield and yield parameters of maize. I_4G_1 produced significantly higher grain weight and grain yield (80.8 q/ha) when compare to rest of the treatment combinations. However, it found on par with grain weight of I_4G_3 and I_3G_1. Significantly higher cob length was recorded with I_4G_3 when compared to rest of the treatments except I_4G_2, I_4G_1, I_3G_3 and I_3G_1. Such results could be attributed to adequate moisture and nutrient availability in the soil under furrow irrigation and (1.0 ETc) drip irrigation which might have supplemented the genetic superiority of the genotypes with better root traits. This might have increased physiological processes and higher rates of photosynthesis leading to increased plant height, dry matter, yield parameters and yield. It is evident in the literature Adamu *et al.* (2014) and Ucak and Gokdogan (2016).

Physiological parameters of maize

The final yield of the crop not only depends on yield parameters but also depends on physiological processes taking place in plant like flowering (silking) and maturity. Irrigation levels had significant effect on days to 50% flowering (silking) and physiological maturity (Table 3). Each increase in irrigation level recorded corresponding delay in flowering. I_4 and I_3 recorded significantly delayed flowering and physiological maturity. Whereas, drip irrigation at 0.6 (I_1) and 0.8 ETc (I_2) showed the earliest flowering. This might be due to higher availability of soil moisture leading to higher plant water status might have continued vegetative growth and postponed the crop physiological processes like tasseling, silking and physiological maturity. However, the early flowering and physiological maturity under I_1 and I_2 might be due to effect of moisture stress on plant anatomical processes that might have forced early production of tassel and silk and maturity in order to escape the unfavorable situation (Eissa and Negim 2018 and Ramdas 2018). Similarly, among the studied genotypes, NK-6240 and CP-818 took more days to 50% flowering and physiological maturity when compared to Pinnacle and RCRMH-2. This is mainly because of genetic dominance of the genotype. These results are also in consonance with Adamu *et al.* (2014) and Ali and Mohammed (2015).

Combined effect of irrigation and genotypes had registered significant effect on days to 50% silking and physiological maturity. Higher irrigation levels (I_4 and I_3) in combination with all 4 genotypes recorded more number of days to 50% silking and physiological maturity when compared to other treatment combinations, except $I_3G_{2.}$ This is mainly because of genetic dominance of the genotypes with well-developed root system to absorb and utilize more growth resources under more favourable soil moisture regimes which might have led to luxurious and prolonged vegetative growth resulting in delaying the silking and maturity processes in plant (Adamu *et al.* 2014 and Singh *et al.* 2015).

Water use and water productivity

The irrigation water and total water usage was 42.0% and 28.6% higher under furrow irrigation over drip irrigation at 1.0 ETc (Table 1). Whereas, significantly the highest water productivity (Table 3) was recorded with drip irrigation at 1.0 Etc over rest of the irrigation treatments. Under drip irrigation treatments, increase in water productivity with increased amount of irrigation water was observed. This might be due to proportionate increase in yield with increased consumptive use of water. Though furrow irrigation received highest irrigation water, it produced the lowest water productivity. This might be due the fact that, ineffective usage applied irrigation water due to losses of applied water through deep percolation and evaporation in furrow irrigation. These results are supported by Ibrahim *et al.* (2016) and Priya *et al.* (2016).

Among the genotypes, the highest water productivity was recorded with NK-6240. Whereas, the lowest water productivity was with Pinnacle. This variation among the genotypes is mainly due to their genetic potential. These findings were in line with the results reported by Ucak and Gokdogan (2016) and Yamusa *et al.* (2017).

Interaction effect of irrigation levels and genotypes showed a significant effect on water productivity. Increase in drip irrigation levels significantly increased the water productivity with all the genotypes and significantly the highest and on par water productivity was observed under drip irrigation at 1.0 ETc with NK-6240 (I_3G_1) and CP-818 (I_3G_3). Which was mainly attributed to the less losses under drip irrigation coupled with superior genetic potential of the genotype to utilize the available soil moisture to maximum extent. The lower water productivity was recorded under I_1G_2 and I_4G_4. This might be due to insufficient moisture in the root zone in 0.6 ETc drip irrigation which has significantly reduced the grain yield and in turn water productivity. Though furrow irrigation has received sufficient

Table 3 Effect of irrigation regimes and genotypes on phenological parameters, water productivity and economics of maize

Treatment	Phenological parameters		WP (kg/ha-mm)	Economics			
	Days taken for 50% silking	Days to physiological maturity		Cost of cultivation (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	B:C ratio
Irrigation level (I)							
I_1	63.1^{b}	101.5^{b}	1.16^{c}	51092	$70,781^{c}$	$19,689^{c}$	1.39^{c}
I_2	63.5^{b}	102.4^{b}	1.43^{b}	51617	$99,206^{b}$	$47,590^{b}$	1.93^{b}
I_3	64.6^{a}	106.0^{a}	1.67^{a}	52067	$1,29,921^{a}$	$78,854^{a}$	2.50^{a}
I_4	65.4^{a}	106.8^{a}	1.14^{c}	51455	$1,38,071^{a}$	$86,616^{a}$	2.69^{a}
Maize genotype (G)							
G_1	64.7^{a}	104.7^{a}	1.50^{a}	50331	$1,20,603^{a}$	$70,271^{a}$	2.40^{a}
G_2	63.5^{b}	103.1^{b}	1.22^{c}	52221	$1,00,504^{d}$	$48,283^{c}$	1.93^{c}
G_3	64.5^{a}	104.7^{a}	1.36^{b}	52665	$1,10,813^{b}$	$57,148^{b}$	2.11^{b}
G_4	63.9^{b}	104.3^{a}	1.32^{b}	51014	$1,06,060^{c}$	$55,046^{b}$	2.08^{b}
Interaction (I × G)							
I_1G_1	63.8^{b-f}	101.7^{ef}	1.24^{de}	49866	$75,286^{h}$	$25,420^{gh}$	1.52^{fg}
I_1G_2	62.3^{f}	100.2^{f}	0.95^{g}	51755	$58,197^{i}$	6442^{i}	1.13^{h}
I_1G_3	63.5^{c-f}	101.8^{ef}	1.19^{ef}	52199	$72,527^{h}$	$20,328^{h}$	1.39^{fg}
I_1G_4	62.8^{ef}	102.3^{e}	1.27^{c-e}	50548	$77,113^{h}$	$26,565^{gh}$	1.53^{g}
I_2G_1	64.2^{a-e}	102.5^{e}	1.71^{ab}	50391	$1,18,567^{f}$	$68,177^{e}$	2.36^{d}
I_2G_2	62.8^{ef}	101.8^{ef}	1.21^{ef}	52280	$83,937^{h}$	$31,657^{g}$	1.89^{f}
I_2G_3	63.8^{b-f}	103.2^{de}	1.41^{c}	52724	$99,015^{g}$	$46,291^{f}$	1.87^{e}
I_2G_4	63.2^{d-f}	102.2^{e}	1.37^{cd}	51073	$95,306^{g}$	$44,233^{f}$	1.87^{e}
I_3G_1	65.2^{ab}	106.5^{a-c}	1.82^{a}	50841	$1,41,582^{ab}$	$90,741^{ab}$	2.79^{ab}
I_3G_2	63.8^{b-f}	104.7^{cd}	1.60^{b}	52730	$1,25,197^{d-f}$	$72,467^{de}$	2.38^{d}
I_3G_3	65.0^{a-c}	106.7^{a-c}	1.68^{ab}	53174	$1,30,951^{b-e}$	$77,777^{c-e}$	2.47^{cd}
I_3G_4	64.5^{a-d}	106.2^{a-c}	1.57^{b}	51523	$1,21,954^{ef}$	$70,431^{de}$	2.37^{d}
I_4G_1	65.5^{a}	108.0^{a}	1.21^{ef}	50229	$1,46,977^{a}$	$96,748^{a}$	2.93^{a}
I_4G_2	65.0^{a-c}	105.7^{bc}	1.11^{ef}	52119	$1,34,685^{b-d}$	$82,566^{b-d}$	2.59^{cd}
I_4G_3	65.8^{a}	107.2^{ab}	1.16^{ef}	52562	$1,40,758^{a-c}$	$88,196^{a-c}$	2.68^{bc}
I_4G_4	65.2^{ab}	106.5^{a-c}	1.07^{fg}	50912	$1,29,865^{c-f}$	$78,954^{c-e}$	2.55^{cd}

WP, Water productivity. Treatment details are given under Materials and Methods.

water, it has recorded lower water productivity due to ineffective use of water and inferior genetic potential of the genotype. These results are in agreement with Ali and Mohammed (2015) and Ben *et al.* (2019).

Economics of maize

The economics data (Table 3) depicted that, cost of cultivation increased with increase in irrigation amount under drip irrigation and highest was with I_3 (₹5206/ha). Whereas, the lowest cost of cultivation was observed under I_1 (₹51092/ha). Further, there was increase in gross returns, net returns and benefit cost with higher irrigation levels. Among the tested genotypes, the maximum cost of cultivation was recorded with G_3 whereas; G_1 recorded minimum cost of cultivation. G_1 recorded highest returns and benefit cost ratio. Similar findings were reported by De-Souza *et al.* (2016) and Ben *et al.* (2019).

The highest cost of cultivation was recorded with I_3G_3 (₹53174/ha) and maximum net returns (₹96748/ha) and benefit cost ratio (2.93) was recorded with I_4G_1 followed by I_3G_1 and I_4G_3 in descending order. Whereas, the lowest net returns (₹6442/ha) and benefit cost ratio (1.13) was observed under I_2G_2. Higher cost of cultivation was incurred due to higher amount of water and cost drip setup. However, positive impact of drip irrigation has led to on par yield which resulted in higher and on par net returns and benefit cost ratio with furrow irrigation. These results are in consonance with the findings of Ucak and Gokdogan (2016) and Ben *et al.* (2019).

The above results clearly showed that, furrow irrigation with 0.8 IW/CPE ratio and drip irrigation with 1.0 ETc were found statistically on par with each other with respect to growth parameters, yield parameters and grain yield. Among the 4 genotypes tested, NK-6240 recorded significantly superior over rest of the genotypes. The interaction effect of furrow irrigation at 0.8 IW/CPE ratio with NK-6240 genotype recorded significantly higher growth parameters as compared to other treatment combinations. However, it remained statistically on par with drip irrigation at 1.0 ETc with NK-6240, furrow irrigation at 0.8 IW/CPE ratio with CP-818 with respect to grain yield of maize. Hence, drip irrigation with NK-6240 can be recommended to farmers over furrow irrigation and rest of the genotypes which could achieve 28.6% water saving over furrow irrigation.

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