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Residual Effect of Irrigation Levels and Maize Genotypes on Performance of Succeeding Blackgram (*Vigna mungo* L.) in Maize-blackgram Sequence Cropping

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ABSTRACT

Background: Maize is the third most important food crop in India. Conventionally it is a furrow irrigated crop and hence, it calls for an effective on-farm management of water in field through micro irrigation. Intensive agriculture practice like continuous monocropping without following the principles of crop rotation and sequence have resulted in several ecological complications. Hence, blackgram was introduced as a succeeding crop after drip irrigated maize. The aim of the study was to examine the residual effect of drip irrigation levels and maize genotypes and their interaction on succeeding crop *i.e.* blackgram.

Methods: During summer 2018 and 2019, maize experiment was conducted with four irrigation levels (drip irrigation at 0.6, 0.8 and 1.0 ETc and furrow irrigation at 0.8 IW/CPE ratio) and four maize genotypes (NK-6240, Pinnacle, CP-818 and RCRMH-2). After maize, succeeding blackgram was taken up under rainfed condition of Dharwad during *kharif* 2018 and 2019.

Result: Performance of blackgram was superior under residual effect of drip irrigation treatments over furrow irrigation method. Among the interactions, significantly higher yield, RWUE and net returns were recorded with residual effect of I_1G_4 treatment combination. However, it was on par with I_1G_2, I_1G_3, I_1G_1, I_2G_1, I_2G_2, I_2G_4, I_3G_2 and I_3G_3 treatment combinations.

Key words: Drip irrigation, Furrow irrigation, Grain yield, Net returns, Rain water use efficiency, Residual effect.

INTRODUCTION

Agriculture consumes 83 per cent of India's water resources, leaving only 17 per cent for domestic and industrial use. By 2030, India will be able to meet only 50 per cent of its projected demand of 1,498 billion m^3 of water (Anonymous, 2018). However, India's poor water productivity record offers the greatest scope for improvement of irrigation water productivity in crop production. Modest measures like micro irrigation technologies that have proved successful in horticulture crops can be adopted in irrigated field crops like sugarcane, cotton and maize, so it can lead to significant improvements in water productivity. Maize is one of the most important cereal crops of the world and it is conventionally grown in furrow irrigated system. Hence, judicious use of irrigation water coupled with suitable crop genotypes having an efficient rooting pattern is also more important to enhance water productivity thereby total food grain production. Thus, response of maize genotypes to drip irrigation levels on root architecture, yield and water productivity in maize-blackgram sequence cropping was studied during summer and *kharif* seasons of 2018 and 2019.

However, intensive agriculture practices like continuous monocropping without following the principles of crop rotation and sequence have resulted in several of ecological and other complications. Continuous monocropping leads to depletion in the input resources availability in the soil and degradation of soil strata. This cropping system also leads to more pest and disease infestation intensity because various parasites was hibernates in the residues of the crop. Thus, resource conservation technologies like intercropping or sequence cropping system approach may offer many advantages like soil and water conservation, restoration of soil fertility and resource use efficiency, which can play a vital role in saving the scarce natural resources (Kumbhare *et al.,* 2014). Since pulses are well known to benefit the succeeding crops by sustaining soil health, hence it is logical to include pulses in sequence/rotation (Srinivas Rao, 2006). In this context, blackgram is known for efficient utilization of resources like residual soil moisture and residual under rainfed condition. Apart from this, drip irrigation system laid out for the preceding crop can also be utilized efficiently in the succeeding crop (Saini *et al*., 2006).

Blackgram is one of the important pulse crops grown throughout India and Northern parts of Karnataka. It is consumed in the form of 'dal' or perched. Urd differs from other pulses in its peculiarity of attaining a mucilaginous pasty character when soaked in water. In South India, it is consumed in variety of ways in preparation of different

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regular and popular dishes like *vada, idli, dosa, halwa, imarti* in combination with other food grains. Also used as a nutritive fodder for milch cattle. In India, blackgram accounts for 54.39 lakh hectares area with an annual production of 35.62 lakh tonnes and productivity of 655 kg ha^{-1} (Tiwari and Shivhare, 2018). In Karnataka, blackgram was cultivated in an area of 1.36 lakh ha with a production of 0.65 lakh tonnes and productivity of 478 kg ha^{-1}.

Owing to its short duration and fast growing nature, blackgram fits well in cropping systems. The work done elsewhere indicated that, maize-pulses is one of the important cropping sequences practiced in India. Cropping sequences like rice-maize-blackgram, rice/maize-wheat-mungbean/urdbean and maize-potato-mungbean/urdbean and maize-potato-mustard-urdbean were found more productive with respect yield, soil health and land utilization index as compared to crop rotation without legume (Srinivasrao, 2006 and Sindhi *et al*., 2016). It is consequently essential to determine the effect of residual soil moisture and fertility of drip irrigation regimes and maize genotypes on growth and yield of succeeding blackgram in sequence cropping. There are no such studies that have examined varietal differences in maize rooting habit at different irrigation regimes during summer condition followed by their residual effect on blackgram. Considering the all above facts the present study was planned with an objective to know the interaction effect of drip irrigation soil moisture regimes and maize genotypes on growth and yield of succeeding blackgram in sequence cropping.

MATERIALS AND METHODS

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka) on medium deep black soil under rainfed condition during *kharif* 2018 and 2019. During the crop growth period (June to September), total rainfall received was 233.8 mm during 2018 and 786.7 mm during 2019 with rainy days of 30 during and 50 days, respectively. The soil of the experimental site was clay with pH of 7.1 and EC of 0.32 dS m^{-1}. The soil type of the experimental site was black clayey. The soil was neutral to slightly alkaline in reaction (7.75 pH) with normal in electrical conductivity (0.23 dS m^{-1}), low in organic carbon (0.45%) and medium in available nitrogen (243 kg ha^{-1}) and available phosphorus (32.2 kg ha^{-1}) and available potassium (385.5 kg ha^{-1}). The experiment was laid out in strip plot design involving 16 treatment combinations replicated thrice. The treatments included during maize experiment were four irrigation levels such as drip irrigation at 0.6 ETc, 0.8 ETc and 1.0 ETc and furrow irrigation at 0.8 IW/CPE ratio and four maize genotypes such as NK-6240, Pinnacle, CP-818 and RCRMH-2. The soil was analyzed for residue of N, P_2O_5, K_2O and organic carbon after harvest of the maize crop.

Immediately after receiving rain and the harvest of maize crop, a bold and healthy seeds of blackgram of a variety DBGV 5 were hand dibbled. Blackgram seeds were dibbled @ 15 kg ha^{-1} under no till condition at spacing of 30 cm between rows and 10 cm within the row. Recommended dose of fertilizers (150:65:65 kg ha^{-1}) and 10 t ha^{-1} FYM were applied for preceding maize crop, whereas, no fertilizer was applied for blackgram. The extra plants of blackgram were thinned and kept one at one hill out and maintained optimum plant population at recommended spacing between the plants (10 cm).

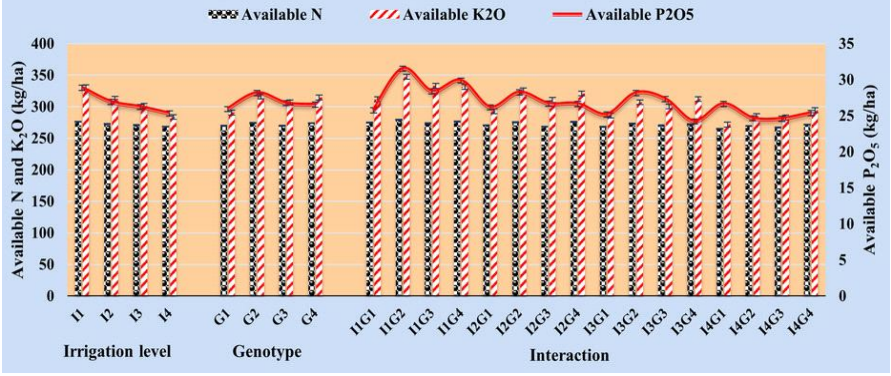
Five plants were selected randomly from net plot and tagged with label for taking various observations on growth parameters like plant height (cm), number of trifoliate leaves and total dry matter production and yield parameters like number of pods per $plant^{-1}$, test weight and g yield (kg ha^{-1}). The experimental data obtained was complied and subjected to statistical analysis by adopting Fischer's method of analysis of variance (Gomez and Gomez, 1984). The critical difference (CD) values given in the table at 5 per cent level of significance were used. 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.

RESULTS AND DISCUSSION

Residual soil nutrient status after maize and blackgram

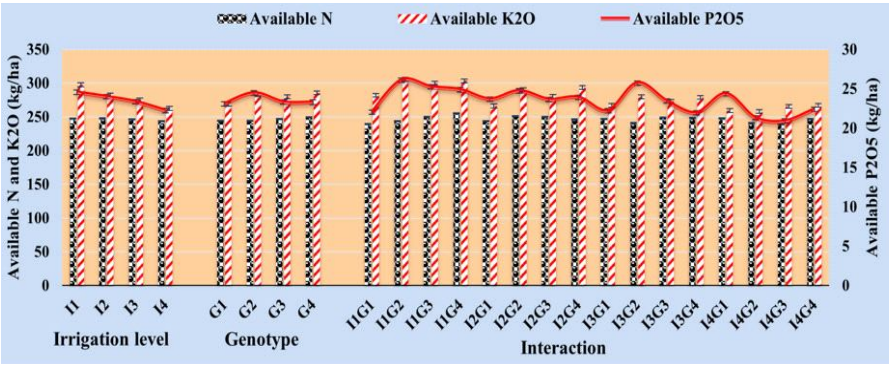
The available nutrient status of the soil after maize harvesting was significantly differed with irrigation levels except the soil available nitrogen (Fig 1). Significantly higher available phosphorus (28.9 kg ha^{-1}) and available potassium (330.9 kg ha^{-1}) were recorded with drip irrigation at 0.6 ETc as compared to the rest of the treatments. This was mainly due to lower quantity of irrigation water applied in maize root zone. Smaller wetting zone might have restricted the solubilization and mobilization of the nutrients in the root zone. Root architecture was inefficient under low soil moisture conditions and thus reduced the uptake of available nutrients. This was resulted in higher available nutrient status in the soil. These results are in conformity with Yadav *et al.* (2017). However, significantly the lowest available phosphorus (25.3 kg ha^{-1}) and available potassium (283.6 kg ha^{-1}) were recorded with furrow irrigation at 0.8 IW/CPE ratio. This was mainly because of the application of higher amount of irrigation water. Higher soil moisture availability in the root zone resulted in higher root growth, root exudation and microbial activity. This enhanced the nutrient solubility, mineralization and mobilization and thus resulted in higher uptake by maize. Besides, the higher amount of irrigation water might have subjected to leaching of the nutrients beyond the crop root zone (Roja *et al.*, 2017).

However, genotypes had no significant effect on available nutrient status of the soil. The interaction effect of irrigation levels and genotypes also did not influence significantly on available nutrient status of the soil except with available potassium (Fig 1). However, numerically higher available nutrients were recorded under lower irrigation regimes. Among the different treatment combinations, I_1G_2 (347.3 kg ha^{-1}), I_1G_3 (333.1 kg ha^{-1}), I_1G_4



Note: Irrigation levels (I): I_1- Drip irrigation at 0.6 ETc, I_2- Drip irrigation at 0.8 ETc, I_3- Drip irrigation at 1.0 ETc and I_4- Furrow irrigation at 0.8 IW/CPE ratio. Maize genotypes (G): G_1- NK-6240, G_2- Pinnacle, G_3- CP-818 and G_4- RCRMH-2.

Fig 1: Soil available nitrogen, phosphorus and potassium after harvest of maize as influenced by irrigation levels and maize genotypes (pooled data of 2 years).



Note: Irrigation levels (I): I_1- Drip irrigation at 0.6 ETc, I_2- Drip irrigation at 0.8 ETc, I_3- Drip irrigation at 1.0 ETc and I_4- Furrow irrigation at 0.8 IW/CPE ratio. Maize genotypes (G): G_1- NK-6240, G_2- Pinnacle, G_3- CP-818 and G_4- RCRMH-2.

Fig 2: Soil available nitrogen, phosphorus and potassium after harvest of blackgram as influenced by residual effect of irrigation levels and maize genotypes (pooled data of 2 years).

(331.4 kg ha^{-1}), I_2G_2 (325.5 kg ha^{-1}) and I_2G_4(321.0 kg ha^{-1}) recorded significantly higher and at par available potassium as compared to other treatment combinations. Higher available potassium under lower irrigation regimes was mainly due to lower soil moisture and efficiency of genotypes. However, furrow irrigation at 0.8 IW/CPE ratio recorded significantly the lowest available potassium (271.9 kg ha^{-1}). This was mainly due to higher soil moisture content leading to higher nutrient mobilization in soil. This resulted in higher availability of soil nutrients and increased nutrient assimilation and photosynthetic efficiency of maize under higher soil moisture conditions (Pepo and Karancsi, 2017). There is no significant effect was found among the different treatments combination on available soil nitrogen. This difference in soil available nutrients after maize significantly influenced the performance of succeeding blackgram (Table 1, 2 and 3).

The residual nutrient availability after harvesting of the blackgram is also represented in Fig 2. Results indicate that, the available nutrient status of the soil after harvesting of blackgram was non significant (Fig 2).

Growth performance of blackgram

Two years pooled data revealed that, the residual effect of irrigation levels on growth parameters of succeeding blackgram differed significantly (Table 1). At 45 DAS, the residual effect of drip irrigation at 0.6 ETc produced significantly higher plant height (29.4 cm), number of trifoliate leaves (9.73) and total dry matter production (6.33 g plant^{-1}) as compared to other treatments. However, it remained on par with residual effect of drip irrigation at 0.8 ETc. growth parameters of blackgram did not differ significantly in response to residual effect of genotypes at 45 DAS. The interaction effect of irrigation levels and genotypes had a

Table 1: Growth parameters of blackgram as influenced by residual effect of irrigation levels and maize genotypes at 45 DAS (pooled data of 2 years).

G/I	Plant height (cm)					Number of trifoliate leaves					Total dry matter production (g plant^{-1})				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
G_1	29.8^{a}	27.4^{a}	26.7^{a}	27.1^{a}	27.8^{a}	9.48^{ab}	8.77^{ab}	8.28^{b}	8.21^{b}	8.68^{a}	6.19^{a-c}	5.75^{a-c}	5.43^{a-c}	5.16^{c}	5.63^{a}
G_2	30.1^{a}	29.4^{a}	29.1^{a}	28.0^{a}	29.1^{a}	10.41^{a}	9.32^{ab}	9.08^{ab}	9.10^{ab}	9.48^{a}	6.47^{a}	5.92^{a-c}	5.61^{a-c}	5.32^{bc}	5.83^{a}
G_3	28.9^{a}	28.6^{a}	28.1^{a}	27.9^{a}	28.4^{a}	9.38^{ab}	8.67^{ab}	8.60^{b}	8.87^{ab}	8.88^{a}	6.26^{a-c}	5.79^{a-c}	5.54^{a-c}	5.29^{bc}	5.72^{a}
G_4	28.6^{a}	29.3^{a}	28.5^{a}	26.9^{a}	28.3^{a}	9.66^{ab}	9.45^{ab}	8.89^{ab}	8.45^{b}	9.11^{a}	6.39^{ab}	6.06^{a-c}	5.64^{a-c}	5.15^{c}	5.81^{a}
Mean	29.4^{a}	28.7^{ab}	28.1^{ab}	27.5^{b}		9.73^{a}	9.05^{ab}	8.71^{b}	8.66^{b}		6.33^{a}	5.88^{ab}	5.55^{bc}	5.23^{c}	
SV			S.Em. ±					S.Em. ±					S.Em. ±		
I			0.41					0.21					0.13		
G			0.49					0.15					0.09		
I × G			1.29					0.47					0.30		

Means followed by the same letter (s) within a column and row are not differed significantly by DMRT (P = 0.05); SV- Source of variation. Irrigation levels (I): I_1- Drip irrigation at 0.6 ETc, I_2- Drip irrigation at 0.8 ETc, I_3- Drip irrigation at 1.0 ETc and I_4- Furrow irrigation at 0.8 IW/CPE ratio. Maize genotypes (G): G_1- NK-6240, G_2- Pinnacle, G_3- CP-818 and G_4- RCRMH-2.

Table 2: Yield and RWUE of blackgram as influenced by residual effect of irrigation levels and maize genotypes (pooled data of 2 years).

G/I	Number of pods per plant					Grain yield (q ha^{-1})					Rain water use efficiency (kg ha-mm^{-1})				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
G_1	18.4^{a-c}	19.5^{a-c}	17.0^{c}	16.6^{c}	17.9^{a}	8.59^{a-c}	9.47^{ab}	7.93^{c}	7.78^{c}	8.44^{a}	2.21^{bc}	2.59^{ab}	2.08^{c}	2.06^{c}	2.23^{a}
G_2	20.6^{ab}	18.2^{a-c}	19.1^{a-c}	17.6^{a-c}	18.9^{a}	9.90^{a}	8.58^{a-c}	9.13^{a-c}	8.04^{bc}	8.91^{a}	2.62^{ab}	2.24^{bc}	2.43^{a-c}	2.08^{c}	2.34^{a}
G_3	18.8^{a-c}	17.2^{bc}	19.1^{a-c}	17.5^{a-c}	18.2^{a}	8.82^{a-c}	8.10^{bc}	8.67^{a-c}	8.33^{bc}	8.48^{a}	2.36^{a-c}	2.27^{bc}	2.27^{bc}	2.09^{c}	2.25^{a}
G_4	21.0^{a}	18.9^{a-c}	16.7^{c}	17.8^{a-c}	18.6^{a}	9.90^{a}	9.00^{a-c}	7.98^{c}	8.14^{bc}	8.76^{a}	2.72^{a}	2.37^{a-c}	2.12^{c}	2.12^{c}	2.33^{a}
Mean	19.7^{a}	18.4^{ab}	18.0^{b}	17.4^{b}		9.30^{a}	8.79^{ab}	8.43^{ab}	8.07^{b}		2.48^{a}	2.36^{ab}	2.23^{ab}	2.08^{b}	
SV			S.Em. ±					S.Em. ±					S.Em. ±		
I			0.44					0.26					0.07		
G			0.30					0.20					0.05		
I × G			0.93					0.45					0.13		

Means followed by the same letter (s) within a column and row are not differed significantly by DMRT (P = 0.05); SV- Source of variation. Irrigation levels (I): I_1- Drip irrigation at 0.6 ETc, I_2- Drip irrigation at 0.8 ETc, I_3- Drip irrigation at 1.0 ETc and I_4- Furrow irrigation at 0.8 IW/CPE ratio. Maize genotypes (G): G_1- NK-6240, G_2- Pinnacle, G_3- CP-818 and G_4- RCRMH-2. The rainfall received was 233.8 mm during 2018 and 786.7 mm during 2019.

significant residual effect on growth of the blackgram (Table 1). Among all the treatment combinations, significantly higher number of trifoliate leaves (10.41) and total dry matter production (6.47 g plant^{-1}) were recorded under residual effect of drip irrigation at 0.6 ETc with maize genotype Pinnacle (I_1G_2). However, it remained on par with residual effect of rest of the treatment combinations except I_4G_1, I_4G_4, I_3G_1 and I_3G_3 combinations. Higher growth parameters under lower irrigation regimes were mainly due to higher residual available nutrients after harvesting of maize (Fig 1) and favorable soil moisture condition coupled with congenial microclimate during crop growth period. Thus resulted in higher uptake of residual available nutrients and increased photosynthesis. Further, increased supply of photosynthates to growing plant parts led to enlargement of meristematic tissues resulted in increased growth parameters. On the contrary, significantly the lowest growth parameters of blackgram were recorded with furrow irrigation at 0.8 IW/CPE ratio. It was mainly due to lower residual soil nutrients available in the crop root zone after harvest of the preceding crop maize (Fig 1). In case of furrow irrigation, application of higher amount of irrigation water might have resulted in leaching of nutrients beyond the effective crop root zone. Hence, reduced the available nutrients in the root zone resulted in lower growth of the blackgram. These results are in conformity with the findings of Bandyopadhyay *et al*. (2016) and Halli and Angadi (2018).

Yield and rain water use efficiency of blackgram

The grain yield and rain water use efficiency (RWUE) of succeeding blackgram differed significantly under residual effect of irrigation levels was shown in Table 2. It is revealed from table significantly higher number of pods (19.7), grain yield (9.30 q ha^{-1}) and RWUE (2.48 kg ha-mm^{-1}) of blackgram

were recorded with residual effect of drip irrigation at 0.6 ETc as compared to other treatments of irrigation levels. However, it remained on par with drip irrigation at 0.8 and 1.0 ETc with respect to grain yield and RWUE. Increased grain yield was due to higher growth and photosynthates production at vegetative stage and its translocation into economic parts as a result of higher residual nutrient pool in the soil (Fig 1). The optimum soil moisture might have promoted the crop to express its full potential by utilizing soil moisture as well as residual nutrients. Further, it might have enhanced the number of flowers and pods. Higher yield attributing characters like number of pods per plant and dry matter partitioning might have produced higher seed yield. Similar research findings were reported by Sangh Ravikiran (2018) in maize-soybean system and Halli and Angadi (2018) in maize-cowpea system. Whereas, the lowest number of pods per plant (17.4), grain yield (8.07 q ha^{-1}) and rain water use efficiency (2.08 kg ha-mm^{-1}) were recorded with residual effect of furrow irrigation at 0.8 IW/ CPE ratio. This was also due to imbalanced and reduced nutrient supply during crop growth period. Lower potassium uptake might have also hindered the translocation of nitrogen and phosphorus ions which was evidenced by significant reduction in available potassium under furrow irrigation (Fig 1). Hence, reduced the number of pods per plant, which is the major yield attributing character in blackgram. Residual effect of irrigation levels on succeeding crop was also reported by Khadka and Paudel (2010) and Halli and Angadi (2018).

However, the residual effect of maize genotypes had no significant influence on yield and RWUE of blackgram. The interaction effect of irrigation levels and genotypes had a significant residual effect on grain yield and RWUE of blackgram (Table 2). Significantly higher number of pods per plant (21.0), grain yield (9.90 q ha^{-1}) and RWUE (2.72 kg ha-mm^{-1}) were recorded with residual effect of I_1G_4 treatment combination. However, this treatment remained on par with I_1G_2, I_1G_3, I_1G_1, I_2G_1, I_2G_2, I_2G_4, I_3G_2 and I_3G_3 combinations. Increased grain yield and RWUE of blackgram was due to balanced and adequate supply of nutrients. This might have resulted in enhanced activity of enzymes and translocation of starch efficiently from sites of production to storage. Besides, adequate supply of phosphorus and potassium might have resulted in maximum synergistic effect in nitrogen fixation of blackgram. Hence, it produced maximum growth parameters (Table 1) which were major contributors to higher yield parameters and yield attributing characters of blackgram. These findings confirm the reports of Ibrahim (2011) and Sangh Ravikiran (2018). Contrarily, residual effect of I_4G_1 recorded the lowest grain yield (7.78 q ha^{-1}) and RWUE (2.06 kg ha-mm^{-1}) as compared to other treatment combinations. Decreased yield and RWUE was attributed to lower number of pods per plant (16.6). Lower yield and yield parameters were due to lower growth parameters like plant height, number of trifoliate leaves and total dry matter production (Table 1). Even though the rainfall was higher during blackgram growing period, these differences in growth

Table 3: Economics of blackgram as influenced by residual effect of irrigation levels and maize genotypes (pooled data of 2 years).

G/I	Gross returns (` ha^{-1})					Net returns (` ha^{-1})					B:C ratio				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
G_1	52,006^{a-c}	57,243^{ab}	48,191^{c}	47,231^{c}	51,168^{a}	35,452^{a-c}	40,688^{ab}	31,637^{c}	30,677^{c}	34,614^{a}	3.14^{a-c}	3.46^{ab}	2.91^{c}	2.85^{c}	3.09^{a}
G_2	59,695^{a}	52,044^{a-c}	55,208^{a-c}	48,777^{bc}	53,931^{a}	43,140^{a}	35,489^{a-c}	38,654^{a-c}	32,223^{bc}	37,377^{a}	3.60^{a}	3.14^{a-c}	3.33^{a-c}	2.94^{bc}	3.26^{a}
G_3	53,457^{a-c}	49,146^{bc}	52,368^{a-c}	50,454^{bc}	51,356^{a}	36,903^{a-c}	32,592^{bc}	35,813^{a-c}	33,900^{bc}	34,802^{a}	3.23^{a-c}	2.97^{bc}	3.16^{a-c}	3.05^{bc}	3.10^{a}
G_4	59,877^{a}	54,389^{a-c}	48,410^{c}	49,355^{bc}	53,008^{a}	43,323^{a}	37,834^{a-c}	31,856^{c}	32,801^{bc}	36,454^{a}	3.62^{a}	3.28^{a-c}	2.92^{c}	2.98^{bc}	3.20^{a}
Mean	56,259^{a}	53,205^{ab}	51,044^{ab}	48,954^{b}		39,704^{a}	36,651^{ab}	34,490^{ab}	32,400^{b}		3.40^{a}	3.21^{ab}	3.08^{ab}	2.96^{b}	
SV			S.Em. ±					S.Em. ±					S.Em. ±		
I			1543					1543					0.09		
G			1226					1226					0.07		
I × G			2698					2698					0.16		

Means followed by the same letter (s) within a column and row are not differed significantly by DMRT (P = 0.05); SV- Source of Variation. Irrigation levels (I): I_1-Drip irrigation at 0.6 ETc, I_2- Drip irrigation at 0.8 ETc, I_3- Drip irrigation at 1.0 ETc and I_4- Furrow irrigation at 0.8 IW/CPE ratio. Maize genotypes (G): G_1- NK-6240, G_2-Pinnacle, G_3-CP-818 and G_4-RCRMH-2. Market price of blackgram grain and haulm was` 5,600 $q^{-1}$ and ` 150 q^{-1}, respectively.

and yield were due to differences in residual nutrient pool and early establishment of the crop. Higher available residual nutrients and sufficient rainfall during seedling stage led to quick growth of the plants. This difference in early growth was further carried to later stages and resulted in differences in growth and yield of blackgram. Besides, the lower available nutrients, lower establishment of blackgram were observed under residual effect of furrow irrigation at 0.8 IW/CPE ratio. Hence, it was harvested lower photosynthetically active radiation and thus affected the crop performance and reflected in terms of reduced growth and yield parameters. These results are in conformity with the findings of Sangh Ravikiran (2018) in soybean and Halli and Angadi (2018) in cowpea.

Economics of blackgram

The residual effect of different irrigation levels significantly influenced the economics of blackgram (Table 3). Gross returns (` 56,259 $ha^{-1}$), net returns (` 39,704 ha^{-1}) and B:C ratio (3.40) were significantly higher with residual effect of drip irrigation at 0.6 ETc and were on par with drip irrigation at 0.8 and 1.0 ETc as compared to furrow irrigation at 0.8 IW/CPE ratio. This increased monetary return was due to higher grain and haulm yield. Whereas, furrow irrigation at 0.8 IW/CPE ratio registered significantly the lowest gross returns, net returns and B:C ratio compare to other treatment combinations. The lower grain and haulm yields under furrow irrigation were the main reasons for decreased monetary returns of blackgram. Similar results were reported by Islam *et al.* (2018) and Halli and Angadi (2018). The residual effect of genotypes did not influence significantly on gross returns, net returns and B:C ratio of blackgram. However, interaction effect of irrigation levels and genotypes had a significant residual effect on the economics of blackgram. Significantly higher and on par monetary returns were recorded under the residual effect of I_1G_4, I_1G_2, I_1G_3, I_1G_2, I_2G_1, I_2G_3, I_2G_2, I_3G_2 and I_3G_3 treatment combinations. Higher net returns and B:C ratio were due to increased grain and haulm yield of blackgram. Increased yield was due to adequate moisture and nutrient supply during crop growth period. Contrarily, significantly the lowest gross returns, net returns and B: C ratio were recorded under furrow irrigation at 0.8 IW/CPE ratio with NK-6240. The lower seed and haulm yields resulted in lower monetary returns of blackgram. These results endorse the findings of Acharya *et al*. (2015) and Sangh, (2018).

CONCLUSION

Owing to shortage of water in agriculture, need of an hour is to adapt improved irrigation technologies like drip irrigation for more crop produce per drop of water. Under intensive cropping situations, no till planting of succeeding blackgram is more suitable not only to maintain the soil fertility and system productivity but also to increase the practical utility of drip system. In light of this, the experiment conducted clearly indicated that, irrigation levels differed significantly with residual effect on the performance of succeeding blackgram. Significantly higher and on par growth and yield parameters, grain yield, RWUE and net returns were recorded with drip irrigation at 0.6, 0.8 and 1.0 ETc as compared to furrow irrigation at 0.8 IW/CPE ratio. Among different treatment combinations, significantly higher and on par growth and yield parameters, seed yield, RWUE and net returns were recorded under the residual effect of I_1G_4, I_1G_2, I_1G_3, I_1G_2, I_2G_1, I_2G_3, I_2G_2, I_3G_2 and I_3G_3 treatment combinations. Hence, drip irrigation in maize with succeeding blackgram may be followed in view of higher yield and net returns than furrow irrigation. As maize is known as heavy feeder crop, it required more nutrients as compare to other seasonal field crops. To maintain soil nutrient balance the crop rotation with legume is to be followed. Blackgram is one of the most beneficial and short duration legume crop and can also fix the atmospheric nitrogen in the soil. The maize-blackgram cropping pattern will helps to maintain the soil health as well as for more production.

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Conflict of interest

I hereby declare that the disclosed information is correct and that no other situation of real, potential or apparent conflict of interest is known to me.

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