International Journal of Research in Agronomy 2024; 7(4): 524-527

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(4): 524-527
Received: 15-02-2024
Accepted: 21-03-2024

N Ramya
Department of Agronomy (Water Management), Advanced Post Graduate Centre, Lam, Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh, India

NV Lakshmi
Department of Agronomy (Water Management), Advanced Post Graduate Centre, Lam, Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh, India

K Chandrasekhar
Department of Agronomy (Water Management), Advanced Post Graduate Centre, Lam, Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh, India

KL Narasimha Rao
Department of Crop Physiology, Special Officer, Advanced Post Graduate Centre, Lam, Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh, India

Corresponding Author:
N Ramya
Department of Agronomy (Water Management), Advanced Post Graduate Centre, Lam, Acharya NG Ranga Agricultural University, Guntur, Andhra Pradesh, India

Evaluating deficit water management techniques on water efficiency, consumptive use, and economics of *rabi* Maize (*Zea mays* L.)

N Ramya, NV Lakshmi, K Chandrasekhar and KL Narasimha Rao

DOI: https://doi.org/10.33545/2618060X.2024.v7.i4g.613

Abstract
A field experiment was conducted on sandy loam soils of Agricultural College Farm, Bapatla during *rabi*, 2017-18 to analyze the effect of deficit irrigation on yield and water use efficiency of maize. Results of the experiment were statistically analyzed using a split-plot design and revealed that the maximum water use efficiency (16.4 kg ha mm^{-1}) was recorded from the alternate furrow method of irrigation (I_1) when compared to fixed alternate furrow (I_2) and conventional furrow irrigations (I_3). Irrigating the crop at 30 mm depth (D_1) resulted in higher water use efficiency (15.4 kg ha mm^{-1}) compared to irrigating the crop at 45 mm (D_2) and 60 mm depths (D_3). Consumptive use of water (422.4 mm) and soil moisture use rate (3.8 mm day^{-1}) was found maximum under conventional furrow irrigation followed by alternate furrow irrigation and minimum under fixed alternate furrow irrigation. Irrigation at 60 mm depth resulted in higher consumptive use of water (492.9 mm) and 30 mm depth of irrigation recorded lower consumptive use of water (302.5 mm). Among different irrigation practices, maximum gross returns (87521 Rs ha^{-1}), net returns (44562 Rs ha^{-1}) and BC ratio (1.03:1) were recorded with alternate furrow irrigation and minimum with fixed alternate furrow irrigation. 60 mm depth of irrigation recorded maximum gross returns (90377 Rs ha^{-1}), net returns (45731 Rs ha^{-1}) and BC ratio (1.02:1) over 45 mm and 30 mm.

Keywords: Maize, furrow irrigation, moisture use efficiency and consumptive use of water

Introduction
Maize is the principle cereal crop after rice in Andhra Pradesh. Though it is mainly grown as rainfed crop during *kharif* season, it is also being cultivated as an irrigated crop during *rabi* season. Even though maize makes productive utilization of water, it is considered more susceptible to water stress than other crops. So, irrigation might be designed in such a way that it makes productive utilization of water which finally enhances water productivity in maize. Furrow irrigation is considered as one of the main methods of surface irrigation in maize though uses much of the water than drip and sprinkler irrigation but saves water compared to flooding and check basin methods of irrigation. Since, scarcity of irrigation water is the major constraint for crop production, improving the management of irrigation water is very crucial to reduce the water losses and thereby enhancing water use efficiency. Alternate furrow irrigation and fixed alternate furrow irrigation are such irrigation practices in which one out of two adjacent furrows is irrigated. As alternate furrow irrigation facilitates horizontal (lateral) water movement, it can reduce water losses via deep percolation and runoff.

Materials and Methods
The field trial was conducted at Agricultural College Farm, Bapatla during *rabi*, 2017-18. Soil of the experimental site was sandy loam in texture, moderately alkaline in reaction, low in organic carbon (0.2 %), available nitrogen (201 kg ha^{-1}) and phosphorus (6 kg ha^{-1}) and medium in available potassium (169 kg ha^{-1}). Irrigation was applied through furrows using three different methods which were taken as main plots: 1) Alternate furrow irrigation (AFI) in which neighboring furrow was alternately irrigated during consecutive watering. 2) Fixed Alternate Furrow Irrigation (FAFI) in which irrigation was fixed to either of the furrow in every irrigation 3) Conventional Furrow Irrigation (CFI) in which all the furrows were irrigated. Three different depths of irrigation were taken as subplots *i.e.*, 1) 60 mm 2) 45 mm and 3) 30 mm.

The crop was sown on 4th November 2017. The volume of water to be given for each treatment is calculated by multiplying the area with depth and the measured quantity of water was given to different treatments according to depth of irrigation by using Parshall flume (Parshall, 1950) [1]. Bulk density of the experimental soil at 0-30 cm, 30-60 cm and 60-90 cm depth was estimated using core sampling method (Piper, 1966) [3] recorded as 1.44 g cc^{-1}, 1.63 g cc^{-1}, 1.69 g cc^{-1}, respectively. Field capacity of the soil was 24.5 cm per meter depth of soil. Soil moisture was determined thermo-gravimetrically from four different soil layers *viz.,* 0-30, 30-60, 60-90 and 90-120 cm. The moisture content was estimated, and the values were used to compute the consumptive use and moisture extraction pattern by the crop. Water use efficiency (kg ha mm^{-1}) for a given treatment was calculated by dividing the kernel yield with the responsive total consumptive use for the crop period. The data recorded on various parameters of crop was subjected to statistical scrutiny by the method of analysis of variance outlined by Panse and Sukhatme (1985) [2].

Results and Discussion

Results of the experiment revealed that irrigating the crop in alternate furrows under deficit conditions produced less reduction in yield when compared with irrigation through conventional and fixed alternate irrigation practices. Among different irrigation practices, alternate furrow irrigation recorded the maximum kernel yield (6251 kg ha^{-1}) which was significantly superior over fixed alternate furrow irrigation (4714 kg ha^{-1}) and conventional furrow irrigation (5503 kg ha^{-1}) though the same amount of water was applied through all the practices. Depth of irrigation water also significantly influenced the kernel yield. When the crop was irrigated with 60 mm depth of irrigation, higher kernal yield (6455 kg ha^{-1}) was recorded and found significantly superior over 45 mm (5348 kg ha^{-1}) and 30 mm depth of irrigation (4665 kg ha^{-1}). With the reduction in 25 and 50 percent of irrigation water, the yield reduction noticed was only 17 and 28 per cent respectively. Interaction between irrigation practices and depth of irrigation on kernel yield of maize was found significant. The highest kernel yield (7566 kg ha^{-1}) was observed under alternate furrow irrigation at 60 mm depth of irrigation (I_1D_1) which was significantly superior to the rest of the treatments. Less irrigation through alternate furrow irrigation practice could maintain the same kernel yield as that of conventional furrow irrigation with high amount of irrigation water.

Among different irrigation practices, the higher moisture use efficiency (16.4 kg ha-mm^{-1}) was recorded under alternate furrow irrigation, which was significantly superior over conventional furrow irrigation (13.3 kg ha-mm^{-1}) and fixed alternate furrow irrigation (12.4 kg ha-mm^{-1}). Alternate furrow irrigation recorded higher water use efficiency 18.9 % and 24.4 % more compared to conventional and fixed alternate furrow irrigations. This improved water use efficiency under alternate furrow irrigation might be due to reduced leaf transpiration as stomatal control of leaf gas exchange and transpiration loss. Similar results were also reported by Kang *et al.* (2000) [4]. Among the irrigation depths, the highest water use efficiency (15.4 kg ha-mm^{-1}) was recorded under 30 mm depth of irrigation which was 11.7 % and 14.3 % higher 45 mm (13.6 kg ha-mm^{-1}) and 60 mm depths (13.2 kg ha-mm^{-1}) respectively. Providing irrigation at 60 mm depth resulted in significantly lower water use efficiency due to lesser increase in yield despite of giving high quantity of water. This might be due to increased water application that resulted in increased crop water use without a corresponding increase in kernel yield. Increase of water productivity with decrease in irrigation depth was in conformity with that of Adamu *et al*. (2014) [5] and Kar and Verma (2005) [6].

Consumptive use of water was found minimum when the irrigation was given through fixed alternate furrows (381.3 mm) compared to irrigation through alternate (385.4 mm) and conventional furrows (422.2 mm). Among different depths of irrigation, the consumptive use of water was found minimum under 30 mm depth (302.5 mm) and the highest was recorded under 60 mm depth of irrigation (492.9 mm). Irrigation with 30 mm depth of water reduced the consumption of water by 46.5% compared to 60 mm depth. These results are in agreement with Tantawy *et al.* (2007) [7]. Moisture use rate by crop was significantly higher under conventional method of irrigation (3.8 mm day^{-1}) over alternate furrow irrigation (3.5 mm day^{-1}) and fixed alternate furrow irrigation (3.5 mm day^{-1}). Among the depths, irrigation at 60 mm depth recorded significantly higher soil moisture use rate (4.5 mm day^{-1}) compared to irrigation given at 45 mm (3.5 mm day^{-1}) and 30 mm depths (2.8 mm day^{-1}). The lowest moisture use rate under 30 mm depth might be due to the plants experienced water stress and resulted in early maturity and low consumptive use compared to 60 mm and 45 mm depth of irrigation.

Among different practices of irrigation, alternate furrow irrigation recorded significantly higher gross returns (Rs. 87,521 ha^{-1}), net returns (Rs. 44,562 ha^{-1}) and returns per rupee invested (1.03) compared to conventional and fixed alternate furrow irrigation practices. While, BC ratio resulted under conventional furrow irrigation at 60 mm depth was comparable as that of alternate furrow irrigation at 45 mm depth. Higher net returns and benefit cost ratio under increased depth of irrigation water was also reported by Sushma *et al.* (2017) [8], Ramachandiran and Pazhanivelan (2016) [9] and Subba Reddy *et al.* (2015) [10].

Table 1: Kernel yield (kg ha^{-1}), Stover yield (kg ha^{-1}) and Harvest Index (%) of maize as influenced by irrigation practices and depth of irrigation

Treatments	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
Method of irrigation (I)			
I_1: Alternate furrow irrigation (AFI)	6251	6038	50.3
I_2: Fixed alternate furrow irrigation (FAFI)	4714	5278	47.0
I_3: Conventional furrow irrigation (CFI)	5503	5764	49.2
SEm ±	121	156	0.79
CD (p=0.05)	475	611	3.1
CV (%)	6.6	8.2	4.9
Depth of irrigation (D)			
D_1: 60 mm	6455	6015	51.7
D_2: 45 mm	5348	5579	49.0
D_3: 30 mm	4665	5486	45.8
SEm ±	141	186	0.91
CD (p=0.05)	436	NS	2.8
CV (%)	7.7	9.8	5.6
Interaction (I X D)	NS	NS	NS

Table 1a: Kernel yield (kg ha^{-1}) of maize as influenced by irrigation practices and depth of irrigation

Treatment	Irrigation practices			Mean
Depth of irrigation	I_1(AFI)	I_2 (FAFI)	I_3 (CFI)	
D_1: 60 mm	7566	5676	6125	6455
D_2: 45 mm	5927	4745	5373	5348
D_3: 30 mm	5262	3721	5012	4665
Mean	6251	4714	5503	
		SEm ±	CD (p=0.05)	CV (%)
Irrigation practices		120.9	475	6.6
Depth of irrigation		141.4	436	7.7
Interaction (I X D)		244.9	755	
Interaction (D X I)		233.7	773	

I x D – To compare two subplot treatment means at a given main plot treatment
D x I - To compare two main plot treatment means at each level of subplot treatment

Table 2: Consumptive use of water (mm), soil moisture use rate (mm day^{-1}) and moisture use efficiency (kg ha-mm^{-1}) of maize as influenced by irrigation practices and depth of irrigation

Treatments	Consumptive use of water (mm)	Soil moisture use rate (mm day^{-1})	Moisture use efficiency (kg ha-mm^{-1})
Method of irrigation (I)			
I_1: Alternate furrow irrigation (AFI)	385.4	3.5	16.4
I_2: Fixed alternate furrow irrigation (FAFI)	381.3	3.5	12.4
I_3: Conventional furrow irrigation (CFI)	422.4	3.8	13.3
SEm ±	4.55	0.04	0.39
CD (p=0.05)	17.8	0.2	1.6
CV (%)	3.4	3.5	8.4
Depth of irrigation (D)			
D_1: 60 mm	492.9	4.5	13.2
D_2: 45 mm	393.6	3.5	13.6
D_3: 30 mm	302.5	2.8	15.4
SEm ±	5.55	0.05	0.49
CD (p=0.05)	17.1	0.2	1.5
CV (%)	4.2	4.2	10.3
Interaction (I X D)	NS	NS	NS

Table 3: Gross Returns (GR), Net Returns (NR) and Benefit Cost Ratio (BCR) of maize as influenced by irrigation practices and depth of irrigation

Treatments	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	BCR
Method of irrigation (I)			
I_1: Alternate furrow irrigation (AFI)	87521	44562	1.03
I_2: Fixed alternate furrow irrigation (FAFI)	65991	23033	0.53
I_3: Conventional furrow irrigation (CFI)	77043	34084	0.79
SEm ±	1498	1498	0.04
CD (p=0.05)	5882	5882	0.14
CV (%)	5.8	13.3	13.7
Depth of irrigation (D)			
D_1: 60 mm	90377	45731	1.02
D_2: 45 mm	74872	31914	0.74
D_3: 30 mm	65306	24035	0.58
SEm ±	2032	2032	0.05
CD (p=0.05)	6260	6260	0.15
CV (%)	7.9	18.0	18.0
INTERACTION (I X D)	NS	NS	NS

Conclusion

Based on the experiment, it can be concluded that applying water using the alternate furrow method of irrigation under deficit water conditions, at depths of 45 mm and 30 mm, proved to be a profitable irrigation practice for enhancing the water productivity of maize during the rabi season. This method showed superior results compared to applying water through every furrow and fixed alternate furrow techniques.

References

1. Parshall RL. Measuring water in irrigation channels with Parshall flumes and small weirs. USDA, Circular No. 843; c1950. p. 500.
2. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research. New Delhi; c1985. p. 205-210.
3. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay; c1966. p. 15-39.
4. Kang S, Liang Z, Pan Y, Shi P, Zhang J. Alternate furrow irrigation for maize production in an arid area. Agric. Water Manag. 2000;45:267-274.
5. Adamu C, Aravinda Kumar BN, Rajkumara S, Patil BR, Patil HY, Kuligod VB, *et al.* Physiological response, molecular analysis and water use efficiency of maize (*Zea*

mays L.) hybrids grown under various irrigation regimes. Afr. J Biotechnol. 2014;13(29):2966-2976.
6. Kar G, Verma HN. Phenology based irrigation scheduling and determination of crop coefficient of winter maize in rice fallow of eastern India. Agric. Water Manag. 2005;75:169-183.
7. Tantawy MME, Ouda SA, Khalil FA. Irrigation scheduling for maize grown under Middle Egypt conditions. Res. J Agric. Biol. Sci. 2007;3(5):456-462.
8. Sushma BS, Ilhe SS, Wadile. Influence of irrigation and mulching on yield and economics in summer sweet corn. Int. Res J Agric. Econ Stat. 2017;8(2):315-319.
9. Ramachandiran K, Pazhanivelan S. Influence of irrigation and nitrogen levels on growth, yield attributes and yield of maize (*Zea mays*). Indian J Agron. 2016;61(3):360-365.
10. Reddy S, Thomas CG, Deva S. Effect of irrigation and tillage practices on yield and economics of fodder maize (*Zea mays*. L). Int. J Agric. Sci. 2015;11(1):189-192.