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Water Use Efficiency of Corn as Affected by Every Other Furrow Irrigation and Planting Density

Masoud Rafiee and Ghodratolah Shakarami

Islamic Azad University, Branch Khorramabad, Iran

Abstract: For increasing water use efficiency in corn (*Zea mays* L.) crop at different planting densities and decrease water wastesin usual methods of surface irrigation, an experiment was carried out in Khorramabad, Iran. Three irrigation methods include: conventional furrow irrigation (CFI), fixed every other furrow irrigation (FFI) and alternate every other furrow irrigation (AFI) and three different plant densities (7, 8 and 9 plant m^{-2}) were used. The results showed that there were no difference between both FFI and AFI, but the performance of them decreased irrigated water at the rates of 26.2% and 23%, respectively comparing with control and then yield at the rates of 11% and 13.6%, respectively. In this respect, FFI resulted in the highest water use efficiency for biological yield of 4.4 kg m^{-3} and economical (grain) yield of 1.91 kg m^{-3}. Higher planting density resulted in higher irrigated water in spite of lower grain yield, but the highest economical water use efficiency was found in lower plant population of 7 plant m^{-2}.

Key words: Corn · Every other furrow irrigation · Water use efficiency · Planting density · Yield

INTRODUCTION

In different arid and semiarid parts of Iran, such as khorramabad, corn production relies heavily on repeated irrigation and growers often have to apply at least 10 irrigations or more in a dry summer season, depending on duration of growth season and region environment, where shortage of water is an important limiting factor in crop production.

Some researchers revealed that using every other furrow irrigation gave higher yield compared to every furrow irrigation in peppermint (*Mentha piperita* L.) [1], corn [2] and grain sorghum [3], or lower yield in sugar cane [, 9], corn [2, 8] and starch content of potato [12]; or similar yield in corn [3] and sugar cane [1], but the surprising result was that all of these researchers found thatevery other furrow irrigation reduced the volume of water used and improved water use efficiency. Irrigation water application may be reduced up to 50 percent by implementing every other furrow irrigation. In every other furrow irrigation the reduction of yield is due to the water stress caused by the smaller amount of applied irrigation and water use efficiency is increased mainly by reduced evaporation from the soil surface, as in the case of drip irrigation [5, 7, 9, 13].

The objective of this research was to study the effect of different surface irrigation methods and planting density on yield and WUE of corn in semi arid sought west Iran.

MATERIALS AND METHODS

A Field experiment was conducted as a split plot based on RCBD with four replications at Kamalvand field research of Islamic Azad University, branch Khorramabad, Iran, during the dry summer season.

Irrigation Was Applied as Main Factor Through Furrows in Three Ways: conventional furrow irrigation (CFI) in which every furrow was irrigated during each watering throughout the growth season; fixed every other furrow irrigation (FFI) in which irrigation was fixed to one of the two neighboring furrows; and alternative every other furrow irrigation (AFI) in which one of the two neighboring furrows was alternately irrigated throughout the growth season. Sub-plots were three plant densities incloud 7, 8 and 9 plant m^{-2}.

Each sub-plots consisted of 6 furrows with 8 m long and 0.7 m spacing. There were 6 and 1m distance between the main-plots and sub-plots, respectively.

Corresponding Author: Masoud Rafiee, Islamic Azad University, Branch Khorramabad, Iran.

The crop was sown at a 5-6cm depth with 3 seeds per hill on 27th of May, 2009 on a well prepared seedbed using the seed of maize hybrid single cross 704.

A basal dose of 250 kg N + 100 P205 ha^{-1} was used. Full dose of phosphorous in the form of ammonium phosphate and half nitrogen in form of urea were applied at the time of planting and half nitrogen was applied in at side dressing after thinning. Thinning was practiced at 4-6 leaf stage. All other agronomic practices were kept normal and uniform for all the treatments under study.

Irrigations of all methods were scheduled using a mini-evaporation pan with a pan water deficit 80 mm. The amount of water for each irrigation was determined to reach soil water content in root zone to field capacity. Electrical conductivity of water and soil was less then 1.5 ds m^{-1}. Surface run off was not occurred during the research year because of surrounded subplots. Plots irrigated by a volumetric counter. Prior to imposing every other furrow treatments, irrigations were conducted in these plots using the CFI technique.

Data on morphological traits viz. rows ear^{-1}, grains ear^{-1}, 1000-grain weight, grain yield, biological yield and harvest index were recorded using standard procedures. Water use efficiency for biological yield (WUE) and for grain (economical) yield (EWUE) were determined.

RESULTS AND DISCUSSION

Irrigation Methods: Irrigated water decreased significantly in both FFI and AFI (26.2 and 23.0, respectively) (Table 1). Furthermore the performance of FFI and AFI all showed a substantial decrease in grain yield (11.0% and 13.6, respectively) and biological yield (8.8 and 9.9, respectively). Bakker *et al.* [1] and Sepaskhah and Ghasemi [10] reported that small amount of applied water reduce crop yield in every other furrow irrigation (AFI and FFI) as compared to CFI due to water stress, when the same irrigation frequency was applied which supported the result of this research.

There were no difference between every other irrigation methods in grain yield and biological yield, however, yield reduction in AFI was higher than FFI. FFI and AFI were also found to produce an improved crop WUE and EWUE, due to lower yield reduction than irrigation water. The highest EWUE and WUE of 1.9 and 4.4 kg m^{-3}, respectively, were observed in FFI and the lowest ones were showed in CFI (1.6 and 3.6 kg m-3, respectively). These results are supported by achievement of Sepaskhah and Khajehabdollahi [9], Sepaskhah and Ghasemi [10] and Shayannejad and Moharrery [12].

Table 1: mean comparison of morphological characteristics of corn in different treatments

IM	PD	Rows ear-1	grains ear-1	1000-grain weight	Grain yield (kg/ha-1)	Yield Biological (kg ha-1)	Harvest index (%)	Irrigated water	EWUE	WUE
CFI		15.0	570.0a	327.8	10446.8a	23674.0a	0.44	6621.7a	1.59b	3.6b
FFI		14.9	534.9b	320.2	9294.3b	21578.9b	0.43	4886.7b	1.91a	4.4a
AFI		14.7ns	533.7b	318.7ns	9026.0b	21323.5b	0.43ns	5095.8b	1.78ab	4.2ab
	70	14.9	562.7a	329.3	10007.4a	21015.6b	0.48a	5215.8b	1.94a	4.1
	80	14.9	561.6a	323.0	9827.7b	22262.9ab	0.44ab	5542.5ab	1.78ab	4.1
	90	14.8ns	514.3b	314.3ns	8932.1b	23297.9a	0.39b	5845.8a	1.55b	4.0ns
CFI	70	15.1	578.7	335.3	10550.0b	21773.0bc	0.48	6157.5b	1.71	3.5
CFI	80	15.1	596.4	325.5	11333.3a	24139.3a	0.47	6637.5ab	1.71	3.6
CFI	90	14.9	534.8	322.8	9457.2bcd	25109.8a	0.38	7070.0a	1.34	3.6
FFI	70	14.9	557.3	328.3	9927.5bc	20911.5cd	0.48	4610.0e	2.15	4.5
FFI	80	14.9	547.9	322.3	9138.8cde	21458.5cd	0.43	4942.5de	1.85	4.3
FFI	90	14.9	499.5	310.0	8816.8de	22366.8b	0.40	5107.5cde	1.73	4.4
AFI	70	14.9	552.2	324.5	9544.8bcd	20362.3d	0.47	4880.0de	1.96	4.2
AFI	80	14.8	540.4	321.3	9011.0cde	21191.0bcd	0.43	5047.5cde	1.78	4.2
AFI	90	14.4ns	508.6ns	310.3ns	8522.3e	22417.3b	0.38ns	5360.0cd	1.59ns	4.2ns

IM= irrigation method (CFI, FFI and AFI are conventional furrow irrigation, fixed every other furrow irrigation and alternative every other furrow irrigation, respectively). PD= planting density (7, 8 and 9 plant m^{-2}). EWUE and EWUE= water use efficiency for grain (economical) yield and biological yield, respectively.

There were no differences among irrigations methods in harvest index, 1000-grain weight and rows ear^{-1}, but grains ear-1 were higher in CFI (570.0) than FFI (534.9) and then AFI (533.7), concluded that grain yield reduction due to water stress was mainly due to the decrease in the grains ear^{-1}. This result is similar to the result obtained by Sepaskhah and Khajehabdollahi [9].

Planting Density: Despite the significant increasing in biological yield at the rates of 5.9% and 10.9%, grain yield significantly decreased at the rate of 1.8% and 10.7% by increasing plant population from 7 to 8 and 9 plant m^{-2}, respectively. Rows ear^{-1} and thousand-grain weight were not affected by plant population. The highest grains ear^{-1} and harvest index (562.7 and 0.48, respectively) were found in lower plant population and decreased by increasing plant density, which was similar to the result obtained by Shakarami and Rafiee [11] and Hashemi *et al.* [4].

Mean with similar leter(s) in each column are not significantly different at the 0.05 probability level according to DANCAN.

Irrigated water significantly increased as planting density increased from 7 to 9 plant m^{-2}, due to more evapotranspiration in higher plant population [11]. The highest EWUE of 1.94 kg m^{-3} was obtained in 7 plant m-2, but there was no significant difference among plant densities in WUE, showed that grain yield is more susceptible than biological yield to stress condition.

Interaction Effects: Result showed that the highest grain yield of 11333.3 kg ha^{-1} was obtained from 8 plant m^{-2}, in case of CFI method, because this method supplied enough water to crop and higher plant density of 8 plant m^{-2} could produce more grain yield than 7 plant m-2. However, 7 plant m^{-2} showed more grain yield than higher plant populations in FFI and AFI, means that every other furrow irrigation (FFI and AFI) combined with higher planting density resulted in a more water stress that is expected to reduce grain yield [1, 9, 10, 11], for these reasons higher grain yield in FFI and AFI achieved in the lowest plant density.

Interaction effect mean showed that FFI produced higher EWUE and WUE (2.15 and 4.5 kg m^{-3}, respectively) in 7 plant m-2. There were significant difference in irrigated water due to irrigation method × planting density interaction. Changing in plant density from 7 to 9 plant m^{-2} in AFI and then FFI increased irrigated water more than CFI.

CONCLUSION

This research showed that both every other furrow irrigation methods (FFI and AFI) permits more efficient use of irrigated water, but the highest WUE and EWUE achieved by FFI in spite of lower grain yield due to water stress as compared to CFI.

Thus, further work is required to determine the full rage of conditions and management practices necessary to develop practical guidelines, such as more frequently application of FFI in response to the crops evapotranspirative demand in different plant population.

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REFERENCES

1. Bakker, D.M., S.R. Raine and M.J. Robertson, 1995. A preliminary investigation of alternate furrow irrigation for sugar cane production. Conference Proc. 'Clean water-clean Environment-21st Century', March 1995, Kansas City, Missouri, ASAE.
2. EL-Noemani, A.A., A.K.A. EL-Halim and H.A. EL-Zeiny, 1990. Response of maize (Zea may L.) to irrigation intervals under different levels of nitrogen fertilization. Egyptian J. Agron., 15:147-158. (Irri: and Drain. Abst., 19:259-1993).
3. Fishbach, P.E. and H.R. Mulliner, 1974. Every-other furrow irrigation of corn. Trans. ASAE., 17(3): 426-428.
4. Hashemi, A.M., S.J. Herbert and D.H. Putnam, 2005. Yield response of corn to crowding stress. Agron J., 97: 839-846.
5. Kang, Sh., Z. Liang, Y. Pan, P. Shi and J. Zhang, 2000. Alternate furrow irrigation for maize production in an arid area. Agric. water Management, 45(3): 267-274.
6. Mitchell, A.R., J.E. light and T. Page, 1993a. Alternate and alternating furrow irrigation of peppermint to minimize nitrate leaching. Central Oregon Agriculture Research Center Annual Report 199-1991. OSU AES Spec. Publ., 922: 29-36.
7. Mitchell, A.R., C.C. Shock and G.M. Perry, 1995. Alternating furrow irrigation to minimize nitrate leaching to groundwater. Conference Proc. 'Clean water-clean Environment-21st Century', March 1995, Kansas City, Missouri, ASAE.

8. Selvaraju, R. and M.R. Iruthayaraj, 1993. Effect of irrigation scheduling, methods of irrigation and nitrogen levels on growth analysis parameters of maize. Madras Agric. J., 80: 562-565 (Field Crop Abst., 49: 1561, 1996).
9. Sepaskhah, A.R. and M.H. Khajehabdollahi, 2005. Alternate furrow irrigation with different irrigation intervals for maize (*Zea mays* L.). Plant Prod. Sci., 8(5): 592-600.
10. Sepaskhah, A.R. and M. Ghasemi, 2008. Every-other-furrow irrigation with different intervals for sorghum. Pak. J. Biol. Sci., 11(9): 1234-1239.
11. Shakarami, Gh. and M. Rafiee, 2009. Response of corn (*Zea mays* L.) to planting pattern and density in Iran. Amercan-Eurasian J. Agric. and Environ. Sci., 5(1): 69-73.
12. Shayannejad, M. and A. Moharrery, 2009. Effect of every-other furrow irrigation on water use efficiency, starch and protein contents of potato. J. Agric. Sci., 1(2): 107-112.
13. Tsegaye, T., J.F. Stone and H.E. Reeves, 1993. Water use characteristics of wide-spaced furrow irrigation. Soil Sci. Soc. J., 57: 240-245.