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EVALUATION OF GROWTH AND YIELD TRAITS IN CORN UNDER IRRIGATION REGIMES IN SUB-TROPICAL CLIMATE

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ABSTRACT

A field experiment was conducted to determine the best irrigation practice for maize crop under subtropical condition of Natore, Bangladesh. For this study, four irrigation conditions (I_0 – under rain fed condition i.e. control, I_1-one time irrigation, I_2 -two times irrigation and I_3-three times irrigation) and two hybrid verities of maize (BARI hybrid maize-7 and BARI hybrid maize-9) was used to access the effect of irrigation practices on yield and yield parameters of maize crop. Study was conducted at Natore Sugar Mill area, Natore, Bangladesh during Rabi season in 2013-14. All recommended crop production practices were used during the study. Results of the study revealed that irrigation pattern significantly influenced the plant height, plant girth, total leaves plant^{-1}, effective leaves plant^{-1}, number of non-effective leaves plant^{-1}, total roots plant^{-1}, cob length, cob grain free, cob girth, grain line cob^{-1},grain no. line^{-1},total grains cob^{-1},grain weight cob^{-1}, 1000 grain weight, grain yield (tha^{-1}), straw weight plant^{-1},straw yield (tha^{-1}) and biological yield. Further, results of grain yield suggested that application of three times irrigation (I_3) produced highest grain yield (10.09and 10.21t ha^{-1}) in BARI hybrid maize-7 and BARI hybrid maize-9, respectively. Some varietal effect was also reported on almost all the traits and yield related parameters. The BARI hybrid maize-9 achieved better grain production as compared to the BARI hybrid maize-7. Based on the results, full irrigation is the best treatment to achieve the optimum growth and yield of maize.

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1 Introduction

Maize is an important multipurpose crop which is using as food, fodder, fuel, as well as in the manufacture of industrial products. Furthermore, Maize is widely adapted to several of climate change. Maize has been reported to be very sensitive to water scarcity or drought and requires sufficient water thorough out its growing period for better yield (Otegui et al., 2005; English, 2010). Further, it was reported that water stress conditions may cause 22.61-26.4% yield reduction which is directly correlated with the decrease in number and weight of kernel (Pandey et al., 2010). Singh et al. (2007) suggested that deficit irrigation also has some influence on emergence time, number of leaves / plant, initiation of tasseling and silking, these things directly influence the plant height and vegetative growth of maize. The heading to milking growth phase is highly sensitive period of deficit irrigation and has ultimate effect on productivity of maize (Hussaini et al., 2008).

Maize is grown almost all agro-climatic regions of the world, majority lays in low rainfall and heat stress conditions, where irrigation is the major factor determining yield. For this reason, it is necessary to determine the water regimes that achieving the optimum yield. The production of Maize can be improved positively by sufficient amount of irrigation (Kara & Biber, 2008; Yazar et al., 2009; Farré & Faci, 2013). In field crops, a well-arranged deficit irrigation might maximize water productivity over an area when full irrigation is not possible (Fereres & Soriano, 2007).

With increasing concern about declining water resources, there is a great intension to improve water management in farming systems to improve water use efficiency (Buttar et al., 2006). Several possible approaches such as irrigation technologies and efficient irrigation scheduling may be adopted for more effective uses of limited water supplies (Kirda, 2000). The great challenge of the agricultural sector is to produce more food from less water, which can be achieved by increasing crop water productivity. Irrigated agriculture is the largest water-consuming sector and it faces competing demands from other sectors (Bastiaanssen et al., 2001; Kijne et al., 2003; Sander et al., 2011). Therefore, the present research was undertaken to examine the effect of different irrigation levels on the growth performance and grain yield of maize in a sub-humid climate of Bangladesh.

2 Materials and Methods

The experiment was conducted at *Natore Sugar Mill* area in the Natore district, Bangladesh during the period of 2013-2014 to study different irrigation regimes on the growth, development and yield of maize cultivars. Plant materials (BARI hybrid maize-7 and BARI hybrid maize-9), the hybrids were produced from (BARI), Gazipur, Bangladesh used in this study. The experimental area was under sub-tropical climate characterized by rainfall (average 200 mm) during the "Rabi" season (November to April) and low temperature during the season. The experiment was designed in RCBD and treatments were replicated three time. The plot size was 5m×4m each and was irrigated as per the experimental treatments: I_0 - rainfall (control)/no irrigation, I_1-one irrigation, I_2 two irrigations, I_3 -three irrigations. These three irrigation levels; I_1, I_2, I_3, were set to the growth stages of in root initiation stage (20 DAS), panicle initiation stage (50 DAS) and grain filling stage (90 DAS) respectively.

The irrigation scheduling in conventional method was simulated as farmers do in the field. For this system irrigation interval was adjusted for soil (similar to the intervals applied by farmers).The irrigation requirement in all four irrigation methods was estimated using Penman-Montith equation on the base of the long-term mean meteorological data from the nearest climate station (Allen et al., 1998). All the experimental plots were fertilized with of recommended doses of various fertilizers. The rest of two-thirds of urea were top dressed in two equal splits, one of the crown root initiation stages (50DAS) and the other at pencil initiation stages (80 DAS).The seeds were sown manually with the spacing of 75 cm x 25 cm. Two times weeding before first and second irrigation were adopted. During the experimental period there was no remarkable infestation of insect-pest and diseases in the plots and hence no pest/disease control measures were taken. The data of 10 randomly selected plants were recorded on growth, yield contributing characteristics and grain yield at the harvesting stage. Data on different growth parameters such as (i) plant height, (ii) plant girth, (iii) total leaves plant^{-1}, (iv) effective leaves plant^{-1} (green leaves), (v) non-effective leaves plant^{-1} (dry leaves), (vi) total roots plant^{-1}, (vii) straw weight plant^{-1} and (viii) straw yield (t ha^{-1}), data on different yield parameters such as (i) cob length, (ii) cob grain free length, (iii) cob girth, (iv) grain line cob^{-1}, (v) grain number line^{-1}, (vi) total grain cob^{-1}, (vii) grain weight cob^{-1}, (viii) 1000 grain weight cob^{-1}, (ix) grains yield (t ha^{-1}), (x) straw yield (t ha^{-1}) and (xi) biological yield (t ha^{-1}) were obtained.

The analysis of variance with respect to all the tested parameters in our study together with sources of variation and corresponding degrees of freedom were been presented in Table 1-4. All data were subjected to analysis of variance according to Gomez & Gomez (1984). The statistical analysis was performed using analysis of variance technique by means of "MSTAT-C" software.

3 Results and Discussion

3.1 Effect of irrigation frequency of various growths attributes

3.1.1. Plant height

Irrigation levels showed significant effect on plant height of BARI hybrid maize-7 and BARI hybrid maize-9 (Table 1). The highest plant height (283.33 cm) was observed in level-3 irrigation (I_3) in BARI hybrid maize-9, which was statistically different from I_1 and I_2 irrigation levels and the shortest plant height was recorded with I_0 (control treatment)for both the varieties. The plant height increased with the increasing irrigation levels. BARI hybrid maize-9 always produced tallest plants than BARI hybrid maize-7 at all irrigation levels. While the BARI hybrid maize-7 produced tallest plant only under I_3 level of irrigation, which was statistically similar to BARI hybrid maize-9 under I_2 level of irrigation. Irrigation plays a vital role in vegetative growth of plant and causing improvement plant height. Findings of present study are similar to the findings of Yazar et al. (2012) those who observed

highest maize plant height in full irrigation (three times). Similarly, Otegui et al.(2005) suggested that, maize crop are highly sensitive to drought stress conditions. The application of less water negatively responded on the plant height (crop sensitivity to drought stress) subsequently reducing the grain yield (English, 2010). It was reported by various researchers that various plant growth attributes were reduced under different water stress conditions (Al-Ashkar et al., 2016; Hassan et al., 2016; Rashwan et al., 2016).

3.1.2. Plant girth

Intensity of irrigation showed significant positive effect on plant girth for both tested cultivars and it increased with increasing irrigation levels (Table 1). There was significant variation reported in plant girth with the application of I_2 and I_3 levels of irrigation on both the varieties and the shortest plant girth was observed under control conditions. Various researchers reported that continuous availability of water improve the plant girth in maize (Ayars et al., 1999; Dogan & Kirnak, 2010) and established the need of higher irrigation for better plant girth (Karam et al., 2003; Stone et al., 2006). Similarly, Yazar et al. (2009) and Farre & Faci (2009) suggested that plant girth of maize was positive correlated the irrigation amount and frequency of irrigation.

3.1.3. Total leaves plant^{-1}

Like previous two growth attributes, total leaves plant^{-1} was positively influenced by the irrigation frequency in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 1). The highest total number of leaves plant^{-1} (12.67) was obtained in BARI hybrid maize-9 with I_3 treatment, which were statistically identical with I_1 or I_2 levels of irrigation and the lowest, was observed under control conditions in both the varieties. Lamm et al. (2005) stated that deficit irrigation reduced total number of leaves. Karam et al.(2003) reported reduction in Leaf area index and dry matter yield by the deficiency of irrigation in maize.

3.1.4. Effective leaves plant^{-1}

Proper irrigation frequency significantly increased the number of effective leaves plant^{-1} in BARI hybrid maize-7 and BARI hybrid maize-9. The highest effective leaves plant^{-1} (24) produced with I_3 irrigation while the lowest effective leaves plant^{-1} (7) was produced under control treatment (rain fed condition) at BARI hybrid maize-7 (Table 1). Effective leaves gradually increased with increasing irrigation frequency, this might be probably due to availability of soil moisture that enhanced the uptake of nutrients resulting produced more effective leaves. The results are in agreement with the findings of Gencoglan &Yazar (2009) and Bozkurt et al. (2011) in Mediterranean climatic conditions. Yildirim & Kodal (2008) reported that seasonal rainfall ranged from 30 to102 cm produced maximum effective leaves in maize at Ankara, Turkey.

3.1.5. Non-effective leaves plant^{-1}

The number of non-effective leaves plant^{-1} was significantly influenced by the irrigation treatments in both maize varieties. The non-effective leaves plant^{-1} gradually decreased with increasing irrigation levels. The effect of irrigation frequency on the non-effective leaves was opposite to that of effective leaves (Table 2). I_2 or higher irrigations significantly reduced non-effective leaves plant^{-1}. Similar result was observed by Igbadun et al. (2008) in Marmara region of Turkey.

3.1.6. Total roots plant^{-1}

Irrigation treatments showed significant effect on the total roots plant^{-1} in BARI hybrid maize-7 and BARI hybrid maize-9. The maximum number of roots (51.67) was produced by I_3 treatment while minimum root plant^{-1}(37.33) was produced by without irrigation treatment (Table 2). This result might probably be due to availability of irrigation water enhanced the production of more roots. However, water availability is usually the most important natural factor limiting expansion and development of roots (Kara &Biber, 2008; Yazar et al., 2009; Farre & Faci, 2009).

3.1.7. Straw weight plant^{-1}

Straw weight plant^{-1} is also an important factor in determination of the crop performance. Irrigation treatments significantly affected the straw weight plant^{-1} in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 1).

Table 1 Effect of irrigation on the growth performance of BARI hybrid maize-7 and BARIhybrid maize-9.

Treatments	Plant height		Plant girth		Total leaves plant^{-1}		Effective leaves plant^{-1}	
	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9
(I_0)	216.33^{e}	219.67^{e}	6.00e	7.50^{d}	8.67^{b}	9.67^{b}	7^{d}	9^{d}
(I_1)	248.33^{d}	248.00^{d}	7.00de	9.33^{c}	12.33^{a}	11.33^{a}	9^{d}	14^{c}
(I_2)	262.67^{c}	271.33^{b}	8.17cd	11.04^{b}	12.33^{a}	12.33^{a}	13c	19^{b}
(I_3)	274.67^{b}	283.33^{a}	9.33c	12.97^{a}	12.00^{a}	12.67^{a}	17b	24^{a}
CV (%)	1.01		7.27		1.43		8.38	
LS	4.56*		1.15*		7.50**		2.08**	

The values with same letters(s) in a column are not significantly different as per DMRT

Table 2 Effect of irrigation on the growth and growth performance of BARI hybrid maize-7 and BARI hybrid maize-9

Treatments	No. of non-effective leaves plant^{-1}		Total roots plant^{-1}		Straw weight plant^{-1}	
	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9
I_0	7.17^{b}	7.17^{b}	43.33^{cd}	37.33^{d}	912.67^{e}	928.33^{e}
I_1	7.83^{a}	7.67^{ab}	47.00^{bc}	41.67^{cd}	1070.67^{d}	1132.67^{c}
I_2	8.17^{a}	7.80^{a}	50.33^{ab}	47.33^{ab}	1161.67^{c}	1228.33^{b}
I_3	8.17^{a}	8.17^{a}	54.33^{a}	51.67^{a}	1243.33^{b}	1365.33^{a}
CV (%)	0.57		6.17		2.15	
LS	4.2*		7.68*		43.18**	

The values with same letters(s) in a column are not significantly different as per DMRT.

The highest straw weight plant^{-1} (1365.0 g) was recorded in the I_3 irrigation treatment while the lowest straw weight plant^{-1} (912.67 g) with no irrigation. Increased irrigation frequency gradually increased the straw weight plant^{-1}. This might be because of the availability of water supply. Maize straw yield per plant increased significantly by amount of irrigation water and irrigation frequency (Kara & Biber, 2008; Yazar et al., 2009; Farre & Faci, 2009). Pandey et al. (2010) reported 22.6-26.4% reduction in straw yield when deficit water condition available.

The maximum mean maize straw yield was achieved from full irrigation (Yazar et al., 2012). However, Yildirim & Kodal (2008) reported that straw yields did not improve thought adding excessive irrigation.

3.1.8. Cob length

No-significant difference was found among the irrigation treatments on the production of cob length in BARI hybrid maize-7 and BARI hybrid maize-7 (Table 03). However, maximum cob length (28.67 cm) was achieved with I_3 irrigation and the minimum (18.00 cm) was produced under control treatment. Igbadun et al. (2008) and Pandey et al. (2010) reported that water use efficiency influenced the potential cob length.

3.1.9. Cob grain free length

Cob grain free length gradually decreased with increasing irrigation treatments in the maize hybrids (Table 3). The highest grain free length (1.7 cm) was found under control treatment while the lowest (0.68 cm) was obtained with I_3 irrigation level. The resulting cob grain free length might be probably due to irrigation levels increased not increasing properly. Often the aim of producers is not to improve cob grain free but to maximize profits (Payero et al., 2008).

3.1.10. Cob girth

The cob girth values increased with increasing irrigation frequency in both varieties. The maximum cob girth (25.33 cm) achieved with I_3 irrigation while the smallest cob girth (13.00 cm) obtained in control (Table 3). Increased cob girth might probably due to optimum cell expansion under sufficient water supply. Mansouri Far et al. (2010) reported that limited water reduced cob girth length. This results supported by Karam et al. (2003), Mengu & Ozgurel (2008), Yildirim & Kodal (2008) and Yazar et al.(2012).

3.2 Effect of irrigation frequency of various yields attributes

3.2.1 Grain lines cob^{-1}

It was found grain line cob^{-1} was affected by the treatments of irrigation regimes in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 3). The maximum grain line cob^{-1} (14.00) was reported from the treatment having I_3 irrigation treatment while lowest grain line cob^{-1} (12.33) was obtained from the controlled treatments. Similar results were reported by Kipkorir et al. (2002), Gencoglan & Yazar (2009), Farre & Faci (2009) and Bozkurt et al. (2011). However, Payero et al. (2008) found a ppositive association between grain line /cob and the amount of irrigation seasonally. The adding of excessive water was not significant to improve the production of grain yield.

3.2.2 Grains number line^{-1}

Grain number line^{-1} showed significant effect among the irrigation treatments in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 3). The maximum grain line^{-1}(49.00) counted at I_2 irrigation treatment and the lowest (38.33) at control. The value of grain number line^{-1} irrespective of increasing irrigation significantly increased the production. The reduction of yield (22.6-26.4%) caused by water stress was correlated with a reduction in number and weight of kernel in maize (Pandey et al., 2010). There was no significant variation between $I_1$and I_2irrigation levels on producing grain number line^{-1}

Table 3 Effect of irrigation on the yield and yield performance of BARI hybrid maize-7 and BARI hybrid maize-9

Treatments	Cob length (cm)		Cob grain free (cm)		Cob girth (cm)		Grain line cob^{-1}		Grains no. line^{-1}		Total grains cob^{-1}	
	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9
(I_0)	18.00^{g}	20.33^{e}	1.70^{a}	1.30^{b}	13.00^{e}	17.03^{d}	12.33^{c}	12.33^{c}	38.33^{c}	41.67^{b}	470.7^{c}	520.7bc
(I_1)	19.00^{f}	23.37^{c}	1.23^{b}	0.92^{c}	17.00^{d}	20.07^{c}	12.67^{bc}	14.33^{a}	44.00^{a}	41.67^{b}	557.0^{b}	597.0^{ab}
(I_2)	22.00^{b}	26.33^{b}	1.00^{c}	0.86^{c}	19.20^{c}	23.33^{b}	13.00^{abc}	13.33^{abc}	49.00^{a}	41.33^{b}	636.3^{a}	551.7^{b}
(I_3)	25.87^{d}	28.67^{a}	0.90^{c}	0.68^{d}	22.00^{b}	25.33^{a}	14.00^{ab}	14.00^{ab}	46.00^{a}	45.67^{a}	644.0^{a}	639.3^{a}
CV (%)	1.82		7.01		5.50		1.49		11.13		73.8	
LSD	0.744**		0.137*		1.92*		6.41**		7.12**		7.3*	

In a column figures having common letters(s) do not differ significant as per DMRT.

3.2.3 Total grains cob^{-1}

The grain Total / cob were affected by irrigation regimes in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 3). The maximum total grain cob^{-1} (644.0) was produced with I_3 irrigation treatment and it was statistically similar with I_2 irrigation level. The minimum total grain cob^{-1} (470.7) found in treatment without irrigation, which was statistically differs from all other treatments. Yazar et al. (2012) recorded that the maximum total grain / cob was achieved from full irrigation using drip irrigation method. Ertek & Kara (2013) also reported that deficit irrigation decreased the number of grain per ear, which was in agreement with findings of this study.

3.2.4 Grain weight cob^{-1}

The treatments of irrigation remarkably influenced the grain weight cob^{-1} in BARI hybrid maize-7 and BARI hybrid maize-9 (Table 4). The maximum grain weight cob^{-1}(185.33 g) was recorded with I_3 treatment while the minimum value (124.0 g) was counted with I_0. The grain weight cob^{-1} increased with the increasing of irrigation levels. However, Hanson et al. (2007) reported that irrigation frequencies increased grain weight cob^{-1} and the drip irrigation method was more advantageous over other methods due to reducing the incidence of diseases and weeds in dry row middles and nutrient loss through deep percolation. Maximum mean maize grain weight cob^{-1} produced by complete irrigation (Yazar et al., 2012).

3.2.5 1000-grain weight

The irrigation levels also influenced the weight of 1000-grain in BARI maize-7 and BARI maize-9 (Table 4). The highest 1000-grain weight (289.0 g) was produced with I_3 irrigation treatment whereas the minimum weight of 1000-grain (265.17 g) was produced by the control treatment. Above results are in agreement with the findings of Kipkorir et al. (2002), Bozkurt et al. (2006), Gencoglan & Yazar (2009) and Farre & Faci (2009).

3.2.6 Grain yield

The levels of irrigation remarkably influenced the grain yield in BARI maize-7 and BARI maize-9 (Table 4).Maximum grain yield (10.21 t ha^{-1}) was achieved with the treatment I_3 due to satisfactory soil moisture throughout the growing period, which was statistically similar with I_3treatments produced by BARI maize-7 (10.09 t ha^{-1}). Minimum grain yield (6.61t ha^{-1}) counted from treatment I_0 and it differed statistically from others treatments applications. It was followed by the grain yield of I_1 treatment for both the varieties. In this research, irrigation is the main factor determining the yield. This result is consistent with the findings of Karam et al. (2003), Stone et al.(2006), Kara & Biber (2008), Farré & Faci (2009) , Yazar et al.(2009) and Abd el-wahed et al.(2015) those who reported reduction in grain and dry matter yield, and leaf area index by deficit irrigation conditions. The water stress (deficit water) remarkably influenced productivity and quality in maize (EL Sabagh et al., 2015; Barutcular et al., 2016 a; Barutcular et al., 2016 b; EL Sabagh et al., 2017). Similarly, effect of abiotic stress (deficit water) on the growth and grain quality of wheat was reported by Barutcular et al. (2016c) and Barutcular et al. (2016d). However, water availability is usually the most important crop production factor limiting yield and yield traits of maize.

3.2.7 Straw yield

It was observed that straw yield indicated non-significant effects at irrigation regimes in BARI hybrid maize-7and BARI hybrid maize-9 (Table 4). The highest straw yield (70.54 t ha^{-1}) was observed in BARI hybrid maize-9 in the I_3treatment while the lowest. It might be due to sufficient water enhanced more vegetative growth, resulting more straw yield. BARI hybrid maize-9 was achieved better straw yield than BARI hybrid maize-9 in treatments. The maximum mean maize for the production of straw yield produced from full irrigation Yazar et al. (2012). All studied traits of flax crop significantly influenced by Irrigation intervals (Rashwan et al., 2016).

Table 4 Effect of irrigationn on the yield and yield attributing traits of BARI hybrid maize-7 and BARI hybrid maize-9

Treatments	Grains wt cob^{-1} (g)		1000 grains wt (g)		Grain yield (tha^{-1})		Straw yield (tha^{-1})		Biol. yield (tha^{-1})	
	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9	BARI hybrid maize-7	BARI hybrid maize-9
(I_0)	124.00^{f}	124.33^{f}	265.17^{f}	270.11^{e}	6.61^{f}	6.92^{f}	48.68	49.39	55.29	56.31
(I_1)	149.67^{e}	156.00^{d}	267.25^{ef}	280.58^{c}	7.34^{e}	8.21^{d}	57.10	58.90	64.44	67.10
(I_2)	170.00^{c}	179.00^{b}	270.15^{e}	284.86^{b}	8.97^{c}	9.48^{b}	61.95	64.98	70.92	74.45
(I_3)	176.00^{b}	185.33^{a}	276.26^{d}	289.35^{a}	10.09^{a}	10.21^{a}	66.49	70.54	76.58	80.75
CV (%)	1.36		0.75		2.06		3.96		3.80	
LS	3.81**		3.656**		0.313**		NS		NS	

In a column figures having common letters(s) do not differ significant as per DMRT.

3.2.8. Biological yield

Biological yield increased non-significantly with the increasing irrigation levels in both varieties (Table 4). Full irrigation (I_3) produced the maximum biological yield for both varieties. Among various irrigation treatments, highest biological yield (80.75 t ha^{-1}) was obtained in BARI hybrid maize-9 at I_3 treatment, which was statistically differed with BARI hybrid maize-7at the same treatment. This result may be attributed with vigorous plant growth with sufficient irrigation water. In control treatment, (water stress) both varieties produced the minimum but statistically identical biological yields in this study. Results of present study are similar to the findings of Hanson et al. (2007) and Karasu et al. (2015) those who observed that deficit water in maize yield traits and biological yield. Dry matter yield of maize reduced severely with water deficit condition as reported by Karam et al. (2003).

Conclusion

Increasing soil moisture within the root zone during crop growing period would be a great concern to enhance water use efficiency while saving water. In this study, higher values of growth and yield of BARI hybrid maize-7 and BARI hybrid maize-9were obtained when irrigation was scheduled at three-time available soil moisture depletion. It is recommended that three irrigations could be adopted where ground water quality and quantity is marginal to get high crop production and water use efficiency. Based on the results, it can be suggest that two irrigations approach could be a good strategy to improve water productivity when full irrigation is not possible. The performance of BARI hybrid maize-9 was better than BARI hybrid maize-7 in all measured traits under different irrigation regimes.

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

References

Abd el-wahed MH, EL Sabagh A, Zayed A, Ahmed S, Saneoka H, Barutçular C, (2015) Improving yield and water productivity of maize grown under deficit-irrigated in dry area conditions. Azarian Journal of Agriculture 2: 123-132.

Al-Ashkar IM, Zaazaa EI, EL Sabagh A, Barutçular C (2016) Physio-biochemical and molecular characterization for drought tolerance in rice genotypes at early seedling stage. Journal of Experimental Biology and Agricultural Sciences, 4, 675-687. DOI: http://dx.doi.org/10.18006/2016.4(Issue6).675.687.

Allen RG, Pereira LS, Raes D, Smith M (1998) Crop evapotranspiration – guidelines for computing crop water requirements – FAO Irrigation and Drainage Paper 56. FAO, 1998. ISBN 92-5-104219-5.

Ayars JE, Phene CJ, Hutmacher RB, Davis KR, Schoneman RA, Vail SS, Mead RM (1999) Subsurface drip irrigation of row crops: A review of 15 years of research at the Water Management Research Laboratory. Agricultural Water Management 42: 1-27.http://doi.org/10.1016/S0378-3774(99)00025-6.

Barutçular C, Dizlek H, EL- Sabagh A,Sahin T, EL- Sabagh M, Islam MS (2016a) Nutritional quality of maize in response to drought stress during grain-filling stages in mediterranean climate condition. Journal of Experimental Biology and Agricultural Sciences 4: 644-652. DOI: 10.18006/2016.4 (Issue6).644.652.

Barutcular C, EL Sabagh A, Konuskan O , Saneoka H (2016b) evaluation of maize hybrids to terminal drought stress tolerance by defining drought indices Journal of Experimental Biology and Agricultural Sciences 4:610-616.DOI: http://dx.doi.org/10.18006/2016.

Barutçular C, Yildirim M, Koç M, Akinci C, Toptas I, Albayrak O, Tanrikulu A, EL Sabagh A (2016c) Evaluation of SPAD chlorophyll in spring wheat genotypes under different environments. Fresenius Environmental Bulletin 25:1258-1266.

Barutçular C, Yildirim M, Koç M, Akinci C, Tanrikulu A, EL-Sabagh A, Saneoka H, Ueda A, Islam MS, Toptas I, Albayrak O, Tanrikulu A (2016d) Quality traits performance of bread wheat genotypes under drought and heat stress conditions. Fresenius Environmental Bulletin 25: 6159-6165.

Bastiaanssen WGM, Brito R, Bos MG, Souza RA, Cavalcanti EB, Bakker MM (2001) Low cost satellite data for monthly irrigation performance monitoring: Benchmarks from Nilo Coelho, Brazil. Irrigation and Drainage Systems 15: 53-79. doi:10.1023/A:1017967021198.

Bozkurt S, Yazar A, Mansuroglu GS (2011) Effects of different drip irrigation levels on yield and some agronomic characteristics of raised bed planted corn. African Journal of Agricultural Research 6: 5291-5300.

Bozkurt Y, Yazar A, Gencel B, Sezen MS (2006) Optimum lateral spacing for drip-irrigated corn in the Mediterranean Region of Turkey. Agricultural Water Management 85: 113-120. http://doi.org/10.1016/j.agwat.2006.03.0319.

Buttar GS, Thind HS, Aujla MS (2006) Methods of planting and irrigation at various levels of nitrogen affect the seed yield and water use efficiency in transplanted oilseed rape (*Brassica napus* L.). Agriculture Water Management 85: 253-260. DOI: http://doi.org/10.1016/j.agwat.2006.05.008.

Dogan E, Kirnak H (2010) Water temperature and system pressure effect on drip lateral properties. Irrigation Science, 28: 407-419. DOI: 10.1007/s00271-009-0202-z

EL Sabagh A, Barutçular C, Islam MS (2017) Relationships between stomatal conductance and yield under deficit irrigation in maize (*Zea mays* L.). Journal of Experimental Biology and Agricultural Sciences 5:15-21. DOI 10.18006/2017.5 (1).014.021.

EL Sabagh A, Barutçular C, Saneoka H (2015) Assessment of Drought Tolerance Maize Hybrids at Grain Growth Stage in Mediterranean Area. International Journal of Agricultural and Biosystems Engineering 2: 962-965.

English M (2010) Deficit irrigation I: Analytical framework. Journal of Irrigation, Drainage and Engineering, 116: 399-410. DOI:http://dx.doi.org/10.1061/(ASCE)0733-9437(1990)116:3(399).

Ertek A, Kara B (2013)Yield and quality of sweet corn under deficit irrigation. Agricultural. Water Management 129:138-144. http://doi.org/10.1016/j.agwat.2013.07.012

Farre IR, Faci P (2013) Response of varied irrigated maize to organic and inorganic fertilizer at Kasinthula Research Station in Malawi. Ph. D. Thesis submitted to the Cranfield University, Silsoe, United Kingdom.

Farre IR, Faci P (2009) A revised Thorn Thwaite-type global climate classification. Physical Geography 26:442-466. DOI: 10.2747/0272-3646.26.6.442.

Fereres E, Soriano MA (2007) Deficit irrigation for reducing agricultural water use. Journal of Experimental Botany 58: 147-159. DOI: https://doi.org/10.1093/jxb/erl165.

Gomez KA, Gomez AA (1984) Statistical Procedures for Agriculture Research. International Rice Research Institute, John Wiley and Sons. New York. USA. pp: 139-240.

Gencoglan C, Yazar A (2009) The effects of deficit irrigations on corn yield and water use efficiency. Turkish Journal Agriculture and Forestry 23: 233-241.

Hanson BR, Schwankl LJ, Schulback KF, Pettygrove GS (2007) A comparison of furrow, surface drip and sub-surface drip irrigation on lettuce yield and applied water. Agricultural Water Management 33: 139-157. DOI: http://doi.org/10.1016/S0378-3774(96)01289-9.

Hassan HM, Arafat EFA, ELSabagh A (2016) Genetic Studies on Agro-Morphological Traits in Rice (*Oryza sativa* L.) under Water Stress Conditions. Journal of Agricultural Biotechnology 01 : 76- 84. DOI: https://doi.org/10.20936/JAB/160205.

Hussaini MA, Ogunlela VB, Ramalan AA, Falaki AM (2008) Mineral Composition of Dry Season Maize (*Zea mays* L.) in Response to Varying Levels of Nitrogen, Phosphorus and Irrigation at Kadawa, Nigeria. World Journal of Agriculture and Science 4 : 775-780

Igbadun HE, Salim BA, Tarimo AKPR, Mahoo HF (2008) Effects of deficit irrigation scheduling on yields and soil water balance of irrigated maize. Irrigation Science 27:11-23. DOI: 10.1007/s00271-008-0117-0

Kara T, Biber C (2008) Irrigation frequencies and corn (*Zea mays* L.) yield relation in Northern Turkey. Pakistan Journal Biological Science 11: 123-126.

Karam F, Breidy J, Stephan C, Rouphael J (2003) Evapotranspiration, yield and water use efficiency of drip irrigated corn in the Bekaa Valley of Lebanon. Agricultural Water Management 63: 125-137. DOI: http://doi.org/10.1016/S0378-3774(03)00179-3.

Karasu A, Kuscu H, Öz M, Bayram G (2015) The Effect of Different Irrigation Water Levels on Grain Yield, Yield Components and Some Quality Parameters of Silage Maize

(*Zea mays indentata* Sturt.). Notulae Botanicae Horti Agrobotanici Cluj-Napoca 43:138-145.DOI:10.15835/nbha4319602

Kijne JW, Barker R, Molden D (2003) Water productivity in agriculture: limits and opportunities for improvement. CAB International, Wallingford, UK.

Kipkorir EC, Raes D, Massawe B (2002) Seasonal water production functions and yield response factors for maize and onion in Perkerra, Kenya. Agricultural Water Management 56: 229-240. DOI: http://doi.org/10.1016/S0378-3774(02)00034-3.

Kirda C (2000) Deficit irrigation Scheduling based on Plant growth stage showing water stress tolerance Deficit irrigation practices, FAO.

Lamm FR, Manges HL, Stone LR, Khan AH, Rogers DH (2005) Water requirement of subsurface drip-irrigated corn in northwest Kansas. Transactions of ASAE 38: 441-448.

Mansouri-Far CSA, Sanavy MM, Saberali SF (2010) Maize yield response to deficit irrigation during low-sensitive growth stages and nitrogen rate under semi-arid conditions. Agricultural Water Management 97: 12-22 DOI: http://doi.org/10.1016/j.agwat.2009.08.003.

Mengu GP, Ozgürel M (2008) An evaluation water-yield relations in maize (*Zea mays* L.) in Turkey. Pakistan Journal of Biological Science 11: 517-524. DOI: 10.3923/pjbs.2008.517.524.

Otegui ME, Andrade FH, Suero EE (2005) Growth, water use, and kernel abortion of maize subjected to drought at silking. Field Crops Research 40 : 87-94. http://doi.org/10.1016/0378-4290 (94)00093-R.

Pandey AK, Prakash V, Mani VP, Singh RD (2010) Effect of rate of nitrogen and time of application on yield and economics of baby corn (*Zea mays* L.). Indian Journal of Agronomy 45:338-343.

Payero JO, Tarkalson DD, Irmak S, Davison D, Petersen JL (2008) Effect of irrigation amounts applied with subsurface drip irrigation on corn evapotranspiration, yield, water use efficiency, and dry matter production in a semiarid climate. Agricultural Water Management 95: 895-908. doi:10.1016/j.agwat.2008.02.015.

Rashwan E, MousaA, EL-SabaghA, Barutçular C (2016) Yield and Quality Traits of Some Flax Cultivars as Influenced by Different Irrigation Intervals. Journal of Agricultural Science 8:226-240. DOI:http://dx.doi.org/10.5539/jas.v8n10p226.

Sander JZ, Bastianssen AS, Wim GM (2011) Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. Agricultural Water Management 67:115-133.DOI:http://doi.org/10.1036/j.agwat.2004.04.007.

Singh AK, Roy AK, Kaur DP (2007) Effect of irrigation and NPK no nutrient uptake pattern and qualitative parameter in winter maize + potato intercropping system. International Journal of Agriculture and Science 3: 199-209.

Stone LR, Schlegel AJ, Gwin RE, Khan AH (2006) Response of corn, grain sorghum, and sunflower to irrigation in the High Plains of Kansas. Agricultural Water Management 30: 251-259. DOI: http://doi.org/10.1016/0378-3774 (95)01226-5

Yazar A, Sezen SM, Gencel B (2012) Drip irrigation of corn in the Southeast Anatolia Project (GAP) area in Turkey. Irrigation and Drainage 51: 293-300. DOI: 10.1002/ird.63

Yazar A, Howell TA, Dusek DA, Copeland KS (2009) Evaluation of crop water stress index for LEPA irrigated corn. Irrigation Science, 18: 171-180. DOI: 10.1007/s002710050059

Yildirim E, Kodal S (2008) Effect of irrigation water on corn grain yield in Ankara conditions. Turkish Journal of Agriculture and Forestry 22: 65-70.