INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 6, No. 2, p. 15-23, 2015

RESEARCH PAPER OPEN ACCESS

Effect of zinc foliar, potassium elements and irrigation terms of concentrations of nitrogen, phosphorus and potassium in grain and some quantitative characteristics of corn (KSC704)

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Key words: Corn (Zea mays), water deficit stress, concentration elements, foliar.

http://dx.doi.org/10.12692/ijb/6.2.15-23 Article published on January 18, 2015

Abstract

This study investigated the effects of nutritional elements on quantity characteristics and concentration of N, P and K in grain of Corn (*Zea Mays L.* K.S.C704) under water deficit stress. The research was conducted with complete randomized block experimental design with split-plot arrangement with three replications. In this experiment, the main plots consisted of water deficit with 3 levels: alternate furrow irrigation (AFI), conventional furrow irrigation (CFI) and fixed furrow irrigation (FFI), and subplots with different fertilizer combinations: P+N (control) (1) P+N+K (2) P+N+K+Zn (3) P+N+K+Zn+B (4), P+N+K+Zn+B+Fe (5). Interaction effects of treatments of irrigation and fertilization indicate that the Zn foliar increased concentrations of these elements in the grain.The highest and lowest of N, P and K uptake, grain yield and LAI were 117.56, 42.73, 55.7 Kg.ha, 12950 Kg.ha 3.86 and 113.42, 17.4, 16 Kg/ha, 8894 Kg/ha, 2.41 from Alternate furrow irrigation and (C+ K, Zn,B, Fe) fertilizer treatment and fixed furrow irrigation and control respectively. The highest of light use efficiency were obtained from Alternate furrow irrigation and conventional furrow irrigation and(C+K,Zn,B,Fe) fertilizer treatment with 0.175 Kg.Kcal.m_2. In order to utilize the water sources efficiently and increase corn production under limited water supply, we propose the use of circular irrigation care along with instance, K, Zn, B and Fe fertilizer.

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Introduction

Water deficit stress and mineral nutrient deficiencies often limit the productivity of corn (*Zea Mays L.*). In many of the important corn growing regions of the world (Tandon, 2005).

Water is a scarce resource in Iran because of highly variable amounts of rainfall. The intensity of the effects of water stress on plants is variable according to the timing, duration and magnitude of the deficit (Pandey *et al*, 2001).

In many regions of the world, in -cluding Iran, water stress is one of the most important factors responsible for decreasing agricultural crop yields(Zahedi *et al.*, 2012).

On the global scale, Maize has the third cultivation and output after wheat and rice. About 17 percent of the global area has under Irrigated agriculture (Cavero *et al.*, 2006). During water shortage, plants that used the methods to obtain tolerance to water stress (Bartles and Villalobos, 2009). One of these methods is using nutritional element supplies such as potassium and zinc (Tisdalo, 2005). Productivity is often limited by periods of water deficit and in a number of regions zinc deficiency occurs, but the interaction between zinc nutrition and water stress has not been studied extensively (Khan *et al.*, 2004) .The amount of K uptake by plants is higher than any other mineral element except nitrogen; its catalytic role that activate about 60 enzymes in the plant is of special importance (Hodges, 2007). The relationship between potassium and protein is of particular importance in plant metabolism. The investigation showed that the potassium deficiency, accumulation of free nitrogen in leaves is higher (Beegle, 2004). If Zinc deficiency, conversion of nitrogen into protein compounds is reduced and amino acids and amides accumulate in plant (Khurana and Chatterjee, 2008). The main effect of zinc is on the P uptake of the grain that this issue is due to reducing insoluble or low-soluble compounds of phosphorus (Fixen, 2010). Daniel *et al*, (2008) reported that Zinc deficiency in the soil cause that was reduced yield and efficiency of nitrogen, phosphorus and potassium respectively. The studies of Denmead & Shaw (1992) showed that water deficit stress during pollination stage, in the later stages of vegetative growth and in the stage of ear growth reduced the grain yield by 50, 25 and 21 percent respectively (Song & Dia, 2006). For foliar applications, powdered zinc sulfate can be dissolved in water and applied to the leaf tissue. The amount dissolved should supply 0.5 to 1.0 lb. Zn per acre when a rate of 20 gallons of water per acre is used. A zinc chelate can also be mixed with water. The amount of chelate mixed with water should supply 0.15 lb. Zn per acre when water is sprayed at a rate of 20 gallons per acre. Kaya and Higgs (2002) evaluated the response of tomato (*Lycopersicon esculentum* L.) cultivars to foliar application of zinc when grown in sand culture at low zinc. Foliar treatments entailed applying zinc as either 0, 0.35 or 3.5 mmol l!1 $ZnSO_4{\cdot}7H_2O$ to the tops of plants grown at low zinc (0.15 µmol l!1) in nutrient solution twice a week during the course of the experiment. Plants treated with 0.15 µmol l!1 Znin the nutrient solution and high levels of zinc (3.5 mmol l!1) applied as a foliar spray showed a significant decrease in the production of dry matter, chlorophyll and green fruit yield as compared with those grown both at 7.70 µmol l!1Zinc in the nutrient solution and at 0.15 µmol l!1Zinc in nutrient solution with 3.5 mmol l!1Zinc applied as a foliar spray. There were differences between the cultivars but no consistent link between these differences and nutrient concentrations within the plant. It seems that placing fertilizer in the non-irrigated furrow of an alternate-furrow irrigation system or placing fertilizer in the row with either alternator every-furrow irrigation has the potential to decrease fertilizer leaching and nutrient elements poisoning without reducing crop productivity (Kajdi and Pocsia, 2003). Kassab(2005) indicated that foliar application of Zn, Mg, Mn and Fe significantly increased growth parameters, yield and its components in mungbean plants.

The objective of the present study was to evaluate the response of maize growth; yield and quality parameters to different irrigation management and nutrient supply with a view to reducing irrigation applied and extend the farming lands with a minimum of yield loss.

Materials and methods

A new irrigation method under different nutritional element supplies for maize production was designed and tested for seed quantitative parameters with complete randomized block experimental design with split-plot arrangement with three replications. This study was conducted under various irrigation strategies and fertilizer combinations with the corn hybrid"KSC704". Irrigation was applied through furrows in three ways as the main plots: alternate furrow irrigation (AFI), fixed furrow irrigation (FFI), and conventional furrow irrigation (CFI). AFI means that one of the two neighboring furrows was alternately irrigated during consecutive watering. FFI means that irrigation was fixed to one of the two neighboring furrows. CFI was the conventional way where every furrow was irrigated during each watering. Each irrigation method was further divided into five sub-treatments with different fertilizer combinations: (1) P+N (control) (2) P+N+K (3) P+N+K+Zn (4) P+N+K+Zn+B (5)P+N+K+Zn+B+Fe. One third of nitrogenous fertilizer was used at sowing and the remaining was used at the beginning of germination. Required Fe was extracted from iron sequestering fertilization source (13% Fe) whereas Zn and B were extracted from their commercial resource and according to advices of laboratory, The Zn, Fe and B micro-fertilizers with 4000, 8000 and 6000 ppm condensations concentrations respectively were used through three stages and the beginning of implantation. Before harvesting, yield components such as the number of grains and 1000 grain weight in each row were recorded. Grain yield was calculated in each split-plot after grain moisture reached 14% and the weight of each grain was determined after counting and finally the harvest index was calculated by ratio of grain yield to total above ground biomass. Within each plot, an area of 4 m_2 was hand harvested to determine grain yield, leaf area index and total above ground biomass. Dry weights were recorded after the plant material had been oven-dried at 70°C for 48 h. The extinction coefficient (k) was calculated by the received daily light by canopy surface (lo) and latitude according to Nassiri Mahalaty & Kropft, (1997). The extinction coefficient (K) was calculated by the following equation Based on Floyed *et al.*,(2007). Ii/Io=e-kl.

Light use efficiency calculated from the slope of the regression line between cumulative dry matter and light were calculated with Excel software (Nassiri Mahalaty& Kroph, 1997).

LAI (leaf area index): After separating the leaves, the leaves area was measured immediately in the samples by using the portable LAI meter, model IM-300. To measuring nutrient concentrations of nitrogen, phosphorus and potassium on seed was used from Wet digestion method. Uptake of nitrogen, phosphorus and potassium was calculated by multiplying the concentration of the element in the grain on grain yield.

At the end of growth stage we collected 10 plants from each plot randomly for determination of plant characteristics and data were subjected to analysis of variance (ANOVA) using Statistical Analysis System [SAS, 1988] and followed by Duncan's multiple range tests. Terms were considered significant at $P< 0.05$.

Results

Results of analysis of variance showed that the interaction effects of water deficit and nutritional elements on the characteristics of N Concentration, P Concentration, K Concentration, N Uptake, P Uptake, K Uptake, Number of grains per row, 1000 grains weight, Leaf area index, Radiation use efficiency, Grain yield, biological yield, Number of grains per row, were significant at the ($P<0.05$).

Data of interactive effect between that water deficit and Zn Foliar and potash has been demonstrated in table 2, 4.

Nitrogen concentration and uptake in the grain

Results of analysis of variance showed that the interaction effects of irrigation and nutritional elements on Nitrogen concentration and N uptake in the grain were significant at the ($P<0.05$) (Table 1). The highest and lowest concentration of nitrogen and N uptake were obtained that the treatments of alternate furrow irrigation (CFI) and fertilizer treatment (C + K, Zn, B, Fe) (A_1*B_5) and CFI *C+K+Zn+B(A_1*B_4) with (1.68 %) and (217.56 Kg ha^{-1}) and the alternate irrigation of fixed and control (A_3B_1) with (1.42 percent and 113.62 Kg ha^{-1}), respectively. Many researchers have been reported that Zn is increasing N uptake in plants. The reason of increasing N uptake is considered because of increasing the dry weight of aerial components (Gupta& Singh, 2005). Foliar application of Zn and Mn increased concentration of these two elements in seed (Movahhedy- Dehnavy *et al*, 2009).

Table 1. Mean squares of some biochemical parameters.

		M.S					
SOV	df	N Concentration	P Concentration	K Concentration	N Uptake	P Uptake	K Uptake
Replication	2	6.41^{ns}	0.31^{ns}	3.46^{ns}	1.877^{ns}	13.249^{ns}	30.805^{ns}
Irrigation (I)	2	188.8^{**}	1.61^{*}	4.25^{**}	1.49^{**}	0.0007^{*}	0.135^{*}
Error(a)	4	2.01	0.24	0.05	0.001	0.0001	0.015
Fertilizer (F)	4	7.29*	3.81*	0.78^{*}	0.16^{*}	0.0052^{*}	0.061^{*}
I×F	8	201.4^{**}	39.25^{**}	28.45^{**}	2.25^{**}	0.145^{**}	18.45^{**}
Error (b)	24	1.24	0.49	0.11	0.0021	0.0008	0.009
CV (%)	-	6.32	5.25	6.09	8.41	9.23	7.89

*.** means significant in 0.05 and 0.01 Level of probability respectively and ns: non-significant.

Table 2. The interaction of Zn Foliar and potash on nutrient concentration and nutrient Uptake under water deficit stress.

Treatments	N Concentration (%)	P Concentration (%)	K Concentration (%)	N Uptake (kg ha-1)	P Uptake (kg ha-1)	K Uptake (kg ha-1)
CFI *C(A_1*B_1)	1.55^{bc}	0.27^{bc}	0.29^{d}	146.47^{de}	25.51^{cde}	27.4^{f}
CFI *C+K(A_1*B_2)	1.59^{b}	0.29^{b}	0.37^{bc}	163.45^{cd}	29.8^{bc}	38.03^{d}
CFI *C+K+Zn(A_1*B_3)	1.64^{ab}	0.32_{a}	0.41^{ab}	177.12^{bc}	34.56^{b}	44.3^{c}
CFI *C+K+Zn+B(A_1*B_4)	1.68^{a}	0.34^{a}	0.43^{a}	206.64^{a}	41.82^{a}	52.9^{ab}
CFI*C+K+Zn+B+Fe(A_1*B_5)	1.68^{a}	0.33^{a}	0.43^{a}	217.56^{a}	42.73^{a}	55.7^{a}
AFI*C(A_2*B_1)	1.52^{bc}	0.25^{cd}	0.23^{ef}	141.97^{de}	23.35^{de}	21.5^{fg}
AFI*C+K(A_2*B_2)	1.57^{b}	0.26^{c}	0.28^{de}	160.6^{cd}	26.6^{cde}	28.6^{ef}
AFI*C+K+Zn(A_2*B_3)	1.6^{ab}	0.28^{bc}	0.34^{c}	169.9^{c}	29.73^{c}	36.1^{d}
AFI*C+K+Zn+B(A_2*B_4)	1.63^{ab}	0.32^{a}	0.37^{bc}	196.58^{ab}	38.6^{ab}	44.6^{c}
AFI*C+K+Zn+B+Fe(A_2*B_5)	1.64^{ab}	0.32^{a}	0.38^{b}	204.5^{a}	39.9^{a}	47.4^{bc}
FFI*C(A_3*B_1)	1.42^{c}	0.22^{d}	0.2^{f}	113.62^{e}	17.6^{e}	16^{g}
FFI*C+K(A_3*B_2)	1.47^{c}	0.24^{cd}	0.25^{e}	123.58^{e}	20.17^{e}	20.17^{g}
FFI*C+K+Zn(A_3*B_3)	1.52^{bc}	0.26^{c}	0.28^{de}	133.4^{e}	23.12^{de}	24.9^{fg}
FFI*C+K+Zn+B(A_3*B_4)	1.52^{bc}	0.28^{bc}	0.33^{c}	147.6^{de}	27.19^{cde}	32^{def}
FFI*C+K+Zn+B+Fe(A_3*B_5)	1.52^{bc}	0.28^{bc}	0.33^{c}	156.1^{cd}	28.75^{c}	33.9^{de}

CFI, AFI and FFI: conventional furrow irrigation, alternate furrow irrigation and fixed furrow irrigation, respectively. Means with the same letter in each column have not statistically significant difference.

Phosphorus concentration and uptake in grain

The Interaction of treatments of irrigation and nutritional element supplies on the concentration of phosphorus and its uptake was significant at one percent level (Table1). The highest and lowest amount were obtained from the treatments of conventional irrigation and fertilizer (C + K, Zn, B) with 0.34 percent and alternate irrigation or fixed and control (A_3B_1) with 0.22 percent respectively. Interaction of irrigation and nutritional element supplies on P uptake in the grain was significant at one percent level. The highest and lowest rate of P uptake in grain with 42.73 Kg ha^{-1} and 17.6 Kg ha^{-1} were obtained from the levels of conventional irrigation and fertilizer treatments (C + K, Zn, B, Fe) and alternate irrigation of fixed and control (A_3B_1), respectively. There is a positive interaction between zinc and phosphorus that the use of boron increases this interaction. In this case the amount of P uptake in the grain and the yield increase that is consistent with the results of this research. Bacon *et al* (2007) Which result to decreased growth and development or death of plant. It has also been well documented that water content and other mineral levels were all positively correlated with organic nitrogen level (Janssen, 1993). The results of the present investigation on increased Fe, phosphorus and nitrogen levels in relation to water deficit samples confirm this report. Jupp and Newman (1987) reported an increase in phosphorus uptake by plant during mild drought. The results obtained on the significant increase in phosphorus level of water deficit samples (WOC) confirm the earlier report of Jupp and Newman (1987).

Table 3. Mean squares of some biochemical parameters.

		M.S					
SOV	df	Number of grains per row	1000 grains weight	Total above ground biomass	Grain yield	Leaf area index	Radiation use efficiency
Replication	2	69.21^{ns}	1201.49^{ns}	368541.55^{ns}	589882.0^{ns}	0.375^{ns}	0.039^{ns}
Irrigation (I)	2	29.88**	24815.47**	1897921.35**	21582314.21**	5.893*	0.354*
Error(a)	4	0.559	525.44	525.0	374249.44	1.525	0.051
Fertilizer (F)	4	135.42**	21423.71**	1241392.26**	6579938.11**	29.354**	0.128**
I×F	8	75.42**	27001.47**	998841.35**	33414111.39**	17.421**	0.268**
Error (b)	24	0.529	1589.51	989.3	253928.21	0.980	0.020
CV (%)	-	10.28	8.45	16.36	15.89	6.12	7.80

*.** means significant in 0.05 and 0.01 Level of probability respectively and ns: non-significant.

Table 4. The interaction of Zn Foliar and potash on some quality and quantity characteristic under water deficit stress.

Treatments	Number ofgrains per Row (N.o)	1000grains Weight (gr)	Total above ground biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Leaf area index	Radiation use Efficiency (Kg $kcal^{-1}m^{-2}$)
CFI *C(A_1*B_1)	26.3 ^{e}	326 ^{cd}	20485 ^{e}	9450 ^{ef}	3.23 ^{bc}	0.099 ^{d}
CFI *C+K(A_1*B_2)	28.4 ^{d}	330 ^{c}	21345 ^{d}	10280 ^{d}	3.41 ^{b}	0.108 ^{d}
CFI *C+K+Zn(A_1*B_3)	30.7 ^{cd}	342 ^{bc}	22420 ^{c}	10800 ^{c}	3.54 ^{ab}	0.118 ^{cd}
CFI *C+K+Zn+B(A_1*B_4)	34.6 ^{b}	354 ^{b}	23400 ^{b}	12300 ^{b}	3.71 ^{a}	0.140 ^{bc}
CFI*C+K+Zn+B+Fe(A_1*B_5)	36.8 ^{a}	382 ^{a}	24920 ^{a}	12950 ^{a}	3.86 ^{a}	0.166 ^{ab}
AFI*C(A_2*B_1)	25 ^{ef}	321 ^{cd}	19936 ^{f}	9340 ^{ef}	2.74 ^{cd}	0.106 ^{d}
AFI*C+K(A_2*B_2)	27.7 ^{de}	327 ^{cd}	21040 ^{d}	10230 ^{d}	2.87 ^{cd}	0.111^{d}
AFI*C+K+Zn(A_2*B_3)	30.2 ^{cd}	340 ^{bc}	22159 ^{c}	10620 ^{c}	2.995 ^{c}	0.127 ^{c}
AFI*C+K+Zn+B(A_2*B_4)	34 ^{b}	349 ^{bc}	23274 ^{b}	12060 ^{b}	3.14 ^{bc}	0.155 ^{b}
AFI*C+K+Zn+B+Fe(A_2*B_5)	35.9 ^{ab}	374 ^{a}	24760 ^{a}	12470 ^{a}	3.38 ^{b}	0.175 ^{a}
FFI*C(A_3*B_1)	21.1 ^{g}	304 ^{d}	18431 ^{h}	8002 ^{g}	2.41 ^{d}	0.108 ^{d}
FFI*C+K(A_3*B_2)	23.6 ^{f}	312 ^{d}	18972 ^{g}	8407 ^{g}	2.63 ^{d}	0.114 ^{cd}
FFI*C+K+Zn(A_3*B_3)	26 ^{e}	319 ^{cd}	19530 ^{f}	8894 ^{f}	2.84 ^{cd}	0.130 ^{c}
FFI*C+K+Zn+B(A_3*B_4)	28.9 ^{d}	327 ^{cd}	20186 ^{e}	9710 ^{e}	2.99^{c}	0.154 ^{b}
FFI*C+K+Zn+B+Fe(A_3*B_5)	31.6 ^{c}	334 ^{c}	20729 ^{de}	10270 ^{d}	3.13 ^{bc}	0.163 ^{ab}

CFI, AFI and FFI: conventional furrow irrigation, alternate furrow irrigation and fixed furrow irrigation, respectively. Means with the same letter in each column have not statistically significant difference.

Potassium Concentration and uptake in the grain

The Interaction of treatments of irrigation and nutritional element supplies on the concentration of potassium and its uptake was significant at one percent level (Table 1). The highest and the lowest amount achieved from treatments of conventional irrigation and fertilizer treatment (C + K, Zn, B) and (C + K, Zn, B, Fe) with 0.43 percent and alternate irrigation or fixed and control (A_3B_1) with 0.2 percent respectively. Interaction of irrigation treatment and nutritional element supplies on K uptake in the grain was significant at one percent level. The highest and lowest rates of K uptake in grain with 55.7 Kg ha^{-1} and 16 Kg ha^{-1} were obtained from the levels of conventional irrigation and fertilizer treatments (C + K, Zn, B, Fe) and alternate irrigation of fixed and control (A_3B_1), respectively. The Zn effect on increasing the concentration of potassium in the grain has been reported by other researchers including (Daniel *et al*, 2008 & Fixen, 2005). But Karimiyan (1995) observed that increasing the Zn concentration in wheat grain, K concentrations in the grain is decreased but N and P concentrations in grain is increased. But in this study by the use of zinc, K concentration has not decreased that is inconsistent with the result of Karimiyan (1995). The uptake of K, N and P by water deficit plants showed their relevance and significance in plant growth and development (survival). It is well established that K is involved in the formation of enzymes, and nitrogen fixation.

The number of seed per row

The results of interactions showed that the treatment of conventional irrigation and fertilizer levels (C + K, Zn, B, Fe) with 36.8 had the highest number of seeds in the row and the least amount was obtained from the alternate irrigation of fixed and control fertilizer treatment with 21.1 number. Water shortage causes the delay in appearance of silk (Tandon, 2005) and reduction of Zn uptake and nutrient, specially the drought stress at flowering stage prevent from the emergence of primary cells of flower and affect the number of seed per ear (Lauer, 2003) that it is quite evident in this study.

Thousand seed weight

The interactions showed that and the lowest amount achieved from treatments of conventional irrigation and fertilizer treatment (C + K, Zn, B, Fe), with average of 382 gr had no significant difference with the alternate irrigation of rotational and fertilizer treatment (C + K, Zn, B, Fe) and alternate irrigation or fixed and control fertilizer treatment with the average 304 gr, respectively.

Water stress in corn reduces the transfer of photosynthesis materials and prevents from the growth and expansion of the seed (Nelson, 2006) and thousand seed weight is reduced. In this research, the treatment containing macronutrients and three micronutrients obtained the highest rate of thousand seed weight in the condition of low irrigation which is consistent with results of other researchers (Wasson *et al*, 2009). The water tension in corn, because of leaf water, decreases the photosynthesis and transposition of the materials and excludes the growth of seed (Nelson, 2006) and so the weight of 1000 grains declines. The inspections declared that the total carbohydrate, starch and protein of grain have increased using Fe and Zn and thus the resistance of plant against the deficit irrigation increase (Marschner, 1995). Deficit irrigation in the regeneration stage of corn leads to the death of granule tube in spike and using some elements such as enough Zn, B and K in the soil leads to lessening this damage and their processes in the soil increase the resistance of plant against the possible damages resulted from deficit irrigation (Lauer, 2006).

Grain yield

The treatment of conventional irrigation and fertilizer levels (C + K, Zn, B, Fe), with 12950 kg.ha had the highest seed yield that had no significant difference with the treatment of alternate irrigation of rotational and fertilizer treatment (C + K, Zn, B, Fe) and were located at the same statistical group. The lowest amount of yield is also obtained from the treatment of alternate irrigation of fixed and control fertilizer treatment with 8002 kg.ha. According to Nelson (2006), if low irrigation conditions will be applied in the stages of tasseling and filling and the pasty stage seed yield is decreased by 35. 24 and 10 percent, respectively. Fertilizer treatment applied in this study increased the seed yield by 25% that reflects importance of the elements used in increasing the plant tolerance to drought stress. The presence of elements such as zinc, boron and potassium in the soil, in condition of low irrigation, increase the tolerance of corn through different mechanisms (Lauer, 2003). The results obtained here suggest that foliar Zn and Mn application can improve the seed yield and seed quality of safflower grown under drought stress (Movahhedy- Dehnavy *et al*, 2009).

Biological yield

The highest and lowest biologic yield were acquired from conventional irrigations and fertilizer treatment (C + K, Zn, B, Fe) with an average 24920 Kg ha^{-1} which wasn't so different from alternate irrigation of rotational and fertilizer treatment (C + K, Zn, B, Fe), fixed and control fertilizer treatment with 18431 Kg ha^{-1} respectively. Isarangkura *et al,* (2007) reported the increase of dry matter production in the crop corn by using one kilogram of zinc as solution spray or 10 to 20 kilograms per hectare of zinc as the land use. They found that dry matter yield of corn is reduced by 50 percent due to stress of Zn deficiency. The results obtained from this study also indicate that the use of potassium and zinc elements can increase the biological yield by 12%.

This confirms that Zn solution spray together with the alternate furrow irrigation of fixed and the use of micronutrient fertilizer+ Zn foliar spray is increased by 11 percent compared to its similar treatment with fixed irrigation and control fertilizer treatment that shows the effect of Zn element. By taking Zinc, N uptake increase that is due to increasing dry weight of aerial components (Gupta & Singh, 2005). Chimenti *etal* in 2002 which express occurrence of water deficit stress has significant difference on total above ground biomass at end of flowering stage, but microelement Consumption prevented severe reduced total above ground biomass and HI, also this is viewed on grain in row.

LAI

The highest leaf area index was obtained from two treatments of conventional irrigation and fertilizer treatment (C + K, Zn, B, Fe) with an average of 3.86 that had not significant difference with the treatment of conventional irrigation and fertilizer treatment (C + K, Zn, B) and both were located at the statistical class of a and the lowest amount of LAI was obtained from the treatment of alternate irrigation of fixed and control fertilizer treatment with the average of 2.41. The results obtained in this study showed that low irrigation reduced leaf area that is inconsistent with the results of Boyer (2006); in this study the stress applied from the very beginning of vegetative growth that has influenced growth and expansion of the leaf.

Radiation use efficiency

The highest RUE was obtained from the levels of alternate furrow irrigations and fertilizer treatment (C + K, Zn, B, Fe) with an average 0.175 Kg kcal^{-1}m^{-2}and the lowest amount was obtained from the treatment of conventional irrigation and control fertilizer treatment with an average of 0.099 Kg kcal^{-1}m^{-2}. There is a direct relationship between two elements of LAI and RUE and by increasing LAI per unit area, the extinction coefficient is reduced and URE is increased. In this study, Zn foliar spray together with macronutrient increase the green area of corn plant compared to other treatments and by applying the special methods of irrigation, RUE has significant difference with fertilizer treatment and the triple irrigation that this indicates that the effect of zinc on RUE is more than the irrigation method applied in this research.

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