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Maize (*Zea Mays* L.) Growth and Yield Response to Ethephon Application under Water Stress Conditions

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ABSTRACT- The aim of the present investigation was to study the growth, yield and yield components of maize (*Zea mays* L.) single cross 704 under different levels of irrigation, plant density, and ethephon in southern Iran where this particular crop has not yet been studied in detail. A field experiment was performed in the 2004 5 growing season at the experimental farm of the College of Agriculture, Shiraz University, Shiraz, Iran, located at Badjgah. The experimental design was a randomized complete block with four replicates where the treatments had a split split plot arrangement. Irrigation level (low and high) was the main plot, plant density (53,333 and 80,000 plants/ha) the subplot, and ethephon level (0, 0.56, 0.84 kg/ha a.i., applied at the 6 leaf stage) the sub subplot. The results showed that the rates of foliar application of ethephon could play an important role in maize growth indices, and attribute to grain yield components. Application of ethephon was associated with a decrease in Leaf Area Index (LAI), Leaf Area Index Duration (LAID) and Crop Growth Rate (CGR). Furthermore, ethephon reduced plant and ear height. Increasing the application rates of ethephon showed a significant reduction in early season plant height and LAI, LAID. The control plants had lower grain yield than those treated with different rates of ethephon. Indeed, this research showed that under conditions of water stress, the maize plant is able to make better use of available water if vegetative growth is partially restricted early in the season. The results also indicated that the yield response of maize to ethephon application would vary with plant density and available water conditions. Ethephon treatment was found to be more beneficial for grain yield with higher plant densities and under water stress conditions.

Keywords: Ethephon, Growth analysis, Water stress, Plant density and *Zea mays* L

INTRODUCTION

Drought, like many other environmental stresses, has adverse effects on crop yield, and is the most limiting factor in crop production (2, 20, 29 and 30). Maize is reported to be relatively tolerant to water stress during its vegetative growth phase, very sensitive during tasseling, silking and pollination, and moderately sensitive during grain filling stages (31). Thus, if a crop is relying heavily on a limited supply of stored soil water, slowing the rate of soil water extraction prior to anthesis should increase the amount of available water remaining in the soil afterwards (13). One way to reduce the rate of soil water extraction would be to reduce the size of the evaporative surface or leaf area index (13 and 26).

Plant growth regulators such as ethephon (2-chloroethyl phosphonic acid) have been primarily used as anti lodging agents in corn fields grown under optimum conditions (4, 10, 21 and 27). Alternatively, plant growth retardants could be used to reduce early season crop water use by reducing LAI, resulting in extended water

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availability for critical reproductive and grain filling processes and thereby increasing grain yield under drought stress (13, 23 and 28). Some studies confirm that for Mediterranean environments, ethephon can induce modifications in crop growth and development, to improve the efficiency of water use in maize under severe water stress conditions (e.g. 5 and 25). Plant density also affects LAI, which in turn influences the pattern of seasonal water use, as well as grain yield, of corn. Optimal plant densities are highly dependent on available seasonal water; lower plant densities are more suited to lower available seasonal water (8 and 13).

The objective of the present study was to examine the effects of water stress, plant density and plant growth regulator (ethephon) on the growth, development and grain yield of maize (*Zea mays* L.) single cross 704, under agroclimatic conditions of southern Iran at Badjgah.

MATERIALS AND METHODS

A field experiment was conducted at the Experimental Farm of College of Agriculture, Shiraz University, Shiraz, Iran, located at Badjgah (29° 50′ N and 52 ° 46′ E; elevation 1810 m above mean sea level) in the 2004-2005 growing season. The soil characteristics of the experimental site, Daneshkadeh soil series (Fine, mixed, mesic, Calcixerollic, Xerochrepts), are given in Table 1. The experimental design consisted of a factorial combination of two irrigation levels (low and high), two plant densities (53, 333 and 80, 000 plants ha $^{-1}$), and three ethephon levels (0, 0.56 and 0.84 kg ha $^{-1}$, applied at the 6-leaf stage) in a randomized complete block with a split-split plot arrangement and four replications. Irrigation levels constituted the main plots, plant densities the subplots, and ethephon treatments the sub-subplots.

The seeds were hand-sown, in plots of 3 m wide and 5 m long. Within each row the seeds were 19 cm (high density) and 29 cm (low density) apart, and rows were 70 cm apart. Uniformity of sowing depth was achieved by using a hand dibber to make holes of 5 cm deep.

Nitrogen and phosphate were applied to each plot as urea and ammonium phosphate at the rate of 400 kg ha^{-1} and 250 kg ha^{-1}, respectively.

Half of the nitrogen fertilizer (urea) was top dressed at the 6-leaf stage. The plots were regularly hand weeded. The low and high irrigation levels consisted of approximately 30 and 100% replacement of weekly evapotranspiration (ET) losses. The plots were irrigated by furrow irrigation. The amount of water applied to each plot was determined by the following equation, (18):

$$d = (FC - \Theta)\, D/100 \qquad (1)$$

Where

FC= field capacity, % (volume basis)

Θ= soil moisture content, % (volume basis)

D= soil depth, cm

d= irrigation water depth, cm

Table.1. Soil Physicochemical characteristics of the experimental site

Properties	Index or amount
Classification	CX*
Field capacity (%)	34
Wilting point (%)	15
Silt (%)	48
Clay (%)	30
Sand (%)	22
Soil texture	clay
Soil pH	7.68
Potassium (mg kg^{-1})	590
Phosphorus (mg kg^{-1})	26
Organic carbon (%)	1.17
Organic matter (%)	1.75
Total nitrogen (%)	0.114
Electrical conductivity (dS m^{-1})	0.402

*** CX= Calcixerollic, Xerochrepts**

The rates of ethephon application at any individual application were 0 (none), 0.56 (medium, M) and 0.84 (high, H) kg a.i. ha^{-1}, and time of application was based on the 6-leaf growth stage. In early morning (to prevent evaporation), ethephon was foliarly sprayed using a back sprayer system consisting of a hand-held boom with nozzles spaced 0.76 m apart. The solution containing ethephon and a surfactant (10 ml L^{-1}), was delivered at a pressure of 207 kPa in a spray volume of 233 L.ha^{-1}. During spraying each plot was surrounded by plastic walls to avoid the drift of solution to the adjacent plots.

Plots were sampled throughout the growing season from after sowing to the final harvest. At each sampling, 5 adjacent plants in two rows of each plot were taken for laboratory measurements of plant height, the internodes' length, the internodes' diameter, LAI, and dry matter. Plant height was measured from the soil surface to the collar of the tassel. The length of each internode was measured by tape and then averaged. After detaching the leaves along with the leaf sheath, the diameter of each 1^{st} to 3^{rd} internode was measured with a caliper with an accuracy of 0.01mm. Leaf area index and dry matter yield were determined by destructive vegetative samplings. Plants from two central rows within each plot were cut from the soil surface and the leaves were removed from the leaf collar.

Leaf area was determined with a leaf area meter, Delta T Device model. Crop growth rate (CGR), leaf area index (LAI), and leaf area index duration (LAID) were determined using the following equations(9):

$$CGR = 1/G_A . (W_2 - W_1)/ (T_2 - T_1) \qquad (2)$$

$$LAI = (1/ G_A). (L_{A2} + L_{A1})/2 \qquad (3)$$

$$LAID = (L_{A2} + L_{A1})/G_A . (T_2 - T_1)/2 \qquad (4)$$

Where

L_{A1} and L_{A2} = area, cm^2

G_A = ground area, cm^2

T = duration, d

W = dry weight, g

Dry weights were determined after the plant materials were oven-dried at 65 º C for 72 hours. At maturity, the following characters were measured from the center of two rows in each plot: Ear number per plant (ENP), kernel row number per ear (KRNE), kernel number per ear row (KNER), kernel number per ear (KNE), mean kernel weight (MKW) (mg), grain yield (GY) (t/ha), harvest index (HI) (%), ear length (cm) and ear diameter (mm).

ANOVA was conducted on the data by MSTATC software using the SAS statistical procedure, and treatment means were compared using a least significant difference (LSD) test.

RESULTS AND DISCUSSION

LAI and LAID

Two rates of foliar ethephon treatments (0.56 and 0.84 kg .a.i ha^{-1}) at the 6-leaf stage decreased LAI in both years, as compared to the control. Ethephon significantly reduced LAI at both rates of application though not at all samplings (Fig. 1). LAID was also decreased by ethephon application (Table 2) following a decrease in LAI. Similar results were reported by Shanahan and Nielsen (28), Kasele et al (13), Peltonen-Sainio and Peltonen (23) and Riccardo et al (25), where they found that LAI and dry matter of maize plants were reduced 10% to 40%, under ethephon treatment compared to the control plants.

This reduction in early vegetative growth, particularly LAI, was very likely responsible for a reduction in early season soil water extraction associated with ethephon treatments, resulting in conserving more available soil water for later growth in the season, and has also been noted by others e.g. (17, 23 and 28).

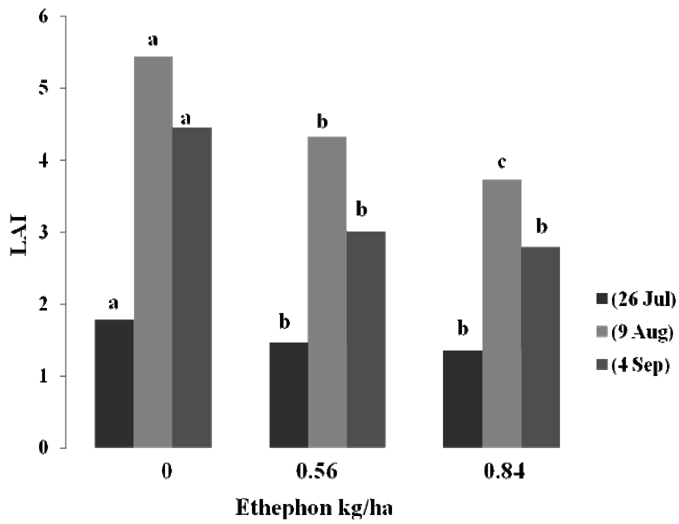

Fig 1. Effect of ethephon on LAI of maize plant (2005) Columns with the same letters are not significantly different for each sampling date, LSD (0.05)

Results of this experiment also indicated that, vegetative growth indicators such as LAI and LAID were affected by the irrigation treatment. Water stress reduced both LAI and LAID (Table 2). The plant density and ethephon rate had a significant interaction with LAI (Table 3). Plants without ethephon at higher plant density had the highest LAI. Other levels of ethephon at higher plant density reduced LAI. Such reduction in LAI and LAID at higher plant density and higher ethephon rate (Table 2), showed a reduction in plant water stress symptoms under water deficit conditions which was associated with an increased late-season plant growth. Our results appear to substantiate the conclusions of Kasele et al (1994), who suggested that PGRs (ethephon) could be used to increase avoidance of drought stress under higher plant densities in the maize crop.

Table 2. Effect of irrigation regime, plant density and ethephon on vegetative growth factors of maize plants

Treatment	LAI	LAID (LAI d)	CGR (g m^{-2} d^{-1})	LAI_{max}	Dry matter (g/plant)
Irrigation regime					
High	**3.42a**	**39.99a**	**12.92a**	**4.905a**	**100.1a**
Low	**2.87b**	**32.99b**	**8.727b**	**4.095b**	**65.80b**
Plant densities (plants/ha)					
80 000	**3.23a**	**37.31a**	**10.87a**	**4.816a**	**74.70b**
53 333	**3.06b**	**35.67a**	**10.78a**	**4.185b**	**91.20a**
Ethephon (kg/ha)					
0	**3.88a**	**44.32a**	**12.96a**	**5.450a**	**90.35a**
0.56	**2.93b**	**34.72b**	**10.53b**	**4.327b**	**84.98ab**
0.84	**2.61b**	**30.44c**	**8.975c**	**3.724c**	**73.52b**

Means within each column with the same letters are not significantly different using, LSD (0.05)

Mean CGR and total dry matter (TDM) production

CGR was reduced due to ethephon application (Fig. 2). CGR is an index of canopy photosynthesis and its trend represents the rate of biological yield (dry weight) accumulation (9). Ethephon also reduced total dry matter (total dry weight) of each plant. This finding was in agreement with the results of Georgiev (11), and Cox and Andrade (1988), who evaluated a lodging-susceptible and lodging-tolerant hybrid (Cornell 281 and Pioneer 3901) under recommended (64 000 plants/ha) and high plant density (76 000 plants/ha) in the absence and presence of ethephon. Their results showed that ethephon reduced both growth parameters (i.e. CGR and dry matter).

Indeed, ethephon affected LAI negatively (shown Fig. 1), and this was associated with the reduction in mean CGR and total dry matter in both years. Earley and Slife (7) also demonstrated that increasing the rate of ethephon applied at several different stages before tasseling reduced leaf area, LAI and other growth parameters such as CGR. Our data also suggested that growth retardant (ethephon) might be more beneficial under water stress conditions, (Fig. 3) since it reduced LAI and mean CGR and therefore improved water availability for the reproductive phase of the crop. However, this reduction in LAI and mean CGR was not beneficial for the maize crop under optimum moisture conditions. This finding was in agreement with the results of Georgiev (11) and Cox and Andrade (4).

Table 3. Interaction effect of plant density and ethephon on LAI

Ethephon (kg/ha)	80,000 (plants/ha)	53,333 plants/ha	Mean
0	5.074 a	3.842 b	3.88A
0.56	3.291bc	2.745 cd	2.93B
0.84	3.073c	2.503 d	2.61B
Mean	3.23A	3.06B	

Means with the same letters are not significantly different using, LSD (0.05)

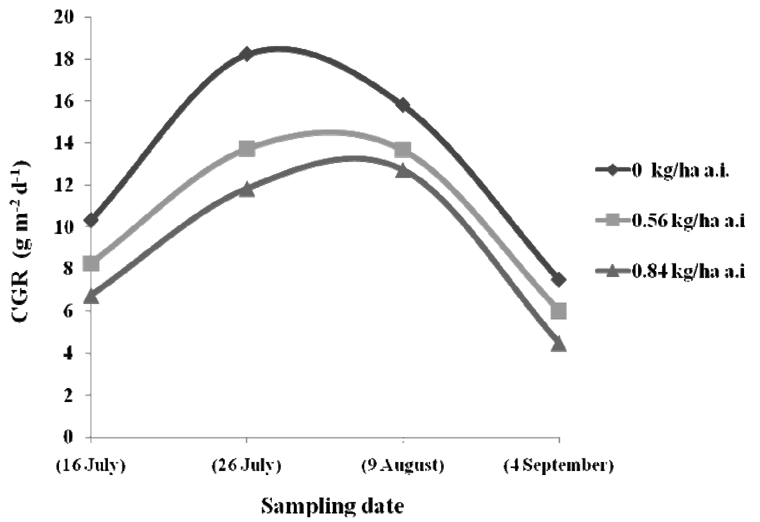

Fig 2. Seasonal patterns of crop growth rate (CGR) and effect of different ethephon levels on it in 2005 growing season

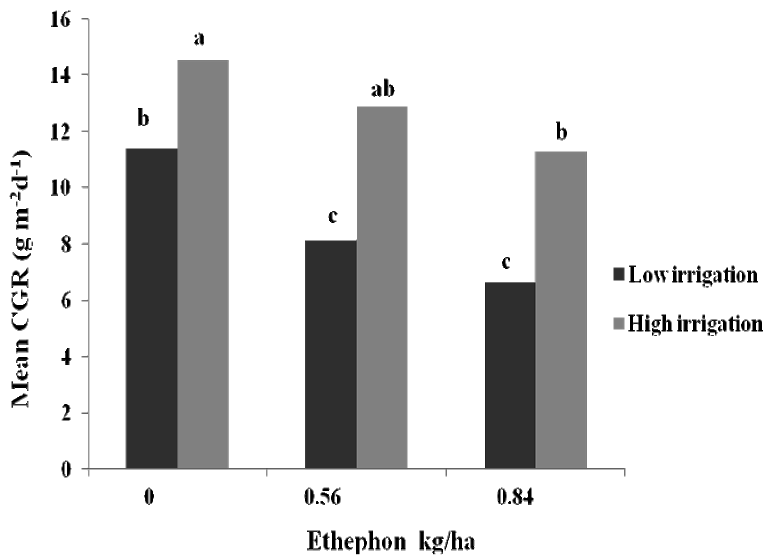

Fig 3. Interaction between different levels of irrigation and ethephon levels on CGR of maize plant. Columns with similar letters are not significantly different, LSD (0.05)

Plant and ear height

Results of the present investigation indicated that ethephon application significantly reduced the maize plant and ear height as compared to the control (Table 4). In general, the higher the rate, the greater the retardation of stem growth. Ethephon rate has been reported to have highly significant effects on plant height (4), ear height (5, 13 and 25) and internode length (7), and increasing the ethephon rate has been associated with more reduction in plant height. Hence ethephon could reduce lodging in maize (5, 10, 14 and 32). When the potential for lodging is high, introducing ethephon at the higher rates and late applications may be more effective in preserving the maize yield (10). However, if lodging is not a significant problem (like our experiment), early ethephon application might be advisable for improving grain yield through increased water saving by reducing LAI and plant height at higher plant densities and under drought stress conditions.

Internode length and diameter

As reported by many researchers, reduced plant height might be due to decreased internode length upon ethephon application (3, 5, 16 , 21 and 24). In our experiment the length of internodes was reduced by ethephon application (Fig. 4). Since the internode length of control plants was increased towards the top of the plant, it follows that maximum plant height reduction could be obtained by ethephon treatment immediately prior to cell elongation (i.e. early stage, 6-leaf) of the longest, uppermost stem internodes.

Ethephon also had a significant effect on internode diameter, such that there was significant increase in internode diameter following ethephon application (Fig. 5). Therefore, when there is a potential for lodging, ethephon application might be effective in reducing lodging through increasing the basal internodes' diameter (5,10, and 14).

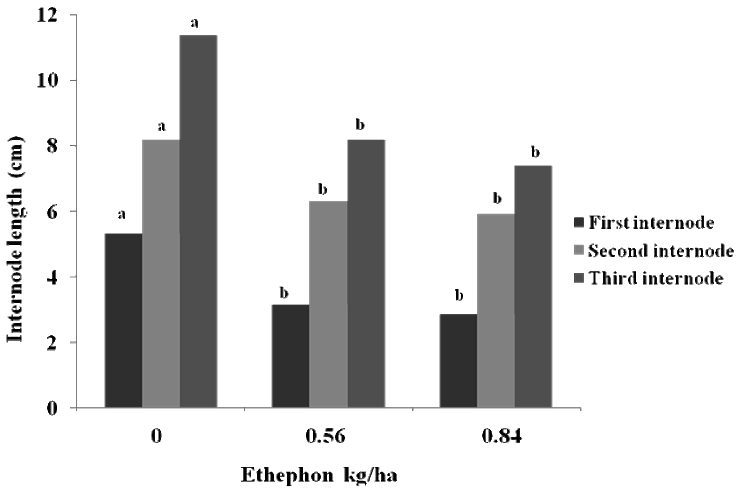

Fig 4. Effect of ethephon on internode length of maize plant in 2005 growing season. Columns with the same letters are not significantly different for each internode, LSD (0.05)

Leaf number

It was shown that ethephon application reduced the leaf number of maize plants (Fig. 6). There was no significant difference between the two levels of ethephon application in either growing season. It appeared that ethephon altered the morphology and vegetative growth of maize producing plants with lower, smaller and thicker leaves (1, 14 and 15).

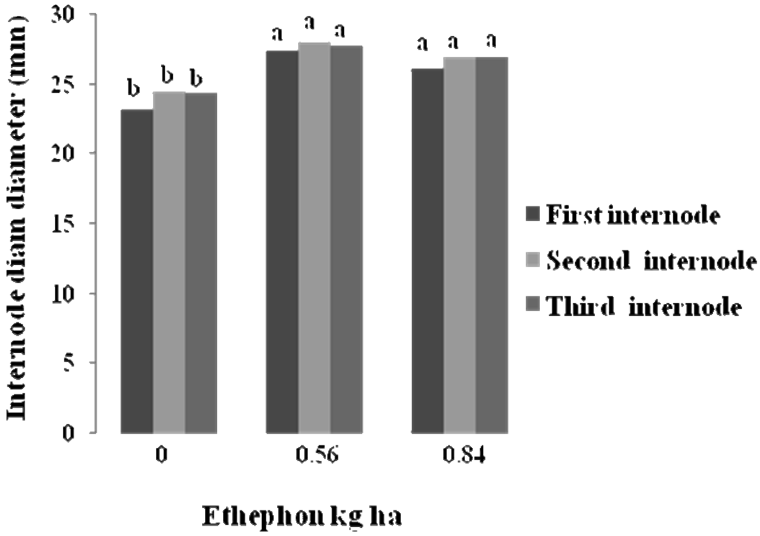

Fig 5. Effect of ethephon on internode diameter of maize plant in 2005 growing season. Columns with the same letters are not significantly different for each internode, LSD (0.05)

Under low irrigation conditions, leaf number reduction following ethephon application could enablemaize plant s to make better use of available water, if provided that vegetative top growth is restricted early in the season (28).

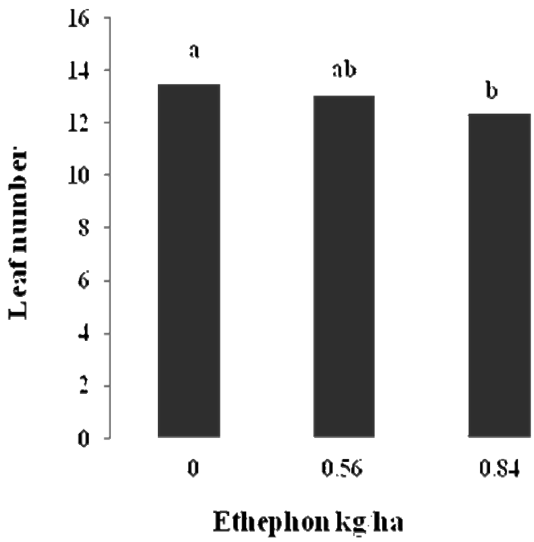

Fig 6. Effect of ethephon levels on leaf number of maize plant in 2005 growing season. [Columns with the same letters are not significantly different for ethephon rates], LSD (0.05)

Table 4. Vegetative growth of maize plants as affected by irrigation, plant density and ethephon (2005)

Treat-ment†	Plant height cm	Ear height cm	Inter-node length cm			Inter-node number	Inter node number from soil to ear	Leaf number	Inter-node diameter		
			1st	2nd	3rd				1st	2nd	3rd
			cm						mm		
IRG-R											
High	260.5a	107.1a	3.875a	7.608a	10.26a	13.29a	8.083a	13.00a	26.74a	27.91a	27.33a
Low	196.8b	78.86b	3.700a	5.996b	7.696b	13.17a	7.958a	12.96a	24.49b	25.56a	25.48a
P-D (P/ha)											
53 333	224.7b	90.73a	3.883a	6.675a	8.321b	13.54a	8.042a	13.67a	26.16a	27.31a	27.14a
80 000	232.7a	95.27a	3.692a	6.929a	9.633a	12.92b	8.000a	12.29b	25.06a	25.66a	25.66a
Et (kg/ha)											
0	241.8a	102.6a	5.325a	8.175a	11.35a	14.06a	8.500a	13.50a	23.25b	24.55b	24.42b
0.56	225.6b	91.51b	3.169b	6.306b	8.175b	13.06b	7.875b	13.06ab	27.43a	27.95a	27.80a
0.84	218.6c	84.94c	2.869b	5.925b	7.406b	12.56c	7.688b	12.38b	26.16a	26.95a	26.99a

†- IRG-R (Irrigation regime), P-D (Plant density), Et (Ethephon); Means with the same letters in each column are not significantly different using, LSD (0.05)

Yield and yield components

A highly significant difference was found between grain yield for the low and high irrigation levels. Thus, the irrigation regime significantly affected productivity (Table 5). Kernel number per unit area (KN) and the mean kernel weight (MKW) were responsible for the difference in yield between the two irrigation levels observed in this study (Table 5). Although there was no significant difference between ethephon-treated and control plants for the grain yield (Table 5), a significant cross over interaction between irrigation regimes and ethephon treatment was observed for the grain yield in this study. Grain yield increased in response to increasing rates of ethephon under water stress conditions. Conversely, grain yield decreased in response to the ethephon treatment under the high irrigation treatment (Table 6). Similar results have been reported (13 and 28). Indeed the effect induced by ethephon in conserving early season soil water use and ultimately reducing water stress during silking and early grain development was very likely to be responsible for the differences in yield under low water level conditions (Table 6).

Westgate and Boyer (33) found that water stress during the critical period of silking to early grain development inhibits photosynthesis and consequently lowers the carbohydrate reserves to levels that are insufficient to support optimum reproductive development. Such effects explain the observations made in this study concerning the reduction of kernel number per unit area in the control versus ethephon treated plots under water stress conditions (data not shown). In fact, the control plants were under greater water stress conditions than the ethephon-treated plants.

Table 5. Grain yield (GY), ear number per plant (ENP), kernel row number per ear (KRNE), kernel number per ear row (KNER), kernel number per ear (KNE), kernel number per square meter (KN), mean kernel weight (MKW), harvest index (HI), ear length (EL) and ear diameter (ED) of maize plants as affected by irrigation regime, plant density and ethephon (2005)

Treatment	GY (t/ha)	ENP	KRNE	KNER	KNE	KN No m^{-2}	MKW (mg)	HI (%)	EL (cm)	ED (mm)
IRG-R										
High	10.77a	0.8636a	14.75a	42.50a	624.1a	3579a	230.0a	60.74a	20.29a	24.60a
Low	7.298b	0.7389b	14.79a	41.21a	609.5a	3076b	201.9b	48.48b	19.85a	21.63b
P-D (P/ha)										
80, 000	10.35a	0.7423b	15.13a	39.46b	596.3a	3615a	217.6a	57.92a	19.38b	22.82a
53,333	7.719b	0.8601a	14.42b	44.25a	637.3a	3041b	214.3a	51.30a	20.77a	23.41a
Et (kg/ha)										
0	9.109a	0.7622a	15.19a	42.19a	639.6a	3189a	210.0b	49.27a	20.94a	21.37b
0.56	9.544a	0.8274a	14.88ab	41.00a	608.5a	3438a	219.1a	59.11a	19.75b	23.73a
0.84	9.574a	0.8141a	14.25b	42.38a	602.4a	3355a	218.8a	55.48a	19.52b	24.25a

† IRG-R (Irrigation regime), P-D (Plant density), Et (Ethephon); Means within each column with the same letter are not significantly different using, (LSD 0.05)

However, with optimal irrigation it seems likely that maximum leaf area development is necessary for full interception and conversion of solar radiation to photosynthate and carbohydrate reserves in order to support maximum reproductive development and grain growth. Thus, the reductions in leaf area during vegetative growth due to ethephon application resulted in lower grain yields when plants were well-watered (Table 6). This finding was in agreement with the results of Shanahan and Nielsen (28), Riccardo et al (25), and Dahmer et al (5) who reported that under conditions of water stress, a maize plant is able to make better use of available water if vegetative top growth is restricted early in the season by ethephon treatment.

Under water deficit conditions, maximum yield was attained for ethephon application of 0.84 kg/ha a.i. as well as the highest plant density (Table 6). Similar modifications in the grain yield of corn have been reported (13) and for bean plants (12). Ethephon treatments appear effective in reducing leaf surface area, especially during early season, and thus the conservation of water. While direct measurements of plant water stress were not accounted for in this study, the observed increases in number of kernels per unit area and mean kernel weight (MKW) with ethephon application at high plant density indicated that ethephon application has probably reduced plant water stress during such critical phases as reproductive and grain filling. Furthermore, the results indicated that ethephon application was most beneficial to yield and yield components at high plant density and under water stress conditions. These results are likely due to the reduction in early-season evapotranspiration associated with ethephon application and reduced plant water stress during reproductive growth, particularly for the high plant density treatment. Several studies have shown that plant water stress during reproductive growth negatively impacts kernel number, kernel size and grain yield (e.g.5, 6 and 19).

Table 6. Effect of PGR (ethephon) level, plant density and irrigation levels on grain yield of maize plants (t/ha) (2005)

Ethephon (kg/ha)	Plant densities (plants/ha) 53 333	80 000	Mean
	Low irrigation level		
0	5.185de	8.285cd	6.335C
0.56	5.048e	8.600cd	7.324B
0.84	5.115e	8.925c	7.834B
Mean	6.058C	8.537B	
	High irrigation level		
0	9.810bc	12.65a	11.23A
0.56	9.390c	11.70ab	10.55A
0.84	8.740cd	12.15a	10.55A
Mean	9.380B	12.17A	

Means with the same letter are not significantly different using, LSD (0.05)

Ethephon, as a growth regulator, was shown to be an effective means of reducing the excessive vegetative growth of maize plants (5 and 13)In this study, it was shown that the yield and yield components could be affected by the foliar ethephon application at the 6-leaf stage. The rates of ethephon foliar treatments can play an important role in maize growth indices and attributed grain yield components. Indeed, this research has shown that under conditions of water stress, a maize plant is able to make a better use of available water if vegetative growth is restricted early in the season. Apparently, the ethephon mediated effects on crop canopy development and seasonal water use are of greater importance to field performance under water stress conditions than potential reductions in intrinsic single leaf water use efficiency. The results also indicated that the yield response of maize to ethephon application would vary with plant density and available water conditions. Ethephon treatment was beneficial for grain yield responses at higher plant densities and under water stress conditions.

As the data suggest ethephon application seems to have potential use for improving maize crop performance under water stress conditions which is worthy of further explorations.

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واکنش رشد و عملکرد ذرت (*Zea mays L.*) به کاربرد اتفان تحت شرایط تنش آبی

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چکیده- اثر اتفان بر تغییرات رشد رویشی با لحاظ نمودن مصرف آب، در تراکم های مختلف بوته ذرت طی شرایط تنش خشکی در جنوب ایران هنوز به طور دقیق بررسی نشده است. هدف مطالعه حاضر بررسی اثرات تنش آبی، تراکم کاشت و تنظیم کننده رشد (اتفان) بر رشد، نمو و عملکرد دانه ذرت (*Zea mays* L.) سینگل کراس ۷۰٤ ، تحت سطوح مختلف آبیاری می باشد. این پژوهش در قالب آزمایشی مزرعه ای در مزرعه پژوهشی دانشکده کشاورزی، دانشگاه شیراز واقع در باجگاه در سال زراعی ۸٤-۸۳ ، انجام شد. این مطالعه به صورت کرت های دوباره خرد شده در قالب بلوک کامل تصادفی با چهار تکرار اجرا شد. سطوح آبیاری (کم آبیاری و آبیاری مطلوب) در کرت های اصلی، تراکم کاشت با دو سطح (۵۳,۳۳۳ و ۸۰,۰۰۰ بوته در هکتار) در کرت های فرعی وتنظیم کننده رشد (اتفان) با سه سطح (۰ ، ۰/۵٦ و۰/۸٤ کیلوگرم ماده موثر در هکتار ، که در مرحله 6 برگی اعمال شد) در کرت های فرعی فرعی قرار داده شدند. نتایج نشان داد که کاربرد سطوح مختلف اتفان به صورت برگ پاشی بر شاخص های رشد و اجزای عملکرد دانه مرتبط با آن نقش مهمی داشت. کاربرد اتفان سبب کاهش سرعت رشد محصول (CGR)، شاخص سطح برگ (LAI) و دوام شاخص سطح برگ (LAID) شد. بعلاوه، کاربرد اتفان از ارتفاع بوته و ارتفاع بلال کاست. کاهش ارتفاع بوته، LAI وLAID در ابتدای فصل رشد با افزایش مقدار اتفان مرتبط بود. بوته های شاهد در مقایسه با بوته هایی که اتفان دریافت کرده بودند، عملکرد کمتری داشتند. در واقع این پژوهش نشان داد که چنانچه در ابتدای فصل رشد از رشد رویشی ذرت کاسته شود، می توان از آب موجود استفاده بهتری کرد. همچنین نتایج نشان داد که پاسخ عملکرد ذرت به کاربرد اتفان به تراکم بوته و فراهمی رطوبت بستگی خواهد داشت. تاثیر مفید کاربرد اتفان بر عملکرد دانه در شرایط تراکم زیادتر بوته و تنش آبی، زیادتر بود و این موضوع شایسته پژوهش‌های بیشتری در آینده است.

واژه های کلیدی: اتفان، آنالیز رشد، تنش آبی، تراکم کاشت و ذرت

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