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Effect of different levels of drought tension and Ca. on qualitative and quantitative characteristics of maize crop (ksc 704)

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ABSTRACT

In order to compare the effect of elemental calcium on qualitative and quantitative indicators of maize crop under drought tension, a study was conducted in a field located in Kamarbandi, Varamin, as split plots according to complete randomized blocks design in triplicates in 2009. The results showed that the highest performance of grains was obtained at 14467.1 kg/ha through conventional irrigation and spraying 8% Ca. The highest performance components such as grain umbers per row and rows per maize obtained at 18.4 and 14, respectively, by conventional irrigation and spraying 8% Ca. The highest performance components such as grain numbers per row and rows per maize obtained at 18.4 and 14, respectively, by conventional irrigation and spraying 8% ca. the highest weight of thousand, 283.6g, resulted from conventional irrigation and spraying 4 ppm ca. Oil and protein percentage were also affected by irrigation and calcium treatments. The highest and the lowest percentage of oil obtained respectively through conventional irrigation treatment and spraying 8% ca. and discontinued irrigating treatment from 7-9 leaves to rolling stage and control at 4.81% , while discontinued irrigation treatment from 7-9 leaves to rolling stage and spraying 8% ca. resulted in the highest protein percentage at 9.43%. the results showed that oil and protein percentages have a reverse relationship where increasing the amount of one of them results in decreasing the others'. The highest amount of leaf prolin was obtained at 0.726 micrograms per g through discontinued irrigation treatment (a4) to leaf rolling stage and the lowest one, 0.221 m/g, resulted from conventional.

Keywords : maize, calcium, drought tension, prolin, performance, performance components.

INTRODUCTION

Thension or stress was, for the first time applied by biological scientists about living beings [3]. Drought is a term used in meteorology representing a period with a level of rainfall representing a period with a level of rainfall lower than the potential evaporation and perspiration levels. When the internal moisture of the plants is below 50% due to the dryness of the weather, the plants is exposed to deficit stress water [7]. According to Majidi Heravan (2002) dryness, from the viewpoint of agriculture, applied to a condition in which the amount of rainfall is so small that will cause the reductipn of crop performance. Plants ability to adapt to the drought effects and to grow and reproduce under drought tension because of having characteristics obtained through their evolution affected by environmental conditions and natural selection is called drought resistance [35]. Tibbits (1979) proved that appling 25mm water at critical growth stage, same as 100 mm water in the watering season, is useful. Edmeades et.al. (1994) suggested water deficiency as one of the most important problems for a successful production. Annually about 17 percent of global performance is lost because of dryness which my even increase up to 70% [7]. One of the most common responses of the plants to the environmental tensions specially osmotic variations (caused by dryness and salinity) is osmotic adjustment or osmotic balance [2]. This is to increase the swelling pressure of cells to perform some important physiological activities including cells growth and pores movements [35]. The plants response and adaptation to this condition is very complicated and partly variable. The plants use some ways to be tolerant against spryness. These are include some variations in metabolic processes [24], variations of membrane structure [16]. Producing a specific gene [37] and producing secondary metabolites [32]. When the plants are exposed to drought, salinity, and low temperature, their free proline amount increases [2] . research showed that grain numbers per row and grain numbers per maize of genotype ksc 704 significantly affected by nitrogen and drought tension, that drought tension reduced grain numbers per maize and grain umbers per row, but increased nitrogen uptake improved these at the stage of and filling grains reduces final grain weight consequently thousand grains weight [27]. Drought tension affects the biological performance of the plant so that water deficiency reduces the biological weight of the plant. This is confirmed by Boyer's research (1997). Researchers suggested that under dryness conditions, the harvest index significantly affected by drought tension, but nitrogen had no significant effect on this index [6]. Shirinzadeh (2004), in contrast to wastigit (1994) who suggested that harvest index is constant under tension and drought condition, stated grain performance and biomass decrease, harvest index should be reduced. One of the adaptation processes used by maize plant under drought conditions is reduction of leaf area in order to reduce perspiration [31] in general, drought plants and grains [9]. Investigators believe that although dryness has a negative effect on performance and performance components, water deficiency specially at production and granulation stages increases protein percentage [14] . calcium deficiency may reduce merystem tissues, deform the leaves and chlorize young leaves [28] . studies show that treting maize grains whith 15-20 mmol ca. solution improve heat – tolerance of maize embryos [23] . other studies suggest that ca. loading in root cells over-stimulates oxygen and releases it under drought tension [29].

MATERIALS AND METHODS

In order to examine the effectiveness of using ca. on quantitative characteristics of maize of genotype ksc 704 under dryness condition at atmosphere condition of Varamin, a study was conducted as split plots according to complete randomized blocks design in triplicates and 12 treatments at field located in Kamarbandi, Varamin, in 2009.

The location characteristics were as follows. Eastern longitude of 39' and 51˚, and northern the treatments included four irrigation levels at main plots as follows :

1. Conventional irrigation
2. Discontinued irrigation at 7-9 leaves stage for 12 d.
3. Discontinued irrigation at 7-9 leaves for 20 d.
4. Discontinued irrigation at 7-9 leaves til leaves rolling and included three levels of fertilizer containing ca. as :

1- Spraying pure water
2- Spraying 4% ca.

3- Spraying 8% ca. at minor plots.

The required fertilizer applied according to the recommended soil test including 300kg/ha urea, 60 kg/ha super triple phosphate, and 120 kg/ha potassium sulphate where all fertilizers, but urea applied at plowing.

One – third of nitrogen fertilizer used at planting and the remaining applied with first and second spraying at early stem – forming and flowering. It should be noted that ca. was of the fertilizer source was performed evenly by a back – sprayer at calm days. Conventional irrigation was performed for the plots. At the growth period, needed practices include weeding at three stages by hand and removing weed between replicates by a rotivator were performed.

Leave area index measured by leaf area Meter.

Following each tension step, cell membrane stability was measured through making a diskette of leaves of each treatment, then placing it in distilled water for 8h and measuring Ec of the remained solution.

To determine the relative water content in leaves at complete irrigation stages, the temporary and complete wilt ness points, 3 leaves were cut of the highest leaves of each bush at 11.30 AM and then a circular disk was removed from these leaves and measured (fresh weight) immediately by an accurate weight (gram thousandth), then the samples were put in distilled water to swell completely. Having removed from distilled water, the surface of the samples was dried and then they were weighed.

They samples were placed in aluminum containers in an oven (dryer) at 104˚c for 8 h. to measure their dry weight. At the end, relative water content (RWC) and water saturation deficiency (WSD) were measured using these formulae [4] :

$$Rwc = \frac{Fw - Dw}{Tw - Dw}.100 \qquad Wsd = \frac{Tw - Fw}{Tw - Dw}$$

Fw = fresh weight
Dw = dry weight
Tw = turgidity weight

Finally, before harvesting, considering the elimination of marginal effects in all treatments in triplicates, performance components include bush numbers per mm^2, maize numbers per bush, row numbers, and grain numbers per row were measured, crop harvesting performed at 6000 mm2, and grain performance was measured after the moisture of grains reached 14%.

Thousand grains weight determined following enumeration. Biological performance was measured through adding aerial part faction and grain performance (14% moisture) and harvest index was calculated through (biological function / economic performance) *100.

The samples, then, transferred to laboratory to determine oil percentage using succulence method [1] and protein percentage through Kjeldal method.

Measuring ca. percentage was done with the help of moist oxidation and use of three acids mixture (perchtoric, sulfuric, nitric).

For measuring purloin, 0.5g leaf materials was crused in 5ml 95% ethanol, the top part of the solution was removed, its precipitate rewashed by 70% ethanol and its surface was added to the previous part. The obtained solution centrifuged at 3500 rpm for 10 min.

The top part of the solution was removed and stored at 4˚c before determining purloin [21].

At the end, the obtained data generalized to hectars. Varance analysis was performed using done using multi-range Duncan test at 5 and 1%.

RESULTS AND DISCUSSION

Height of bush

Table 1 shows that the simple effect of irrigation and using fertilizer containing ca. and the mutual effects of the factors were significant at 1%. Table 2 shows that the highest bush, 218.6cm was obtained through conventional irrigation which was at the top of the table with treatment a2. The lowest bush, 143.6cm, obtained using discontinued irrigation treatment at 7-9 leaves stage to leaf rolling. Applying ca. showed the highest and the lowest bush height. Respectively, at 197.75 cm with b3 and 165.5 cm with b1.

Table 1 : Variance analysis of bush height, chlorophiyll content, leaf area index, relative water content, and water saturation deficiency affected by irrigation.

Variation resources	Freedom degree	Bush height	Leaf area index	Chlorophyll content	Relative water content	Water saturation deficiency
Replicate	**2**	**14/28***	**2/35 ns**	**0/000411 ns**	**165/41***	**170/32***
Irrigation	**3**	**184/42 ****	**72/83 ****	**0/00496 ****	**1845/60 ****	**945/44****
A error	**6**	**39/99**	**13/13**	**0/000725**	**111/49**	**69/68**
Ca. spraying	**2**	**21/82 ***	**1/48 ns**	**0/00131***	**99/45***	**109/85***
Ca. *irrigation A*B	**6**	**200/42 ****	**104/84 ****	**0/00918 ****	**2503/04****	**1004/45****
B error	**16**	**19/40**	**7/77**	**0/00483**	**39/49**	**75/79**
CV		**12/21**	**7/91**	**11/45**	**10/05**	**8/87**

*Ns: no significant difference *and** : difference at 5% and 1%*

Table 2 : mean comparison of mutual effects of simply treatment and ca. fertilizer on bush height, chlorophyll content, leaf area index, relative water content, water saturation deficiency.

Treatment	Bush height (cm)	Leaf area index	Chlorophyll content (mg/g)	Relative water content (%)	Water saturation deficiency(%)
Conventional irrigation	**218/6 a**	**6/18a**	**40/3 a**	**92 a**	**8 d**
Discontinued irrigation at 7-9 leaves stage to 12d	**200/3 a**	**6/15 a**	**39/7 a**	**73/63 b**	**26/37 c**
Discontinued irrigation at 7-9 leaves stage to 20d	**167 b**	**4/88 b**	**32/6 b**	**53/96 c**	**46/04 b**
Discontinued irrigation at 7-9 leaves stage to leaf rolling	**143/6 c**	**3/82 c**	**20/3 c**	**34/13 d**	65/**87 a**
Pure water spraying	**165/5 b**	**5/14 b**	**30/35 b**	**58/55 b**	**41/45a**
4% ca. spraying	**184 ab**	**5/27 a**	**34 a**	**63/9 b**	**36/1a**
8% ca. spraying	**197/75a**	**5/35 a**	**35/35 a**	**76/85 a**	**23/15 b**

Means with the same letter in each column have not statistically significant difference

Table 3: mean comparison of mutual effects of irrigation treatment and ca. fertilizer on bush height, chlorophyll content, leaf area index, relative water content, water saturation deficiency.

Treatment	Bush height (cm)	Leaf area index	Chlorophyll content (mg/g)	Relative water content (%)	Water saturation deficiency(%)
Conventional irrigation *pure water	**b204**	**a6/13**	**b37/8**	**a88/6**	**g11/4**
Discontinued irrigation * 4% ca.	**ab220**	**a6/17**	**ab40/8**	**a92/4**	**gh7/6**
Discontinued irrigation * 8% ca.	**a232**	**a6/24**	**a42/3**	**a95**	**h5**
Discontinued irrigation to 12d* pure water	**c176**	**a6/11**	**b37/5**	**b70/4**	**e29/6**
Discontinued irrigation to 12d* 4% ca.	**b201**	**a6/14**	**ab39/9**	**b73/2**	**ef 26/8**
Discontinued irrigation to 12d* 8% ca.	**a224**	**a6/19**	**a41/8**	**b77/3**	**f 22/7**
Discontinued irrigation to 20d* pure water	**d154**	**bc4/72**	**d28/9**	**D47**	**c53**
Discontinued irrigation to 20d* 4% ca.	**cd168**	**bc4/91**	**bc34/6**	**cd55/3**	**d44/7**
Discontinued irrigation to 20d* 8% ca.	**c179**	**b5/01**	**c34/2**	**c59/6**	**d40/4**
Discontinued irrigation to leaf rolling *pure water	**e128**	**bc4/72**	**f17/2**	**e28/2**	**a71/8**
Discontinued irrigation to leaf rolling *4% ca.	**d147**	**c3/87**	**e20/7**	**e34/7**	**b65/3**
Discontinued irrigation to leaf rolling *8% ca.	**d156**	**c3/98**	**e23/1**	**de39/5**	**b60/5**

Means with the same letter in each column have not statistically significant difference

Table 3 showed that the highest bush, 232cm obtained using conventional irrigation and ca. fertilizer which is 54.1% higher compared to discontinued irrigation to leaf rolling and pure water spraying at 128 cm. because elemental calcium is not movable, plants are exposed to ca. deficiency at rapid growth stage which results in low plants requiring ca. [28].

Leaf area index

Table 1,2 and 3 showed that simple effects of irrigation treatment and mutual effects of irrigation and ca. spraying had statistically significant differences. Although ca. spraying slightly changed leaf area index, but simple effects of ca. spraying on leaf area index were not significant and all three treatment placed in the same statistical class (table 1).

The obtained data show that discontinued irrigation at 7-9 leaves stage to leaf rolling decreased leaf area index from 6.18 to 3.82 in discontinued irrigation treatment at 7-9 leaves stage to leaf rolling.

It should be noted that treatment a2 and conventional irrigation treatment were assigned the same statistical class (table 2).

The mutual effects of these two factors had more effect on the leaf area index as the highest leaf area index at 6.24 obtained through treatment a1b3 and a4b2 at 3.87 was assigned the last one.

Boyer (1997) suggests that under dryness or discontinued irrigation conditions, leaf area index is not affected by tension factor and it does not much change. While pander et.al. (2000) state that under drought condition maize reduces its leaf area to decrease perspiration there by optimizes water and nutrients [34].

Chlorophyll content

Tables 1, 2 and 3 show that simple effects of irrigation and ca. treatments and their mutual effects on chlorophyll content were significant at 1%.

Data showed that conventional irrigation treatment changed chlorophyll content of leaves by 49.3% compared to discontinued irrigation to leaf rolling stage – which reached 20.3 mg/g fresh leaf by a4 from 40-3 mg/g fresh leaf by conventional irrigation treatment to 12d also resulted in the highest leaf area index. Simple effects of ca. fertilizer treatment showed that the highest amount of chlorophyll in leaves obtained using 8% ca. spraying at 35.35mg/g which had no significant difference b2 and both were placed in the first statistical class of mean comparison table. Pure water spraying at 30-35 fresh leaf mg/g showed the lowest content.
Mutual effects of tested factors showed that chlorophyll content of leaves from 42-3 mg/g through conventional irrigation and 8% ca. spraying to 17.2 mg/g by discontinued irrigation treatment at 7-9 leaves to leaf rolling stage and pure water spraying. Under sever tensions, in is spite of increased specific weight, more chlorophyll destroyed. [26,15] which results in more chlorophyll losses that is in agreement with the obtained results in this study.

Relative water content of leaves:

Table 1,2 and 3 showed that simple effects of irrigation and ca. fertilizer and the mutual effects of the factors affected the relative water content and the differences were significant at 1%. Conventional irrigation treatment produced the highest relative water content of leaves at 92%, while through discontinued irrigation treatment at 7-9 leaves stage to leaf rolling it was 34-13. Ca. fertilizer treatment also slightly increased relative water content. The highest amount of relative water content obtained through ca. fertilizer treatment at 76.85 and the lowest one resulted from pure water irrigation treatment at 58.55. Mutual effects of double factors, ca. fertilizer and irrigation were significant at 1%.

The highest amount of relative water content obtained using a1b3 at 95% which had no significant differences from a1b1, and a1b2 and all three treatment assigned the some statistical class A.

The lowest amount resulted from a4b1 at 28.2% which was at the same level with a4b2. Drought tension reduces relative water content and osmotic potential of leaf cells (i.e. increased soluble matter concentration) so cell tumescence and then perspiration and growth will be reduced [25]. Also there was a positive correlation between reduced moisture of soil and relative water content of leaves [13].

Water saturation deficiency of leaves:

Table 1, 2 and 3 showed that simple effects of irrigation and ca. fertilizer and their mutual effects affected water saturation deficiency of leaves and the differences were significant at 1%. Discontinued irrigation treatment at 7-9 leaves to leaf rolling stage resulted in the highest percentage of water saturation deficiency of leaves, while through conventional irrigation treatment it was 8% ca. fertilizer treatment also slightly changed water saturation deficiency of leaves. The lowest percentage of relative water content obtained through 8% ca. spraying treatment at 23.15 and the highest on resulted from pure water spraying at 41.45% which were placed with b2 in the same class.

Mutual effects of double factors, ca. fertilizer and irrigation treatment on water saturation deficiency were significant at 1%. The highest percentage of water saturation deficiency of leaves obtained through discontinued irrigation treatment at 7-9 leaves to leaf rolling stage and pure water treatment at 71.8% and the lowest on resulted from conventional and 8% ca. spraying at 5%.

Corn numbers per bush:

Data (tables 4, 5, 6) showed that simple effects of irrigation and mutual effects of the double factors, irrigation and ca. fertilizer, were significant at 1%. Drought tension at growth stage to leaf rolling stage reduced corn numbers per bush. Corn numbers per bush in this treatment reached by 1.3 which was not significantly different from a3 and both were assigned the last rank. The highest number of corn per bush resulted through conventional irrigation treatment at 2.63 which had no significant difference till 12d and both were assigned the first statistical class.

Table 4: variance analysis of corn numbers per bush, row numbers per corn, grain numbers per row, thousand grains weight affected by irrigation and ca. fertilizer treatments.

Variation resources	Freedom degree	Corn numbers per bush	Row numbers per corn	Grain numbers per row	Thousand grains weight
Replicate	**2**	**0/041 ns**	**1/42 ns**	**9/94 ns**	**0/045 ns**
Irrigation	**3**	**10/42 ***	**6/25****	**88/49 ****	**0/89****
A error	**6**	**3/20**	**0/97**	**20/82**	**0/029**
Ca. spraying	**2**	**1/08 ns**	**0/87 ns**	**17/79***	**0/065 ns**
Ca. *irrigation A*B	**6**	**22/84 ****	**18/41 ****	**101/88 ****	**0/42 ****
B error	**16**	**3/21**	**0/60**	**14/40**	**0/031**
CV		**6/20**	**5/85**	**14/42**	**6/18**

*Ns: no significant differences *and**difference at 1% and 5%*

Tale 5 : mean comparison of simple effects of irrigation and ca. fertilizer treatments on corn numbers per bush, row numbers per corn, grain numbers per row, thousand grains weight.

Treatment	Corn numbers per bush	Row umbers per row	Grain numbers per row	Thousand grains weight(g)
Conventional irrigation	**2/63 a**	**15/1 a**	**22/5 a**	**279/5 a**
Discontinued irrigation at 7-9 leaves stage to 12d	**2/47 a**	**14/9 a**	**21/2 a**	**272/5 a**
Discontinued irrigation at 7-9 leaves stage to 20d	**1/52 b**	**13/1 b**	**17/1 b**	**236/9 b**
Discontinued irrigation at 7-9 leaves stage to leaf rolling	**1/3 b**	**11 c**	**14/5 c**	**182/8 c**
Pure water spraying	**1/8 a**	**12/8 a**	**16/4 b**	**237/5 b**
4% ca. spraying	**2 a**	**13/7 a**	**19/2 a**	**247/3 a**
8% ca. spraying	**2/12 a**	**14/1 a**	**20/8 a**	**244/5 a**

Means with the same letter in each column have not statically significant difference

Ca. fertilizer treatment caused no significant changes in corn numbers per bush, although fertilizer containing. Slightly increased corn numbers per bush, but the differences were not statistically significant.

Mutual effects of irrigation and ca. fertilizer treatments caused significant changes in corn numbers per bush at 1%. The highest numbers of corn per bush obtained through conventional irrigation and 4% ca. fertilizer (a1b2) at 2.8 which assigned rank A and the lowest one was related to discontinued irrigation to leaf rolling stage and pure water (a4b1) at 1.1.

Tale 6 : mean comparison of mutual effects of irrigation and ca. fertilizer treatments on corn numbers per bush, row numbers per corn, grain numbers per row, and thousand grains weight.

Treatment	Corn numbers per bush	Row numbers per row	Grain numbers per row	Thousand grains weight(g)
Conventional irrigation *pure water	**2/4 a**	**14/2 b**	**19/9 bc**	**275/2 ab**
Discontinued irrigation * 4% ca.	**2/8 a**	**15/3 ab**	**22/8 ab**	**283/6 a**
Discontinued irrigation * 8% ca.	**2/7 a**	**15/8 a**	**24/7 a**	**280/9 ab**
Discontinued irrigation to 12d* pure water	**2/33 a**	**14 b**	**18/4 c**	**268/6 b**
Discontinued irrigation to 12d* 4% ca.	**2/5 a**	**15/2 ab**	**21/7 b**	**275/8 ab**
Discontinued irrigation to 12d* 8% ca.	**2/6 a**	**15/5 ab**	**23/4 ab**	**274/3 ab**
Discontinued irrigation to 20d* pure water	**1/37 bc**	**12/7 bc**	**15/1 d**	**230/4 c**
Discontinued irrigation to 20d* 4% ca.	**1/51 bc**	**13/2 b**	**17/4 cd**	**241/6 c**
Discontinued irrigation to 20d* 8% ca.	**1/7 b**	**13/6 b**	**18/9 c**	**238/7 c**
Discontinued irrigation to leaf rolling * pure water	**1/1 c**	**10/4 c**	**12/3 e**	**176 d**
Discontinued irrigation to leaf rolling * 4% ca.	**1/3 bc**	**11 c**	**14/9 d**	**188/1 d**
Discontinued irrigation to leaf rolling * 8% ca	**1/5 bc**	**11/6 c**	**16/2 d**	**184/2 d**

Means with the same letter in each column have not statically significant difference

Grain numbers per row:

Tables 4, 5 and 6 showed that simple effects of irrigation and mutual effects of irrigation and ca. fertilizer were significant at 1%. Drought tension at growth stage to leaf rolling reduced grain numbers per row, so that it reduced from 22.5 by conventional treatment to 14.5 with discontinued irrigation at 7-9 leaves to leaf rolling stage.

Ca. fertilizer treatment caused significant changes in grain umbers per row and it increased grain numbers per row and the differences were statistically significant at 5%.

The highest numbers of grain per row resulted from 8% ca. spraying treatment averaged at 20.8 which was 21.1% higher compared to the last treatment (pure water spraying).

Mutual effects of irrigation and ca. fertilizer treatments caused 502% change in grain numbers per row. The highest grain numbers per row obtained through conventional irrigation and 8% ca. fertilizer treatment (a1b3) at 24.7 and the lowest one resulted from discontinued irrigation to leaf rolling stage and pure water (a4b1) at 12.3. Research showed that grain numbers per row and grain numbers per corn of genotype Ksc704 significantly affected by nitrogen and drought tension which the tension reduced grain numbers per corn and grain numbers per row while increasing nitrogen resulted in the improved qualities [6, 11].

Row numbers per corn:

Data (tables 4, 5, 6) shows that the differences of simple effects of irrigation and mutual effects of irrigation and ca. fertilizer treatments are significant at 1%. The highest number of row per corn was related to conventional irrigation at 15.1 which were in.

Statistical class A of mean comparison table along with discontinued irrigation treatment. The lowest number of 11 resulted from discontinued irrigation treatment to leaf rolling stage placed in rank C which showed 27.1% reduction compared to the first rank.

Thousand grains weight:

Table 4, 5, 6 showed that the highest thousand grains weight produced through conventional irrigation at 279.5 which was not significantly different from discontinued irrigation treatment at 7-9 leaves stage for 12 d and both assigned the same statistical class. The lowest weight was related to discontinued irrigation treatment through leaf rolling at 182.8.

Ca. fertilizer treatment also affect thousand grains weight reduced it from 247.3 g using 4% ca. spraying treatment to 237.5g by pure water spraying.

Mutual effects of irrigation and ca. fertilizer treatments on thousand grains weight were significant.

The highest weight obtained through a1b2 at 283.6g and the lowest one produced using a4b1 at 176g which assigned rank D that showed 37.9% reduction compared to rank A. The results of a study showed that water deficiency shortens the period of grain filling but it has no effect on accumulating dry matter in endosperm and embryo [36]. At this time, drought tensions reduces photo synthetic of the leaves or transporting of photo synthetic matters, thus the grain weight affected by the tension and will be reduced. Water deficiency causes wildness, prevents from grain development and reduces thousand grains weight [30].

Grain performance:

Tables 7.8 and 9 suggest that simple and mutual effects of irrigation and ca. fertilizer treatments on grain performance were significant and the differences were statistically significant at 1%.

Table 7: Variance analysis of grain performance, biological performance and harvest index affected by irrigation and ca. fertilizer treatments.

Variation resources	Freedom degree	Grain performance (kg/ha)	Biological performance (kg/ha)	Harvest index(%)
Replicate	**2**	**631/22 ***	**1445/3 ***	**6/62 ns**
Irrigation	**3**	**144685/2****	**29282079/1****	**47/59***
A error	**6**	**302/21**	**8641/5**	**6/80**
Ca. spraying	**2**	**652192/6****	**87451/9***	**8/40 ns**
Fertilizer *irrigation A*B	**6**	**7906521/1****	**35407590/8****	**39/83****
B error	**16**	**449/35**	**10145/3**	**3/49**
CV		**14/89**	**15/98**	**13/35**

*Ns: no significant differences *and** : differences at 1% and 5%*

Tale 8 : mean comparison of simple effects of irrigation and ca. fertilizer treatments on grain perform, biological performance and harvest index.

Treatment	Grain performance (kg/ha)	Biological performance (kg/ha)	Harvest index (%)
Conventional irrigation	**12763/8 a**	**24581/2 a**	**51/7 a**
Discontinued irrigation at 7-9 leaves stage to 12d	**12228/3 a**	**23658/8 a**	**51/5 a**
Discontinued irrigation at 7-9 leaves stage to 20d	**5156/2 b**	**10123/5 b**	**51/2 a**
Discontinued irrigation at 7-9 leaves stage to leaf rolling	**2420/1 c**	**5296/4 c**	**45/8 b**
Pure water spraying	**6361/8 c**	**12856/5 b**	**49/6 a**
4% ca. spraying	**7969 b**	**16638/5 a**	**50/1 a**
8% ca. spraying	**9459 a**	**18300 a**	**50/5 a**

Means with the same letter in each column have not statically significant difference

Tale 9 : mean comparison of mutual effects of irrigation and ca. fertilizer treatments on grain perform, biological performance and harvest index.

Treatment	Grain performance (kg/ha)	Biological performance (kg/ha)	Harvest index(%)
Conventional irrigation *pure water	**10167/1 c**	**20857/2 bc**	**48/8 c**
Discontinued irrigation * 4% ca.	**13657/4 ab**	**25654/6 ab**	**53/2 a**
Discontinued irrigation * 8% ca.	**14467/1 a**	**27231/8 a**	**53/1 a**
Discontinued irrigation to 12d* pure water	**9797/5 c**	**19565/2 c**	**50 c**
Discontinued irrigation to 12d* 4% ca.	**12988/7 b**	**24922/3 b**	**52/1 ab**
Discontinued irrigation to 12d* 8% ca.	**13898/6 ab**	**26489/1 ab**	**52/5 ab**
Discontinued irrigation to 20d* pure water	**3854 f**	**7346/1 f**	**52/5 ab**
Discontinued irrigation to 20d* 4% ca.	**5230/2 e**	**10139/4 e**	**51/6 b**
Discontinued irrigation to 20d* 8% ca.	**6384/3 d**	**12885 d**	**49/5 c**
Discontinued irrigation to leaf rolling * pure water	**1628/5 g**	**3457/2 g**	**47/1 d**
Discontinued irrigation to leaf rolling * 4% ca.	**2546/1 g**	**5838 f**	**43/6 e**
Discontinued irrigation to leaf rolling * 8% ca	**3085/8 fg**	**6594 f**	**46/8 d**

Means with the same letter in each column have not statically significant difference

The highest grain performance related to conventional irrigation averaged at 12763.8 kg/ha which was not significantly different from discontinued irrigation treatment at 7-9 leaves stage for 12 d and both assigned rank A. the lowest one obtained through discontinued irrigation to leaf rolling reduced to 2420.1 equivalent to a 81% reduction.

Simple effects of Ca. fertilizer on grain performance were also significant. The highest grain performance produced by 8% Ca. spraying at 9459 kg/ha and the lowest on resulted from pure water spraying averaged at 6361.8 kg/ha.

Mutual effects of the tested factors on grain performance were significant so that the highest grain performance obtained using conventional irrigation and 8% Ca. spraying (a1b3) at 14467.1 kg/ha which showed a 88.7% increase compared to the last rank of the mean comparison table (a4b1) at 1628.5 kg/ha suggesting the importance of calcium under drought stress for grain performance. Some researchers have focused on enough water at corn growth stage and suggested that although drought tension at growth stage and before pollination had less effect on the final performance compared to flowering and grain filling stages but it is of great importance because it affect leat and stem development and change the accumulation of matters [30].

Biological performance:

Date (tables 7,8 and 9) suggest that biological performance also affected by the two tested factors and the differences were significant at 1%.

The highest biological performance resulted from conventional irrigation treatment at 24581.2 kg/ha assigned the same statistical class along a2. Discontinued irrigation to leaf rolling stage produced the lowest performance at 5296.4 kg/h.

Ca. fertilizer treatment caused a 29.75% increase in biological performance which increased to 18300 kg/ha by 8% Ca. spraying water spraying.

Mutual effects of the two factors on biological performance were significant.

The highest biological performance results from conventional irrigation and 8% Ca. spraying treatments at 272318.8 kg/ha. Treatment a4b1 produced the lowest amount at 3457.2 kg/ha.

Sever drought reduction of Co_2 absorption and dry matter production (Hsiao, 2000). Drought tension affects biological performance results in reduced biological weight. This is supported by Boyer (1997) research.

Harvest index:

As shown in tables 7,8 and 9, simple effect of irrigation and mutual effect of the tested factors were significant and the differences were significant at 1%, while fertilizer treatment had no effect on harvest index, the difference were not statistically significant and all three treatment assigned rank A.

The highest harvest index was result of conventional irrigation at 51.7% which had no significant different from a2 a3 and both placed in rank A. The lowest on obtained through discontinued irrigation to leaf rolling at 45.8%.

The highest harvest index produced by conventional irrigation and 4% Ca. spraying at 53.2% which had no significant different from 8% Ca. spraying and both assigned the first statistical class. The lowest one was obtained through discontinued irrigation at 7-9 leaves to leaf roling and 4% Ca. spraying at 43.6. Researchers stated that under drought conditions harvest index was significantly affected by drought tension [6]. While Rahnama et. Al. (2004) believe that drought tension has no significant effect on harvest index but merryland studies showed that dryness at different weight and changed dry weight of the stem because of the effect of photosynthesis tension and dry matter accumulation in the plant.

Oil percentage:

Tables 10,11 and 12 showed that simple effects of irrigation and mutual effects of Ca. fertilizer and irrigation were significant at 5%, while Ca. fertilizer treatment had no significant effect on oil percentage and all treatments assigned the same statistical class.

Mutual effect of the factors showed that the highest oil percentage obtained through a1b3 at 7.1% which had no significant difference from a1b1, a1b2, a2b2, a2b3 and all treatments were assigned class A. The lowest amount obtained using discontinued irrigation to leaf rolling and pure water spraying at 4.81%. Generally drought tension reduces oil amount in all plant species [9].

Table 10: Variance analysis of oil percentage, oil performance, protein percentage and protein performance, prolin content of leaf and Ca. content of grains

Variation resources	Freedom degree	Oil percentage (%)	Oil performance (kg/ha)	Protein percentage (%)	Protein performance (kg/ha)	Prolin content (µmol/gr)	Ca. content (ppm)
Replicate	**2**	**0/0042 ns**	**60/2 ns**	**0/066 ns**	**106/42 ns**	**0/0086 ns**	**1/06 ns**
Irrigation	**3**	**0/079 ***	**285/42 ****	**0/0062 ns**	**1045/39 ****	**0/46****	**3/35***
A error	**6**	**0/0080**	**22/11**	**0/027**	**111/17**	**0/036**	**0/049**
Ca. spraying	**2**	**0/049 ns**	**101/40 ***	**0/021 ns**	**201/41 ***	**0/490***	**8/49 ***
Fertilizer *irrigation A*B	**6**	**0/090***	**308/42 ****	**0/044 ns**	**1583/31****	**1/35****	**15/39 ****
B error	**16**	**0/0041**	**17/21**	**0/009**	**85/84**	**0/099**	**0/030**
CV		**4/46**	**7/29**	**4/72**	**6/18**	**6/92**	**9/83**

*Ns: no significant differences *and** : differences at 1% and 5%*

Tale 11 : mean comparison of simple effects of irrigation and ca. fertilizer treatments on oil percentage, oil performance, protein percentage and protein performance, prolin content of leaf and Ca. content of grains .

Variation resources	Freedom degree	Oil percentage (%)	Oil performance (kg/ha)	Protein percentage(%)	Protein performance (kg/ha)	Prolin content (µmol/gr)	Ca. content (ppm)
Conventional irrigation	**6/9 a**	**883/7 a**	**9/02 a**	**1154/4 a**	**0/221 c**	**376 a**	**6/9 a**
Discontinued irrigation at 7-9 leaves stage to 12d	**6/86 a**	**841/9 a**	**9/11 a**	**1116/3 a**	**0/157 c**	**367/6a**	**6/86 a**
Discontinued irrigation at 7-9 leaves stage to 20d	**5/09 b**	**366 b**	**9/21 a**	**477/3 b**	**0/448 b**	**355 ab**	**5/09 b**
Discontinued irrigation at 7-9 leaves stage to leaf rolling	**4/9 b**	**119/2 c**	**9/28 a**	**225/7 c**	**0/726 a**	**328 b**	**4/9 b**
Pure water spraying	**5/76 a**	**398/3 b**	**8/92 a**	**565/7 b**	**0/432 a**	**339/5 b**	**5/76 a**
4% ca. spraying	**5/97 a**	**559/9 ab**	**9/26 a**	**791/6 a**	**0/366 ab**	**358 ab**	**5/97 a**
8% ca. spraying	**6/08 a**	**623 a**	**9/3 a**	**873 a**	**0/308 b**	**377 a**	**6/08 a**

Means with the same letter in each column have not statically significant difference

Table 12: Mutual effect of irrigation and Ca. fertilizer treatments on oil percentage, oil performance, protein percentage, protein performance, prolin content, Ca. content

Treatment	Oil percentage (%)	Oil performance (kg/ha)	Protein percentage (%)	Protein performance (kg/ha)	Prolin content (µmol/gr)	Ca. content (ppm)
Conventional irrigation × pure water	**6/65 a**	**676/1 b**	**8/83a**	**897/8 b**	**0/147 fg**	**364 bc**
Conventional irrigation × 4% Ca.	**6/94a**	**947/8a**	**9/1 a**	**1243 a**	**0/118 g**	**382ab**
Conventional irrigation × 8% Ca.	**7/1a**	**1027/2a**	**9/14 a**	**1322/3a**	**0/101 g**	**400 a**
Discontinued irrifation to 12 d × pure water	**6/59a**	**645/6b**	**8/92 a**	**874 b**	**0/197 f**	**350 bc**
Discontinued irrifation to 12 d × 4% Ca.	**6/92a**	**898/8a**	**9/21 a**	**1196/3 a**	**0/152 fg**	**368 b**
Discontinued irrifation to 12 d × 8% Ca.	**7/06a**	**981/2a**	**9/2 a**	**1278/7 a**	**0/124 fg**	**385 ab**
Discontinued irrifation to 20 d × pure water	**5/02b**	**193/5cd**	**8/93 a**	**344/2 d**	**0/517 d**	**336 c**
Discontinued irrifation to 20 d × 4% Ca.	**5/11b**	**267/3c**	**9/32 a**	**487/5 cd**	**0/432 e**	**353 bc**
Discontinued irrifation to 20 d × 8% Ca.	**5/16b**	**329/5c**	**9/4 a**	**600/1 c**	**0/397 ef**	**376 ab**
Discontinued irrifation to leaf rolling × pure water	**4/81b**	**78/3e**	**9 a**	**146/5 e**	**0/867 a**	**308 c**
Discontinued irrifation to leaf rolling × 4% Ca.	**4/93b**	**12/5de**	**9/41a**	**239/5 de**	**0/701 b**	**329 c**
Discontinued irrifation to leaf rolling × 8% Ca.	**4/98b**	**153/7cd**	**9/43 a**	**291 de**	**0/611 c**	**347 bc**

Means with the same letter in each column have not statistically .

significant difference Kajdi and Pocsia (1999) suggest that the stress results from drought tension on maize in the main reason of oil percentage reduction in this plant. According to Francois (1994), oil percentage under irrigation conditions for 3 y reached 6.5%, while Nelson (2003) reported oil percentage of corn genotypes in clorado under drought tension at grain filling stage at 5.2 – 4.5%.

Oil performance:
As showen in tables 10,11 and 12, simple effects of irrigation and Ca. fertilizer and the mutual effects of the double factors were significant at 1%. The highest oil performance was obtained through conventional irrigation at 883.7 kg/ha which were placed in the first statistical class along with a2. The lowest one produced by discontinued irrigation.

8% Ca. spraying treatment produced the highest oil percentage at 623 kg/ha and pure water spraying treatment showed the lowest one at 398.3.

Mutual effect of the tested factors on oil performance were significant. The highest performance obtained through conventional irrigation and Ca. spraying at 1027.2 kg/ha which showed a 92% increase compared to discontinued irrigation to leaf rolling and pure water spraying averaged at 78.3 kg/ha. Considering the obtained results it should be noted that oil performance was more affected by drought tension than Ca. spraying.

Protein percentage:
Tables 10, 11 and 12 showed that simple effects of irrigation and Ca. spraying and their mutual effect on protein percentage were not significant, although there were slight difference, but they were not statistically significant and all of them assigned class A. researchers believe that although dryness has a negative effect on performance and performance components, water deficiency particularly at production and granulation stage increases protein percentage [14].

Protein performance:
The results (tables 10, 11, 12) showed that simple effects of irrigation and Ca. fertilizer and mutual effects of the tested factors on protein performance were significant at 1%. The highest protein performance results from conventional irrigation at 1154.4 kg/ha and assigned the same statistical class along with discontinued irrigation to 12 d which showed a 80.4% increase compared to discontinued irrigation to leaf rolling at 225.7 kg/ha.

8% Ca. spraying produced the highest protein performance at 873 kg/ha and pure spraying resulted in the lowest one at 565.7.

Mutual effects of the double factors on protein performance were significant. The highest protein performance obtained from conventional irrigation and 8% Ca. spraying at 1322.3 kg/ha which had no significant difference from a2b2, a1b2, a2b3 and all of them assigned the statistical class A. the lowest performance resulted from discontinued irrigation to leaf rolling and pure water spraying at 146.5 kg/ha which placed in rank E, showing a 89% reduction compared to 89%.

Because grain performance follows a declining trend under drought tension, protein performance reduced [5].

Prolin content of leaf:
The results showed that simple effects of Ca. fertilizer and irrigation treatments and their mutual effects on prolin content were significant and the difference were statistically significant at 1% (table 10, 11, 12)

Irrigation treatment caused a significant different din prolin content of leaves. The highest prolin content produced by discontinued irrigation to leaf rolling at 0.72 μg/g and the lowest one obtained through conventional irrigation at 0.122 μg/g. water deficiency increases prolin content by 10-200 times [4]. Drought tension increases prolin content simultaneously [10] and prolin accumulation may increase by 50 to 150 times. Importance of prolin accumulation in the plant under drought tension caused many conflicting discussions [4,10].

Ca. content of grain:
The results suggested that simple effects of Ca. fertilizer and irrigation and their mutual effects were significant and the differences were statistically significant at 1% (tables 10,11,12).

Irrigation treatment reduced Ca. content from 376 ppm through conventional to 328 ppm using discontinued irrigation to leaf rolling. While Ca. spraying increased Ca. content of grain from 339.5 ppm by pure water spraying to 377 ppm using 8% Ca spraying mutual effect of the tested factors increased Ca. content of grain from 308 ppm using a4b1 to 400 ppm through a1b3 which is notable. Ca. deficiency may reduce merystem tissues growth, change leaf shapes, and chlorize young leaves [28]. In this study, Ca. spraying tension reduced it.

Mutual effects off drought tension and Ca. spraying suggest the importance of Ca. spraying for increasing Ca. content in the plants.

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