Effect of Water Stress Distributed for Growth Stages on Some Chemical Properties of Maize Seeds (*Zea mays* L.)

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ABSTRACT

A field experiment was carried out in autumn season 2016 in one of the farmers' field on the banks of the Euphrates river in Ramadi on the maize (Abaa5018 ***Zea mays* L),** which is a newly derived synthetic variety in Iraqi agriculture, with the goal of studying the effect of two levels of irrigation 75% and 50% of maize with three stages of growth on the production of maize. Seeds were sown on 15/07/2016 and harvested on 14/11/2016, the two levels of irrigation were distributed randomly over the stages of growth and eight coefficients were obtained. The stages of growth included the vegetative stage, which begins from the date of isolation of irrigation coefficients at 1/8 till the onset of emergence of male inflorescence, the flowering stage, which begins with the emergence of male inflorescence until the end of emergence of female inflorescence and then the last stage which begins from the end of second stage till the maturation of seeds. The coefficients of the experiment were randomly distributed and according to randomized complete block design (R.C.B.D). While the irrigation coefficient (T8) which is irrigated by the second level of 50% throughout the season of growth gave the lowest rate for each of leaf area, dry matter, and grain harvest with water consumption of 276 mm. Showed gradation in the production of grain, dry matter and leaf area, according to the distribution of irrigation water over the sensitive stages of growth for each character and are limited between the productions of irrigation coefficients (T1 & T8). They also varied in water consumption, total water requirement and water consumption efficiency. This variation occurred as a result of distribution of irrigation levels over the coefficients according to stages of growth.

تأثير الإجهاد ألمائي موزعا على مراحل النمو في بعض الخصائص الكيميائية لبذور الذرة الصفراء (*Zea mays* L.)

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الخلاصة

تم تنفيذ تجربة ميدانية في موسم الخريف 2016 في أحد حقول المزارعين على ضفاف نهر الفرات في الرمادي على محصول الذرة الصفراء (ABaa5018) ، وهو الصنف مستنبط حديثا في الزراعة العراقية، الهدف من التجربة هو دراسة تأثير مستويين من الري 75٪ و 50٪ مع ثلاث مراحل من النمو على إنتاج الذرة. تم زراعة البذور في 2016/07/15 وتم حصادها في 2016/11/14، وتم توزيع مستويي الري عشوائيا على مراحل النمو للحصول على ثمانية معاملات. مراحل النمو اشتملت على المرحلة الخضرية التي تبدأ من تاريخ عزل المعاملات عند 8/1 حتى ظهور اول تزهير ذكري ومرحلة الإزهار الذكري حتى نهاية ظهور التزهير الانثوي ومن ثم المرحلة الأخيرة التي تبدأ من نهاية المرحلة الثانية إلى نضوج البذور. تم توزيع معاملات التجربة عشوائيا وطبقا للتصميم العشوائي الكامل .(R.C.B.D) حيث أن معامل الري (T8) الذي يتم ريه بالمستوى الثاني من 50٪ خلال موسم النمو سجلت أدنى معدل لكل الصفات المدروسة عدا معدل البرولين، وفقا للدراسة تبين ان مرحلة التزهير هي اكثر المراحل تحسسا لقلة مياه الري، اظهرت نتائج الدراسة تفاوتا كبيرا بين المستوى T1 الذي لم تتعرض في النباتات للإجهاد المائي و المستوى T8 والذي تعرضت فيه النباتات للإجهاد المائي في جميع مراحل النمو.

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INTRODUCTION

The Water resources are among the natural resources that life is associated with its existence and the preservation of these resources has become a necessity. The agricultural sector is considered the main consumer of this resource in most of the Arab countries, consuming about 90% of the available water (Sullivan, 2017). The management of water resources and its appropriate utilization is considered a priority in dry and semi-dry areas or in the areas of low rainfall such as Iraq. Among the good methods of management of agricultural production is to control the amount of water given in each irrigation and reduce the number of irrigations used as per the ability of absorption of the soil and the plant need in various stages of growth in order to reach the highest productivity(Muttucumaru, Powers, Elmore, Mottram, & Halford, 2015) . There has been newly adopted agricultural applications that aim to overcome the physiological symptoms that arise in the plants growing in harsh environments such as thirst, desiccation and lack of ground water, which also contributes to the supply of some of the water need of the plants. It has been observed that the plants which were gradually exposed to drought in one of its growth stages become more resistant to it when exposed to another period of drought in comparison to other plants which were not exposed to at all (Dhugga, 2016).

The method of evaporation basin class (A) in the calculation of water consumption for any crop is considered as an indirect method that can be adopted by using the crop coefficient, which is considered as one of the good indicators in determining the amount of irrigation for any crop if the results were comparable to the reality(Garde-Cerdán et al., 2015). Evaporation can be calculated by this method using the impact of sun rays on the water surface of evaporation basin, the temperature of air in contact with the surface of the basin and wind speed (Ehlers & Goss, 2016). (Morscher, Kranner, Arc, Bailly, & Roach, 2015)had used evaporation data of evaporation pan class _A_ as a proof in their study about the amount of irrigation water added to maize and obtained a good results. The study Objectives:

1. To identify the most appropriate amount of water to produce the best quantity of grain dry matter.
2. To identify the most sensitive stage of growth to the decrease in soil moisture and its impact on the production.
3. To determine the possibility of using crop coefficient plants and evaporation pan class _A_ in estimating the amount of water to be added to the crop.
4. To determine the feasibility of adopting ten days time interval between successive irrigation events in autumn season.

METHODOLOGY

A field experiment was carried out in autumn season2009 in one of the farmers' fields on the banks of Euphrates River in the city of Ramadi/Al-Anbar province. The field soil is classified as sedimentary soil of muddy slimy texture. The field is irrigated from Euphrates River. A sample of the field soil was taken prior to planting, it is then dried, milled and passed through a sieve of 2mm diameter pores in order to estimate some of the chemical and physical properties of the soil of the study (Table 1).

The methods used in estimation of these properties are:

1. Soil Texture: It was estimated by absorbent method as reported in(Chatterjee, Morscher, Rodriguez, Pattabiraman, & Rasio, 2015).

2. Bulk Density: It was estimated by Core Sampler method(Badigannavar, Girish, Ramachandran, & Ganapathi, 2016).

3. Electrical conductivity: It was measured in the saturated paste extract using Conductivity Bridge apparatus according to the method reported by (Mzid, Todorovic, Albrizio, & Cantore, 2017).

4. Soil Moisture: estimated at tensions of 1/3 Bar to estimate field capacity and 15 Bar to estimate wilting point using Pressure membrane apparatus and Pressure Plate according to

the method reported by (Li et al., 2015).
5. pH: It was measured in the saturated paste extract using pH-meter according to the method reported by(Liu, Mei, Yan, Gong, & Zhang, 2016).
6. Organic matter: Estimated by Black and Walkley`s method mentioned in (Sullivan, 2017).
7. Available Nitrogen: Estimated by Bremmer`s method (1960) mentioned in (Jeżowski et al., 2017)
8. Available phosphorus: Estimated by Oslen`s method (1960) mentioned in (Le Quéré et al., 2015)
9. Available Potassium: It was extracted using ammonium acetate solution (N1) and estimated using flame photometer as mentioned in (Badigannavar et al., 2016) and the results were recorded in table (1).
10. **Percentage of protein in the seeds (%).**
The percentage of protein in the seeds was estimated by following method Micro – Kjeldal as mentioned in AOAC (1980) as described (Sheoran & Sheoran, 2006).
11. **Proline content in the seeds (m.g-1).**
Free proline accumulation was determined using the method of Bates et al., (1973) that Described by (Marín & Velázquez Flores, 2010) Where extracted the free proline (unencumbered)by adding 10 ml of 30% aqueous sulfosalicylic acid on the fresh sample to 5.0 g, the sample was then ground and filtered, 2 ml of the filtrate was taken. It was added to 2 ml of reagent solution (ninhydrin acid) (which was prepared by dissolving ninhydrin in glacial acetic acid and phosphoric acid), and after that added to the mixture of 2 ml glacial acetic acid. Subsequently heating the sample with the reagent in a water bath for an hour after cooling the sample was added to 4 ml of toluene shaking well, then separating the aqueous phase and using the upper part (layer toluene), to measure the optical density at a wavelength 520 NM by using UV/ visible ، spectrophotometer.
12. Oil content in the seeds (%).
Oil content was estimated in the seeds by Soxhlet continues extraction, according to the standard method (AACC-1989) as described (Khamchum, Punsuvon, Kasemsumran, & Suttiwijitpukdee, 2013). Oil content in maize seeds powder was quantitated using a Soxhlet extraction method. Seed powder (15 g) was extracted using hexane (200 ml) as a solvent at 70 °C for 4 h in Soxhlet extractor. After 4 h, the solvent was evaporated using a rotary evaporator and the remaining yellow oil was weighed for determination of oil content. All analysis was performed in duplicates.

Table 1 some chemical and physical properties of the experimental field soil prior to planting.

The value	Analysis Type
The characteristic	2.35
Electrical conductivity ds.$^{m-1}$	7.35
Sale Nutrients:	
Nitrogen is ready PPm	64.2
WP-ready PPm	13.7
Potassium ready PPm	141
Organic matter g/kg	1.09
Bulk density^{m3}	1.22
Volumetric distribution of soil dismissed during pregnancy (G. kg-1 soil)	
Sand	144
Clay	320
Silt	536
Conception	sandy , loamy
Percentage soil moisture when you tighten 1/3 bar	31.4**%**
Percentage of soil moisture at 15 bar tightens	16.6**%**

Irrigation process.

Crop coefficient was used (Calculated in advance by..) In order to calculate the amount of water to be added to each sector, as shown in table 2

Table 2 shows the typical values of Kc (crop coefficient) for the maize calculated for every ten days (Al-Shaheen & Soh, 2016).

The time period	75%	50%
8/1 To 8/10	0.19	0.12
11/8 To 20/8	0.20	0.13
21/8 To 30/8	0.22	0.15
31/8 To 9/9	0.33	0.22
9 /10 To 9/19	0.68	0.46
9/20 To 9/29	1.00	0.67
9 /30 To 10/9	0.94	0.63
10/10 To 10/19	0.54	0.35
10/20 To 10/29	0.48	0.31

The two levels of irrigation were distributed randomly over the stages of growth and eight **coefficients were obtained as shown in table (3):**

Table (3) Levels of irrigation used to distribute over the experiment coefficients according to the stages of growth of yellow maize.

The plants	Stages of growth		
	Vegetative stage	Flowering stage	Maturity
T1	75%	75%	75%
T2	75%	75%	50%
T3	75%	50%	75%
T4	75%	50%	50%
T5	50%	75%	75%
T6	50%	75%	50%
T7	50%	50%	75%
T8	50%	50%	50%

The amount of irrigation to be added for each level was calculated using the following equation: $Kc * Epan = Eta$

Where,

Kc = Crop coefficient of yellow maize.

Epan = the value is obtained by multiplying pan coefficient Kp into the amount of evaporated water from evaporation pan class A.

And the value of Kp varies depending on the type of the pan, the surrounding vegetation and the nature of soil surface.

The wetting events were distributed over the stages of growth with 4 wettings in the vegetative stage, two wettings in the flowering stage and three wettings at maturity stage (Table 2).

Results and discussion:

The amount of proline in leaves (micromol /g):

Figure (1) indicates that irrigation levels have an effect on the levels of the Proline in the leaves. The treatments of irrigation where the plants exposed to water stress along the season (T8), was a significant superiority compared with other levels, where it gave the highest Proline rate reached 86 micromol /g, while it is given the treatment of irrigation T1, the lowest Proline rate reached 71 micromoles \ g, it may be attributed of water stress it leads to raise the proportion of proline in the leaf of the plant. (Muttucumaru et al., 2015) found that the lack of plant water content has inhibited the process of the amino acid building, This may be due to the lack of a wet medium for the activity of enzymes that was contributing to the formation of amino acids. T2 irrigation treatment showed a difference when compared with T1 irrigation treatment where the Proline rate was 73 micromol / g but this difference did not a significant, may be due to the low irrigation effect in maturity stage for most of the plant biological activities (Greenwood, 2014). The treatment of irrigation, which plants were exposed to water stress in flowering and maturing stages (T4) It gave Proline rate was 71micromol / g There was no significant difference when compared with T5, T6 and T7 which gave the Proline rate of 77, 80 and 83 micromol, respectively. This is consistent with the results of (Dhugga, 2016) Who pointed out that the exposure of maize, wheat and other crops in the growth period had led to elevated the proline content to ten fold. Previous results indicated that the water stress in the sensitive plant stages, it leads to raising the level of proline in the flag leaf, some researchers have suggested that was selected the proline as a water stress indicator for the purpose of determining the irrigation scheduling and a good indicator for the varied selection that are resistant to drought, because Proline one of the most amino acids which are increasing in plants that was exposed to drought (Ehlers & Goss, 2016).

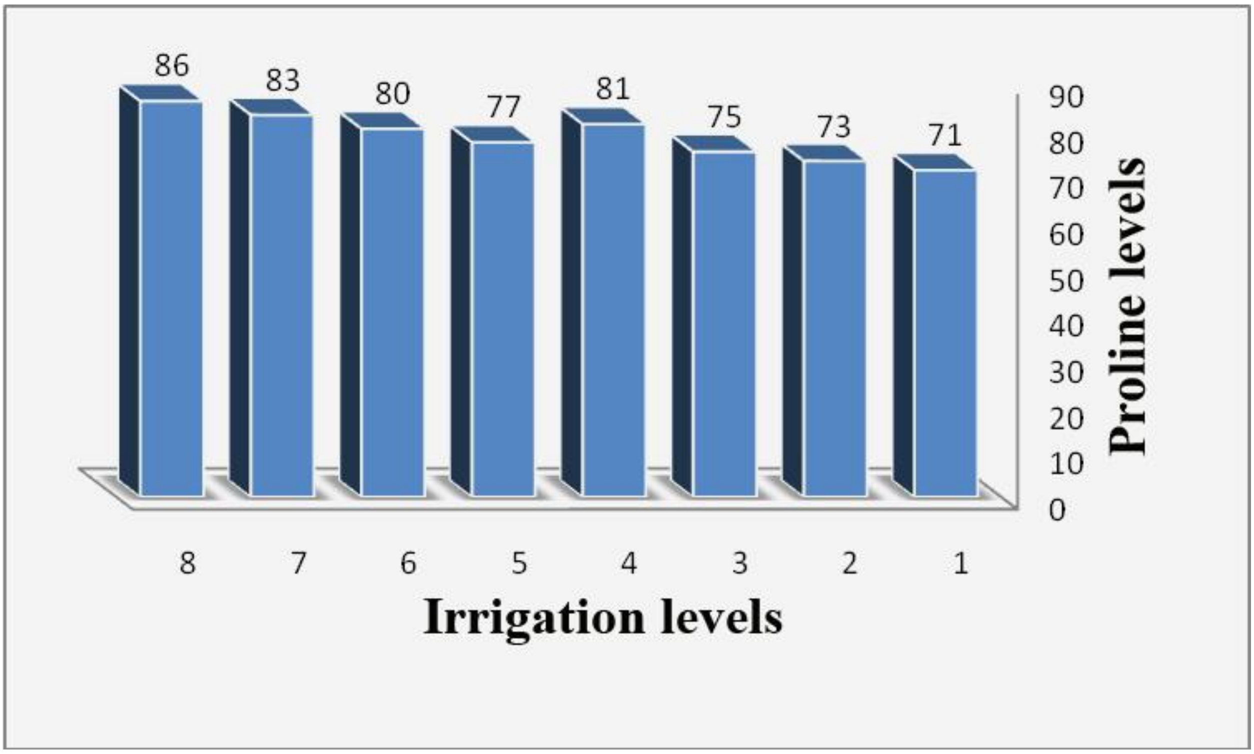

Figure (1) Effects of irrigation treatments on Proline rate. **LSD = 4.59**

2. The proportion of protein in the seeds.

Figure (2) Indicate that the levels of irrigation have significant influence on the percentage of protein in the seeds. Has been recorded a highest percentage of protein when the plants weren't exposed to water stress along the growing season (T1) where it is given a protein percentage

reached 8.7%, while the lowest percentage of protein was recorded when the plants exposed to water stress along the growing season (T8), It gave a protein percentage reached 8.2%, This may be due to the effect of water stress on the protein building in the plant. The results are consistent with (Ehlers & Goss, 2016) which indicated that was inhibited the plants building process of the protein.
Irrigation treatment T2 when the plant was exposed to water stress during the maturation stage, it did not appear a significant difference when compared T1 with protein percentage reached 8.6%. The lack of water at the end of maturity stage was effected on the most of the plant's vital activities.
Where the plants exposed to water stress in the flowering and maturing stages (T4) has given a protein percentage reached 8.6%, with an insignificant difference when compared with T5 and T6 which gave a protein percentage reached 8.6% for both treatments.
This may be due to the importance of the vegetative and flowering stages in the proportion of the protein in the seeds. This is consistent with the results of (Morscher et al., 2015) who confirmed that the most protein in the seeds of the sunflower occurs early in the first flowering period.
Previous results indicate that water stress in the sensitive stages of plant growth leads to inhibition of enzyme activity where it enters into the protein building process, thus leads to increase the level of amino acids in the plant, this is consistent with the results of (Badigannavar et al., 2016) on sorghum. The results of) Mzid et al., 2017 (showed that the exposure of wheat to water stress lead to a significant decrease in the proportion of protein in the seeds. It was concluded that the protein composition is directly proportional to the availability of moisture at each stage of plant growth.

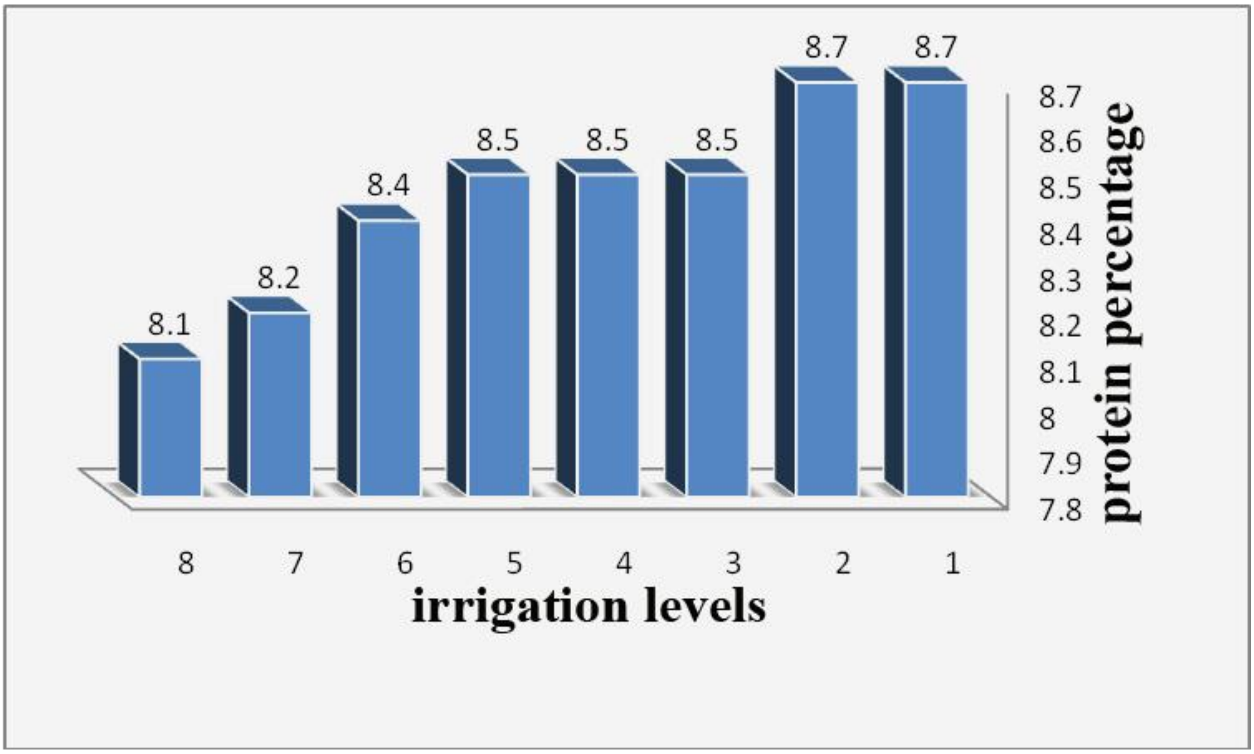

Figure (2) Effects of irrigation treatments on protein percentage. LSD = 0.18

3. Percentage of oil.

Figure 3 refers to the effect of irrigation levels on the oil ratio in the seeds. It was the highest percentage of oil when the plant was not exposed to water stress along the growing season (T1), where it gave an oil percentage reached 3.7% while the lowest percentage of oil when the plant was exposed to water stress throughout the growing season (T8) , It gave the oil ratio stood at 3.0% This may be due to the impact of water stress On the proportion of oil in seeds This is consistent with (Dhugga, 2016) who pointed out that the lack of plant content of water was effected on the percentage of oil in the seeds of the sun flower. The results showed that the plant was exposed to

water stress during the maturity stage (T2) has a significant difference when compared with T1 where the rate of oil was 3.4% , this may be due to the low importance of maturity stage on the most activities of the plant (Muttucumaru et al., 2015).The plants were exposed to water stress in flowering and maturing stages (T4) have gaven an oil percentage reached 3.6% , While insignificant difference was shown when compared with T5 and T6, which gave the oil ratio reach 3.5 and 3.4% respectively.

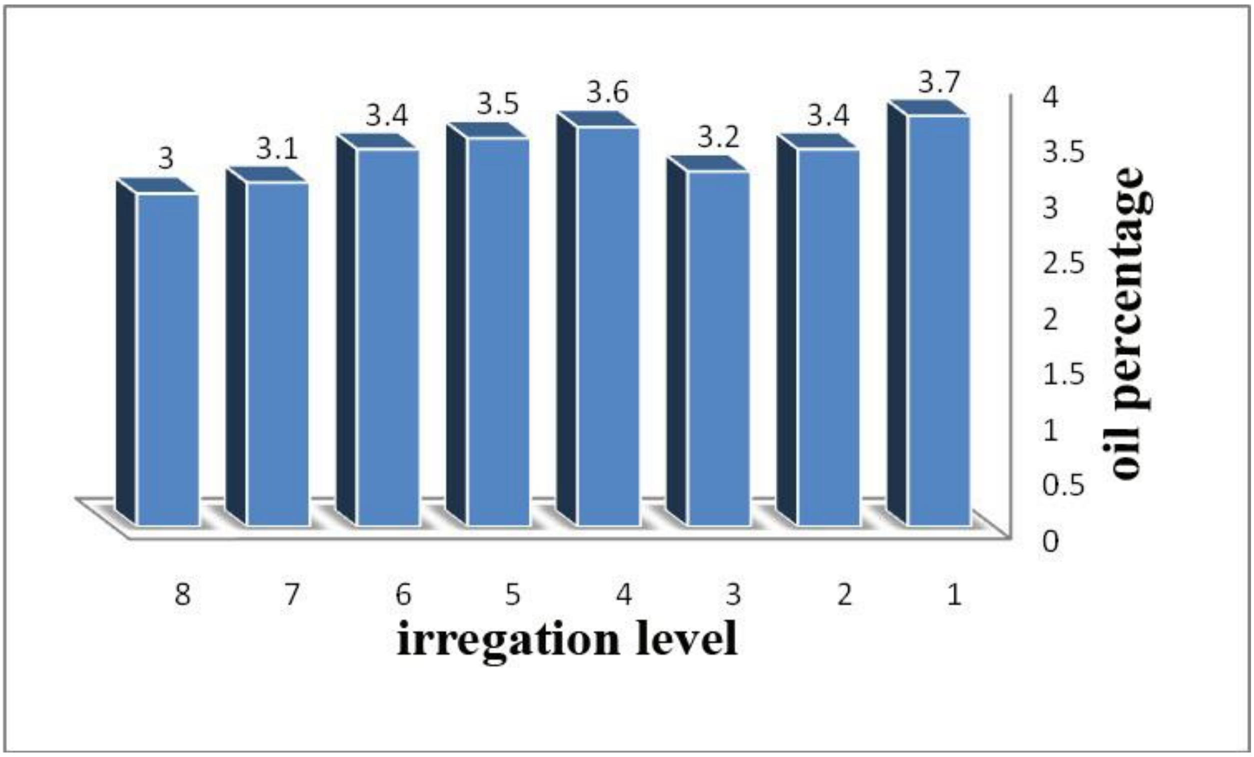

Figure (3) Effects of irrigation treatments on Oil percentage. LSD: 0.44

Conclusion

The results of the experiment showed the water stress in vegetative and flowering stages have the greatest effect on the proline, protein percentage and oil percentage and this effect is dissimilar depend of the growth stages, also concluded the possible of utilization the proline as an indicator of drought.

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