Response of Maize (*Zea mays* L.) genotypes to temperature and light intensity under green-house and field conditions

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Abstract :

An experiment conducted at the Qlyasan Agricultural Research Station,- Faculty of Agricultural Sciences, during the fall season of 2011- to study the response of four maize genotypes (SC 301, Mar Ket , Talar and Cadiz) to the temperature and light intensity under field and greenhouse conditions. Obtain all genotypes from different sources (IRAN, Turky, Local and, Turky). Randomized complete block design (RCBD) and complete randomized design (CRD) were used with four replications for field and greenhouse experiments , respectively. Light intensity measured by PHY-WE-type- LUX meter. Shading used for diminishing over heat. Light- bulbs used for balancing light interception inside the greenhouse .Result showed significant differences among maize genotype under field conditions in their response to the temperature and light intensity in studied vegetative growth traits except plant height and chlorophyll content which measured in post-silking. There were significant differences in accumulated numbers of Crop heat unit among genotypes, in which genotype SC 301 needed minimum numbers of Crop heat unit (2121.6) , while genotype Talar needed maximum numbers of Crop heat unit (2346.625) and there were differences in the distribution pattern of the accumulated heat units on the growth stages of the genotypes. There were significant differences among four maize genotypes in the rate of leaf appearance across the growth season, and in the number of Crop heat unit required for phyllochron in different stages of growth , and the superiority was to genotype Talar compared to other genotypes. The significant exceeding of genotype Talar also was in Leaf Area Index due to larger numbers of leaves.

Keywords: Maize (*Zea mays* L.) , leaf Area Index , Crop Heat Unite.

استجابة تراكيب وراثية من الذرة الصفراء (*Zea mays* L.) لدرجات الحرارة و شدة الاضاءة تحت ظروف الحقل و البيت الزجاجى .

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المستخلص:

تم أجراء تجربة في محطة أبحاث الزراعية في قلياسان – كلية العلوم الزراعية – خلال موسم الخريفى لعام 2011 – لدراسة استجابة أربعة تراكيب وراثية من الذرة الصفراء (SC 301، Mar Ket، Talar and Cadiz) لدرجة الحرارة شده الاضاءة تحت ظروف الحقل والبيت الزجاجي للحصول على جميع التراكيب الوراثية من مصادر مختلفة (إيرانية ، التركية ، المحلية ، والتركية) على التوالى تم استخدام تصميم القطاعات العشوائية الكاملة (RCBD) والتصميم العشوائي الكامل (CRD) وباربعة مكررات في الحقل تجربتي والبيت الزجاجي على التوالى شدة الضوء المقاسة بـ PHYWE-type - LUX meter يستخدم التظليل للتناقص على الحرارة. المصابيح المضيئة تستخدم لموازنة اعتراض الضوء داخل البيت الزجاجية. أظهرت النتائج وجود فروق معنوية بين النمط الوراثي للذرة تحت ظروف الحقل في استجابتها لدرجات الحرارة وكثافة الضوء في صفات النمو الخضري المدروسة باستثناء ارتفاع النبات ومحتوى الكلوروفيل الذي تم قياسه في مرحلة ما بعد التزهير الازهار الانثويه. كانت هناك فروق ذات دلالة إحصائية في الأعداد المتراكمة لوحدة الحرارة المحصولية بين تراكيب وراثية حيث احتوى تركيب وراثي SC 301 على أقل عدد ممكن من وحدة الحرارية للمحصول (2121.6) بينما احتوى تركيب وراثي Talar على أكبر عدد من وحدة الحرارية للمحصول (2346.625) وكانت هناك اختلافات في التوزيع. نمط من وحدات الحرارة المتراكمة على مراحل النمو من تراكيب وراثية. كانت هناك فروق ذات دلالة إحصائية بين أربعة تراكيب وراثية من الذرة في معدل ظهور الأوراق خلال موسم النمو ، وفي عدد الوحدة الحرارية للمحصول المطلوبة لمشتق phyllochron في مراحل النمو المختلفة ، وكان التفوق تركيب وراثي Talar بالمقارنة مع تراكيب وراثية الأخرى. زيادة كبيرة في تركيب وراثي تالار كان أيضا في مؤشر مساحة الأوراق نتيجة الأعداد الكبيرة من الأوراق.

الكلمات المفتاحية: ذرة الصفراء , دليل المساحة الورقية، وحدات حرارية للمحاصيل .

Introduction :

Maize as C4-plant is an important crop grown for both biomass and grain production in a variety of climatic conditions around the world , the ecological factors, affecting plant growth and evolution would be useful to know minimum, optimum and maximum temperatures and light intensity required for plant growth and development (9). Maize has a wide range of tolerance to environmental conditions and there are a

large number of varieties with different maturity periods, simple differences in climatic temperature , significantly affecting maize growth, and increased biomass production could result from a better understanding of the effects of temperature on metabolism and growth rates of maize (8 and, 19) .
Temperature and solar radiation have a direct effect on maize production. Total dry matter production is a function of net CO_2 assimilation over the whole growing season , affected by both solar radiation and temperature (8). Temperature is among the most important environmental factors that control plant development, growth and yield . All biological processes respond to temperature, and all responses can be summarized in terms of three cardinal temperatures, namely the base or minimum temperature (T min.) , the optimum temperature (T opt.) and the maximum temperature (T max.) temperatures. The nature of the response to temperature between these cardinal points , is important for calculating the phenology , adaptation and yield of various crops . High temperature reduced leaf number in maize and rate of plant growth was also negatively affected by high temperature, consequently affecting kernels number (6).
lthough light is essential to greenhouse production, it is one of the most variable inputs, and one of the most challenging and expensive to regulate light requirements. Climatic effects of light must be considered at all stages of greenhouse design and orientation. Crop production and environmental control strategies must be employed to maximize the benefits of light while mitigating the negative consequences associated with natural light variability (10). There are great opportunity for maize cultivation to play great role in the economy and the future of agriculture in Kurdistan region due to its effect on the two major sectors of agriculture, plant and animal production , but in order to be expanded successfully , there is necessity to be studied under different conditions which related to growth and yield especially in case of involving climatic and environmental factors for minimizing their negative effects.
The present study was investigating the response of four maize genotypes to temperature and light intensity under the field and green house conditions .

Materials and methods :

An experiment conducted at the Qlyasan Agricultural Research Station, Faculty of Agricultural Sciences, during fall season of 2011 to study the response of four maize genotypes (SC 301, Mar Ket , Talar and Cadiz) to the temperature and light intensity under field and green house conditions . Randomized complete block design (RCBD) and complete randomized design (CRD) were used with four replications for field and greenhouse experiments, respectively. Field experiment conducted under natural conditions of light density and temperature. Each experimental unit area was 4m x 2.5m, included 4 rows with 4 m length, the distance between each two rows was 0.70 m and between plants within row was 0.25 m in order to achieving plant population near to 50000 plant ha^{-1}. A greenhouse experiment was conducted under controlled conditions using 32 pots with size (30 x 25 x 20 cm^3) for each genotype.
The planting dates were on (July 2^{nd} of 2011)Recommended fertilizations (Nitrogen and phosphorus) were applied as urea 46% (200 kg ha^{-1}) and phosphorus a basal dose

at the rate of 200 kg ha^{-1} was applied as triple super phosphate 48%, as well as all required agricultural processes were done as needed. The harvested date was adjusted at physiological maturity for all genotypes in the field and in the greenhouse. Air temperature was adjusted at (25°C –30°C) ±2 by air conditioner (10 and , 12) while light intensity was measured by PHYWE – Type - LUX Meter, Order no. 07137.00 (Serial no. 460300015566- Germany).

Crop heat units (CHUs):

It was Determined by the following equation,(3)for each growth stage for all genotypes.

$$CHU=(T_{max.}+T_{min.})/2-T_{base}$$

Where Tmax and Tmin are the maximum and minimum daily temperature, respectively, and T base is the base temperature at which the crop grows.

Statistical analysis:

For both field and green house experiments the data were statistically analyzed according to the ANOVA by (-XLSTAT-) program, and comparisons among the means were calculated following test of least significant different (L.S.D) at 0.05 significant level .

Result and Discussion:

Table 1 reveals the studied vegetative characters of maize genotype, in which there were significant differences among genotypes in all studied criteria except plant height and chlorophyll content of second determination . There were superiority of genotype Talar in total leaf number per plant , the period from seeding to 50% tasseling and silking by(14.5 leaves, 53.5 days, 63.5 days) respectively, while genotype Cadiz exceeded other genotypes in the period from silking to Physiological maturity, but genotype SC 301 recorded minimum number of leaves per plant and minimum number of days to 50% tasseling and silking , and from silking to Physiological maturity which were (10.5 leaves, 38 days, 49 days, and 53 days) respectively as well as shortest growth period from seeding to Physiological maturity , which was 102 days , that may be interpreted by the genotype response to high temperature that caused reduction in growth , these results were in agreement with (8 and ,11) .There were significant differences in chlorophyll contents among genotype with superiority of genotype Mar Ket by 0.699 µg/ml compared to other genotypes.

Table 1: Vegetative growth criteria of maize genotypes under field conditions .

Genotypes	Plant	Total	LAI	No. of days	No. of days	No. of	No. of days	Chlorophyll

	height (cm)	leaves no.		from seeding to 50% tasseling	from seeding to 50% silking	days from silking to PM	from seeding to PM	content (μg/ml)	
								Sept.01	Sept.29
SC 301	162.9	10.5	1.9	38	49	53	102	0.400	0.330
Mar Ket	164.1	12.5	2.7	49	57	78	135	0.699	0.328
Talar	154.5	14.5	3.8	53.5	63.5	72.3	135.7	0.625	0.327
Cadiz	168.5	13	3	48	56	79	135	0.647	0.320
$LSD_{0.05}$	**N.S**	**1.0**	**0.386**	**1.7**	**1.7**	**1.5**	**0.4**	**0.187**	**N.S**

***N.S : Non Significant**

Table 2 : shows significant differences among genotype in the number of required Crop heat unit for tasseling , silking and from silking to Physiological maturity and from seeding to Physiological maturity, the genotype Talar needed the highest number of Crop heat unit to tasseling which was (1273.9), indicating the longest vegetative stage or highest number of required days to 50%tasseling compared to other genotypes, while the genotype SC 301 needed minimum accumulated Crop heat unit which was (928.15) , showing the shortest vegetative growth, and this pattern of responses of genotype to temperature was the same in the period from seeding to silking, in which G_3 needed (1481.825) crop heat units and genotype SC 301 needed (1171.35) units , but there was different responses of genotypes for the period from silking to Physiological maturity which considered as the filling period in cereals, in which the genotype Talar required minimum numbers of Crop heat unit which was 864.8 Crop heat unit for 72 days ,but the largest number of Crop heat unit (1015.7) was accumulated by genotype Cadiz for the period of (79 days) , which was the longest filling period among all genotypes that may positively affected dry matter accumulation and partitioning to kernels , and also affected the final kernel yield .There were significant differences among genotypes in the required Crop heat unit along the growth season and the pattern of the distribution of the heat units over the growth stages, in which Talar required maximum number of Crop heat unit (2346.625) but with different distribution between vegetative and reproductive growth stages, while genotype SC 301 needed minimum number (2121.6) . Differences among genotypes in required Crop heat unit showed variation in temperature effect on the rate of growth from stage to other of genotypes and may be useful for identification of its suitability to the sowing in spring or fall seasons according to their requirement to short or long season (1 , 16 and , 21) . Significant differences in the growth stages and Crop heat unit requirement may be related to light intensity or incident Photosynthetic active radiation where daily Intercepted Photosynthetically active radiation is often a critical component of maize simulation models because it determines daily biomass increase as well as kernel number , These results were in agreement with (12, 13 , 19 and , 20).

Table 2: Crop Heat Unit (CHU) determined for growth periods of maize genotypes under field conditions.

Genotypes	CHU needed from seeding to tasseling	CHU needed from seeding to silking	CHU needed from silking to PM	CHU needed from seeding to PM
SC 301	928.150	1171.350	950.250	2121.600
Mar Ket	1171.350	1351.750	994.250	2346.000
Talar	1273.900	1481.825	864.800	2346.625
Cadiz	1149.000	1330.600	1015.700	2346.300
LSD $_{0.05}$	**39.871**	**36.071**	**36.349**	**0.542**

***N.S : Non Significant**

Table 3 : showed significant differences among genotypes in some studied vegetative characters under the green house condition , especially in characters related to the length of different stages of growth season .The length of the vegetative stage or number of days from seeding to 50% tasseling , in which genotype Talar needed maximum number of days which was 73 days and the genotype SC 301 required minimum number of days which was only 50 days. There were also significant differences in number of days required from seeding to silking in which genotype Talar exceeded other genotypes with 83 days , while the shortest period was recorded by genotype SC 301 with 61 days . However there were differences at the post-silking stage in number of days required from silking to physiological maturity which considered as an important stage due to its relevant to reproductive characters and kernel filling period , in which genotype SC 301 had the longest stage of 60 days and the shortest stage was recorded by genotype Talar with 52 days. There were significant differences in the length of growth period or number of days required from seeding to physiological maturity with the longest period was to genotype Talar with 135 days and the shortest period was recorded by genotype SC 301 and Cadiz with 121 days each . Significant differences among genotypes may reflect variation in their genetic components and their capability in responding to the environment factors such as temperature and light intensity under green house condition (2 ,5 ,14 ,15 and , 18).There were no significant differences in chlorophyll contents among genotypes.

Table 3 :Vegetative growth criteria of maize genotypes under green house conditions.

Genotypes	Plant height(cm)	Total leaves no.	No .of days from Seeding to 50% tasseling	No .of days from Seeding to 50% silkining	No .of days from Silking to PM	No .of days from Seeding to PM	Chlorophyll content (µg/ml)	
							Sept.01	Sept.29
SC 301	230.5	9.8	50	61	60	121	0.435	0.311
Mar Ket	178.8	10.8	57.5	68.5	53.8	122.3	0.477	0.322
Talar	173.5	11.8	73	83	52	135	0.550	0.304
Cadiz	192.3	12	56	67	54	121	0.467	0.278
LSD $_{0.05}$	N.S	N.S	0.8	0.8	1.2	1.9	N.S	N.S

***N.S : Non Significant**

Table 4 : revealed that there were significant differences among genotypes in number of crop heat units required for each genotype to pass the growth stages in order , the genotype Talar required maximum numbers of Crop heat unit from seeding

to 50% tasseling 1288.5 while genotype SC 301 genotype needed 910 Crop heat unit . At the stage from seeding to 50% silking , the genotype Talar significantly exceeded other Genotype by accumulating 1448.5 Crop heat unit, while genotype SC 301 recorded minimum number of Crop heat unit with 1094 Crop heat unit, but at the period from 50% silking to Physiological maturity the genotype SC 301 showed significant superiority with 804 Crop heat unit and genotype Talar accumulated only 490.5 Crop heat unit . There were close relationship between the length of the different growth stages and the number of accumulated Crop heat unit (4 and , 7).

Table 4: Crop Heat Unit (CHU) determined at different growth period of studied maize genotype .

Genotypes	CHU needed from seeding to tasseling	CHU needed from seeding to silking	CHU needed from silking to PM	CHU needed from seeding to PM
SC 301	910.000	1094.000	804.000	1898.000
Mar Ket	1003.575	1218.875	666.875	1885.750
Talar	1288.500	1448.500	490.500	1939.000
Cadiz	1010.500	1193.500	704.000	1897.500
LSD $_{0.05}$	**1.348**	**12.133**	**2.500**	**17.333**

***N.S : Non Significant**

Conclusion:

Concerning the temperature and light intensity requirement for maize genotypes as C4-plants for growth and development are generally high enough to show positive response ,to the surrounding factors under the field conditions. Based on accumulated Crop heat unit and measured of light intensity , there was close relationship between the effect of temperature and light intensity that considered as complementary effect on growth and development if maize of genotypes **.**

Variations in the growth period and stages among maize genotypes under similar environmental conditions may be due to the genetic components of genotypes and their capabilities to express under particular environmental condition especially temperature and light intensity. Genotypes with great tolerance to temperature and light intensity fluctuations at the end of growth season may show certain acclimation to the fall season growth in Sulaimani region.

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