RADIATION USE EFFICIENCY OF MAIZE UNDER INFLUENCE OF DIFFERENT LEVELS OF NITROGEN FERTILIZATION AND TWO DIFFERENT SEASONAL CONDITIONS

A. A. Mohammed
Asst. Prof
Dept. of Crop Sciences Dept., Coll. of Agric. Sciences, Univ. of Sulaimani
aram.muhammed@univsul.edu.iq

ABSTRACT

The objective of this study to estimate the Radiation Use Efficiency under effect of three levels of nitrogen (N_1 = 80 Kg N ha^{-1}, N_2 =120 Kg N ha^{-1}, and N_3=160 Kg N ha^{-1}) for a set of maize hybrids include (Gloria, Market, Cruze and Draxma) in two different seasons in spring and fall of 2017 in Qlyasn-Sulaimani. The experiment was conducted using split plot design with three replicates . The results revealed higher intensity of PAR in autumn season than that of spring (15.672 and 10.555)$MJm^{-2}d^{-1}$ respectively that led to higher RUE in autumn revealing (4.311,3.546, and 4.702)g MJ^{-1} m^{-2} under the effect of (N_1,N_2, and N_3) respectively, while the results of the autumn were higher (5.237, 4.681, and 6.019) g MJ^{-1} m^{-2} under the same levels of nitrogen fertilization, the highest application of nitrogen was more effective in autumn. The RGR and the rate of total dry matter accumulation were higher in autumn season displaying positive performance of studied maize hybrids to the higher intercepted of solar energy as well higher temperature.

***Key wo*rds: RUE, RGR, PAR, nitrogen levels.**

كفاءة استخدام الاشعاع للذرة الصفراء تحت تاثير ثلاثة مستويات مختلفة من التسميد النيتروجيني في موسمين مختلفين للنمو

أرام عباس محمد
استاذ مساعد
قسم علوم المحاصيل الحقلية- كلية العلوم الزراعية - جامعة السليمانية

المستخلص

اجريت هذه الدراسة لتقدير كفاءة استخدام الإشعاع لمجموعة من هجن الذرة تشمل (كلوريا ، ماركت ، كروز ودراخما) تحت تأثير ثلاثة مستويات من النيتروجين N1 = 80 Kg N ha-1) وN2 = 120 Kg N ha-1 وN3 = 160 Kg N ha- (1في موسمين مختلفين في ربيع وخريف عام 2017 في حقول قلياسان- جامعة السليمانية. نفذت هذه الدراسة باستعمال الالواح المنشقة وبثلاث مكررات .من خلال تقدير تراكم المادة الجافة في مراحل النمو المختلفة وكذلك معدل النمو النسبي (RGR)لغرض التنبؤ بمعدل المادة الجافة المتراكمة تحت تاثير تذبذب شدة الإشعاع الضوئي (PAR)في مراحل النمو المختلفة ومع تقدم الموسم. تم حساب PARالمعترضة باستخدام جهاز LCA-4 المحوسبة في مراحل النمو المختلفة في موسمي النمو. وقد وجدت الدراسة الحالية شدة أعلى لـ PARفي فصل الخريف مقارنة من تلك التي في الربيع (15.672 و 10.555 MJm-2d-1 (على التوالي والتي أدت إلى ارتفاع RUE في كفاءة استخدام الاشعاع في الخريف مبينا (4.311،3.546 و 4.702 g MJ-1 m -2 (تحت تأثير N1) وN2 و (N3على التوالي في موسم الربيع، في حين كانت نتائج الخريف أعلى (5.237، 4.681،) 6.019 g MJ-1 m-2 (تحت نفس مستويات التسميد النيتروجيني، كانت تاثير اعلى مستوى من النيتروجين أكثر فعالية في الخريف و وكان اعلى معدل لكل من معدل النمو النسبي RGRومعدل تراكم المادة الجافة ايضا تمت تسجيلها في موسم الخريف حيث كانت أداء الهجن اكثر في ظل توافر اشعاع اعلى و كذلك مع ظروف درجات حرارة اعلى في الخريف.

الكلمات المفتاحية: RUE، RGR، PAR، مستويات النيتروجين.

*Received:21/1/2018, Accepted:17/5/2018

INTRODUCTION

Crop Productivity has often been found to be linearly related to the photosynthetically active radiation (PAR) intercepted and absorbed by crops, When PAR is absorbed by cells containing chloroplasts. The efficiency of photosynthesis can be defined as the ratio of energy stored in the form of carbohydrates to the absorbed radiant energy (17). The slope of this relationship is the radiation use efficiency (RUE), especially in crops where growth is not limited by water or nutrient shortage, or by other adverse climatic conditions that may decrease RUE (11, 24 , 25 , 26 , 30). Crop RUE was defined as the ratio between the TDM and the sum of intercepted PAR, a strongly positive correlation was observed between above ground biomass and cumulative IPAR that was varied across the growing season, (12 32). The value of the RUE differs depending on whether it is calculated as PAR absorbed (RUEa) or as PAR intercepted (RUEi), (8). The radiation use efficiency varies through the crop growing season, differences in RUE ascribe to differences in the rate of photosynthesis and the net assimilation rate produced (24). RUE differs between crops (4, 22, 28), with plant nitrogen situation (3, 5, 27) and with growth stages of the crop cycle, especially (pre-silking as vegetative growth and post-silking as reproductive growth stage), the variability of RUE in different growth effectively during the crop life cycle and to variation in photosynthetic properties of the plant canopy (35).Canopy photosynthesis relation to the nitrogen content (and thus photosynthetic properties) of leaves is the distribution of solar radiation in a canopy in relation to the light gradient in such a way that daily canopy photosynthesis is optimized in relation to light (7), there is then a linear relationship between daily canopy photosynthesis and interclepted PAR (3, 10). The results imply that all leaves in a canopy have constant PhRUE over one day (daily PhRUE), independent of their canopy position and PAR exposure (24). The conclusion of Souza et al., (29), indicated to the mean daily incident solar radiation which was below 20 MJ m^{-2} during the whole cycle, with mean values of PAR around 8 MJ m^{-2}, although the daily values of 12 MJ m^{-2} were observed in some days, but rarely reaching values below 6 MJ m^{-2} day^{-1}. The interactions between some genotypes and higher rates of nitrogen fertilization in a previous investigation showed more accumulated radiation interception than control, having mean values of(815.0, 813.6, 811.8, 812.3 and 811.3) MJm^{-2}. (14) whom they found the minimum grain yield basis radiation use efficiency (4.41 g MJ-1) was attained by Bhakar genotype with no nitrogen application. The use of nitrogen fertilizers is most essential mineral nutrient for higher grain yield in cereals for its role in plant growth and the physiological and biochemical processes, production of carbohydrates and the protein synthesis, especially the small molecular weight proteins which associated with tolerance to stress conditions (14 , 21), while the higher application of nitrogen fertilization departs as waste through different deleterious processes, although there was an inverse results were shown on yield losses with higher applications of nitrogen, therefore it require to increase its use efficiency (9 ,16) Climatic factors are crucial to the high productivity of the crops. The maize plants response to the nitrogen fertilization showed differential growth and distinct influences of the assimilated partition between their structures, RGR of Plants grown using 75% of the recommended dose of N at sowing had a higher relative growth rate compared to the other doses (33). Solar radiation is a fundamental factor to determine the plant growth, RUE is influenced by low and high temperature too, the photosynthetic efficiency, increased or decreased with fluctuations between respiration and photosynthesis under the impact of temperature that directly affect the net photosynthesis (2, 18, 20). The aim of the present study was to investigate the RUE of four maize hybrids under effect of two different seasonal conditions using different levels of Nitrogen fertilization.

MATERIALS AND METHODS

The efficiency of using radiation by four maize hybrids under influence of three levels of nitrogen fertilizer was studied in two different climatic conditions. Two different field experiments were conducted at the Qlyasan Research Station\ university of

Sulaimani (Lat. 35o 34' 307"; N, Long 45o 21' 992"; E, 765 masl) during the spring and fall seasons in 2017. The experiments were laid out in a split- plot design with three replications. Three different levels of nitrogen were used in the main plot factor N_1 = 80 Kg N ha^{-1}, N_2 =120 Kg N ha^{-1}, and N_3=160 Kg N ha^{-1}), which were applied as Urea 46% at two different growth stages, the 1st at seedling and the 2nd dose at tasseling, (1). Four maize hybrids(GLORIA, MARKET\ Butik Co. Turkey, CRUZ\Feto Co. Spain, and DRAXMA\Cenmenta Co. SWS) as (H_1, H_2, H_3 and H_4) respectively, cultivated in the subplots. The phosphorous fertilization with 200 kg ha^{-1} was applied at seeding, while all the crop management practices were behaving as required. The subplots were divided into 4 rows with 0.7 m spacing between the rows and 0.25 m between plants within the rows. The date of sowing in spring season was in April 05 and Jul.04 for 2017 autumn, the duration of the growth stages in both vegetative and reproductive growth in both seasons was evaluated, especially the dates of 50% tasseling and 50% silking, and 50% physiological maturity. Destructive sampling were used for determining the rate of dry matter accumulation from V5 to R3, pre and post- silking (V4-5, V8-10, V10-12, VT, and R3) as well as Physiological maturity (PM) which synchronized with the dates at (May05, May 26, Jun 20, and Jul 20) in spring season while in autumn season the growth stages were corresponded with (Jul 21, Aug05, Aug26, and Sept.16). For predicting the increase or decrease in the rate of dry matter accumulation along the growth stages in both season, the following equation was used for determining the relative growth rate (RGR):

RGR ($g\ g^{-1} d^{-1}$) = $\mathbf{lnW_2 - lnW_1 / t_2 - t_1} =$

Where: lnW_2 is the natural logarithm of the plant weight at a later date, lnW_1 is the natural logarithm of the plant weight at a previous date, t_2 is the time 2 or later date, and t_1 is the previous date. The photosynthetically active radiation (PAR) was measured for six leaves in the upper part of the plant during (900 – 1200) h, for the same mentioned growth stages (V4-5, V8-10, V10-12, VT, and R3) in clear or partial overcast day hours, according to the RUE over the course of the day is constant for the canopy leaves, the intercepted PAR was measured for the whole day, according to (Rosati and Dejong, 2003). The LCA-4 computerized instrument was used for measuring the PAR in $\mu Molm^2s^{-1}$ and then converted to MJ m^{-2}, also the leaf chamber temperature in degree Celsius, estimating of radiation use efficiency was done according to the following equation:

RUE (Kg MJ^{-1} m^{-2}) **= Plant Dry Weight** (Kg m^{-2}**) / PAR** (MJ^{-1} m^{-2})

RESULTS AND DISCUSSION

Growth and development of investigating maize hybrids incorporated in accumulation of dry matter were varied according to their responses to climatic conditions of both growing season, especially the photosynthetic efficiency that correlated to the intensity of photosynthetically active radiation (PAR). Fig 1, clarify the intensity of the intercepted PAR during the different growth stages in both season. There were lower intensity of intercepted PAR in the spring season, which was between (9.501-12.790) $MJm^{-2}d^{-1}$ with the average of (10.555 $MJm^{-2}d^{-1}$), in comparison to the higher intensity of intercepted PAR during the autumn season with (18.545 and 19.416) MJm^{-2} d^{-1}, and with the average of (15.672 MJm^{-2} d^{-1}), there was declining toward the end of the season (Fig.1).

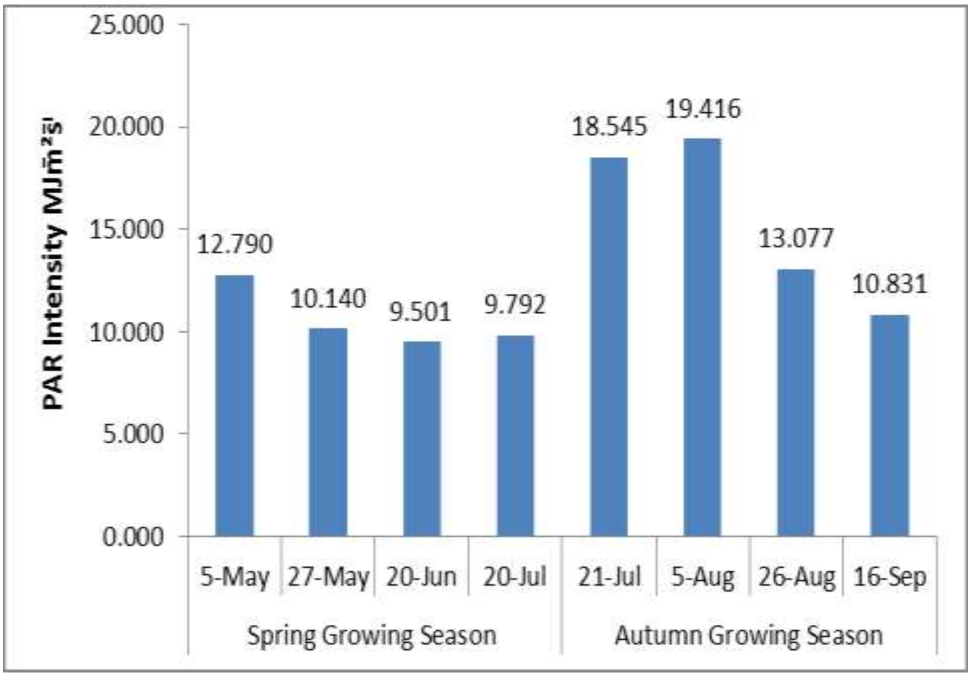

Fig 1. Average of daily PAR intensity in different growth stages in both seasons

The intensity of solar radiation that intercepted on the plant leaves was directly affected the leaf temperature of maize hybrids, the minimum temperature was recorded in the leaf chamber in spring growing season was during the vegetative period that did not exceed 32.5°C, while the fall season started with higher temperature more than 37°C and continued to the end of the season.

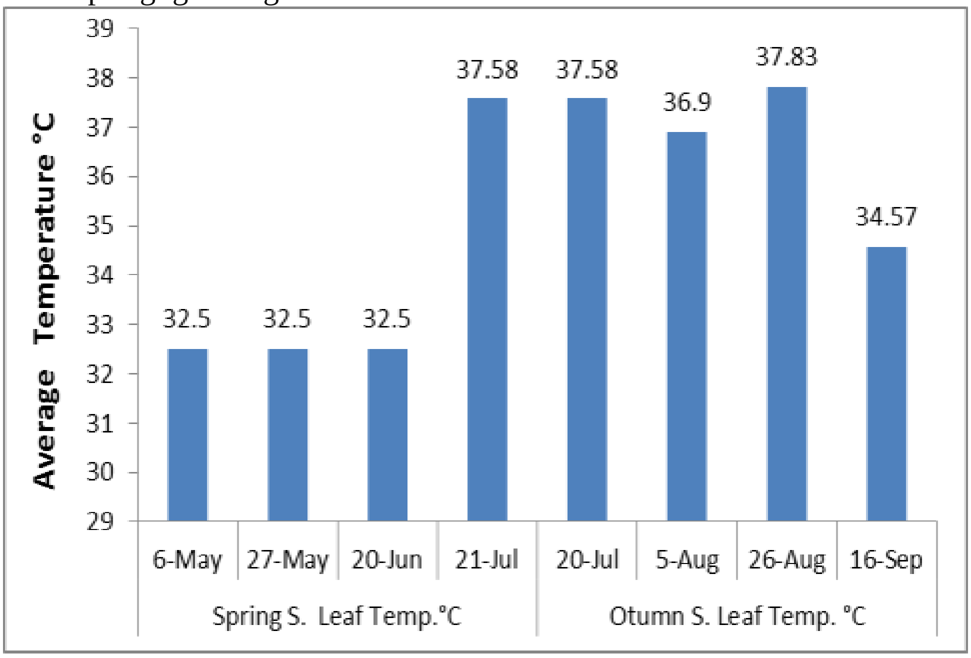

Fig 2. Daily average temperature °C in both growing season

Dry matter accumulation

The rate of total dry matter accumulation is considered as an expressive parameter for the rate of growth and development of plants, the amount of intercepted radiation usually influences the photosynthesis and the efficiency of photosynthesis, the efficiency of photosynthesis is also affected by the temperature of the leaves and the nutrient status especially nitrogen that impacted the net assimilation rate and plant total dry matter. The effect of nitrogen levels on the rate of accumulated dry matter of seedling stage (V4-5) to (PM) in both seasons shows in Table 1, there were signalize increasing in the plant dry weight along the growing season, the maximum dry weights were revealed in the period post-silking for three different levels of nitrogen with the significant superiority of the effect of N_3 at PM in both season. The relative growth rate (RGR g g-^{1}d^{-1}) was significantly varied with the effect of nitrogen levels and growth stages in spring season, Fig.3 A indicate to significant accumulating of plant dry weight in the linear phase with maximum RGR at tasseling (VT 4.06 g g^{-1}d^{-1}) under influence of N_1, while maximum RGR which was obtained with the impact of N_2 and N_3 were at post silking R3 with 4.109 and 6.501 g g^{-1}d^{-1}, the accretion in RGR was correlated with the effect of nitrogen level N_1, N_2, and N_3 with r^2 value of 0.89, 0.99, and 0.70 respectively. The performance of maize hybrids significantly displayed across the growth stages in the spring season, (Fig.4 A), there were significant increasing in relative growth rate with development of growth stages from seedling (27DAS) to V8-10 (49DAS), and from V8-10 to VT and from VT to R3 and then declined toward the physiological maturity(PM), the maximum relative growth rate was shown by H4 at two different growth stages V8-10 and PM revealing (1.071 and 2.506 g g^{-1}d^{-1}), while the hybrid H_1exceeded others at tasseling stage (VT) performing 4.327 g g^{-1}d^{-1}, however hybrid H_3 was show distinction in reproductive stage R3 with 7.136 g g^{-1}d^{-1}. The increasing in RGR of all hybrids was correlated with the growth stages advancement from seedling to VT and to R3 and then declined in PM, exhibiting r^2 value of 0.98, 0.99, 0.63, and 0.64 for H_1, H_2,H_3, and H_4 respectively. In fall season there were considerable differences of RGR under the effect of nitrogen levels too, Fig. 4. A, manifest increasing in RGR from seedling(15DAS) to V8-10(30DAS), and from V8-10 to VT, and from VT to R3 and then from R3 started decreasing till PM. The maximum RGR with the impact of the first level of nitrogen was obtained at R3 which was 5.886 g g^{-1}d^{-1}, while the effect of second level N_2 was displayed in the mid season at tasseling (VT) demonstrating 4.173 g g^{-1}d^{-1}, but the third level N_3 was not overridden in any growth stages. The relative growth rate of four maize hybrids in autumn season (Fig.4,B)demonstrated significant differences in different growth stages, the Hybrids GLORIA(H_1), and MARKET (H_2) were shared significant superiority in the reproductive growth stage post silking at R3, obtaining (5.006 and 5.437) g g^{-1}d^{-1} respectively, while exceeding of Cruze (H_3) was at latest stage at PM (2.294 g g^{-1}d^{-1}), and the significant performance of Draxma (H_4) was in tasseling showing maximum RGR with 4.441 g g^{-1}d^{-1}.

Table 1. Effect of Nitrogen levels on the rate of Dry matter accumulation in different stages in both seasons

Nitrogen levels	DM accumulation(g) - Spring season					DM accumulation(g) - Autumn season				
	V4-5	V8-10	VT	R3	PM	V4-5	V8-10	VT	R3	PM
N1	1.48	19.493	104.453	155.741	229.416	0.439	16.428	91.729	215.332	234.179
N2	1.175	17.683	96.982	158.628	187	0.424	17.794	105.432	163.935	206.493
N3	1.204	30.708	95.601	193.122	209.416	0.421	14.84	96.592	188.505	251.937
L.S.D	N.S	1.765	N.S	9.821	N.S	N.S	N.S	8.664	12.183	10.613

Table 2. Dry matter accumulation of maize hybrids in different growth stages in both seasons

Maize Hybrids	DM accumulation(g) - Spring season					DM accumulation(g) - Autumn season				
	V4-5	V8-10	VT	R3	PM	V4-5	V8-10	VT	R3	PM
H1	1.525	21.602	112.589	184.055	200.666	0.488	17.801	93.452	198.59	233.767
H2	0.992	22.102	95.551	156.978	207.222	0.377	15.152	85.627	199.824	241.223
H3	1.055	22.486	77.056	184.098	197.444	0.345	16.166	103.035	146.174	224.174
H4	1.572	24.321	110.852	151.522	229.111	0.501	16.296	109.557	212.441	224.315
L.S.D	0.246	2.348	19.047	9.133	N.S	0.115	N.S	6.456	8.334	6.437

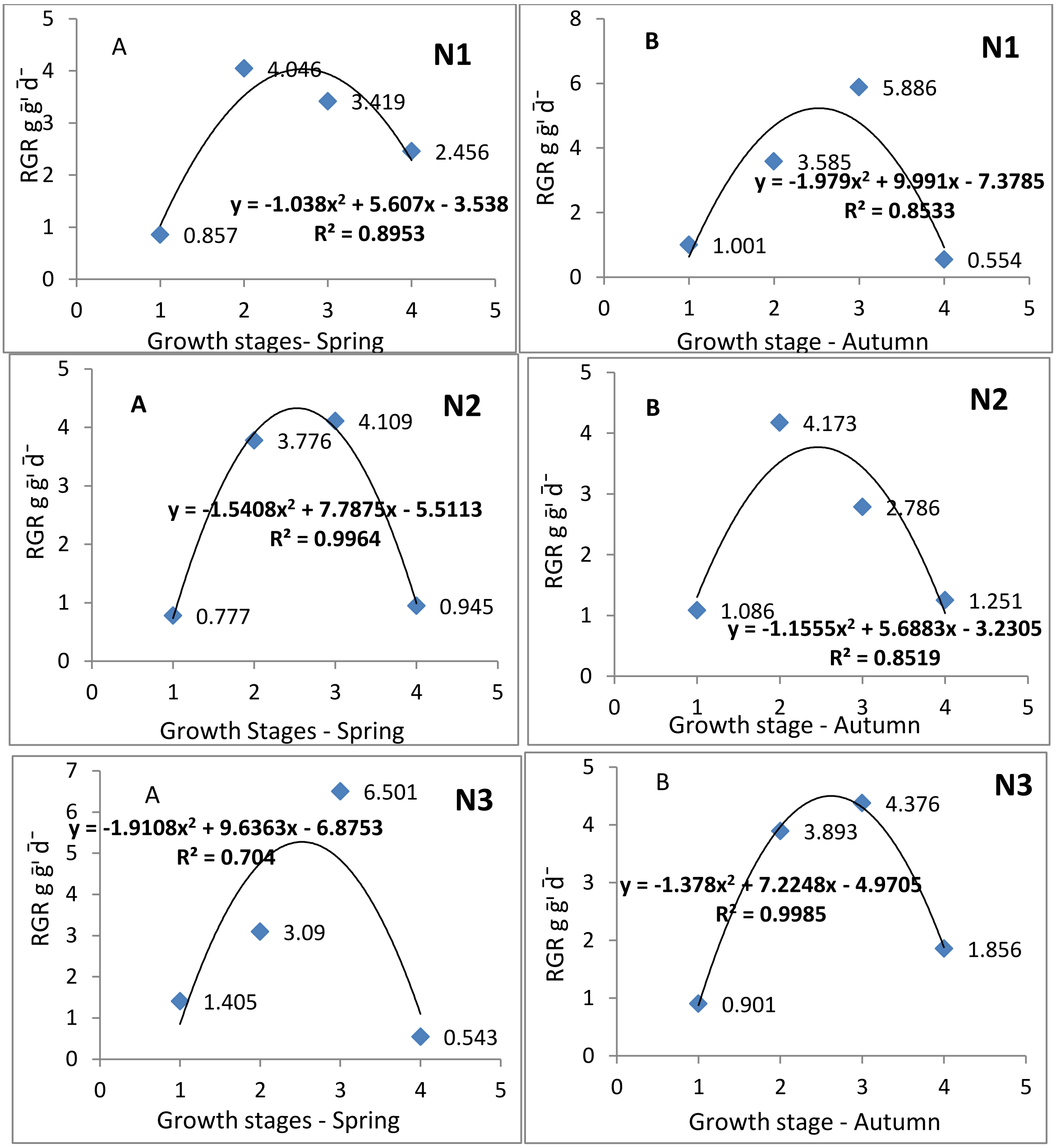

Fig.3 A and B, Effect of nitrogen levels on the Relative Growth Rate(RGR) in different growth stages of both seasons

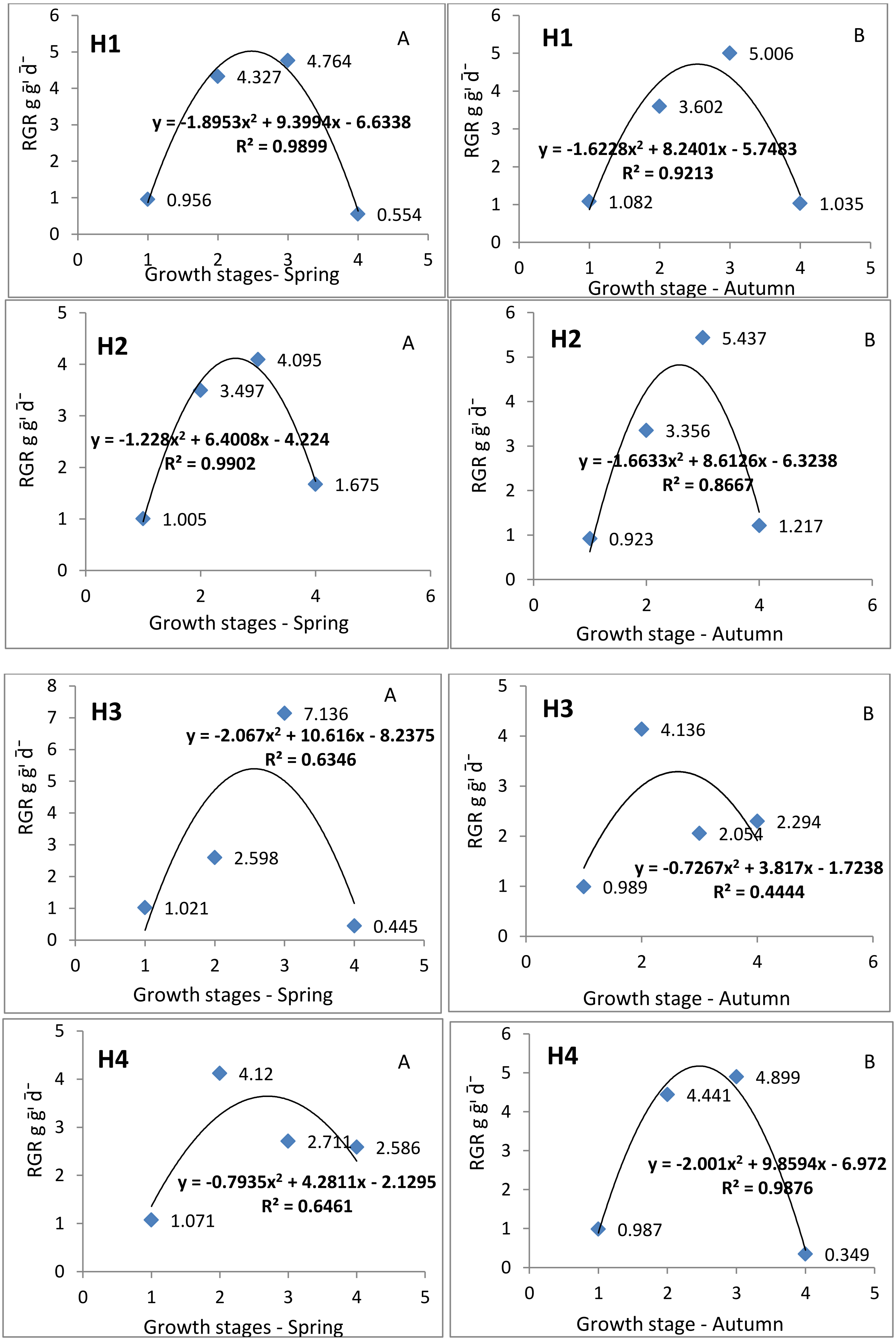

Fig 4. A and B. Relative growth rate of maize hybrids in both seasons

Radiation use efficiency

Plant production and dry matter accumulation of dry matter can be related to the intercepted and absorbed light energy on the plant canopy, the incident PAR will increase the slope between net assimilation rate, which leads to dry matter accumulation, the slope of this relationship is radiation use efficiency (RUE), (17). Fig.5, demonstrate the influence of nitrogen levels on the RUE in different growth stages from seedling to PM. In spring season there were linear increasing in the efficiency of radiation using under effect of three nitrogen levels along the different growth stages, maximum value of RUE in spring season was obtained with highest level of nitrogen application in two growth stages only, (Seedling and tasseling) revealing 0.441 and 3.492MJm^{-2}s^{-1} in May05 and Jun20, while the maximum RUE with the effect of the first level of nitrogen was demonstrated in stage pre-tasseling in May 27, and at physiological maturity showing 1.887 and 4.311 MJm^{2}s^{-1} respectively. In the autumn season there was a linear increase of RUE from seedling to the PM too(Fig.6), the maximum efficiency of radiation using at the later stages of growth was with the effectiveness of the highest application of nitrogen(N_3) on tasseling and PM with4.022and 6.019Mjm^{2}s^{-1} respectively. The RUE values in fall season were higher than that in the spring.

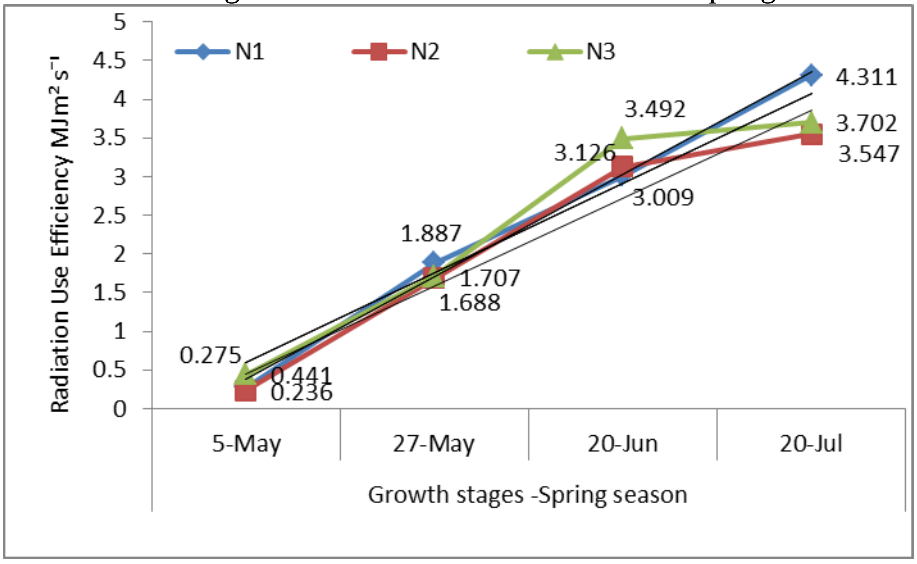

Fig 5. RUE under the effect of nitrogen levels in spring seasons

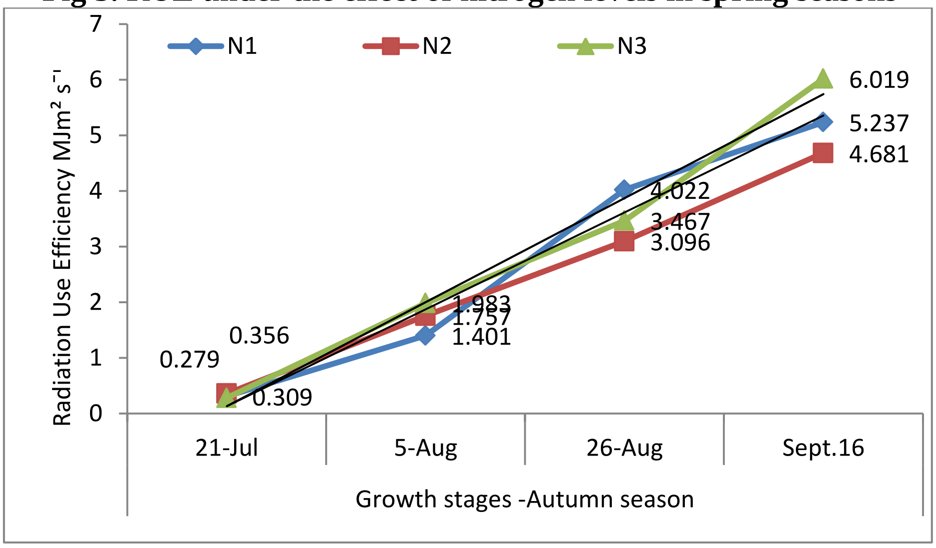

Fig 6. RUE under the effect of nitrogen levels in autumn season

Responses of maize hybrids to solar energy under effect of three different levels of nitrogen across different growth stages from seedling to Physiological maturity displayed in Figs. 7, 8 , 9, and 10. In the vegetative growth stage V8-10(Fig.7), the RUE that measured for the period from seedling (V4-5), indicated to higher efficiency of solar radiation, used by most of maize hybrids was more efficient in the autumn season than that in spring season under the effect of the first and second levels of nitrogen, while the efficacy of using radiation under influence of third level was changed to be higher in the spring for all hybrids with significant exceeding of the H_3. Results of RUE of maize hybrids under influence of three levels of nitrogen at tassling VT (Fig.8), referd to significant differences were found between RUE of maize hybrids in the VT stage, according to effect of levels of nitrogen, there was surpassing of performance of all hybrids except H_3 with the effect of N_1 in the spring season, whilst with the influence of second level of nitrogen the hybrids H_3 and H_4 exceeded in spring only, but the hybrids H_1 and H_2 showed significant efficiency in using radiation in autumn. The hybrids H_1 and H_2 exceeded with the third level of nitrogen in spring, but conversely the hybrids H_3 and H_4 overridden in fall season

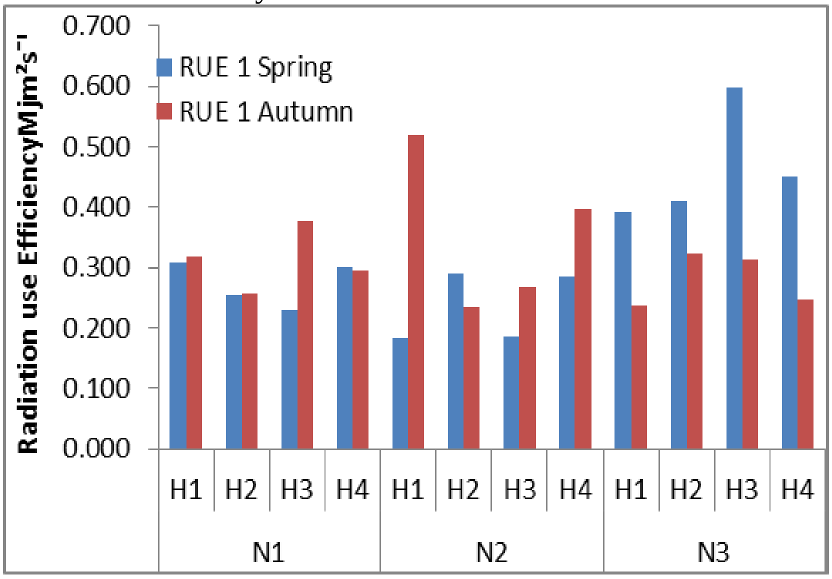

Fig 7. Radiation use efficiency of maize hybrids with the effect of nitrogen levels in vVegetative growth stages V8-V10)

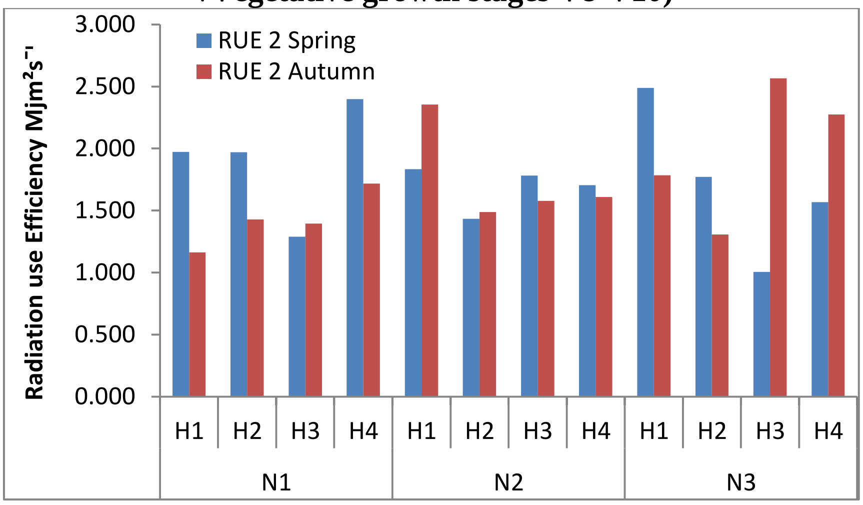

Fig 8. Radiation use efficiency of maize hybrids with the effect of nitrogen levels in vegetative growth at tasseling(VT)

During the reproductive growth stage post-silking (R3), there was higher RUE of all hybrids with the effect of N_1, while the hybrids H_1 and H_2 showed higher RUE with N_2 and N_3, however the hybrid H_3 performed better in spring and the higher RUE of H_4 was with the maximum rate of nitrogen in fall (Fig.9). The performance of maize hybrids in the end of the two growing seasons at physiological maturity (Fig.10)was indicated to higher RUE under all the nitrogen levels N_1, N_2, and N_3 in autumn season except the hybrid H_4 with the second level of nitrogenN_2, which reveal the seasonal patterns and the canopy photosynthetic responses to the responses to direct PAR

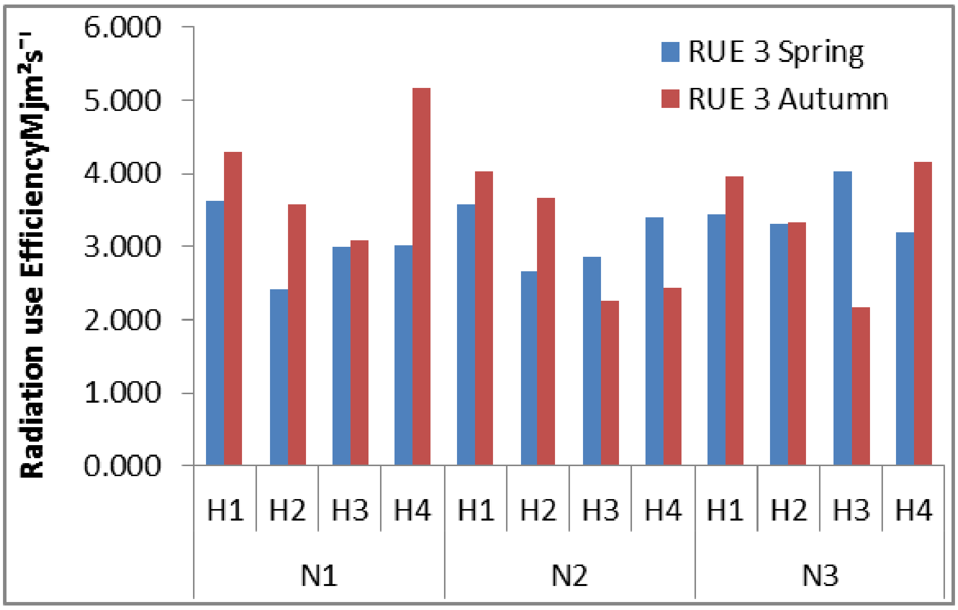

Fig 9. Radiation use efficiency of maize hybrids with the effect of nitrogen levels in reproductive growth stage post-silking, R3

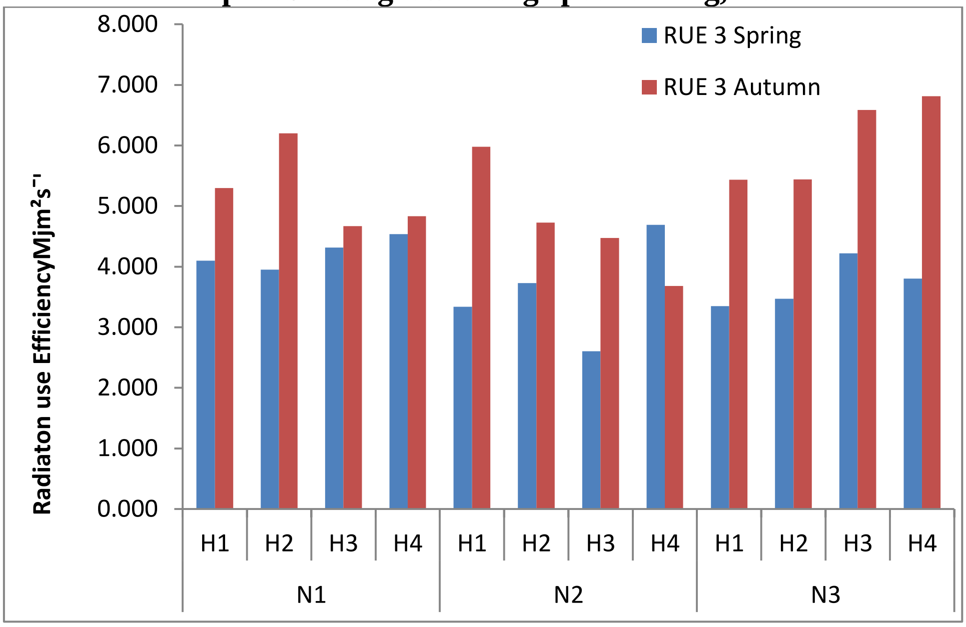

Fig 10. Radiation use efficiency of maize hybrids with the effect of nitrogen levels on reproductive growth stage at physiological maturity (PM)

To determine the effect of growth stages on the radiation use efficiency in both seasons, the correlation coefficient between growth stages in both seasons were calculated (Tables 3, and 4), in order to demonstrate the correlation between growth stages in case of RUE values, there were no significant effect between growth stages in spring season, while in autumn season there was significant correlation between the rapid growth stage during (Aug.05) and the period around physiological maturity(Sept.16) revealing higher rate of dry matter accumulation during rapid growth stage of autumn which indirectly influenced the later stages as a component of RUE. The results of Tables 3 and 4 are considered as signalize indication to the effect of the intensity of intercepted PAR during each growth stage in dependently

Table 3. Correlation coefficient value for the RUE - Spring season

	May.5	May.27	Jun.20	Jul.20
May.5	1			
May.27	-0.217	1		
Jun.20	0.510	-0.171	1	
Jul.20	0.177	-0.139	0.019	1

Table 4. Correlation coefficient value for the RUE - Outman season

	Jul.21	Aug.5	Aug.26	Sept.16
Jul.21	1			
Aug.5	0.242	1		
Aug.26	-0.099	-0.080	1	
Sept.16	-0.119	0.577*	0.250	1

*** Correlation is significant at t(0.05, 10) =2.228**

**** Correlation is significant at t(0.01, 10) =3.169**

In order to calculate the RUE of maize hybrids, the Photosynthetically active radiation (PAR µMol m^2s^{-1})was determined with accumulated dry matter during the growth stage intervals, (Fig.1) which demonstrate the variation in PAR intensity between the two seasons and also within the season periods (29), in spring growing season the daily intercepted PAR was between 9.792 to 12.790 MJm^2s^{-1}, while in autumn season was between 10.831 to 19.416 MJm^2s^{-1} revealing higher means of intercepted PAR that caused higher air temperature and leaf temperature of maize hybrids (Fig.2), the higher means of temperature in autumn, (34.57-37.83)°C, has direct effect on physiological and biochemical processes that indirectly influenced the growth and development acceleration, there was nearly 15 days (with average daily intercepted PAR 15.672 MJm^2s^{-1}) required for passing growth stages, conversely to the same periods in the spring season, which required 21 days or more with 10.555 MJm^2s^{-1} and leaf temperature means (32.5°C), our results were in line with previous studies of (2 , 20). The influence of nitrogen levels on the dry matter accumulation demonstrated in table 1 and 2, that display significant surpassing of the highest level of the nitrogen on the rate of dry matter accumulation in the spring season in growth stages V8-10 and R3, representing linear growth and silking in which more effective growth including leaf appearance and stem elongation as well as initiation and formation of the tassel and the ear, which require effective source for more nutrient supply, results of (12) indicated that corn is more responsive to variability in plant emergence, which variability significantly affected dry matter accumulation, and grain yield, as well the favorite temperature around 32.7°C for the C4-plant such as maize (3 , 10 , 14). Effect of nitrogen levels in autumn season was shown in the later stages of the growth VT, R3 and PM in which N_3 exceeded significantly in PM, the improve uptake of resources may result from increased interception of seasonal incident radiation,(33). The prevailing environmenal condition of autumn may be a requirement for additional quantities of the nitrogen to corresponding with higher temperature means that may expose to high rate of depletion, these results were in agreement with those by (2, 18, 20, 24). he relative growth rate indicate to the rate of accumulated dry matter as influenced by nitrogen levels in different growth stages, furthermore it represents the net photosynthesis of maize hybrids in different growth stages which allocate as dry matter to different parts of the plants, the RGR showed curvilinear relation for the effect of three levels of nitrogen dew to increasing rate from seedling to V8-10, and from V8-10 to VT and also from tasseling to R3 and then declined from R3 to PM because of the end of the season with the maturity in which the canopy close to seasing and the growth declining (12), the maximum RGR with second and third levels of nitrogen in spring season were at R3(4.109 and 6.501) g $g^{-1}d^{-1}$ respectively,while in autumn the maximum RGR with 1st and 3rd levels at R3(5.886 and 4.376) $gg^{-1}d^{-1}$, whilst maximum RGR with 2nd level was at tasseling. The performance of maize hybrids in performing RGR varied significantly with obvious indication to growth stages tasseling(VT) and silking(R3) in both season, demonstrating maximum value of RGR for all hybrids that in addition to the effect of higher application of nitrogen fertilizaer manifesting effectivity of these two stages in RUE dew to higher demand to the photosynthetic and source-sink relationship(35). The high RGR of maize hybrids Cruze(H_3) and Draxma(H_4) at silking stage, revealing high efficiency of these two hybrids that lead to higher yields,(Table, 3). Those previous results also documented by (5, 19, 27).Effect of nitrogen fertilization on the Radiation Use Efficiency in both seasons was displayed in figs.5 and 6, demonstrating linear effect along the growth stages in both season, the daily moderate mean tempeatures in spring season (32.5 °C) enabled maize plants to perform better in the rate of dry matter accumulation owing to positive relation between rates of photosynthesis and respiration and associated biochemical reactions too, that directly influence on accumulation of dry matter and radiation use efficiency especially in the initial stages(10.790 and 10.140) MJm^{-2} d^{-1} in which the daily intercepted radiation was higher than later stages(9.591 and 9.790) MJm^{2} d^{-1} in this season, the efficiency of photosynthesis directly influenced with the relationship between respiration and photosynthesis,(14, 15) The autumn season was started with higher intercepted PAR (Fig.3) which was (18.545 and 19.416) MJm^{2} $d^{-1}$and in the later stages was (13.077 and 10.831) MJm^{2} d^{-1} which were too high than that in spring season, the climatical condition of this season of higher daily temperature and higher intensity of PAR led to growth acceleration and higher values of RUE too demonstrating (5.237, 4.681, and 6.019) g $MJ^{-1}m^{-2}$ higher than that obtained in previous research, the results were in agreement with those found by (6 13 31). The high interception of solar energy caused a direct effect on leaf temperature of maize hybrids that raised to daily averages more than 37°C at the biginning of the season and then declined to 34.57 °C, the physiological and biochemical processes of C4-plants usually are in line with this extent of temperature, although exceeded the optimum range, (7). The effectiveness of the third dose of nitrogen in its influence on RUE which may relate to the impact of abundant nutrient, especially nitrogen in minimizing the deleterious effect of the heat stress (3, 11). The effect of nitrogen levels and maize hybrids on their performance in RUE were showing significant differences in both seasons and also within growth stages in each season, Figs.8,9,10, and 11 manifested variations in RUE under interactions of maize hybrids and also the nitrogen levels with demonstrate significant exceeding in autumn that may consider as an approach of the micro environment inside a plant canopy including intercepted radiation is differ spatialy and temporally, owing to unstable of the radiation angle, as well variation in the structure and physiological capability (14, 33, 36). Radiation Use Efficiency of the maize hybrids was varied along the growth stages in both seasons, the variation in the intercepted PAR intensity in both seasons with the variation in the patterns of radiation angles or the canopy features in responding this pattern of radiation within growth stages was directly influenced the RUE of maize hybrids. The effect of the rate of the accumulated dry matter as a component of RUE with integration of nitrogen levels as well daily temperature, which was considered as the major factor in determining the net photosynthesis that usually fluctuated during the both growing seasons. Although high correlation was obtained between RGR and nitrogen application, the maximum relative growth rate was revealed before PM. The maximum total dry matter was accumulated during the post-silking as well maximum RUE was in the autumn season, with the highest level of nitrogen for all maize hybrids. The correlation coefficient between growth stages in both seasons showed signalize indication to the effect of the intensity of intercepted PAR during each growth stage independently.

REFERENCES

1. Albrizio, R. and P.Steduto. 2005. Resource use efficiency of field-grown sunflower, sorghum, wheat and chickpea I. Radiation use efficiency. Agricultural and Forest Meteorology, 130:254–268

2. Bat-Oyun, T., M. Shinoda and M. Tsubo. 2012. Effects of water and temperature stresses on radiation use efficiency in a semi-arid grassland. Journal of Plant Interactions.7:214-224

3. Dewar,R.C.1996. The Correlation between Plant Growth and Intercepted Radiation: An Interpretation in Terms of Optimal Plant Nitrogen Content.Annals of Botany 78: 125–136

4. Gosse G, C. Varlet-Grancher R., Bonhomme , M. Chartier , J.M. Allir and G. Lemaire . 1986. Production maximale de

matieÁre seÁche et rayonnement solaire intercepteÂ veÂgeÂtal. Agronomie 6: 47-56
5. Green, CF. 1987. Nitrogen nutrition and wheat in growth in relation to absorbed solar radiation. Agric. For. Meteorol. 41:207–248
6. Gu, L., D. Baldocchi, S.B. Verma, T. A. Black, T. Vesala, E. M. Falge, and P.R. Dowty. 2002. Advantages of diffuse radiation for terrestrialecosystem productivity. J. Geophysical Res.107: D6, 405
7. Hiros, T., and M.J.A. Werger. 1987. Maximizing daily canopy photosynthesis with respect to daily nitrogen allocation pattern in the canopy. Oecologia.72:520-526
8. Justes,E. P. Denoroy, B. Gabrielle, and G. Gosse. 2000. Effect of crop nitrogen status and temperature on the radiation use efficiency of winter oilseed rape. European Journal of Agronomy, 13 : 165–177
9. Kostandi, S.F., and M.F. Soliman. 1991. Effect of nitrogen rates at different growth stages on corn yield and common smut disease. Ustilago maydis (D.C.) Corda .J.Agr.Cr.Sci.167: 53-60
10. Kull, O. and P.G. Jarvis. 1995. The role of nitrogen in a sim-ple scheme to scale up photosynthesis from leaf to canopy. Plant, Cell and Environment 18, 1174–1182
11. Lindquist, J.L., T. J. Arkebauer, D. T. Walters, K. G. Cassman, and A. Dobermann. 2005. Maize radiation use efficiency under optimal growth conditions. Agron. J. 97:72–78
12. Liu, W., M. Tollenaar, G. Stewart, and W. Deen.2004.Crop ecology , management and quality . Crop Sci. 44:847–854
13. Liu, T., F. Song, S. Liu, and X. Zhu. 2012. Light interception and radiation use efficiency response to narrow-wide row planting patterns in maize. Au. J. Cr. Sci. 6(3):506-513
14. Maqsood, M. M.A. Shehzad, Y. R. and A. Sattar. 2014. Effect oF nitrogen nutrition on growth yield and radiation use efficiency o different wheat (*Triticum aestivum* L.) Cultivars. Pak. J. Agri. Sci., Vol. 51(2), 441-448
15. Morales-Ruiz, A., J. M. Loeza-Corte, E. Díaz-López, E. J. Morales-Rosales, O. Franco-Mora, M. D. Mariezcurrena-Berasaín, and G. Estrada-Campuzano. 2016. Efficiency on the Use of Radiation and Corn Yield under Three Densities of Sowing. Volume 2016, Article ID 6959708, 5 pages http://dx.doi.org/10.1155/2016/6959708
16. Mohsin, A.U., J. Ahmad, A. U. H. Ahmad, R. M. Ikram, and K. Mubeen. 2012. Effect of nitrogen application through different combinations of uirea and farm yard manure on The performance of spring maize (*Zea mays* L.). The Journal of Animal & Plant Sciences, 22:195-198
17. Monteith, J.L.1972. Solar Radiation and Productivity in Tropical Ecosystems. Papers contributed to IBP/UNESCO Meeting on Productivity of Tropical Ecosystems, Makerere University, Uganda, September 1970. Proceedings in preparation
18. Monneveux P, C. Pastenes and M.P. Reynolds . 2003. Limitations to photosynthesis under light and heat stress in three high-yielding wheat genotypes. J Plant Physiol.160:657-666
19. Muchow, R.C., and R. Davis. 1988. Effect of nitrogen supply on the comparative productivity of maize and sorghum in a semi-arid references tropical environment: II. Radiation interception and biomass accumulation. Field Crops Res. 18:17–30
20. Pastenes, C., and Horton, P. 1996. Effect of high temperature on photosynthesis in beans CO2 assimilation and metabolite contents. Plant Physiol.112:1253-1260
21. Pitman, J.I. 2000. Absorption of Photosynthetically Active Radiation, Radiation Use Efficiency and Spectral Reflectance of Bracken (*Pteridium aquilinum* (L.) *Kuhnl*) Canopies. Annals of Botany 85: 101-111
22. Prince, S.D. 1991. A model of regional primary production for use with coarse resolution satellite data. International Journal of Remote Sensing 12: 1313-1330
23. Rosati, A., S.G. Metcalf and B. D. Lampinen. 2004. A Simple Method to Estimate Photosynthetic Radiation Use Effciency of Canopies. Annals of Botany. 93: 567-574
24. Rosati, A., and T.M.Dejong. 2003. Estimating photosynthetic Radiation Use Efficiency Using Incident Light and Photosynthesis of Individual Leaves. Annals of Botany.91:869-877
25. Ruimy, A., P.G. Jarvis, D.D. Baldocchi, B. Saugier and R. Valentini.1995. CO2 fluxes

over plant canopies: a review. Adv. Ecol. Res.26:2—68

26. Runyon, J., R.H. Waring, S.N. Goward and J.M. Welles. 1994. Environmental limits on net primary production and light use efficiencyacross the Oregon Transect. Ecol. Appl. 4:226—237

27. Sinclair,T.R., and T. Horie 1989. Leaf nitrogen, photosynthesis, and crop radiation use efficiency: a review. Crop Science 29: 90–98

28. Sivakumar, M.V.K. and S.M. Virmani 1984. Crop productivity in relation to interception of photosynthetically active radiation. Agricultural and Forest Meteorology 31: 131–141

29. Souza, P.J.O.P., A. Ribeiro, E.J.P. Rocha, J.R.B. Farias, R. S. Loureiro, C. C. Bispo, and L. Sampaio. 2009. Solar radiation use effi ciency by soybean under fi eld conditions in the Amazon region. Pesq. agropec. bras., Brasília.10:1211-1218

30. Stockle, C.O., and J.R. Kiniry. 1990. Variability in crop radiation use efficiency associated with vapor pressure deficit. Field Crop Res.25, 171–181

31. Tewes, A., and J. Schellberg. 2018. Towards remote estimation of radiation use efficiency in maize using UAV-Based low-cost camera imagery. Agronomy.8, 16: 8020016

32. Tiedong, L., F. Song, S.Liu, and X. Zhu. 2012. Light interception and radiation use efficiency response to narrow-wide row planting patterns in maize. Agr. J Cr. Sci. 6(3):506-513 (2012).

33. Tollenaar, A., and J. Wu. 1999. Yield improvement in temperate maize is attributable to greater stress tolerance. Crop Sci. 39:1597–1604

34. Matthew, M.H. 2003. Effects of shading, relative growth rate and population density on weed responses to nitrogen management in corn. Retrospective Theses and Dissertations, Iowa state University. Cited from, https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1585&context=rtd

35. Trapani, N., A.J. Hall, V.O., Sadras, and F.Vilella, 1992. Ontogenetic changes in radiation use efficiency of sunflower crops. Field Crops Research, 29: 301-316

36. Troyjake, C., J.R.Pimentel, , Í.T. D. Padilha, R. A.V. Escalera, L. B. A. Jaques, F. Koch, M. A. Monteiro, G.H. Demari, V.J. Szareski, I. R. Carvalho, L. O. B. Schuch, T. Z. Aumonde, and T. Pedó. 2018. Nitrogen fertilization on maize sowing: plant growth and seed vigor. American Journal of Plant Sciences. 9:83-97.