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Phyllochron and Leaf area ratio of maize influenced by different nitrogen levels and Growing Degree Days in two different climatic conditions

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Abstract

The present study shows the response of maize hybrids to different thermal time conditions with different nitrogen levels, the investigation comprises two different field experiments were conducted in the Qlyasan Research Center\ University of Sulaimani during the spring and autumn seasons in 2017. The experiments were arranged as a split-plot design with three replications. Three different nitrogen levels involved in the main plots and four maize hybrids were cultivated in the sub-plots. In addition to the Phyllochron, the Plant leaf area, and accumulated dry matter were studied in different growth stages for estimating the leaf area ratio of the four maize hybrids. The results manifested efficient impact of thermal time on the studied traits in comparing to nitrogen fertilization, there was a fundamental effect of thermal time expressed as accumulated growing degree days (GDD) on the physiological and biochemical processes of growth and development of maize hybrids. The accumulated GDD from seeding to 50% tasseling was 1050.9 calculated in 58.5 DAS in autumn, whereas in spring season the accumulated GDDs was 1367.6 estimated in 66.25 DAS. Whilst, the linear increases in the leaf appearance and shorter phyllochron manifested in the autumn season, the maximum value of study criteria was not obtained with maximum nitrogen application in all cases. There was a linear decline of the value of LAR across the growth stages from V4-V5 to R3 which was underlined with regression value of r^2 of 0.99 , 0.98, and 0.92 for nitrogen levels (N_1,N_2, and N_3) respectively. The rate of LAR in autumn season was not similar to the previous season, the maximum value of LAR was shown with the effect of second level N_2 in vegetative growth V8-V10 and reproductive growth stage R3 with first level N_1 revealing curvilinear regression.

Introduction

Importance of corn (*Zea mays* L.) comes from its economic value and its wide use in food and feed industry worldwide. Maize development is primarily driven by temperature from emergence to physiological maturity [1] and [2]. Duration of leaf emergence and number of leaves is reflecting the development of the plant leaf area that correlates with the photosynthetic efficiency and the plant potential in dry matter accumulation, development of plant leaf area is directly related to the plant growth and development, an increase in leaf area leads to an increase in rate of dry matter accumulation and rate of dry matter accumulation during early development is directly related to plant leaf area [3] and [4]. Environmental effects such as temperature are the only factor that influences phyllochron or leaf appearance in plants [5]. Temperature is a major factor that drives leaf appearance in maize, phyllochron concept is one approximation to predict the appearance of individual leaves is defined as the time interval between the

appearances of successive leaves, and is considered as an important parameter in the growth and development of any crop, [1], [6], and [7].
The determination of leaf area ratio (LAR) over time gives the number of emerging leaves. The time needed for the appearance of one leaf can be expressed in thermal time (TT), with units of °C day; in this case the phyllochron has units of °C day leaf $^{-1}$, [8].
The duration of leaf appearance or growth stages represents a time interval with respect to a quantity of temperature known as thermal time, which expressed in growing degree days (GDD), which are neatly correlated to growth and developmental processes [9]. Cumulative GDD for a given period of growth are calculated as the summation of mean daily air temperature minus a base temperature (T_b). Cumulative degree-days can be associated with measures of plant development if several conditions are satisfied [10], and [11]. Crops develop and produce leaf canopies differently in different environmental or climatic conditions. Degree days are a measurement unit that combines temperature and time such that the development duration of plant life cycle or any stage of the life cycle. Although temperatures and time may vary, the physiological time remains relatively constant [12].
Specific time intervals between stages and total leaf numbers developed may vary between different hybrids, seasons, planting dates and locations. The rate of plant development for any hybrid is directly related to temperature, so the length of time between the different stages will vary as the temperature varies, environmental stress may lengthen or shorten the time between vegetative and reproductive stages[13].
(Birch *et al* ., 1998) [14] found small variation in phyllochron among maize genotypes, the variation in phyllochron substantially related to the environmental efficacy. Phyllochron is a constant parameter when expressed in terms of thermal time, it got influenced by other factors like inherent capacity of the genotype [15],and [16], and also for the inputs like nitrogen fertilizer application, identifying the response of genotypes to the leaf area development is related to the duration of some developmental stages such as tasseling and silking to support (physically and physiologically) leaf area and grain growth through canopy photosynthesis and dry matter accumulation[17]. The canopy photosynthesis can be determined through plant leaf area and the leaf area ratio (LAR), or the ratio between the plant leaf area and plant dry weight, which is driven by temperature, and influenced by the increase or decreases in the plant leaf number, and also soil available nutrients that usually cause the leaf area expansion [18], [19], and [17].

Nitrogen is realized as one of the most limiting nutrient that influences corn growth and yield optimically, since it is highly mobile, it is subjected to greater loss from the soil plant system. Even under the best management practices 30-50% or more of the applied N is lost [20]and [21]. The uptake of nitrogen by maize is low during early development and increased at tasseling, because of the potential losses of nitrogen, the amount of fertilizer N applied is not necessarily the amount that remains available to the crop, in addition the maize nitrogen uptake can be influenced in growing conditions from one season to the next [22], there was decreasing in nitrogen use efficiency, which was measured in relating to the dry matter accumulation and final yield [19],and [23].

The aims of the present study were to investigate the effect of thermal time on the maize growth and development through estimating phyllochron and the leaf area ratio under influence of different levels of nitrogen fertilization and climatic conditions of two different seasons.

Materials and Methods:

Two different field experiments were conducted at the Qlyasan Research Center, university of sulaimani (Lat. 35^o 34' 307"; N, Long 45^o 21' 992"; E, 765 masl) during the spring and autumn 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}, N_3=160 Kg N ha^{-1}), which were applied as Urea 46% at two different growth stages, seedling and tasseling, applying N before the V8 development stage is best, [22],and [24]. 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 fertilizers (200 kg ha^{-1}) were applied at seedling while all the crop management practices were done 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 according to accumulated Growing degree days (GDD) with the following equation:

$$\text{GDD} = \frac{((Tmax\ +\ Tmin)}{2} - Tbase$$

Where: T_{max} = Maximum daily air temperature, T_{min} = Minimum daily air temperature, T_{base} = Base temperature for maize 10°C was used [6], [25], and [26], daily temperature for the period from April 2017 until the end of October 2017, the meteorological data were obtained from the sulaimani meteorological station. In order to study the Phyllocron and Leaf area ratio, a number of other related criteria such as rate of the leaf appearance, plant Leaf area from seedling to tasseling were estimated through non destructive samples, and destructive samples were involved in the rate of dry matter accumulation which were studied at different growth stages of vegetative growing period pre-silking (V6-V8, V8-V10, V10-V12, VT) and reproductive growing period at R3 post-silking. The plants that were randomly selected to study the phyllochron were marked with coloured adhesive tapes and the leaves of the plant were marked with the permanent marker, identifying of new leaves was done on the base of the entire leaf, weekly in autumn growing season and each 10 days in spring growing season. The leaf area ratio was determined by using the following equation according to [27]:

$$\text{Leaf area ratio} = \frac{Leaf\ area\ Plant\ ^{-1}(cm^2)}{Plant\ weight\ (g)}$$

The data from the two seasons were statistically analysed according to the JMP7, XLSTAT, respectively, and the significant differences of the treatment means were compared with an LSD test at <0.05.

Results and Discussion:

The development of the crop leaf area is directly affected by temperature and there were variation in the rate of accumulating of the crop heat units which expressed as growing degree days(GDD) in spring and autumn seasons, Fig. 1 reveal the lower rate of GDD accumulated in the initial stage of the spring growing season which increased with the development of maize hybrids toward mid and the end of the season, while there was the reverse situation in the autumn season that the growing season started with higher accumulating of growing degree days due to a higher means of daily air temperature and then declined in the later growth stages. The accumulated thermal time was calculated as GDD from seeding to 50% tasseling (VT) which was 1050.9 estimated in 58.5 DAS in autumn, and 1367.6 estimated in 66.25 DAS in the spring season (appendix no. 1). The maize hybrids varied in the number of days and thermal time required to reach tasseling and other growth stages. Variation in the thermal time between the two seasons was based on the daily air temperature during the growing period, daily average temperature over 106 days from seeding to physiological maturity in spring season reveal (17.7, 24.3, 30.1, and 34.8)°C for months April, May, Jun, and only 20 days of July, while the average temperature in the 98 days of autumn to physiological maturity for months July, Augest, September, and only 10 days of October was (34.8, 34.6, 30.7, and 21.3) °C, which demonstrate higher accumulation of GDD that accelerated phyllochron and the growth rate in the autumn season more than the growth rate in the spring season, especially in the vegetative growth stages to 50% tasseling and 50% silking, [5], [9], [10], [14], and [28].

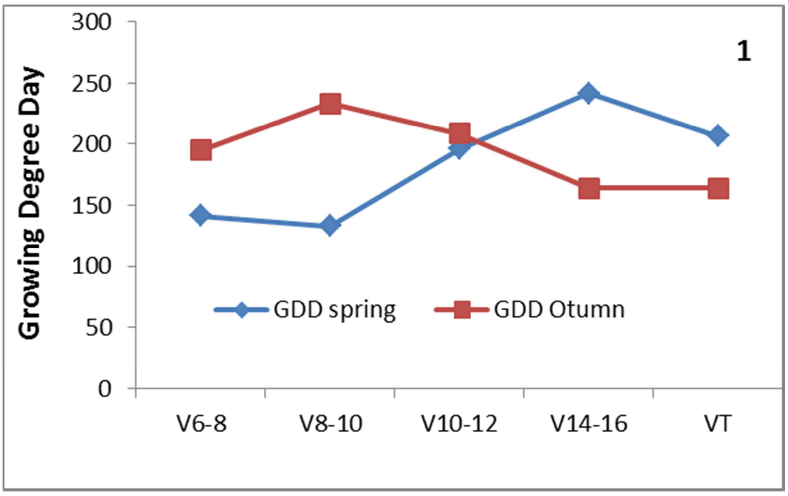


Fig1. Accumulated GDD at different growth stages in both seasons

The rate of phyllochron of maize hybrids as the response to the temperature under effect of three levels of nitrogen in both season was revealed in the Fig. 2 and 3, there was indication to linear increasing by the rate of leaf appearance in both seasons from the beginning of the season to tasseling stage (VT) showing the value of r^2 of 0.92, and 0.99 for spring and autumn respectively. Effect of nitrogen levels on the rate of leaf appearance revealed significantly increasing from N_1 to N_3. The maize hybrids responses to the rate of leaf appearance were significantly varied according to the thermal time with temperature evolution in both seasons, there was exceeding of H4 in spring season in most growth stages in V6-V7 , V8-V9, V11-V12, and V14-V15 while there were adverse responses of four maize hybrids in the autumn season, Fig.3, responses of maize hybrids in this season showed inconstancy in different growth stages, there was exceeding of H3 in V4-V5, and VT but at V6-V7 the superiority was to H_1N_2 and N_3 at 01May and 10Jun in spring and at 20 Jul and 05Aug in autumn growing season. Although there were a primary effect of maximum rate of nitrogen levels [29], the influence of temperature was more effective than the raise of nitrogen application in the rate of leaf appearance and phyllochron, in both seasons, especially under condition of air temperature above 30°C [30]. The results were corresponded with previous research with [13], [9], [31] and [32]. Significant differences among three levels of nitrogen application was manifested in only two stages V4-V5 and VT in spring and V4-V5 and V8-V10 in autumn as shown in Figs, 2and 3 and appendix no.2 in which N2 and N3 surpassed others, higher application of nitrogen may result higher losing of this element especially before the VT [32] and [33].
The effect of the interactions between nitrogen levels and response of hybrids confirms the influence of lower levels of nitrogen to the maize hybrids in manifesting maximum plant leaf area, especially under the influence of environmental factors of the spring season [34].

The rate of phyllochron was differed between nitrogen levels in both seasons, there was lower value of phyllochron in initial stages of vegetative growth in spring due lower averages of accumulated GDD, in the comparable to higher value at same initial stages in the autumn phyllochron manifestation and general growth performance. The phyllochron value of the spring season at V4-V5 was 2.5,1.583, and 1.541 showed under the effect of N_1,N_2, and N_3 respectively, while at the same stage in autumn were 2.583,2.125, and 2.125 for N_1,N_2,and N_3 respectively, the accumulated GDD from seeding to V4-V5 was 229.45 and 428.15 for spring with late emergence and autumn respectively. The phyllochron value of the effect of nitrogen levels in spring season was not shown higher rates till 10Jun near VT in which temperature rising and higher accumulation of GDD, similar results were also documented by [8], and [35].

Response of four maize hybrids to phyllochron were varied significantly in both season, however, to spring season that an overriding of H_4 was shown in most of vegetative stages V6-V7, V8-V10, V10-V12, and VT, unlikely in autumn the superiority in phyllochron was to H_1, H_2,and H_3 revealing negative response of H4 to the climatic condition of the autumn season in comparison to the performance of this genotype in the spring season, [6], and [5]. The regulation of the rate of phyllochron of maize hybrids in autumn was with more arrangement than that in spring season reflecting stability response of maize hybrids to the environmental conditions of the autumn season (Bircha et al., 1998). Variation in the performance of four maize hybrids was reported previously by [4], and [36]. The environmental efficacy in different climatic condition coincided with the results of [37].

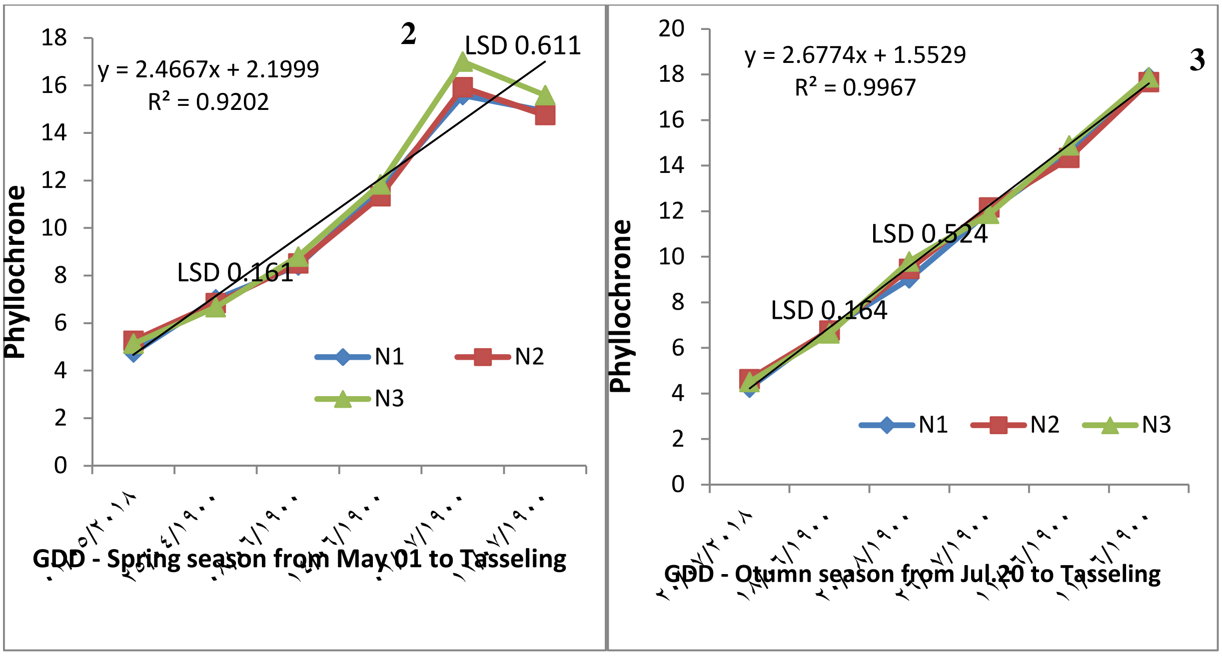
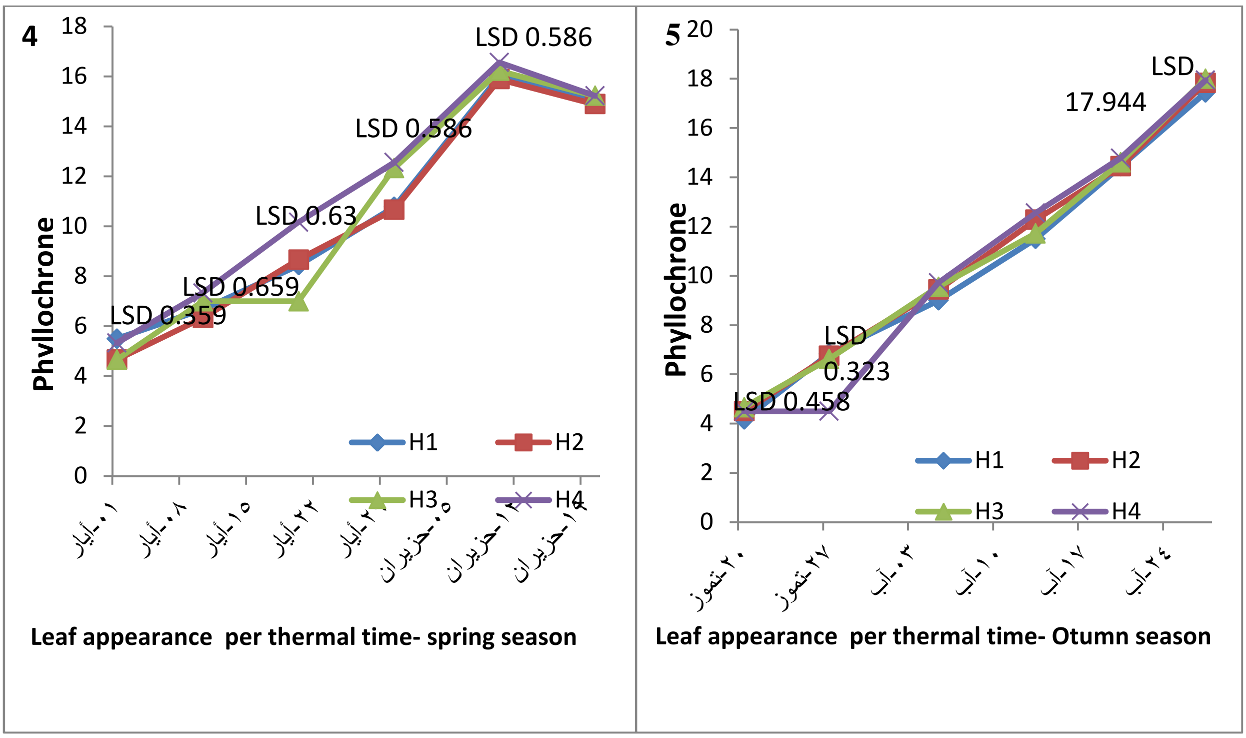


Fig. 2 and 3, effect of nitrogen levels on the phyllochron in both seasons



Figs, 4 and 5 Response of maize hybrids to the rate of Phyllochron in both seasons

3.1 Plant Leaf Area (cm ^{2})

Higher application of nitrogen fertilization levels was influenced significantly the plant leaf area through increasing the rate of leaf appearance and also expansion of leaf area in two different stages in spring season. Table 1 manifested maximum plant leaf area with N3 at V8-10 and VT showing (3727.678 and 5661.325) cm^2 respectively, while the increase in nitrogen application from N_1 to N_3 was not exceeded significant level in all growth stages at autumn season.

Table 2, clarify significant differences among maize hybrids in a plant leaf area in both seasons, the superiority in a plant leaf area in spring season was to H_1 in three different growing stages V6-8, VT, and R3 with plant leaf area(299.365, 7375.064, 5703.704)cm2 respectively, while at autumn season the significant differences were shown in two growth stages which were V6-V8, and R3 for the hybrids H_4 and H_2 respectively. Maximum plant leaf area of the interactions between the effect of nitrogen levels and maize hybrids (Table 3) was revealed in spring growth stages V6-8 (N1H4), V8-10 (N2H2), VT (N3H1), and R3(N_3H_1), while in autumn was shown in V6-8(N2H4), VT(N1H2), and R3(N1H2) demonstrating no impact of the third level on the plant leaf area in autumn and less effect in spring season. Leaf area development in maize is characterized by the regular initiation and appearance of successive leaves, and also the expansion of the leaf area that related to the environmental conditions, significant impact of the third level of nitrogen was revealed in pre-silking around VT and post silking at R3 in spring season, in which the air temperature started to exceed 25°C, and the effectivity of the physiological state raised due to the sink demand for supportive source, evolution of sink in maize closely correlates to the phyllochron that thermal time dependants. According to Hama and Mohammed (2019) [38], the leaf characteristics efficiently display the whole plant growth. Phyllochron correlates with the mean temperature from emergence to tassel initiation, there variation in leaf expansion in different growth stages and also in both seasons, these results are in line with [9], [14], and [33]. Furthermore, in autumn with higher averages of temperature there were no significant influence of nitrogen levels in all growth stages while the rate of phyllochron was shorter than that in the spring [39]. The performance of four maize hybrids in the developing plant leaf area were differed significantly along the spring growing season in which H_1 overrided in initial stage and R3 while H_3 showed superiority at tasseling, and in autumn the superiority was to H_4 and H_2, although there were no significant variation in the number of days to tasseling among hybrids in both seasons, but their response to ambient thermal abundance of both seasons and also the capability of maize genotypes for leaf expansion and leaf area duration with photosynthetic potential and senescence delay [40].

Table 1, effect of nitrogen levels in the plant leaf area in both seasons

Nitrogen levels	*Plant leaf area - Spring season*				*Plant leaf area-Autumn season*			
	V6-8	*V8-10*	*V10-12*	*VT*	*V6-8*	*V8-10*	*V10-12*	*VT*
N1	*279.958*	*2656.52*	*7980.05*	*4838.15*	*161.694*	*2287.76*	*4693.11*	*5438.32*
N2	*245.947*	*3126.73*	*6962.39*	*4688.17*	*174.831*	*2396.68*	*4724.1*	*5390.91*
N3	*261.706*	*3727.68*	*6681*	*5661.66*	*161.325*	*2310.6*	*4668.01*	*5382.82*
L.S.D	*174.976*	*1102.72*	*3198.23*	*309.291*	*94.312*	*1082.7*	*537.495*	*724.655*

Table 2, Rate of plant leaf area of maize hybrids in both season

Maize Hybrids	*Plant leaf area - Spring season*				*Plant leaf area-Autumn season*			
	V6-8	*V8-10*	*V10-12*	*VT*	*V6-8*	*V8-10*	*V10-12*	*VT*
H1	*299.365*	*3019.317*	*7375.064*	*5703.704*	*141.575*	*2517.097*	*4916.195*	*5579.336*
H2	*202.949*	*3378.274*	*5843.886*	*5306.063*	*154.155*	*2243.65*	*4784.141*	*5635.463*
H3	*257.516*	*2934.268*	*8300.95*	*4712.261*	*164.137*	*2469.135*	*4610.562*	*5126.266*
H4	*290.317*	*3349.383*	*7311.345*	*4528.602*	*203.933*	*2096.842*	*4469.086*	*5274.984*
L.S.D	*63.959*	*1002.68*	*1801.083*	*241.708*	*59.379*	*893.952*	*557.003*	*433.014*

Table 3, Effect of the interactions between nitrogen levels and maize hybrids in the plant leaf area

Nitrogen levels x Hybrids		Plant leaf area - Spring season				Plant leaf area - Autumn season			
		V6-8	V8-10	V10-12	VT	V6-8	V8-10	V10-12	VT
N1	H1	311.343	2892.12	6345.325	5505.875	131.249	2250.035	4659.739	5406.812
	H2	206.898	2837.947	6965.613	5142.545	199.102	2122.025	4938.225	6001.572
	H3	252.83	2055.32	6740.625	4421.048	165.037	2689.45	4667.441	5004.625
	H4	348.761	2840.692	6672.44	4283.122	151.386	2089.525	4507.017	5340.25
N2	H1	252.106	2213.993	7623.68	5505.495	185.107	2939.656	2127.012	5517.822
	H2	210.872	3993.627	5811.855	4534.28	141.705	2322.987	4826.242	5630.002
	H3	236.826	2897.666	11153.94	4845.683	140.25	2120.58	4377.848	5081.985
	H4	283.986	3401.65	7330.72	3867.21	232.262	2203.5	4565.311	5333.812
N3	H1	334.647	3951.837	8156.189	6099.743	108.37	2361.6	4962.738	5813.375
	H2	191.077	3303.249	4754.19	6241.365	121.657	2285.937	4587.956	5274.812
	H3	282.893	3849.818	7008.291	4870.053	187.125	2597.375	4786.396	5292.187
	H4	238.205	3805.807	7930.875	5435.473	228.15	1997.5	4334.928	5150.89
L.S.D		110.784	1736.692	3119.563	418.652	102.849	N.S	964.758	749.813

Dry Matter Accumulation (g):

The effect of three different levels of nitrogen fertilization on dry matter accumulation in both season demonstrated in Figs. 6 and 7, there was significant, exceeding of third level N_3 in two different stages V8-10 and R3 in the spring season with (30.708 and 193.122) g, respectively, whereas the level N_1 surpass the second level, but did not override N_3 significantly, the maximum accumulation of dry matter was at physiological maturity (PM) for three different levels. Accumulation of dry matter under effect of three different levels of nitrogen exhibit significant variation in the three later stages of growth VT, R3, and PM indicates to non similar results of the spring season, the maximum dry weight presented to the effect of N2, N1 and N3 at VT, R3 and PM, The performance of the four maize hybrids was significantly varied in all growth stages except PM in the spring season, the maximum accumulation of dry matter in growth stages V4-5, and V8-10 was shown by the variety (Cenmenta) H_4 with 1.572 and 24.531 g, respectively, but at VT the superiority was to H1(Gloria), however, it was not exceeded H_4 significantly, the superiority in accumulation of dry weight in R3 was to H_3 and H_1 and there was not significant differences at PM.

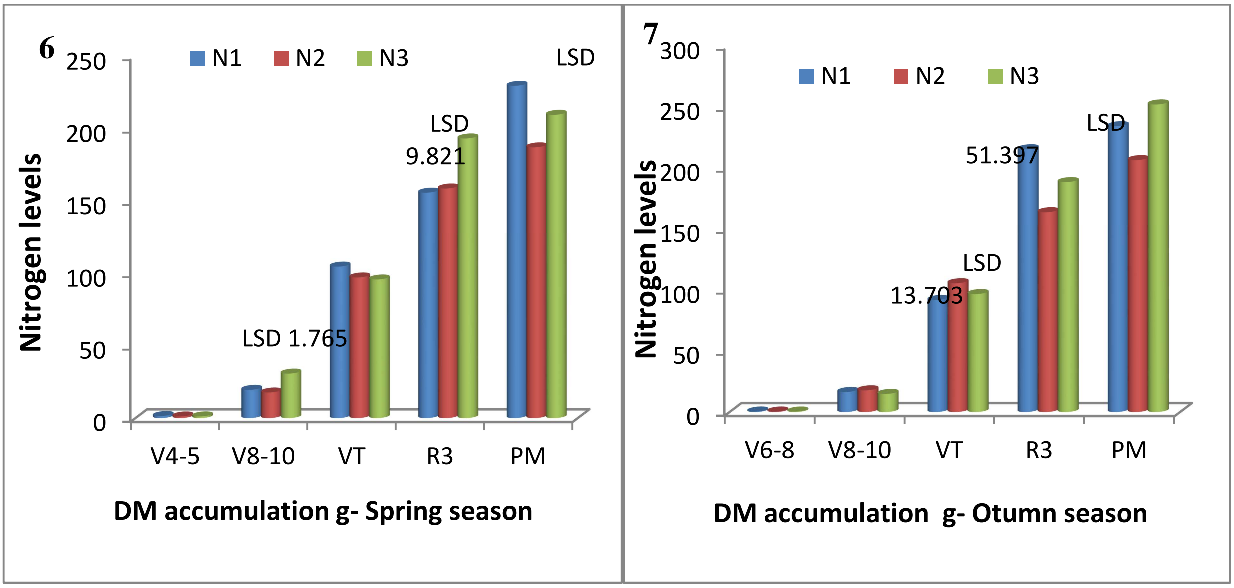


Fig.6, 7 Effect of Nitrogen levels on dry matter accumulation g in different growth stages

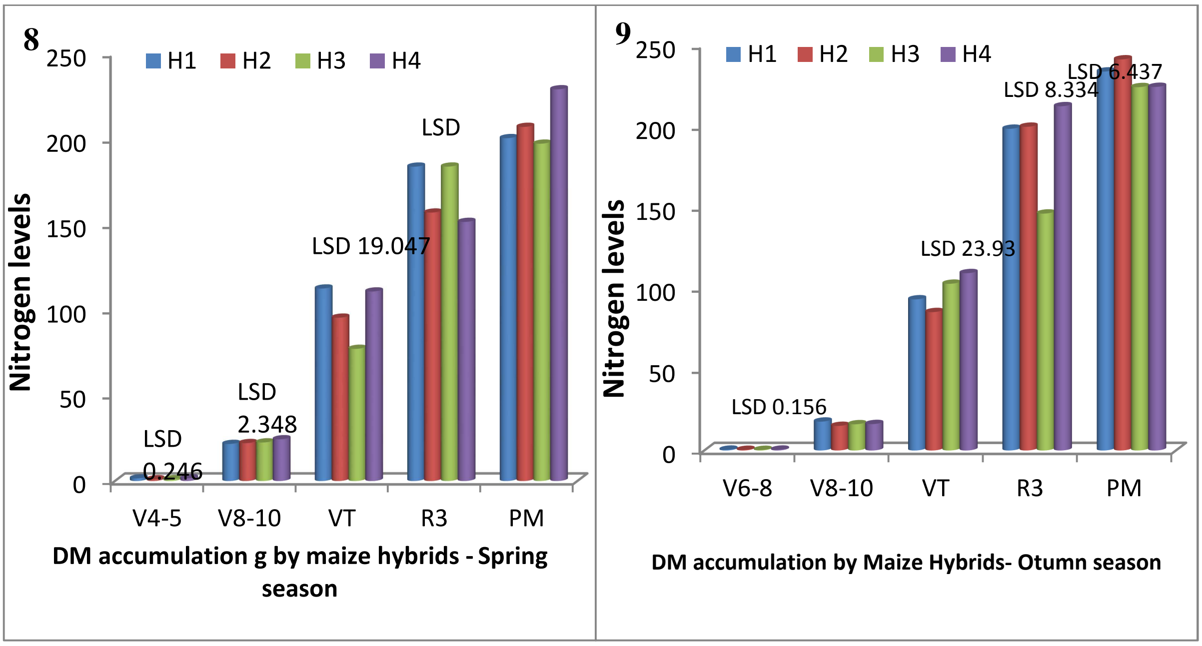


Fig.8,9 Effect of Maize hybrids on dry matter accumulation g in different growth stages

Dry matter accumulation in autumn under effect of three levels of nitrogen was distinguished from that at spring season; the maximum dry weight was shown with the effect of N2 and N1 in growth stages VT and R3 however N3 level effect was represented at PM. The maize hybrid efficiency in accumulating dry matter in autumn season demonstrate significant differences in different growth stages V6-8, VT, R3, and PM there was significant transcendence of hybrid H4 in vegetative sages V6-8, and VT and also in reproductive growth stage R3, with maximum dry weight (0.501, 109.557, and 212.441)g respectively, but the maximum dry weight at PM was 241.223g achieved by H2.respectively. Dry matter accumulation of corn manifest great variation in the vegetative growth period post V12 and in the later stages of reproductive growth period [38], however different responses to dry matter accumulation were shown in the case of the effect of nitrogen levels and performance of four maize genotypes during growth stages in both seasons, the nitrogen concentration in corn plants starts with relatively high value, and then become declining through the growing season, [20], the applicant levels of nitrogen represented adequate quantity for optimal growth unless it was affected by the effectivity of environment especially high temperature.

Effect of nitrogen levels was embodied in the N3 level in the spring and N1 and N2 in autumn that the greatest increase in dry weight partitioned to plant parts was produced, influence of higher levels of nitrogen in spring may indicate to the environmental effects of this season with lower temperature in the period pre-silking while the higher daily temperature in autumn accelerated growth in different growth stages. [41] and [42].

Variation of hybrid performance in the two seasons reveals surpassing of H_4 in the initial stages of the spring growing season and also in later stages of autumn, may manifest the acclimation and tolerance capability to hot growth conditions. High dry matter accumulation may also be attributed a number of environmental conditions and the photosynthesis and respiration relationship according to day-night temperature [43], and also the variation in the efficiency of genotypes and hybrid potential in acclimation to environmental effects may influence significant discrimination in the final biomass building, the results also documented by [44], showed that trait changes resulting in a greater efficiency of grain production have occurred with more modern hybrids.

Leaf Area Ratio (cm^2g^{-1}):

Leaf area ratio is a proper consideration for plant growth and development and vegetative growth period due to the importance of the two components, leaf area and accumulated dry matter, significant effectiveness of nitrogen levels was manifested in the spring season at vegetative growth stage V6-V8 in which the superiority was shown by N_2 (175.612) cm2 and the minimum rate of leaf area was displayed with N_3. Although the influence of nitrogen fertilization levels N_1 and N_3 was not reached significant level in other growth stages but there was a linear decline of the value of LAR across the growth stages from V4-V5 to R3 which was underlined with regression value of r^2 of 0.99 , 0.98, and 0.92 for (N_1,N_2, and N_3) respectively. The rate of LAR in autumn season was not similar to the previous season, there was not linear influence of nitrogen levels, and the maximum value of LAR was shown with the effect of second level N_2 in vegetative growth V8-V10 and reproductive growth stage R3 with first level N_1 revealing curvilinear regression as demonstrated in Fig 10.

Performance in the LAR of all maize hybrids (Fig. 11) showed a linear decline along the growth stages, however, there were significant differences in distinct growth stages during spring season, considerable exceeding of H_3 were recorded only in two different stages V4-V5 and VT, but at R3 stage the unlike superiority was to H_2 hybrid and no significant variation was demonstrated among hybrids at vegetative growth stage V8-V10. All maize hybrids manifested linear decline from V4-V5 to R3 with a regression value of 0.97, 0.95, 0.91, and 0.98 for hybrids H_1, H_2, H_3, and H_4 respectively. In autumn season there were significant differences among maize hybrids in only two different stages V8-V10 and R3 in which the considerable, exceeding in LAR was to H_3 and H_2 respectively. An increase in the LAR value of the four maize hybrids in VT and then declining of those values at R3 showed curvilinear or polynomial regression for all maize hybrids. Importance of leaf area ratio in determining the maize growth and development originated from its components which include a plant leaf area and plant biomass which closely correlated to growth evolution. The expansion of plant leaf area was increased with the rate of phyllochron that defined by [10] as the time terminating between the appearance of two entire leaves, proceeding from this point the phyllochron vary according to the environmental effects of both seasons and response to nitrogen levels. The higher temperature of autumn resulted higher GDD in shorter thermal time, which was leading to shorter phyllochron. In spring season the phyllochrone determined from seeding to V5 in 26 days was 45.89°Cd, while in autumn the V5 was reached with only 16 days 85.6°Cd. Effect of temperature was displayed in the rate of phyllochron too, which there was constant rate of phyllochron in autumn under three nitrogen levels while in spring season there was variable rate, and also temperature effect was clarified in leaf area expansion in which it was declined in the later stage due the increasing in the air temperature while reverse situation was shown in autumn that the plant leaf area was with continuous expanding, led to higher efficiency of photosynthesis and higher net assimilation rate resulted higher dry weight and substantial decreasing in LAR as shown in Figs (10 and 11). The maximum LAR was shown with 2nd level of nitrogen and 1st level in the later stage of reproductive period in autumn indicated to great fluctuation in biomass producing due to the photosynthetic efficiency and the partitioning pattern of accumulated dry matter, and leaf senescence, which were may influenced by high temperature and its impact on the biochemical processes, the results agree with [45], [46], and [47]. The Genotypic performances in phyllochron were greater in spring season than that in autumn for the same hybrids, the influence of environment was through the mean temperature during a relatively short interval after emergence[14]. The variation in the leaf area ratio in both season reveals variation in the rate of growth and development in both seasons with considerable increasing in autumn. Results of previous researchers confirmed that greater biomass of certain hybrid, was associated with greater leaf longevity. Change in source and sink from silking to maturity reveals the difference in supply and demand of assimilates, [48], and [49].

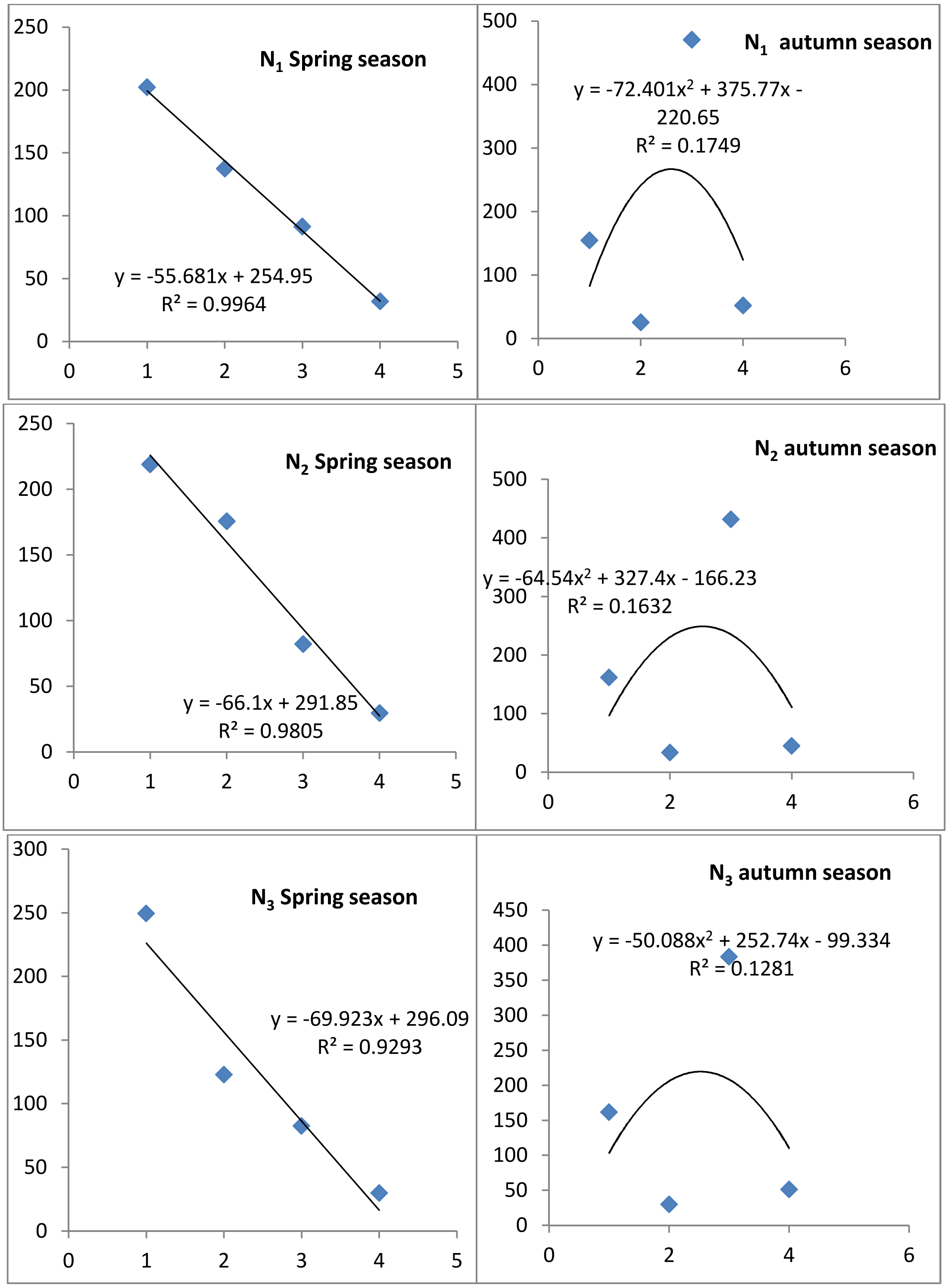


Fig 10, Influence of nitrogen levels on the rate of Leaf area ratio in both seasons

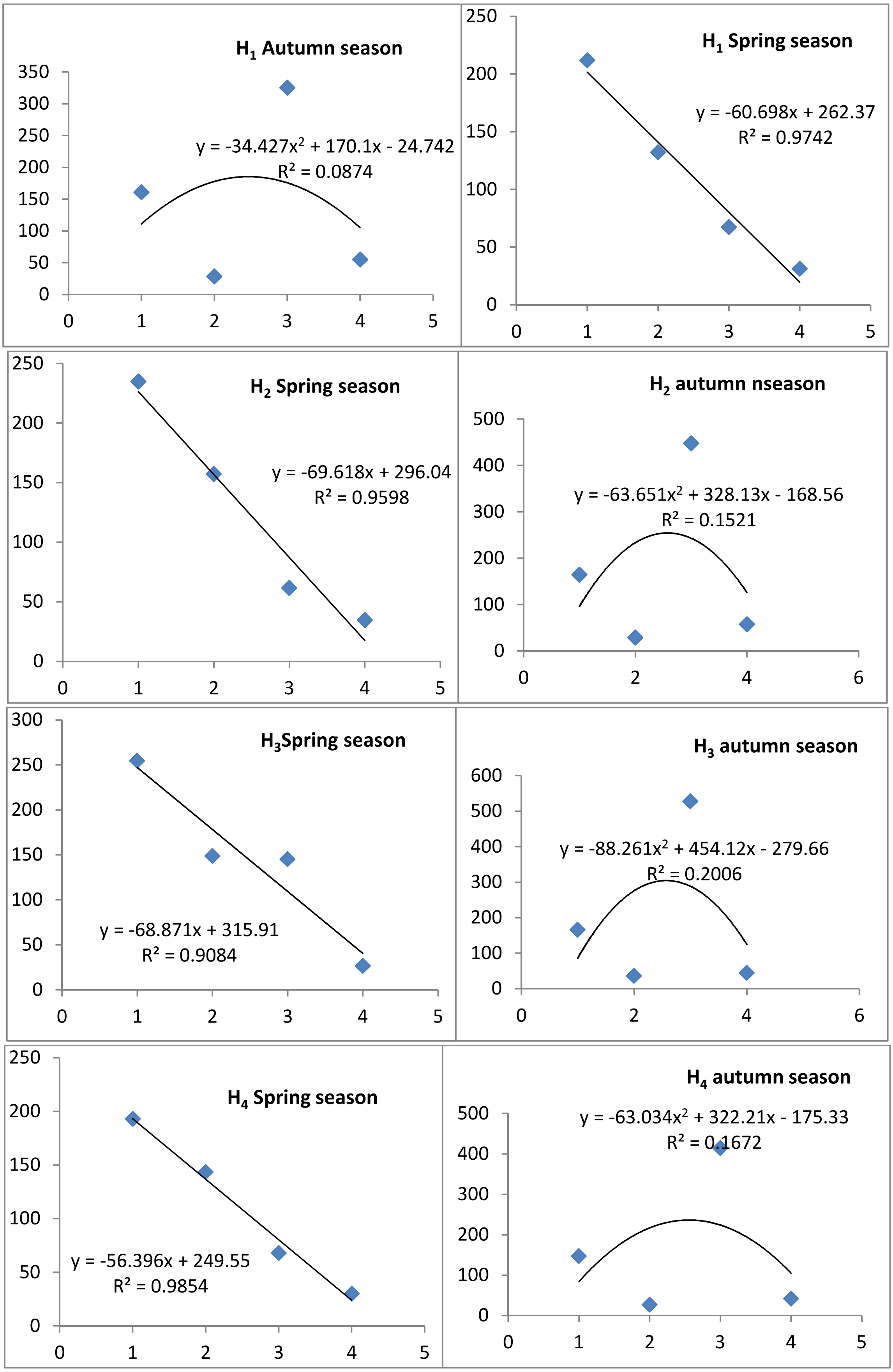


Fig. 11, Performance of maize hybrids in leaf area ratio in both seasons

Conclusions:

Thermal time of the growing seasons was influenced the response of maize hybrids more effectively than nitrogen application, especially in the autumn season with higher quantity of GDD. Phyllochron and leaf area ratio are remarkable in maintaining the duration of the vegetative growth period. The higher accumulation of GDD in autumn produced shorter thermal time, which was led to shorter phyllochron, as well the highest leaf appearance rate in this season was revealed with lower levels of nitrogen applications. Maximum results of leaf area ratio of plant leaf area and accumulated dry matter was not coinciding with maximum application of nitrogen levels during all different growth stages in both seasons. Differences in dry matter accumulation in both seasons and among maize hybrids were due to temperature as accumulated crop heat units which directly influenced the phyllochrone and leaf area ratio, as well as more effective modification in the response of maize hybrids.

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Appendices:

Appendix 1: Effect of Nitrogen levels and responses of maize hybrids and the interactions between them on No. of days required to 50% tasseling and 50% silking in both seasons

Nitrogen levels	Spring season		Otumn	
	Day to 50% Tasseling	Day to 50% Silkingling	Day to 50% Tasseling	Day to 50% Silkling
N1	65.792	68.666	58.416	61.666
N2	66.25	69.916	58.416	64.833
N3	66.75	70.75	59.333	63.083
L.S.D	1.177	2.639	1.474	0.68

Nitrogen levels	Spring season		Otumn	
	Day to 50% Tasseling	Day to 50% Silkingling	Day to 50% Tasseling	Day to 50% Silkling
H1	65.666	69.555	58.444	62.222
H2	66.722	69.777	58.555	61.888
H3	66.333	69.888	58.555	62.333
H4	66.333	69.888	59.333	62.333
L.S.D	0.874	0.638	0.974	1.271

Nitrogen levels	Spring season		Otumn	
	Day to 50% Tasseling	Day to 50% Silkingling	Day to 50% Tasseling	Day to 50% Silkling
H1	65	68.666	58.333	62
H2	66.166	68.666	58	61.666
H3	66	69	58.666	62
H4	66	68.333	58.666	61
H1	66	69.333	57.333	61.333
H2	67	70.333	58.666	61.333
H3	66	69.333	58.333	62
H4	66	70.666	59.333	62.666
H1	66	70.666	58.666	63.333
H2	67	70.333	59	62.666
H3	67	71.333	58.666	63
H4	67	70.666	60	63.333
L.S.D	1.512	1.107	1.643	2.202

Appendex no.2

Rate of Dry Matter accumulation in different growth stages, under effect of nitrogen levels and response of maize hybrids and the interactions between them in both seasons

Nitrogen	Spring season					Otumn season				
levels	V6-8	V8-10	VT	R3	PM	V6-8	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	105.43	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	0.827	1.765	15.912	9.821	55.778	0.114	5.923	8.664	12.183	10.613

Maize	Spring season					Otumn season				
Hybrids	V6-8	V8-10	VT	R3	PM	V6-8	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	103.04	146.174	224.174
H4	1.572	24.321	110.852	151.522	229.111	0.501	16.296	109.56	212.441	224.315
L.S.D	0.246	2.348	19.047	9.133	35.215	0.115	4.292	6.456	8.334	6.437

N Fert. X Hybrids		Spring seasons					Otumn season				
		V6-8	V8-10	VT	R3	PM	V6-8	V8-10	VT	R3	PM
N1	H1	2.133	22.664	104.613	189.632	232	0.583	15.193	73.617	199.183	222.517
	H2	1.173	17.212	105.476	122.266	207.666	0.333	12.476	91.867	229.217	274.963
	H3	1.153	17.188	73.024	174.61	235.666	0.303	22.033	99.655	186.903	225.329
	H4	1.46	20.907	134.692	136.454	242.333	0.476	16.01	101.78	252.267	213.909
N2	H1	1.2	14.64	97.612	162.646	183	0.45	25.5	123.34	186.903	252.329
	H2	1.033	22.438	89.062	158.855	197.333	0.393	13.306	97.804	195.671	226.179
	H3	0.966	12.939	100.762	150.19	133.666	0.356	12.336	103.7	131.327	190.957
	H4	1.5	20.716	100.494	136.454	234	0.486	20.033	96.85	141.838	156.507
N3	H1	1.243	27.502	135.544	199.886	187	0.433	12.71	83.402	209.684	226.179
	H2	0.77	26.655	92.113	189.814	216.666	0.406	19.673	67.212	174.253	222.527
	H3	1.046	37.332	57.382	227.656	223	0.376	14.13	105.72	126.866	256.236
	H4	1.756	31.342	97.366	155.521	211	0.54	12.846	130.04	243.217	302.53
L.S.D		0.426	4.067	32.99	15.822	60.993	0.199	7.433	14.847	14.435	11.149