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The Study of Phyllochron and Leaf Appearance Rate in Three Cultivar of Maize (*Zea mays* L.) At Nitrogen Fertilizer Levels

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Abstract: In order to investigation of nitrogen fertilizer on phyllochron and leaf appearance rate in three cultivar of maize, a split plot experiment based on randomized complete block design with three replications were conducted in research field of Islamic Azad University, Ardabil branch, Ardabil, Iran, in 2009. Factors were: nitrogen levels in main plots (0, 60, 120 and 180 Kg N ha^{-1}) and corn cultivars in sub plots (Kenez410, Korduna and Konsur). The Results showed those phyllochron and leaf appearance rates were affected by maize cultivars and nitrogen fertilizer levels. Increase in nitrogen levels had significant effect on leaf appearance rate and phyllochron at all of maize cultivars. With increasing nitrogen rate, leaf appearance rate was increased and Phyllochron was decreased. The highest and lowest Phyllochron rate was obtained at Konsur cultivar without nitrogen application and kordona in highest levels of nitrogen fertilizers respectability. Also the highest leaf appearance rate was observed at korduna cultivar and 180 kg nitrogen per hectare. Minimum of leaf appearance rate obtained at Konsur cultivar in control levels of nitrogen fertilizer. Harvest index, kernels yield, 1000 kernels weight and numbers of kernels per ear and row and row per ear numbers were affected by treatments too. Maximum yield was obtained at Korduna×180kg N ha^{-1}. Increasing of nitrogen levels led to significantly increase in number of kernels per row, number of kernel per ear and 1000-kernels weight. In all traits except numbers of row per ear Korduna cultivars was superior. So it was suggested that in order to increasing leaf appearance rate and grain yield was respectively applied korduna cultivar with 180 kg N ha^{-1}.

Key words: Leaf appearance rate · Maize cultivars · Nitrogen fertilizer · Phyllochron · Yield and yield components

INTRODUCTION

Study of phyllochron is a suitable method to better realize the plant vegetative growth and helps simulation of plant growth [1]. In addition, it is the basal parameter in predicting plant total leaf number and date of flowering [2]. Wilhelm and McMaster [3] defined phyllochron as the time elapsing between the visual appearance of two successive leaf tips. Rickman and Klepper [4] reviewed available information on these processes in grasses. The concept phyllochron is based on the fact that the production rate of new phytomers is often found to be nearly constant from seedling stage to flag-leaf expansion when expressed in thermal time units (°Cd, degree-days) in wheat [5], barley [6], maize [7], sorghum [8] and millet [9]. Tollenaar and Lee [10] defined leaf appearance rate as inverse of Phyllochron. Longnecker and Rrobson [11] revealed that nitrogen deficit can decrease the leaf appearance rate. tollenaar and Lee [10] reported that the appeared leaves in Maize were decreased with decreasing available nitrogen. It has been shown that under controlled and field conditions, phenological stage [12], genotype [13] and other environmental conditions, affect Phyllochron. The rate of soil compact ability, seeding depth, vernalization, incident radiation and carbon dioxide, affect the leaf appearance rate, as well [3]. Affecting nutrient elements, humidity, incident radiation and plant physiological stages, density can affect the Phyllochron and the leaf appearance rate. Permanent cool season grasses and small seeded cereals, produce one full expanded leaf each 6-10 days if they subjected to favorable conditions while, in Maize and warm season cereals, this rate is each 4-6 days [2]. Low temperatures may lead to delay of length of vegetative growth period, production of crown flower and reduce available nutrients [14, 15]. Nitrogen is the most limiting essential nutrient

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for maize (*Zea mays* L.) production [16]. Nitrogen has positive effect on storage of protein in Maize seed and hence, the rates of this element are effective in its distribution in plant [17]. Soil high fertility or increase in nitrogen application, leads to increase in grain yield and 1000-grain yield [18].

The aim of this research was to realize effect of different nitrogen levels on Phyllochron leaf appearance rate and yield and yield components of Maize.

MATERIALS AND METHODS

This experiment was conducted in research field of Islamic Azad University, Ardabil branch, Ardabil, Iran, in 2009. The climate is semi-arid. It has 1350 meters altitude from sea level. Based on the soil test, pH was about 7.2, soil texture was loamy-sand and the depth of top soil was 70 cm (Table 1). This investigation was arranged as split-plot experiment based on the randomized complete block design with three replications. Main-plots were assigned to nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and sub-plots to corn cultivars (Kenez410, Korduna and Konsur). Each sub-plot included five rows which their length and spaces from each other were 5 and 0.75 meters. Seeds of three cultivars were sown at depth of 3 to 5 cm. Other agronomy practices did according to soil test (Table 1). In order to measuring yield and yield components, plants of middle rows of each plot in the surface of 2.5 m^2 were harvested. To study Phyllochron, the leaves of their plants of each plot with the length of at least 1 cm, were counted each 3 days. These plants were marked with red stripe during the growth period. The l eaf appearance rate was calculated as follows Eq. 1 [11]. Ears were husked, dried and weighed. In order to evaluate harvest index economical yield divided into biological yield and multiplied at 100 (Eq. 2). Data were subjected to analysis by the SAS software and graphs were drawn using Excel program.

$$\text{Leaf appearance rate} = \frac{1}{phyllocron}$$

$$\text{HI= economical yield/biological yield} \times 100 \qquad \text{(Eq 2)}$$

RESULTS AND DISCUSSION

Phyllochron and Leaf Appearance Rate: Results showed those phyllochron and leaf appearance rates were affected by maize cultivars and nitrogen fertilizer levels. Increase in nitrogen levels had significant effect on leaf appearance rate and phyllochron at all of maize cultivars (Table 2). With increasing nitrogen amounts, leaf appearance rate was increased and Phyllochron was decreased. The highest (4.78 day) and lowest Phyllochron rate (2.64 day) were obtained at Konsur cultivar without nitrogen application and kordona in highest levels of nitrogen fertilizers (180 kg N/ha) respectability (Fig. 4). The highest leaf appearance rate (0.4 1/day) was observed at korduna cultivar and 180 kg nitrogen per hectare. Minimum of leaf appearance rate (0.24 1/day) obtained at Konsur cultivar in control levels of nitrogen fertilizer. There was no significant difference among 120 and 180 kg ha^{-1} nitrogen application on this aspect (Fig. 3). Hokmalipour *et al.* [19] reported that with increasing of nitrogen fertilizer leaf appearance rate was increase and phyllochron was decrease. Longnecker and Rrobson [11] revealed that nitrogen deficit can decrease the leaf appearance rate. tollenaar and Lee [10] observed that the appeared leaves in Maize were decreased with decreasing available nitrogen. Also results showed that koruna cultivar had highest leaf appearance rate in all of the recording stage. It is able to say that Korduna cultivar genetically has more potential for leaf appearance rate.

Effect of recording stages and Interaction effects of recording stage × maize cultivars on Phyllochron and leaf appearance rate, showed that at recording stages specially at stages near to the end of vegetative growth

Table 1: Status of experimental farm

K PPm	P PPm	T.N. (%)	Os (%)	Tex (%)	Sand (%)	Silt (%)	Clay (%)	Sp (%)	PH	EC (Mmhos)	Sampling depth (cm)
355.2	29.9	0.02	0.2	Clay-loam	21	44	35	54	7.7	1.37	0-30

Table 2: Analysis of variance of Leaf appearance rat, Phyllochron, yield, yield component and other traits

Source of variation	df	Leaf appearance rate	Phyllochron	Kernel yield	Kernel yield per plant	1000 kernel weight	Number of kernel per ear	Harvest index
Replication	2	0.00134444**	0.0034**	2523	0.45	*6.04	**14.1	**2.2
Nitrogen	3	0.01888519**	3.240**	**6263286	**1113	**2307	**10018	**23.5
Experimental error	6	0.00000741	0.00028	11898	0.21	1.01	0.26	*0.12
cultivar	2	0.00993611**	1.601**	**9679156	**1720	**7444	**4336	**19.2
Cultivar×Nitrogen	6	0.00003241*	0.0782*	**755790	**134	**676	**244	**10.5
Experimental error	19	0.00418	0.705	2247110	399	1362	2.66	9.35
Cv.	-	1.05	0.56	39	0.66	1.5	0.4	0.022

*,** Significant in 5 and 1 percentage probability respectively

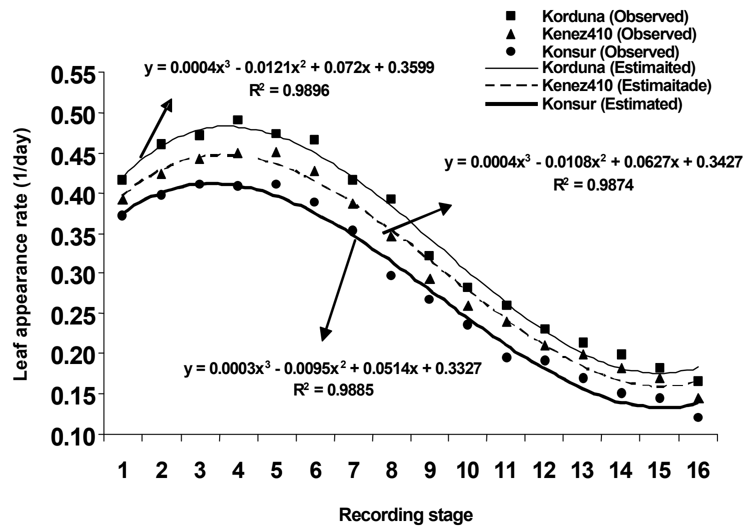

Fig. 1: Trend of the leaf appearance rate changes during the recording stage in three cultivar of maize

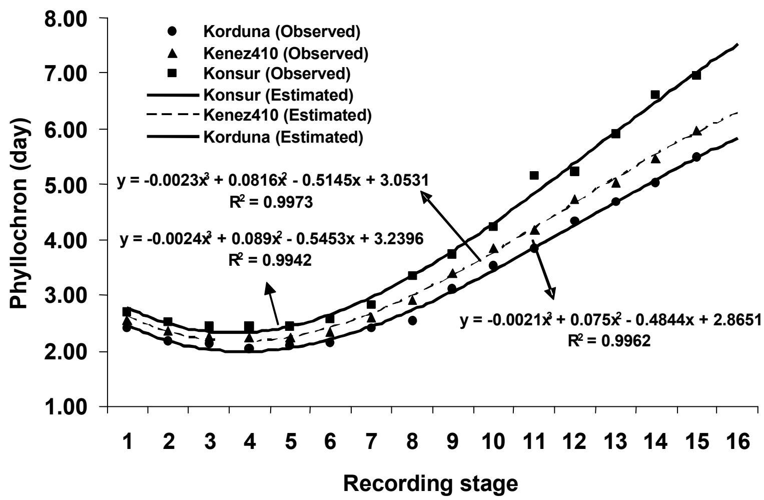

Fig. 2: Trend of the leaf phyllochron changes during the recording stage in three cultivars of maize

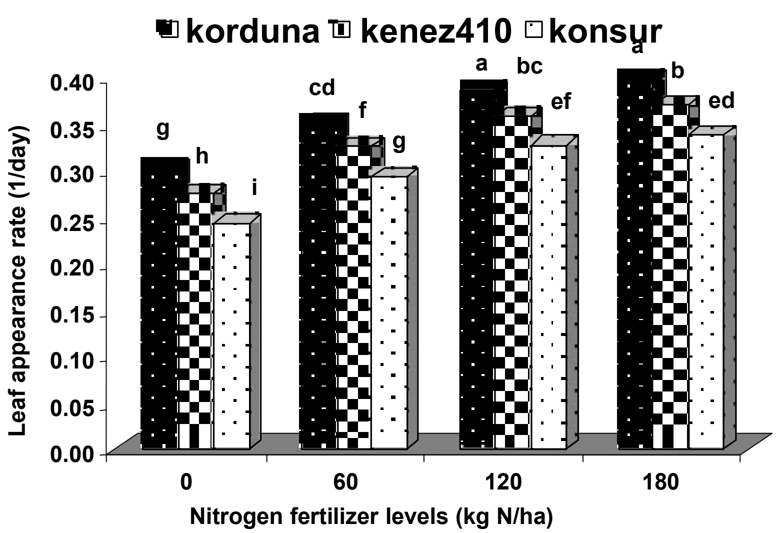

Fig. 3: Leaf appearance rate changes as affected bye nitrogen fertilizer levels in three cultivar of maize

Table 3: Main comparison of Leaf appearance rat, Phyllochron, yield, yield component and other traits

Traits Treatments	Levels	Leaf appearance rate (1/day)	Phyllochron (day)	Kernel yield (kg h^{-1})	Number of rows/ears	Number of kernel/row	Number of kernel per ear	1000 kernel weight (gr)	Harvest Index (%)
Cultivars	Kenez410	0.36a	3.03c	4763b	14b	29.9b	413.3c	152.9b	26.3b
	Korduna	0.33b	3.28b	5876.2a	14b	31.6a	450.6a	172.2a	26.8a
	Konsur	0.30c	3.75a	4098.7c	15.66a	28.3c	442.6b	123.2c	24.4c
Nitrogen levels	0	0.27d	4.19a	3758d	14.44a	26.4c	398.8d	125.7d	27.9a
(kg h^{-1})	60	0.32c	3.37b	4882.6c	14.66a	28.8b	418.7c	155.3c	26.2b
	120	0.36b	2.98c	5343.6b	14.44a	31.8a	450.3b	157.8b	24.9c
	180	0.37a	2.87d	5666.2a	14.66a	32.6a	474.2a	159.6a	24.3d

*Numbers with the same letter, have no significant difference

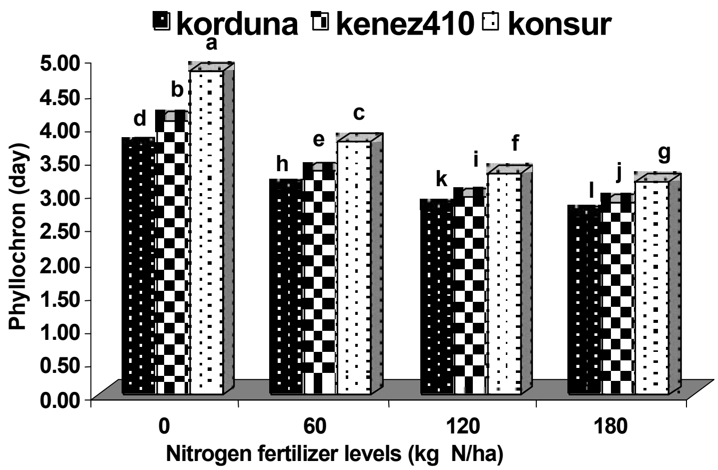

Fig. 4: Phyllochron rate changes as affected by nitogen fertilizer levels in three cultivar of maize

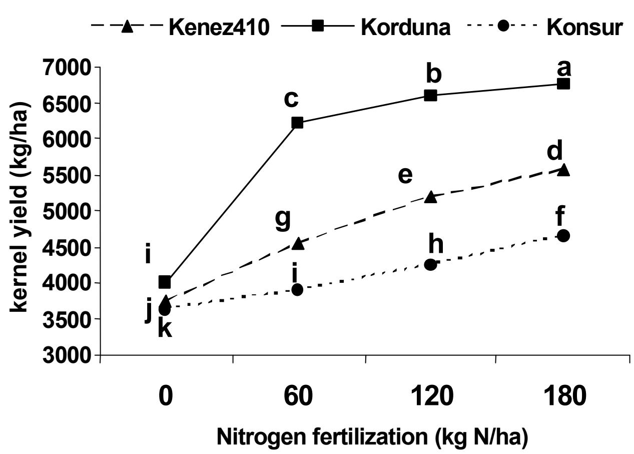

Fig. 5: hnteracttion effect of nitrogen levels and cultivars on kernel yield

period, leaf appearance rate was decreased and Phyllochron was increased (Fig. 1, 2). As show in Fig. 1 and Fig. 2, with increasing nitrogen levels, required time to appear sequential leaves was lower and leaf appearance rate was higher and this trend after eight's recording was more obvious.

Yield and Yield Components: Kernels yield was significantly affected by nitrogen fertilizer levels, cultivars and their interaction at 1% probably (Table 2). Korduna, Kenez410 and Konsur significantly produced maximum kernels yield, respectively. Values of yield were 5876.2, 4763 and 4098.75 kg for above cultivars, respectively. Control produced the lowest kernels yield. With increase in N levels amounts of the yield markedly enhanced and N level of 180 kg ha^{-1} obtained the highest kernels yield (Table 3). In case of interaction effect, kernels yield rose with increase in N rate in all three cultivars but slope of increase for Kenez410 was more than Konsur. Korduna cultivar significantly produced more yield at all three N

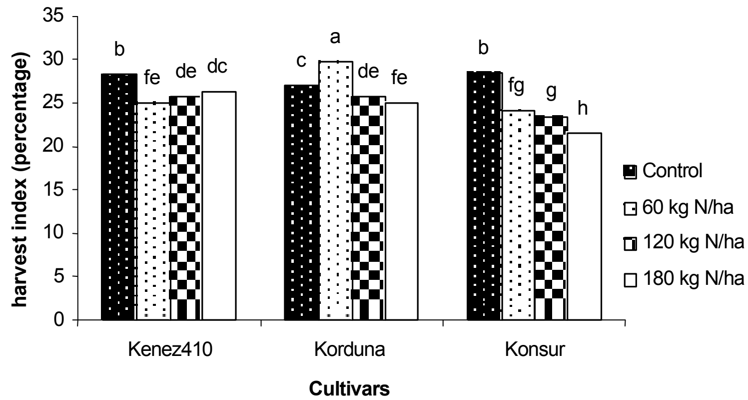

Fig. 6: Harvest index under interaction of nitrogen levels and cultivars

levels than others. Maximum yield belonged to Korduna cultivar at 180 kg N ha^{-1} and differences between control and the other N levels were greater for it (Figure 5). There was no significant effect of N levels on Number of kernel rows per ear. But, cultivars showed significant differences from each other (Table 2). Konsur cultivar remarkably produced highest values than Kenez410 and Korduna cultivars which were in the same group (Table 3). Increasing of applied N fertilizer had significant effect on trait of Number of kernels per row at 1% probably (Table 2). Levels of 180 and 120 Kg N ha^{-1} placed at the same and superior group. 60 kg N ha^{-1} gained the second group and control had the lowest value. Number of kernels per row was markedly influenced by cultivars, too. Korduna cultivar produced the highest kernels per row with production of 31.66 kernels. Cultivars of kenez410 and Konsur gained the following groups, respectively (Table 3). Kernels number per ear was significantly affected by cultivars, N levels and their interaction (Table 2). Cultivars of Korduna, Konsur and Kenez410 produced 450.6, 442.6 and 413.3 kernels per ear, respectively. Control level had the lowest value. With increase in N fertilizer levels kernels number per ear multiplied and 180 kg N ha^{-1} produced the highest number. Interaction effect of cultivars and N levels showed that in all cultivars kernels number per ear raised and lowest and highest value belonged to control and 180 kg N ha^{-1} but the highest and the lowest amounts was significantly obtained at interaction effect of Konsur×180 kg N ha^{-1} and Kenez410×control treatment (Table 3). Results showed that Korduna cultivar markedly produced the highest 1000 kernels weight (172.17 gr). Following Kenez410 with 152.95 gr and Konsur with 123.25 gr placed. Among the N levels control treatment produced the lowest 1000 kernels weight. Increase in N applied from 60 to 180 kg N ha^{-1} significantly led to increase in 1000 kernels weight and 180 kg ha^{-1} gained the highest value. When we focus on interaction effect of N levels and cultivars showed that there were very low differences among N treatments plus control in cultivar of Konsur. Increasing of nitrogen in cultivars of Korduna and Kenez-410 remarkably caused to increase in 1000-kernels weight and this increase for Korduna was more than Kenez410. Therefore, Korduna was the cultivar that its 1000-kernels weight sharply increased by N levels (Table 3). Korduna had the highest kernels number per ear. There fore, Korduna was superior in all traits except numbers of kernel row per ear. Above yield of Korduna perhaps related to much 1000 kernels weight, number of kernels per ear, numbers of kernels per row in it. With increase in N values 1000 kernels weight, number of kernels per ear, numbers of kernels per row and yield increased. There was no significant effect of N on numbers of rows per ear. Therefore increase in mentioned items led to increase in yield. Sabri *et al.* [20] reported that Nitrogen application didn't affect the number of grains per ear. The effect of different maize hybrid on number of grains per cob was highly significant [21]. Increasing nitrogen fertilization rates led to a significant increase in 100 grain weight and grain yield of maize as compared with control treatment [22]. Nitrogen application significantly resulted in increase number of grains per ear, 100 grain weight and grain yield [23]. Application of 120kgNha+40kgP/ha produced the maximum number of grains per ear which was significantly different from all other treatments [24]. Effect of nitrogen fertilizer on grain yield, kernel number per ear and Maximum grain yield was obtained at 276 Kg/ha nitrogen [25]. The maximum No of grains/cob, the highest 1000 grain weight, Grain yield increased with increasing of N rates and maximum grain yield were produced by application of 120 Kg N ha^{-1} [26]. Kernel number per ear in spite of 1000 kernel weight had the largest proportion in kernel yield variation [27]. Sabri *et al.* [20] also reported similar result. 1000 grain weight was affected by cultivars and nitrogen levels. The treatment of (120kgN/ha+40kgP/ha) produced the maximum 1000-grain weight which was significantly different from the rest of all the treatments. The minimum weight of 1000 grains was obtained in control [24]. Maximum 1000-grain weight was attained by 250 Kg N ha^{-1} which was statistically at par with treatment 200 Kg N ha^{-1} [16]. These observations are fully reported by Souza *et al.* [28]. Palta *et al.* [24] reported that Nitrogen levels had pronounced effect on grain yield. They also mentioned the variation in grain yield due to different levels of nitrogen was related to the differences in size of photosynthetic surface and to the relative efficiency of total sink activity. Kostandi and Soliman [29] said that Increasing N rate from 30 to 60 and or 90 kg per acre produced greater response on the N uptake and yield, followed by a limited response at 120 kg N per acre. Increase in grain yield with an increase in nitrogen rates was also observed by others [30, 31]. Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number [24].

Harvest Index: Results showed that harvest index was markedly affected by main and interaction effects of N levels and cultivars (Table 2). Effect of cultivars on harvest index was the same as their effect on number of kernels/row, 1000-kernels.cultivars of Korduna, Kenez410 and Konsur significantly obtained minimum harvest index, respectively. Increase in nitrogen fertilizer adversely affected (Figure 6). There were Significant effects among cultivars and highly significant effect among fertilizer levels on harvest index and HI increased from 150 to 250 Kg N per hectare. They suggest that an optimum supply of nitrogen is essential for favorable partitioning of dry matter between grain and other parts of maize plant [21]. Sabir *et al.* [30] presented similar results. Significant differences of harvest index depended on year [32]. This result is the same as our findings.

CONCLUSION

In this investigation the highest leaf appearance rate was acquired at interaction effect of Korduna × 180 kg N ha^{-1}. Hence, it is able to say that Korduna cultivar genetically has more potential for leaf appearance rate. Highest kernel yield (7679 kg ha^{-1}) was acquired at interaction effect of Korduna × 180 kg N ha^{-1}. Above yield was the more than kernel yield of others cultivars in all N levels. So Korduna cultivar genetically has more potential to produce yield and its response to higher N level is positive. Because of higher kernels number per row and 1000 kernels weight, which have important role in kernels yield, Korduna cultivar had the higher yield than others. In all traits except numbers of row per ear Korduna cultivars was superior. So it was suggested that in order to increasing leaf appearance rate and grain yield was respectively applied korduna cultivar with 180 kg N ha^{-1}.

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