World Applied Sciences Journal 12 (6): 862-870, 2011
ISSN 1818-4952

Investigation of Nitrogen Fertilizer Levels on Dry Matter Remobilization of Some Varieties of Corn (*Zea mays* L)

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Abstract: In order to Investigation of Nitrogen Fertilizer on dry matter remobilization of some varieties of corn, a split plot experiment based on randomized complete block design with three replications was 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). Results showed that, dry matter remobilization and this efficiency, harvest index, kernels yield, 1000 kernels weight and numbers of kernels per ear and row and row per ear numbers were affected by treatments. whit increasing nitrogen levels, dry matter remobilization significantly decreased. Interaction effect of cultivars and N levels showed that cultivar of korduna had highest value of total dry matter remobilization, dry matter remobilization from stem and those of efficiency in Control level of nitrogen fertilizer. Also 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.

Key words: Corn cultivars · Dry matter remobilization · Yield and Yield component

INTRODUCTION

Maize (*Zea mays L.*) is the third most important cereal crop in the world after wheat and rice and known as "King of grain crops". Approximately 8 to 10% of the corn crop is used as food for human consumption. It is not only a source of food, fodder and feed but also many by-products likes glucose, starch and corn oil, etc are prepared from it. Maize is extensively grown in temperate, subtropical and tropical regions of the world. The productivity of maize not only on the accumulation of dry matter, but also on its effective partitioning to plant parts of economic importance and this is a key to yield stability. Remobilization of reserves to grain is critical for grain yield if the plants are subjected to water stress during grain filling [1]. Among cereals and particularly in corn, pre-anthesis assimilates help in yield stability during terminal drought stress [2]. In wheat, pre-anthesis assimilate reserves farmstead sheaths contribute 25-33% of the final grain weight [3-5]. In cereals, grains are the most important sink for carbon and nitrogen after anthesis. In rice, available carbon assimilates for grain production are determined by carbon assimilation during the grain-filling period plus assimilate reserves stored in the straw [6]. Pre-anthesis storage may contribute 20-40% of the final crop yield depending on cultivar, reflecting its importance for attaining higher grain yields [7]. The highest maize yield production depended on many factors i.e. cultivars and nitrogen fertilization [8]. Nitrogen fertilizer is a key nutrient in the production of non legume crops. It is a component in many biological compounds that plays a major role in photosynthetic activity and crop yield capacity [9] and its deficiency constitutes one of the major yield limiting factors for cereal production [10]. Soil high fertility or increase in nitrogen application, leads to increase in grain yield and 1000-grain yield [11]. Over N fertilization is a common problem for the wheat-maize rotation system [12] nitrogen has significant effects on the yield as a result of increase in the number of seeds ear^{-1} [13]. maize grain yield was significantly increased as N-rate increased and maximum figure was obtained due to the addition of 140 kg N and each increase in level of

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nitrogen up to 140 Kg N/fed results in significant increased in stem 100 grain weight, grain yield, plant and grain yield [14]. El-Bana and Gomaa [15] found a significant increase in grain yield as results of increasing nitrogen levels from 100 to 125kg N. Increasing nitrogen fertilization rates led to a significant increase in ear length, number of kernel per rows, ear weight and grain yield [16-19]. Increase in grain yield with an increase in nitrogen rates was also observed by others [20]. In general, cultivars developed by breeding programs are highly productive and respond to applications of N, but have low efficiency in the use of this nutrient [21]. Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number [22].

The aim of this research was to realize effect of nitrogen fertilizer levels on dry matter remobilization, yield and yield component of some varieties of corn in Ardabil region.

MATERIALS AND METHODS

This e xperiment 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 measure yield and yield components, plants of middle rows of each plot randomly were harvested in the surface of 2.5 m^2 at the physiological maturity. Ears were husked, dried and weighed. In order to evaluate harvest index economical yield divided into biological yield and multiplied at 100 (Eq 1).

HI= economical yield/biological yield ×100 (Eq 1)

Samples of 1 m2 area were taken at flowering and maturity from each plot for estimation of dry matter and its components. Samples were dried at 80 C until constant weight. Apparent contributions to grain filling from different sources were estimated as follows [23]:

Dma = TDMmt _ TDMfl (Eq 2)
Dmb = SDMfl _ SDMmt (Eq 3)
EDMa = (DMa/GY) ×100 (Eq 4)
EDMb = (DMb/GY) ×100 (Eq 5)

Where TDM is the total shoot dry matter; SDM the stem dry matter; mt the maturity; fl the flowering; DMa the apparent contribution of current photosynthesis after anthesis to grain filling; DMb the apparent contribution of dry matter partitioning from stems to grain filling; EDMa the efficiency of total dry matter remobilization in grain filling; EDMb the efficiency of dry matter remobilization from stem in grain filling. For these estimates, it was assumed that all of the dry lost from vegetative plant parts were ran located to the developing grain, since losses of dry matter due to plant respiration were not determined. Data were subjected to analysis by the SAS software and graphs were drawn using Excel program.

RESULTS

Analysis of variations, means comparison of main effects and their interaction effects were shown in table 2, 3 and 4, respectively.

Dry Matter Remobilization

Total Dry Matter Remobilization: Results showed that total dry matter remobilization trait was significantly affected by main and interaction effects of nitrogen levels and cultivars (Table 2). So that with increase in nitrogen fertilizer levels total dry matter remobilization decrease. Control level of nitrogen fertilizer had the highest rate (16661 mg) of total dry matter remobilization (Table 3).

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 dry matter remobilization, yield, yield component and other traits

Source of variation	df	Total dry matter remobilization	Efficiency of total dry matter remobilization	Dry matter remobilization from stem	Efficiency of Dry matter remobilization from stem	Kernel yield ha^{-1}	Kernel yield m^{-2}	Kernel yield per plant	1000 kernel weight	Number of kernel per ear	Harves t index
replication	2	134783.3	0.78*	450475	2.26*	2523	2275	0.45	6.04*	14.1**	**2.2
nitrogen	3	116530878.1**	840.1**	113154970.3**	632.8**	6263286**	62639**	1113**	2307**	10018**	**23.5
Experimental error	6	336811.9*	1.11*	756900.9*	3.03**	11898	12.7	0.21	1.01	0.26	*0.12
cultivar	2	149886882.7**	74.82**	163278558.3**	169.7**	9679156**	96721**	1720**	7444**	4336**	**19.2
Cultivar×Nitrogen	6	1434809.9**	15.48**	2157428.7**	11.99**	755790**	7577**	134**	676**	244**	**10.5
Experimental error	19	118394.97	0.27	272252.7	0.707	2247110	22470	399	1362	2.66	9.35
Cv.	-	2.76	2.63	6.17	6.18	39	5.06	0.66	1.5	0.4	0.022

*,** Significant in 5 and 1 persantage probablity respectivily.

Table 3. Main comparison of dry matter remobilization, yield component and other traits.

Treatments	Levels	Total dry matter remobilization (mg)	Efficiency of total dry matter remobilization (%)	Dry matter remobilization from stem (mg)	Efficiency of Dry matter remobilization from stem (%)	Kernel yield (kg h^{-1})	Number of rows/ears	Number of kernel/row	Number of kernel per ear	1000 kernel weight (gr)	HI ((%
	Kenez410	16314.9a	22.73a	12479.2a	17.57a	4763b	14b	29.9b	413.3c	152.9b	26.3b
Cultivars	Korduna	11592.3b	19.51b	7658.3b	13.17b	5876.2a	14b	31.6a	450.6a	172.2a	26.8a
	Konsur	9399.0c	17.81c	5232.5c	10.09c	4098.7c	15.66a	28.3c	442.6b	123.2c	24.4c
	0	16661.1a	33.08a	12555.6a	24.85a	3758d	14.44a	26.4c	398.8d	125.7d	27.9a
Nitrogen levels	60	13768.4b	20.97b	9838.9b	14.61b	4882.6c	14.66a	28.8b	418.7c	155.3c	26.2b
(kg h^{-1}]	120	11026.2c	15.25c	7127.8c	9.57c	5343.6b	14.44a	31.8a	450.3b	157.8b	24.9c
	180	8285.5d	10.76d	4304.4d	5.41d	5666.2a	14.66a	32.6a	474.2a	159.6a	24.3d

*Numbers with the same letter, have no significant difference.

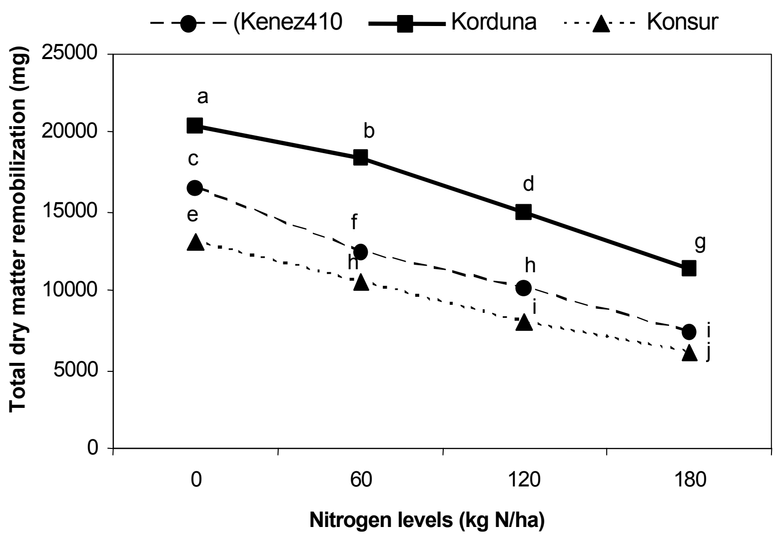

Fig. 1: Interaction effect of nitrogen levels and cultivar on total dry matter remobilization

Also Interaction effect of cultivars and nitrogen levels showed that cultivar of korduna had highest (20374 mg) value of total dry matter remobilization in Control level of nitrogen fertilizer. So At highest nitrogen levels and cultivar of Konsur lowest of efficiency of total dry matter remobilization was obtained (Figure1).

Efficiency of Total Dry Matter Remobilization: Efficiency of total dry matter remobilization was markedly affected by main and interaction effects of nitrogen levels and cultivars (Table 2). Effect of cultivars on efficiency of total dry matter remobilization was the same as their effect on total dry matter remobilization. So that with increasing of nitrogen application, efficiency of total dry matter remobilization in grain filling was decreased. So results showed that at highest of application of nitrogen fertilizer (180 Kg N ha^{-1}) efficiency of total dry matter remobilization in grain filling was lowest (10.76 percentage). Interaction effect of cultivars×nitrogen fertilizers showed that Maximum of

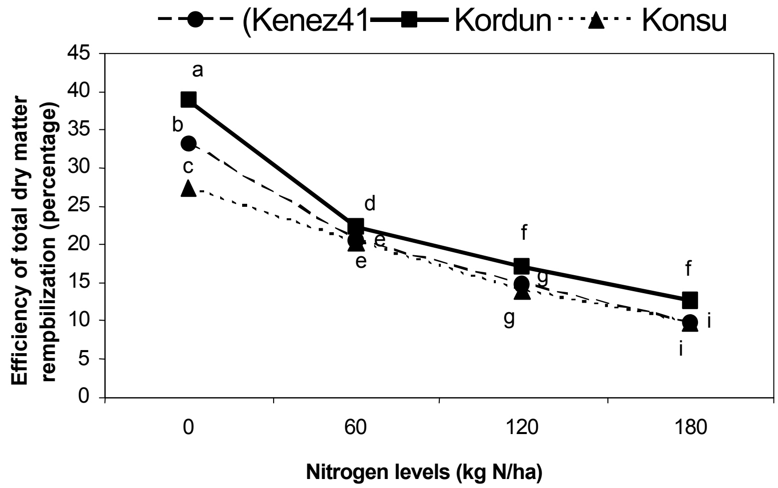

Fig. 2: Interaction effect of nitrogen levels and cultivar on efficiency of total dry matter remobilization

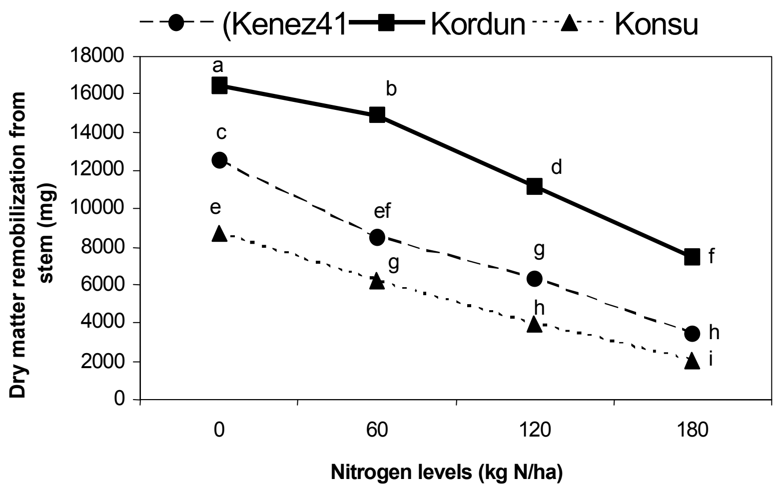

Fig. 3: Interaction effect of nitrogen levels and cultivar on dry matter remobilization from stem

this trait (38.9 percentages) was obtained in control levels of nitrogen level×Korduna. So at highest nitrogen levels and cultivar of Konsur lowest of efficiency of total dry matter remobilization was obtained (Figure 2).

Dry Matter Remobilization from Stem: Results showed that dry matter remobilization from stem was significantly affected by main and interaction effects of nitrogen levels and cultivars (Table 2). Control level had the highest rate of dry matter remobilization from stem. With increasing in nitrogen fertilizer levels dry matter remobilization from stem decrease. Interaction effect of cultivars and nitrogen levels showed that cultivar of korduna had highest value in all N fertilizer levels and highest of this trait (16433.3 mg) was obtained in interaction effect of control levels of nitrogen level×Korduna. So results showed that at highest nitrogen levels and cultivar of Konsur lowest (2080 mg) of efficiency of dry matter remobilization from stem were obtained (Figure3).

Efficiency of Dry Matter Remobilization from Stem: Efficiency of dry matter remobilization from stem in grain filling was markedly affected by main and interaction effects of nitrogen levels and cultivars (Table 2). Effect of cultivars and nitrogen fertilizer levels on efficiency of dry matter remobilization from stem was the same as their effect on Efficiency of efficiency of total dry matter remobilization. with increasing of nitrogen levels, efficiency of total dry matter remobilization in grain filling was decreased. So results showed that at highest of application of nitrogen fertilizer (180 Kg N ha^{-1}) efficiency of dry matter remobilization from stem in grain filling was lowest (5.41 percentage). Interaction effect of cultivars×nitrogen fertilizers identified that Maximum of

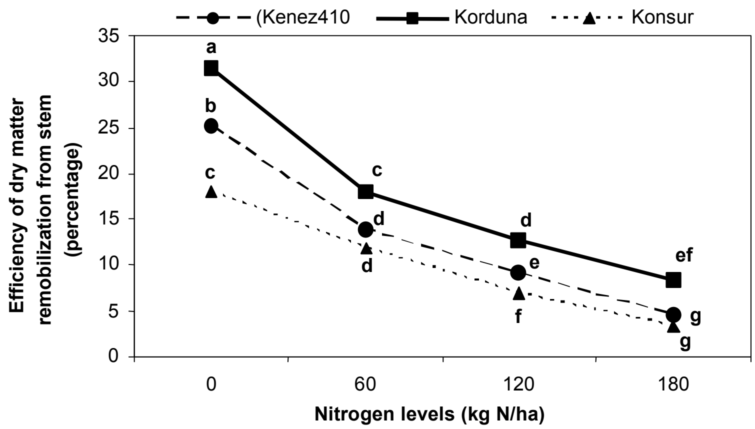

Fig. 4: Interaction effect of nitrogen levels and cultivar on efficiency of dry matter remobilization from stem

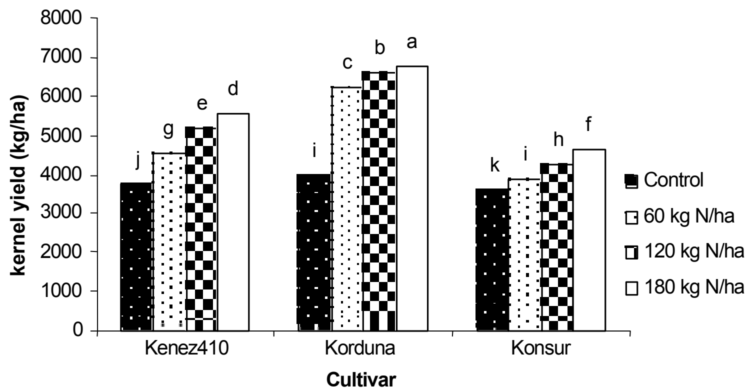

Fig. 5: Interaction effect of nitrogen levels and cultivars on kernel yield

this trait (31.38 percentages) was obtained in control levels of nitrogen level×Korduna. So at highest nitrogen levels and cultivar of Konsur lowest of efficiency of total dry matter remobilization was obtained (Figure 4).

Kernel Yield and Yield Components

Kernels Yield: 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 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).

Number of Kernel Rows per Ear: There was no significant effect of N levels on this trait. 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).

Number of Kernels per Row: 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: 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,

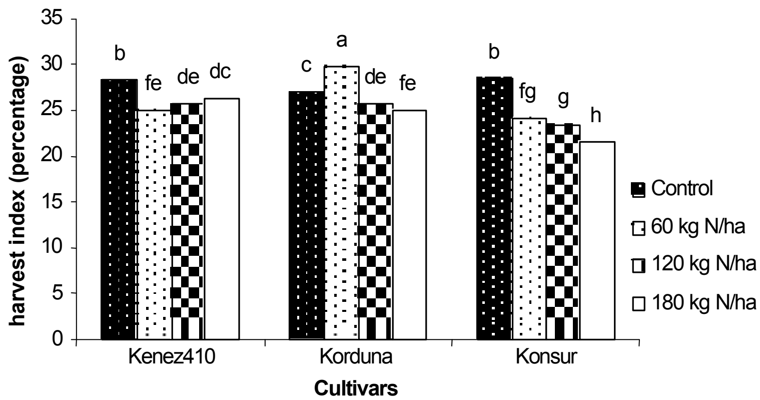

Fig. 6: Harvest index under interaction of nitrogen levels and cultivars

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).

1000 Kernels Weight: 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).

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 (Figure6).

DISCUSSION

The results showed that all of the traits for dry matter remobilization were affected by corn cultivars and nitrogen fertilizers. With increasing nitrogen levels in total cultivars dry matter remobilization and this efficiency was decreased, because at higher levels of nitrogen fertilizer, leaf area expansion and photosynthesis rates were high and grains filling period have enough nutrient to have grown. Schussler and Westgate [24] also reported similar result. Decrease in dry matter remobilization whit increase nitrogen levels was reported whit other researchers [25, 26]. 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. Increasing nitrogen fertilization rates led to a significant increase in 100 grain weight and grain yield of maize as compared with control treatment [27]. Nitrogen application significantly resulted in increase number of grains per ear, 100 grain weight and grain yield [28]. Effect of nitrogen fertilizer on grain yield, kernel number per ear and Maximum grain yield was obtained at 276 Kg/ha nitrogen [29]. 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} [30]. Kernel number per ear in spite of 1000 kernel weight had the largest proportion in kernel yield variation. [31]. Sabri *et al.* [32] 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. These observations are fully reported by Souza *et al* [33]. Palta *et al.* [34] reported that Nitrogen levels had pronounced effect on grain yield and dry matter production. 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 [35] 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 [36]. Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number. 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 [37]. Significant differences of harvest index depended on year [38]. This result is the same as our findings.

CONCLUSION

In this investigation the highest dry matter remobilization was acquired at interaction effect of Korduna × 0 kg N ha^{-1}. Hence, it is able to say that Korduna cultivar genetically has more potential for remobilization of dry matter. 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 general, if the goal of cultivation of corn is decrease in nitrogen application we must elect Korduna cultivar. Because it has acceptable remobilizations dry mater at all three nitrogen levels. Result from this research revealed that highest dry matter remobilization obtained at lowest N level. So, it is recommendable that we must utilize lower N fertilizer to achieve higher this trait. Differences among cultivars in dry matter remobilization were clearer. For the purpose and with regard to our investigation Korduna cultivar is advisable.

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