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Full Length Research Paper

Effect of nitrogen foliar application on grain filling rate and period in 3 cultivars of corn (*Zea mays* L.)

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In order to study the effect of nitrogen foliar application on seed rate and filing period in three cultivars of corn, a complete randomized block design base split plot experiment with three replications was conducted during 2009 at Agricultural Research Station, Islamic Azad University, Tabriz branch, Iran. Cultivars were arranged in three levels: early maturing (KSC_{307}), average maturing (Jeta), and late maturing (KSC_{704}). Urea foliar application arranged in seven levels: control (lack of foliar application), tassel appearance, ear appearance, beginning of grain filling, end of grain filling, concurrent foliar application in tassel appearance and beginning of grain filling stages and concurrent in tassel appearance, ear appearance, beginning of grain filling and end of grain filling. The results showed that foliar application of urea had a significant effect on grain yield. Yield increase with foliar application of urea took place in concurrent foliar application of urea in tassel appearance, ear appearance, beginning of grain filling and end of grain filling stage. Foliar application had a significant effect on leaf area duration and on grain filling rate and period consequently. According to the findings of this survey, it is possible to use foliar application of urea for increasing grain yield per plant and leaf area duration.

Key words: Foliar application, grain filling period, grain yield, leaf area duration, urea.

INTRODUCTION

One of the methods for using nitrogen fertilizers is foliar application of urea. Peltonen (1992) showed that a usual path for receiving nutrition to plant's tissues is roots but, foliar application increases absorbing nutrition via leaves in comparison with absorbing from soil (George, 2003). Shah et al. (2007) indicated that foliar application of urea in different stages of growth has a great effect on cultivated plant, that in comparison with using this fertilizer in soil, the foliar application in different stages of growth caused yield increase. Regarding foliar application, with correct timing and enough care, a high amount of nitrogen can be transmitted to the grain. In this method the leaves are the most important organ of the plant which receives nitrogen, and a slight amount of the absorbed nitrogen is transmitted to the root or entered to the soil (Saradon and Gianibelli, 1990; Havlin et al., 2007). Gebeyehou et al. (2002) stated that there is a strong correlation between final grain weight and grain filling period. Garcia and Honway (1987) reported that foliar application on soybean in grain filling period with a composition of nitrogen, phosphorus, potassium and sulfur increases the yield from 500 to 1500 kg/ha, but Boote et al. (1998) observed that by applying nitrogen, phosphorus, potassium and sulfur composition with foliar application in grain filling period has no significant effect on yield. Stevens et al. (2002) reported that foliar application of nitrogen fertilizer increases tiny nutrition application and cause the leaves to absorb nutrition, and affect harvest amount.

According to these findings, this survey aims at studying the effects of foliar application and the best

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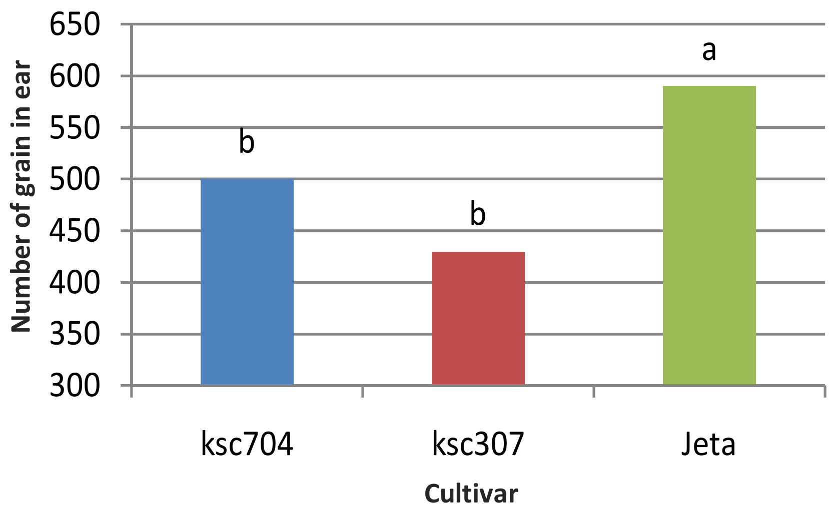

Figure 1. Changes in number of grain in ear among 3 corn cultivars.

timing on corn cultivars with different attendance periods.

MATERIALS AND METHODS

This survey is carried out in the form of split plot experiment, based on complete randomized blocks design in three replications at Agricultural Research Station, Islamic Azad University, Tabriz branch in North West of Iran (latitude 46° 27', longitude 38° 3' N, Altitude 1360 m above sea level). According to De-marten's classification, the region's climate is semi arid cold with warm summers and cold winters. The climate is characterized by mean annual temperature of 10°C, mean annual maximum temperature of 16°C, and mean annual minimum temperature of 2.2°C. This region has loamy sandy soil and its pH is in the range of weak to moderate alkalinities.

The cultivars as main plot include: a_1: early maturing (KarajSingleCross$_{307}$), a_2: average maturing (Jeta), and a_3: late maturing (KarajSingleCross$_{704}$), and different foliar application of nitrogen as sub plot included: b_1: lack of foliar application use, b_2: application in tasseling appearance, b_3: application in earning appearance, b_4: application in beginning of grain filling, b_5: application in grain pasting, b_6: concurrent foliar application in tasseling appearance and beginning of grain filling stages, and b_7: concurrent application in all stages:

$$b = \frac{\sum xy - (\sum x)(\sum y)/n}{\sum x^2 - (\sum x)^2/n}$$

$$\text{Effective filling period} = \frac{\text{weight of grain}}{\text{grain filling Rate}}$$

$$LAD = \frac{(LA_2 + LA_1) \times (T_2 - T_1)}{2}$$

Foliar application of nitrogen was selected according to experimental treatments in 5% concentration. In order to evaluate the weight increase process of dry grain in the grain filling period, the sampling was done after pollination and grain formation 12 times with five day intervals. In each sampling, two plants were randomly selected from every experimental unit. After transmitting to the laboratory, corn grains were drawn out carefully from four rows of upper, middle and lower part of earning and dried in an electrical oven under 70°C for 48 h. Then the dried weight of the grain was measured and by dividing to the number of row in cob, the average weight per grain was calculated. These data were used for estimating the rate and process of grain filling in variance analyzing and correlation. In order to calculate efficient period of grain filling (EFP) and rate of grain filling (b) the following relations were used. Regarding the final weight of grain, efficient period of grain filling is calculated via the following relation (Gebeyehou et al., 2002).

In these relations these abbreviations stands for following factors: b: correlation index (rate of grain filling), x: date number from pollination to physiological maturation, Y: weight of grain. The related variance analyzing is calculated whit SPSS and MSTATC.

The averages were compared with applying Duncan test in five percent possibility and the figures were drawn by using Excel.

RESULTS AND DISCUSION

Number of grains in cob

Jeta cultivar with an average of 573.3 has the highest number of grains in cob and cultivar KSC$_{307}$ with an average of 432.7 has the lowest number of grains in cob (Figure 1). Jeta cultivar had 32.58% higher grain number in cob in comparison with cultivar KSC$_{307}$. Regarding grain number, there is no significant difference between cultivar KSC$_{307}$ and cultivar KSC$_{704}$, but cultivar KSC$_{307}$ had 6.98% less grain number in cob in comparison with cultivar KSC$_{704}$, which bears the least grain number.

The number of grain in cob showed a positive and significant correlation with grain number in row (r =0.714**)

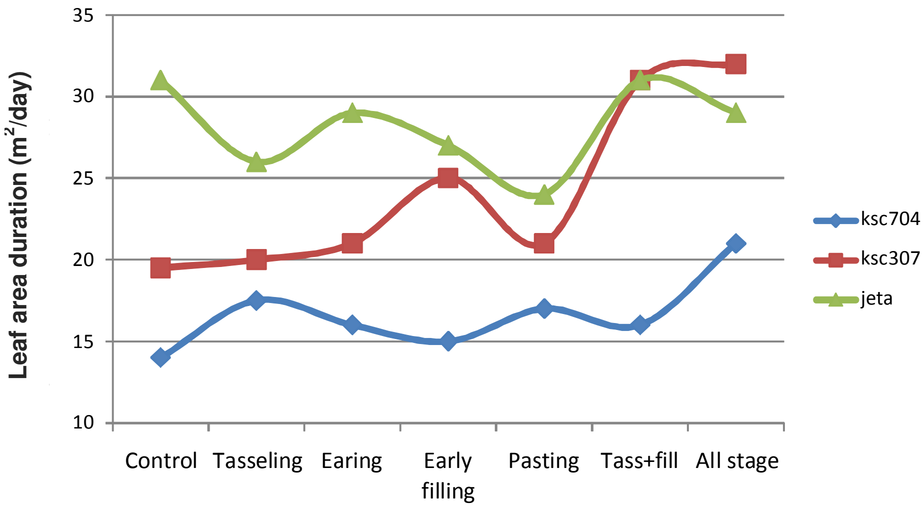

Figure 2. Effect of foliar application on leaf area duration on 3 corn cultivars.

and leaf area duration (r = 0.421**). Stevens et al. (2002) performed foliar application of nitrogen, phosphorus, potassium and sulfur fertilizers after pollination in 2 cultivars of early maturing and late maturing. According to their findings, foliar application of fertilizers caused reduction of grain number in late maturing cultivar in some cases. SadaPhah and Das (2006) reported a significant increase of grain number in wheat spike after foliar application of urea. According to the findings of this survey, increasing grain number in wheat spike is resulted from better condition of feeding for spikes regarding to nitrogen existence in the first phase of growth. MacNeal and Davis (2004) also used nitrogen fertilizers and stated that yield increase is mainly based on increase of tillering, grain number in spike and weight of grain.

Leaf area duration

The reaction of different cultivars to foliar application of urea fertilizer timing was different. Mean comparing showed that the most leaf area stability was observed in treatment of concurrent foliar application in all stages in cultivar KSC_{307} with 31.7 m^2 /day, and the least leaf area stability was observed in treatment of lack of foliar application use in cultivar KSC_{704} with 14.07 m^2/day. Treatment of foliar application in all stages of cultivar KSC_{307} increased leaf area stability 120% comparing control treatment in cultivar KSC_{704} (Figure 2).

According to the findings of experiments about leaf area duration, leaf area index and leaf area stability decreases by lack of nitrogen, and nitrogen exit from leaf caused senescence stimulus in leaves (Allanjones, 1985). Foliar application of urea fertilizer can restrict premature old age in leaves to a significant degree (Seligman, 1993). Koc et al. (2008) studied the effects of foliar application after pollination on leaf area stability and found out that foliar application after pollination in wheat do not increase leaf area stability. According to the results of correlation (Table 3), leaf area duration has a positive and significant correlation with grain filling rate (r = 0.580**), leaf area index (r = 0.901**), grain weight (r = 0.458**) and grain yield (r = 0.350**). This shows that increase of leaf area duration would increase these factors.

Grain filling period

The longest effective period for grain filling increased by foliar application for earning appearance stage in Jeta cultivar with 25.63 days and the shortest effective period for grain filling was for treatment of foliar application in tasseling appearance stage and beginning of grain filling in KSC_{704} cultivar with 19.20 days. Foliar application in earning appearance in Jeta cultivar increased grain filling period 33.48% comparing treatment of foliar application concurrent in tasseling appearance stage and beginning of grain filling in KSC_{704} cultivar (Figure 3). The results carried out by Jongkaewwttana et al. (2003) showed that increase of nitrogen increases grain-filling period. On the other hand, the results of Cho et al. (2007) stated that grain-filling period was not affected by nitrogen fertilizer. Crafts and Egli (1997) reported that it seems that shorter period of grain filling is caused by premature old age of leaves.

Grain filling rate

The highest rate of grain filling was observed in treatment

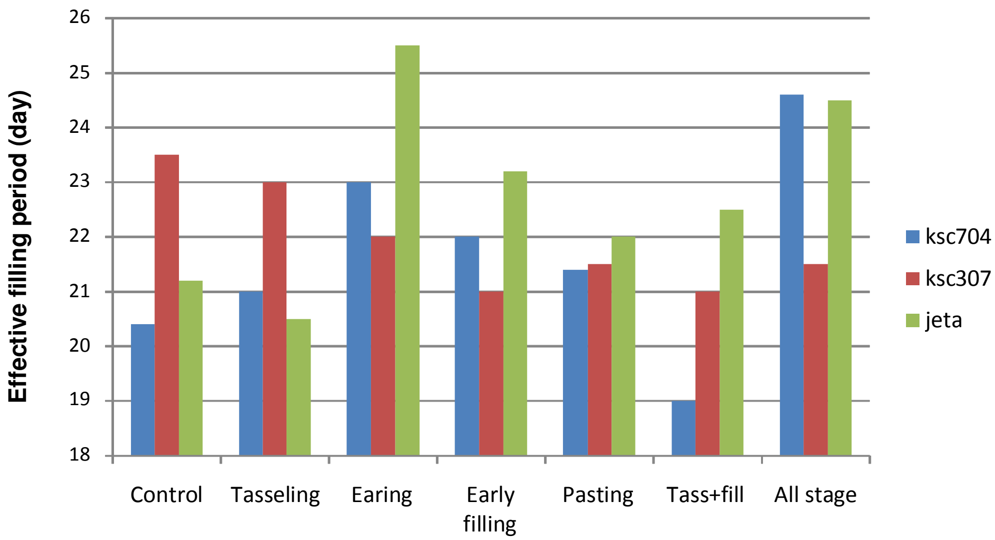

Figure 3. Effect of foliar application on filling period in 3 corn cultivars.

Table 1. Analysis of soil samples taken from 0 to 30 cm depth.

Silt (%)	Clay (%)	Sand (%)	O.C (%)	pH	Ec mS/cm	Pb g/cm3
20	14	66	1.13	7.67	2.05	1.4
Pp g/cm^3	Mn (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)	K (ppm)	P (ppm)
2.5	3.04	2.3	1.12	0.6	571	80

of foliar application in tasseling appearance stage and beginning of grain filling with 68.33 mg.day^{-1} and lowest rate of grain filling was observed in control treatment 54.60 mg.day^{-1}. Also, foliar application of concurrent in tasseling appearance stage and beginning of grain filling increased the rate of grain filling to 25.14% comparing with control treatment (Table 1). It is reported that lack of enough nitrogen decreases the rate of dry grain substance gathering which decreases grain filling period. Guldan and Brun (1985); Munier-Jolian et al. (2004) reported that the rate of dry grain substance gathering is affected by nitrogen rate available for plant during grain filling period. According to Soandele et al. (1999), the rate of dry grain substance gathering in pea during the period of grain filling was affected by available nitrogen and the stability of grain filling depends on nitrogen sources. Lhuillier-Soundele et al. (1999) reported that in soybean, if nitrogen was available, leaves stability and effective photosynthesis period increase, and grain filling period had been increased, which causes the increased weight of dry grains. It seems that process of grain filling has ascended during the growth period, but its stability and filling rate highly depends on environmental resources, especially nitrogen. Also, it is reported that heavier grains have higher rate of grain filling (Jones and Simmons, 2003; Kamiji and Horie, 1988).

Grain yield

The highest grain yield in area unit was observed in cultivar Jeta with an average of 1.430 kg/m^2 and the lowest grain yield in area unit is observed in cultivar KSC_{307} with an average of 0.9143 kg/m^2. Jeta cultivar grain yield was 56.40 % higher than cultivar KSC_{307} (Figure 4). Among different levels of cultivars, cultivar Jeta showed higher grain yield in area unit, 28.02 %, comparing with cultivar KSC_{704}, which was a significant increase.

Grain yield in cereal is composed from two major components, which are grain number in square meter and grain weight, and according to the records, the capacity of grains (sink) for gathering photosynthesis substance is the most important factor for verifying yield potential (Slafer and Savin 1994). Cultivar Jeta with its high genetic ability and having the highest leaf area and long leaf area stability had the highest grain yield. Among treatments of foliar application in different stages, the highest grain yield in area unit was observed by foliar application in concurrent application in all stages with 1.328 kg/m^2 and the lowest grain yield is observed as 1.075 kg/m^2 in control treatment (Table 2). Treatment of foliar application as concurrent in all stages increased grain yield up to 25.53% comparing control treatment.

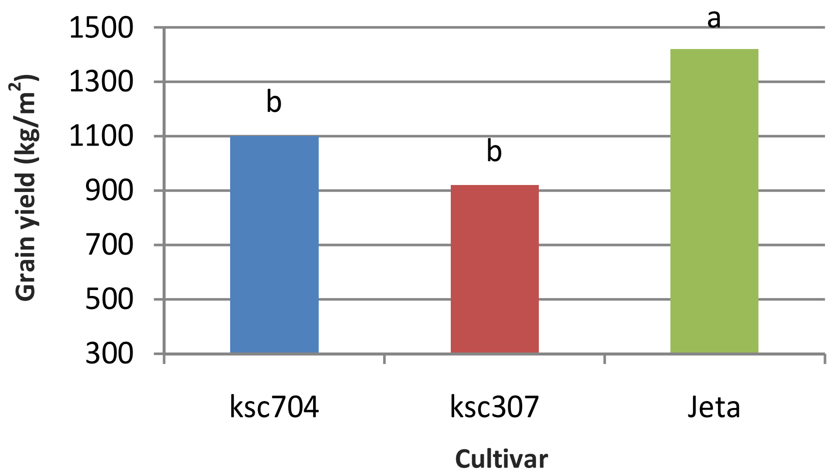

Figure 4. Grain yield in 3 corn cultivars.

Table 2. Analysis of mean squares for the trite studied.

S.o.V	df	Number of grain in ear	Leaf area duration	Grain effective filling period	Filling rate	Yield grain
Rep	2	10217.47	2.387	4.57	505.34	1257620.09*
Cultivars	2	114587*	559.35*	7.37	1266.89	1161658*
Error A	4	7993/62	50.98	14.86	251.28	156701.05
Foliar application	6	4216.01	58.12**	11.29**	222.29**	97156*
C*F	12	2558.26	20.89*	6.05*	77.65	25084.71
Error b	36	5114.55	15.19	2.71	52.01	34607.26
CV%		14.58	16.89	7.42	11.97	17.88

* and ** indicate significant effect at 5 and 1%, respectively.

Table 3. Correlation of between different measured traits.

	Grain yield	Number of grain in ear	Leaf area duration	Grain effective filling period
Number of grain in ear	0.847**			
Leaf area duration	0.350**	0.421**		
Grain effective filling period	0.236*	0.153	0.116	
filling Rate	0.107	0.080	0.580**	-0.120

Table 4. Foliar application in different stages.

Foliar application	Grain yield (kg/m^2)	Filling rate (mg/day)
Control	1.075^{b}	54.60^{b}
Tasseling	1.088^{b}	58.19^{ab}
Earing	1.091^{b}	59.52^{ab}
Early filling	1.142^{ab}	59.30^{ab}
doughy	1.175^{ab}	58.90^{ab}
Tasseling + Early filling	1.176^{ab}	68.33^{a}
All stage	1.328^{a}	67.04^{a}

Mean followed by similar letters in each column are not significantly different at 5% probability level using Duncan`s multiple range test.

Parker and Boswell (2000), and Boote et al. (1998) used a composition of nitrogen, phosphorus, potassium and sulfur and observed that soybean foliar application during grain filling period has no significant effect on yield.

Conclusion

In case of enough nitrogen available for plant, the leaf area index and consequently leaves duration increased which leads to increase of effective photosynthesis period, and this causes grain filling rate increase to 25.14% in Jeta cultivar leads to increase of photosynthesis substance concentration. Also, an increase was observed in grain filling period to 33.48%, which increased yield rate as 56.40%.

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