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Research article

RESPONSE OF YIELD, YIELD ATTRIBUTES AND GRAIN QUALITY OF THREE CORN CULTIVARS TO DEFOLIATION

Sasan Siahkouhian[a] , Mohammad Reza Shakiba[b] , Saeed Zehtab Salmasi [b], Kazem Ghassemi Golezani[b] and Mahmood Toorchi [b]

[a]Former student of department of Agronomy and Plant Breeding, Faculty of Agriculture, Tabriz University, Tabriz, Iran.

[b]Department of Agronomy and Plant Breeding, Faculty of Agriculture, Tabriz University, Tabriz, Iran.

* Corresponding author, e-mail: sasanweb4@gmail.com Tel.: (98 9171392946)

ABSTRACT: Any kind of decrease or inefficiency of corn leaves caused by factors such as pests, diseases, mechanical damages and hail, leads to decrease photo-assimilate translocation to the kernels and yield decrease. In order to investigate the role of each part of maize canopy leaves on yield and yield component, and grain quality, an experiment was conducted in a factorial experiment using randomized complete block design (RCBD) with three replications at the Research Farm of faculty of agriculture, Tabriz University, Tabriz, Iran, during year 2007. maize cultivars were single cross 647, 604, 504 and defoliation treatments contain leaf removal in 1/3 of upper, 1/3 of median, 1/3 of lower part of canopy and control (without defoliation) that imposed at tasseling. The results indicated that while defoliation had significant effects on yield components (except number of row per cob and 100 grain weight), grain yield per unit area, as well as ear length and leaf area index (LAI), quality of produced grains at defoliation levels including protein percent and oil percent did not differ considerably. The maximum LAI belonged to control and the least to the defoliation of the 1/3 in middle part of the canopy. In this study cultivars affected grain yield and mean 100 grain weight. Since the defoliation treatments had no significant impact on stem dry weight so it is concluded that maize leaves and especially median leaves have crucial role on photosynthesis and yield.

Keywords: Corn, Defoliation, Grain quality and Yield.

INTRODUCTION

Defoliation, or leaf damage, such as that associated with hail, frost, wind, crop protection chemicals and insects, can influence pollination and subsequent grain production. In fact defoliation treatments decreases assimilate availability during grain filling [10]. Corn yield is strongly depended on LAI, LAD and leaves efficiency for absorption of solar radiation for photosynthesis process [17]. In addition to leaves other chlorophyll-containing organs such as stems, parts of inflorescences and fruits can also be effective in supplying carbon and thus be able to change pattern of preparation and distribution of materials [24]. Carbohydrates for grain filling supply from current photosynthesis and the transfer of temporary reserves from stems, leaves, cob and ear pods [4]. The above leaves of maize attribute more assimilate to upper organ and underneath leaves transfer more production to the roots [12]. Field trials on sunflower (*Helianthus annus*) showed that whereas defoliation had no effect on stem diameter and plant height, but disk flower diameter, filled grains percentage, one thousand seed weight, harvesting index and grain yield affected by the defoliation treatments. Middle leaves of the stem have most important role than the other leaves because of greater surface and active participation in the photosynthesis. In this research, defoliation of all leaves was result in the least grain yield compared to control due to decrease in grain weight and filled grain percentage [1].

Borras and Otegui [4] found that hybrids have different ability to maintain seed weight loss when source-sink ratio changed. In this experiment factors including leaf area index (LAI), grain dry weight, length cob, hundred grain weight, number of row per cob, number of grain per row, number of grain on each cob, dry weight of cob and dry weight of maize stalk were examined. The aim of this research was to determine the effects of different levels of defoliation on yield components and grain quality of three corn cultivars.

MATERIALS AND METHDS

A field experiment was carried out at the research Farm of Faculty of Agriculture, University of Tabriz, Iran (latitude of 38°, 5' and longitude of 46° at altitude of 1360 m above the sea level) in 2007 growing season. Mean annual temperature and rainfall in 2007 were 10°c and 271 mm respectively. The soil was clay-loam with the pH of 7.3. The experimental factors arranged as a factorial based on randomized complete block design with three replications. Each plot size was 3 m×4 m involving 5 rows with inter-row spacing of 0.6 m. A total of 3 cultivars (Single crosses 604 and 647 with 125-135 days growing period and 504 with 115-125 days growing period) with eight plants/m2 and four defoliation levels (control: no leaves removed, removal of one third upper leaves, removal of one third middle leaves and removal of one third lower leaves) were used. Defoliation treatments were applied on the tassel emergence stage and leaves were removed from ligules.

Sowings were performed manually by planting twice more seeds than the expected plant densities and then, rows were thinned to the required densities. A basal application of nitrogen and phosphorous were carried out at sowing time, using urea and P_2O_5 fertilizers at the rate of 60 kg ha^{-1} and 100 kg ha^{-1}, respectively. About 60 kg ha^{-1} urea was also added to the soil when maize plants were 40–50 cm height. The remaining urea (60 kg ha^{-1}) was added to the soil when maize was in interval of anthesis–silking stages. Irrigation of all plots was performed about weekly, according to crop water requirement in the experimental site. Hand-weeding was done as needed, during crop growth and development.

Two days after plants treated by defoliation, leaf area index (LAI) was determined by Sun Scan in 5 randomly selected plants per plot. In order to evaluate stem dry weight this recording was placed in two stages of tassel emergence and harvest stage. To determine dry weight and dry matter percentage, 5 plants were cut from their collar in each sample. Drying of different organs (leaf, stem, husk, shank, grain and cob) depending on kind of organ and growth stage and was done in oven with 60ºC during 48-72 hours. At harvesting, when black layer was formed at the basal part of grains, maize plants were cut from ground surface. Grains were detached from cubs and weighed after adjusting grain moisture constants levels to 14 percent. A sub sample of grains of each cultivar was put in hygrometer and their moisture content was measured. Grains oil and protein percent was measured by Seed Analyzer. Analysis of variance of the data appropriate to the experimental design and comparison of means at p 0.05 were done using MSTATC software. Word and Excel software were used to draw tables and figures.

RESULTS AND DISCUSSIONS

The results of the treatments analysis of variance on tested traits of three maize cultivars in the present trial are shown in table 1. Leaf area index was similar in all treatments before application of defoliation treatments. The impact of leaf removing on LAI was varying, depending on the intensity of defoliation and leaf position (Table 1). Two days after treating time, LAI values of removing of leaves in 1/3 upper, middle, and lower part of maize canopy were 3, 2.2, 2.83, respectively. (Table 2). The maximum LAI belonged to control and the least amount was connected to 1/3 middle leaves defoliation. This indicates that there are larger leaves in this area as with removing them this index falls considerably in comparison with other two treatments.

There was no difference between control and other defoliation treatments in this character. Chopra and Maheswari [7] reported that there is a highly significant linear relationship between yield and LAI. As well as, Djisbar and Gardner [9] reported that higher grain yield associate with high leaf area index during grain filling. Defoliating of leaves on 1/3 upper and lower part had the same effect as control on grain yield. Removing of 1/3 middle stem leaves decreased grain yield compared to control, however, removing the leaves on the 1/3 upper and 1/3 lower of stem did not have significant effect on grain yield (Table 2). Percentage yield loss is depending on factors such as on the amount of removed leaves, leaf position on plant and also defoliation time [20]. Barimavandi*et al* [3], suggested that the near leaves to ear are main factor of increasing dry matters and growth rate during the development. Kamath et al [14] investigate the effects of different levels of defoliation and leaf position in stem on grain yield and reported that cutting 10 upper leaf loss seed yield by 17.2 % whereas when treatment happened on 10 middle leaves reduced yield by 45.7 % compared to control treatment. The number of grain strongly affected by defoliation, likewise removing of middle leaves decreased about 17.6% of the number of grains on cob (Table 2). Removing of above and under leaves did not have significant effect on the number of grains compare to the control. The results illustrate that middle leaves of stem were most effective than other leaves. Removing of 1/3 middle stem leaves treatment caused to decrease in yield and yield components by decreasing grain number. Decreasing in grain numbers on cob probably is a result of partial number of flower primordia or slight pollination because of dichogamy [8]. This indicates further importance of middle stem leaves in photosynthesis and seed filling. These Leaves have the considerable photosynthetic surface, more activity and are responsible for much of plant photosynthesis. Lower leaves of the plant due to being older has the lowest efficiency so that removal of this leaves have not significant effect on the studied traits compared to control treatment. All three cultivar have highest number of seeds in without defoliation treatment. In maize, seed number is determined in the range of silking and in this period there is high sensitive to provision of assimilate [13]-[16]-[18]. Grain yield reduction was according to the defoliated leaf number and this reduction was related to the grain number decrease [2]. Based on the experiments results, defoliation in the early stages of the reproductive phase loses yield by reducing the number of seeds.

Table 1. Analysis results of defoliation treatments effect on yield and yield components of grain maize cultivars.

Variables	df	Ms											
		Grain yield	number of Row on cob	Grain number on row	grain hundred Weight(g)	Grain number on cob	length Cob	Stem weight (g)	Cob wood weight(g)	LAI	Moisture (%)	Oil (%)	Protein (%)
Replication	2	240163/30**	0/67^{ns}	91/67*	1189/02^{ns}	25113^{ns}	1/26^{ns}	282/52^{ns}	46/63^{ns}	0/50^{ns}	60/29^{ns}	3/36^{ns}	0/68^{ns}
Defoliation	3	190732/20**	0/52^{ns}	132/59**	758/65^{ns}	39236**	14/97**	302/85^{ns}	193/42**	2/78**	4/68^{ns}	2/29^{ns}	0/08^{ns}
Control vs. rest	1	158292/06^{ns}	1/04*	59/19^{ns}	13/09^{ns}	25126/88^{ns}	1/55^{ns}	19/24^{ns}	119/58^{ns}	5/38**	5/31^{ns}	6/18*	0/08^{ns}
Between defoliation	2	206954/47*	0/27^{ns}	169/26**	4/83^{ns}	46290/35*	21/68**	444/74^{ns}	230/33**	1/48*	4/37^{ns}	0/34^{ns}	0/09^{ns}
Cultivar	2	114002/22*	0/08^{ns}	2/67^{ns}	2924/42**	2339^{ns}	0/96^{ns}	81/49^{ns}	3/21^{ns}	0/05^{ns}	19/67^{ns}	0/77^{ns}	0/51^{ns}
Cultivar× Defoliation	6	24604/25^{ns}	0/08^{ns}	21/1^{ns}	546/91^{ns}	5190^{ns}	1/34^{ns}	123/06^{ns}	37/14^{ns}	0/18^{ns}	5/95^{ns}	0/41^{ns}	0/39^{ns}
Error	22	24604/05	0/23	20/67	378/04	7709/63	1/72	219/10	37/05	0/30	16/81	1/10	0/29
Cv (%)	-	15/04	3/15	10/69	9/82	13/37	7/35	27/35	20/46	19/01	9/79	28/80	7/44

ns: non-significant, **: Significant at 1% and *: Significant at 5%.

Table2. Means value of examined parameter

Treatments	Grain Yield (g/m2)	Row number on cob	Seed number per row	hundred Grain Weight (g)	grain number on cob	cob length (cm)	Stem weight (g)	Cob wood Weight (g)	LAI	Protein (%)	oil (%)	Moisture (%)
control	1157/75 a	15/68 a	44/76 a	208/49 a	702/46 a	18/22 a	99/03 a	32/91 a	3/16 a	7/388 a	2/93 b	41/36 a
Remove 1/3 upper	1092/70 a	15/48 ab	43/78 a	200/14 ab	678/63 a	18/64 a	101/41 a	31/64 a	3/10a	7/388 a	4/11 a	42/53 a
Remove 1/3 middle	829/51 b	15/14 b	36/83 b	186/26 b	558/78 b	15/95 b	94/39 a	22/86 b	2/30 b	7/366 a	3/73 ab	42/34 a
Remove 1/3 lower	1091/63 a	15/25 ab	44/80 a	197/28 ab	686/94 a	18/63 a	99/75 a	31/60 a	2/92 a	7/211 a	3/82 ab	41/25 a
Cultivar 604	1056/52 ab	15/38 a	42/76 a	199/10 a	654/18 a	17/96 a	103/11 a	29/39 a	2/87 a	7/525 a	3/541 a	41/5 a
Cultivar 504	939/33 b	15/31 a	42 a	181/93 b	644/17 a	17/54 a	105/36 a	30/34 a	2/80 a	7/416 ab	3/941 a	43/26 a
Cultivar 647	1132/84 a	15/48 a	42/87 a	213/10 a	671/75 a	18/07 a	87/45 b	29/52 a	2/94 a	7/075 b	3/470 a	40/85 a

The result of this experiment showed that the removing of 1/3 middle stem leaves caused to severe decreasing of grain number in rows compare to control (%22) (Table 1), however, removing of above and below leaves of stem did not affect this trait (table 2). It is found that 1/3 middle stem leaves of stem have considerable effects on the number of grain in row character. It is certain that the removing of leaves causes to restriction of carbohydrates in cob, production of many immature and small seeds on ear tip and finally to decrease yield.

In this trial, the effect of defoliation treatments on the hundred grain weight was not significant (Table 1). It seems that partial defoliation in this stage did not affect crop yield by grain weight. Egharevba et al, [11] also reported damage to maize leaves in 50% silking stage to 10 days after it cause to reduced yield by reducing grain number whereas after 20 days or more, yield reduced by reducing thousand Kernel Weight. Various reports also indicate that partial defoliation about 25 or 33 % did not change grain weight in any of the developmental stages of seed [15]-[19]. Cultivars had significant effect on grain weight. Single cross 504 produced the lowest grain weight whereas 604 and 647 had similar hundred grain weight (Table 2). The results show that the row numbers on ear only affected by 1/3 middle stem defoliation, whereas removing of leaves on other part of canopy had no effect on this character. It seems that the number of seed rows per ear will be affected by larger amounts of defoliation (Tables 1 and 2). Barimavandi *et al* [3] noted that the number of rows per ear affected by complete leaf removal, whereas one or more leaves had no impact on this trait.

In this study, there was no significant difference of stem dry weight among defoliation treatments or control and defoliation treatments (table 1). Chauhan and Halima [6] reported that dry weight of straw would be decreased with increasing of defoliation intensity [6]. Due to the partial damage to leave did not change this trait, to access more accurate results leaf manipulation levels could be increased. Regarding to the treatments application in tasseling stage that the vegetative growth was halted, these results indicate that corn is very inefficient in use of assimilate stored before flowering to grain growth [5].

The lowest cob wood dry weight related to defoliating 1/3 middle stem leaves and other treatments had no significant difference with control on this trait (Table 2). This result indicates that there is a reverse relation between intensity of leaf removal in anthesis stage and cob dry weight.

Based on results length cob Decreased by 12% in 1/3 middle stem leaves, whereas other treatments do not have significant effect on cob length (table 2). These results are in agreement with the finding of Egharevba *et al* [11]. Assimilate decrease and lack of enough grain development in the ear tip can cause short corn cob in 1/3 middle defoliation treatments. It seems that distal ear of corn has superior in attribute assimilates than the corn cob tip. It is indicated that ear length is most affect by some factor such as defoliation time, intensity of defoliation and position of leaves on the plant [21]-[22]. Overall, all treatments had not significant effect on protein, oil and seed moisture (Table 1). Below ear defoliation in early maturing cultivar at 5-leaf stage revealed that some characteristics such as plant height, protein and oil percentage were higher than control cultivar [23]. But in the current experiment, there were not significant differences between defoliation treatments with respect to protein percentage and the reason of that can be due to soybean and corn plants differences. To ensure the results can test this defoliation experiment on a wider range on cultivars and in different growth stages.

Results of this study showed that removing of middle leaves decreases yield because of diminishing of number of grains. In addition, some factors including, cob length, cob wood dry weight, and grain row on cob are decreased under defoliation treatments. According to stage treatment imposed on plant – before seed formation or seed filling the most change caused by defoliation seen on traits related to yield such as LAI, grain number on cob, grain number on cob and this cause to decrease in yield. This indicates the early reproductive phase specially flowering and pollination is more sensible to any harmful factor to leaves. Apparently early stages because of enough time for lose compensation and final stages in order to complement of seed filling are less sensible to leaves hurt. From non significant and small effect of lower leaves in grain yield it is concluded that examined cultivars of 604 and 647 are able to be planted in higher densities and they are suitable for intercropping with other plants (for instance legumes). Finally, removing of middle leaves of ear was more effective on the all investigated characteristics because of their bigger photosynthesis area and more activity. Lower leaves are less effective because there are aged and are less effective. In order to make sure we can examined this study in wider range and other stages. The results suggest that the middle leaves should not defoliate, because this treatment has negative effect on the yield.

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