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# EFFECT OF DEFOLIATION BASED ON LEAF POSITION ON MAIZE YIELD, YIELD COMPONENTS AND PRODUCED SEED GERMINATION

H. HEIDARI
*Razi University, Department of Crop Production and Plant Breeding, Faculty of Agriculture, 67149-67346 Kermanshah, Iran*

## Abstract

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Defoliation can affect maize seed yield. In order to determine the effect of defoliation treatments on maize yield, yield components and produced seed germination traits, a field and a laboratory experiments were conducted in 2012. The field experiment included six defoliation treatments (D1= control, no leaf removal, D2 = defoliating tassel leaf, D3 = defoliating ear leaf, D4 = defoliating leaves at the top of the ear, D5 = defoliating leaves under ear, D6 = defoliating all leaves). Germination traits of seed produced from maternal plant were tested at the laboratory experiment. Results showed that complete defoliation severely reduced seed yield, row number per ear, seed number per ear, cob length, cob weight and ear weight ($P < 5\%$). Defoliation treatments had minor effect on produced seed germination traits.

*Key words*: defoliation, leaf position, maternal effect, seed vigor, yield components

## Introduction

Several biotic and abiotic stresses affect maize yield through defoliation. These stresses are insects, rust, hail, herbivores, herbicides and farm machinery. Sunflower (*Helianthus annuus* L.) yields were severely reduced by defoliation at the preflowering stage (Erbas and Baydar, 2007). Zewdu and Asregid (2001) reported that critical rate of defoliation in maize that did not affect seed yield and yield components is 50%. Other researchers have declared a significant effect of defoliation on maturity and soluble solid content (Tollenaar and Daynard, 1987) in maize. Maize (*Zea mays*) plants under complete defoliation had the lowest seed yield, ear weight, row number per ear, cob weight and 100-seed weight, but had higher seed germination percentage, rate and vigor (Heidari, 2013). In common vetch (*Vicia sativa*), plants under different defoliation produced seeds with similar germination percentage (Koptur, et al., 1996). Maize production of Iran was 1 930 000 tons in 2005 (Magiran, 2012 ). In west of Iran, foliage losses from some insects, diseases and herbivores is noticeable. The objective of this study was to determine maize seed yield and seed germination traits as affected by defoliation at different leaf positions.

E-mail: h.heidari@razi.ac.ir

## Materials and Methods

**Experiment 1: Field Experiment**
***Site, experimental design and cultural practices***

The field experiment was conducted at Chamchamal plain, 47 km from Kermanshah, west of Iran in 2012 (Latitude 34°N, longitude 47°E, and altitude 1300 m above sea level). Average annual rainfall of the zone is 442 mm (IMO, 2012). The experimental design was a randomized complete block design (RCBD) with three replications. There were six defoliation treatments:

D1= control, no leaf removal, D2 = defoliating tassel leaf, D3 = defoliating ear leaf, D4 = defoliating leaves at the top of the ear, D5 = defoliating leaves under ear, D6 = defoliating all leaves

Maize seeds (*Zea mays,* cv S.C. 704) were sown on April 18, 2012 using a pneumatic maize seeder. Seeding rate was 25 kg $ha^{-1}$. Plants were irrigated 4 times. Urea fertilizer [46 = N%, CO $(NH_2)_2$] at 250 kg $ha^{-1}$, was applied as top dressing.

Weeds were controlled by Nicosulfuron (Cruz) herbicide (2-[[[[4,6-dimethoxy-2-pyrimidinyl) amino] carbonyl] amino] sulfonyl] –N, N-dimethyl-3-pyridinecarboxamide) and 2,4-D + MCPA herbicide ((2, 4-dichlorophenoxy acetic acid in ammonium (amine) salt: 2, 4-D; 4-chloro-2-methylphenoxy) acetic acid: MCPA).

Plot size was 3 m wide and 3 m long. The distances between plots and between replications were both 1.5 m. Defoliation treatments were imposed at silking stage (91 days after sowing).

***Plant sampling and measurements***

In order to measure the seed yield, five plants were cut and after drying, seed yield was measured as gram per plant. Plants were harvested when they yellowed. Row number per cob, seed number per row and cob length was measured by random selection of three ears per plot. Cob weight, ear skin weight, ear weight and 100-seed weight were measured by random selection of five plants per plot after drying the plant part.

**Experiment 2: Laboratory Experiment**

Seeds of maternal plants were stored for 3 weeks. Then they were used for the laboratory experiment. In the laboratory experiment, the effect of maternal environment was studied by testing seed germination traits. The study was conducted as a Randomized Complete Block Design with three replications in fall 2012.

At first, seeds were sterilized using sodium hypochlorite solution (1% active chlorine) for 10 min to avoid fungal contamination. Then each Petri dish received ten seeds and 10 ml of distilled water. Finally, Petri dishes were kept in a growth chamber at 25°C. The criterion for germination was two millimeters growth of coleoptiles. The trial period was 7 days. Seed vigor was estimated using the formulae (Heidari, 2012; Sharifzadeh et al., 2006):

Seed vigor (% cm) = [Radicle length (cm) + Caulicle length (cm)] * [% Germination]

Seed vigor (% g) = [Radicle weight (g) + Caulicle weight (g)] * [% Germination]

***Data analysis***

Data were analyzed using analysis of variance. Duncan test was used to separate the means (($P < 0.05$). MINITAB (version 14.0), SAS (version 9.1) and SPSS (version 16.0) were used for statistical analysis.

## Results and Discussions

**Experiment 1**

***Ear skin weight and ear weight***

Removing all leaves severely reduced ear weight (Table 1). Ear leaf removal had higher ear weight than defoliating leaves under and at the top of the ear. Maybe it is due to that ear leaf acts as a parasite for ear growth at grain filling period because it is located in central part of maize stem and upper leaves can shade on it. Defoliation treatments had no significant effect on ear skin weight (Table 1). Ear weight and ear skin weight had a significant and positive correlation with all traits except 100-seed weight (Table 2). Some parts of the results are in compatible with Barimavandi et al. (2010) and Heidari (2013) results. Reduction in leaf area reduces resources for grain filling (Koptur et al., 1996).

***Row number per ear and seed number per row***

Complete defoliation severely reduced row number per ear and seed number per row (Table 1). Brimavandi et al. (2010) and Heidari (2013) reported that the row number per ear only was affected by complete defoliation. Minor effect of defoliation on seed number per row and row number per ear is due to that stem reserves can compensate insufficient

**Table 1**
**Effect of defoliation treatments on maize yield and yield components**

| Treatments | Ear weight, g/plant [b] | Ear skin weight, g/plant | Row number per ear | Seed number per row | Cob length, cm | Cob weight, g/plant | Seed yield, g/plant | 100-Seed weight, g |
|---|---|---|---|---|---|---|---|---|
| D1[a] | 122.9 abc | 11.3 a | 13.2 a | 42.0 ab | 17.2 ab | 22.5 a | 100.3 abc | 19.0 a |
| D2 | 133.7 ab | 12.1 a | 13.3 a | 47. 7 a | 19.0 a | 22.5 a | 111.2 ab | 18. 7 a |
| D3 | 149.2 a | 11.4 a | 13.2 a | 48.1 a | 19.4 a | 23.6 a | 125.6 a | 20. 7 a |
| D4 | 88.0 c | 11.1 a | 13.1a | 31.9 b | 16.7 ab | 15.0 bc | 73.0 c | 19. 7 a |
| D5 | 109.3 bc | 11.9 a | 13.3 a | 43.1 ab | 17.8 ab | 18.8 ab | 90.5 bc | 17.0 a |
| D6 | 29.9 d | 8.0 a | 7.0 b | 16.9 c | 14.2 b | 8.9 c | 20.9 d | 16. 7 a |

[a] D1= control, no leaf removal, D2 = defoliating tassel leaf, D3 = defoliating ear leaf, D4 = defoliating leaves at the top of the ear, D5 = defoliating leaves under ear, D6 = defoliating all leaves

[b] Means followed by the same letter within each column are not significantly different at $P < 0.05$ as determined by Duncan's Multiple Range Test.

**Table 2**
**Pearson's correlation coefficients among studied traits in maize under different defoliation treatments**

| | EW | ESW | RNE | SNR | CL | CW | SY | HSW |
|---|---|---|---|---|---|---|---|---|
| EW | 1 | .884* | .877* | .983** | .967** | .984** | 1.000** | .750 |
| ESW | .884* | 1 | .975** | .923** | .882* | .850* | .887* | .573 |
| RNE | .877* | .975** | 1 | .886* | .842* | .837* | .881* | .707 |
| SNR | .983** | .923** | .886* | 1 | .968** | .970** | .982** | .629 |
| CL | .967** | .882* | .842* | .968** | 1 | .921** | .972** | .662 |
| CW | .984** | .850* | .837* | .970** | .921** | 1 | .979** | .704 |
| SY | 1.000** | .887* | .881* | .982** | .972** | .979** | 1 | .755 |
| HSW | .750 | .573 | .707 | .629 | .662 | .704 | .755 | 1 |

EW, ESW, RNE, SNR, CL, CW, SY, HSW are ear weight, ear skin weight, row number per ear, seed number per row, cob length, cob weight, seed yield, 100-seed weight,
* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

photosynthesis from leaves. Row number per ear and seed number per row had a remarkable effect on seed yield (Table 2). Defoliating leaves at the top of the ear produced lower seed number per row than defoliating leaves under ear. Upper leaves receive higher light than lower leaves, so defoliation of upper leaves had more adverse effect on seed number per row than lower leaves.

***Cob length and cob weight***

Complete defoliation reduced cob length compared to D2 and D3 and the difference among other treatments was not significant (Table 1). Cob elongation was most likely partially completed at silking stage and defoliation at this stage did not affect further growth of the organs. Defoliating leaves under the ear (D5) had higher cob weight than defoliating leaves at the top of the ear (D4) (Table 1). It is probably due to that lower leaves receive low light and they are senescent, so they become consumer. Upper leaves are more efficient in absorbing light than lower leaves (Heidari, 2012). Cob length and weight had a positive and significant correlation with all traits except 100-seed weight (Table 2). Fasae et al. (2009) observed that defoliation had no significant effect on cob length.

***Seed yield and 100-seed weight***

Removing all leaves severely reduced seed yield (Table 1). Ear leaf removal had higher seed yield than defoliating leaves under and at the top of ear (D4, D5). It is probably due to that ear leaf is located in central part of maize stem and upper leaves can shade on it, so it becomes consumer and competes with ear for photosynthates. Seed yield had a positive and significant correlation with all traits except 100-seed weight (Table 2). This shows that lower seed yield of complete defoliation is due to lower seed number per row and lower row number per ear. Defoliation treatments had no significant effect on 100-seed weight (Table 1). Maposse and Nhampalele (2009) observed that defoliation decreased seed weight. It seems that seed weight is more dependent on genetic factors than environmental factors (Heidari Zolleh et al., 2009).

**Experiment 2**

***Seed germination percentage***

D2 and D3 had higher seed germination percentage than D5 (Table 3). It may be due to that defoliation as an environmental stress can increase seed germination percentage as described by Heidari (2012). Defoliation of leaves under ear did not have an effect as great as a removal of one leaf of ear or tassel. The reason is that bottom leaves are senescent and receive low light so removal of them does not have great effect on plant growth. Seed germination percentage had a positive and significant correlation with seed vigor based on weight (Table 4). In the common vetch (*Vicia sativa*), defoliation treatments on maternal plant did not have significant effect on days to germination (Koptur et al., 1996).

***Shoot length and root length***

Defoliation treatments had no significant effect on seedling shoot length and root length (Table 3). Root length had a negative and significant correlation with vigor based on weight (Table 4). This negative correlation is due to that when root length reduced, shoot length, seedling weight and germination percent increased (however these changes was not statistically significant) it means heavier root but shorter. In maize, a negative correlation between shoot length and seed vigor based on weight was reported (Heidari, 2013).

**Table 3**
**Effect of defoliation treatments on maize seed germination traits**

| Treatments | Germination, % [b] | Shoot length, cm | Root length, cm | Seedling weight, mg | Seed Vigor, % mg | Seed Vigor, % cm |
|---|---|---|---|---|---|---|
| D1[a] | 83.3 ab | 6.5 a | 14.5 a | 43.3 a | 35.1 a | 17.1 a |
| D2 | 96. 7 a | 7.9 a | 13.9 a | 41.5 a | 41.8 a | 21.2 a |
| D3 | 96. 7 a | 6.0 a | 14.1 a | 43.0 a | 41.6 a | 19.5 a |
| D4 | 90.0 ab | 7.2 a | 13. 7 a | 46. 7 a | 41. 8 a | 18.3 a |
| D5 | 76. 7 b | 7.1 a | 15.5 a | 45.3 a | 34.2 a | 16.9 a |
| D6 | 90.0 ab | 8.6 a | 15.3 a | 41.6 a | 35.6 a | 21.2 a |

[a] D1 = control, no leaf removal, D2 = defoliating tassel leaf, D3 = defoliating ear leaf, $D_4$ = defoliating all leaves at the top of the ear, D5 = defoliating all leaves under ear, D6 = defoliating all leaves
[b] Means followed by the same letter within each column are not significantly different at P < 0.05 as determined by Duncan's Multiple Range Test.

**Table 4**
**Pearson's correlation coefficients among studied traits in maize seed under different defoliation treatments**

| | Germination percent | Shoot length | Root length | Seedling weight | Seed Vigor (based on weight) | Seed Vigor (based on length) |
|---|---|---|---|---|---|---|
| Germination percent | 1 | .089 | -.583 | -.544 | .853* | .788 |
| Shoot length | .089 | 1 | .250 | -.400 | -.156 | .618 |
| Root length | -.583 | .250 | 1 | -.243 | -.824* | -.088 |
| Seedling weight | -.544 | -.400 | -.243 | 1 | -.105 | -.781 |
| Vigor (based on weight) | .853* | -.156 | -.824* | -.105 | 1 | .470 |
| Vigor (based length) | .788 | .618 | -.088 | -.781 | .470 | 1 |

*.Correlation is significant at the 0.05 level
**.Correlation is significant at the 0.01 level

***Seedling weight and vigor***

Defoliation treatments had no significant effect on seedling weight and vigor (Table 3). Contreras (2007) reported that watering treatments during lettuce (*Lactuca sativa* L.) seed production on maternal plant did not affect seed vigor index.

## Conclusions and Suggestions

Removal of all leaves severely reduced seed yield, row number per ear, seed number per ear, cob length, cob weight and ear weight. Ear leaf removal and tassel leaf removal increased seed germination percentage compared to removal leaves under the ear, but other germination traits was not affected by defoliation treatments that confirms past finding about effect of maternal environment effects on seed germination traits. Regarding few researches about maternal environment effects on seed germination traits, it is recommended to study effect of other environmental factors such as light by removing leaves under and at the top of ear on seed germination traits.

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