STUDY OF DEFOLIATION INTENSITY AND NITROGEN RATE EFFECTS ON YIELD, YIELD COMPONENTS AND GERMINATION TRAITS OF PRODUCED SEED IN WHEAT (*Triticum aestivum*)

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Abstract. A field experiment and a laboratory experiment were conducted in 2011-2012 to determine the effect of defoliation intensity and nitrogen rate on yield, yield components and seed germination of wheat (*Triticum aestivum*). The field experiment included three defoliation intensities (0, 1/2 and all leaves per plant) from top to bottom leaves and three nitrogen rates (0, 75 and 150 kg N ha^{-1}). Seeds of the field experiment were used for the laboratory experiment. In the laboratory experiment, germination traits of seed produced from maternal plant under defoliation and nitrogen rate were tested. Results showed that defoliation had a significant effect on seed yield, seed weight, spike weight, seed number per spike, peduncle length and leaf and stem weight. Application of nitrogen fertilizer can save seed yield even under complete defoliation. Defoliation and nitrogen fertilizer application on maternal plant had a minor effect on germination traits of produced seed.

Keywords: defoliation, harvest index, maternal plant effect, nitrogen rate, seed vigor, wheat.

INTRODUCTION

There are many causes for defoliation such as herbivores, hailstorms, wind, insect, diseases, herbicides and farm machinery. Zhang *et al.* (1995) reported that both decreasing defoliation interval and increasing nitrogen fertilizer increased nitrogen level in ryegrass (*Lolium multiflorum* Lam., CV. Marshall). Panditharante *et al.* (1978) observed that Guinea A grass (*Panicum maximum* ecotype A) showed no response to nitrogen fertilizer up to 84 kg nitrogen per hectare and the highest dry matter was achieved when plant was defoliated to a height of 6 inch above ground level at 30 day intervals. Other researchers have declared a significant effect of defoliation on maturity, soluble solid content (Tollenaar and Daynard, 1987) and yield. Luzuriaga *et al*. (2006) reported that in *Sinapis arvensis*, addition of nitrogen to maternal environment reduced germination rate of seeds. In another research, seed germination percentage reduced due to increasing maternal nutrient and light levels (Galloway, 2001). In *Vicia sativa*, seeds produced by plants in different defoliation treatments had similar germination percentage and germination time (Koptur *et al*., 1996). Wheat is widely cultivated in west of Iran. In The area, foliage loss from hail results in economical problems for farmers. There are a few studies about effect of material plant environment such as defoliation and nitrogen on seed germination of crop plant, nitrogen as a macro element has a important role in plant rapid growth and leaf formation, so if this element was used when the plant losses its leaves maybe this practice reduces nitrogen-deficit stress and improves seed vigor. The objective of this study was to determine wheat (*Triticum aestivum*) seed yield and seed germination traits at different levels of artificial defoliation and nitrogen rate.

MATERIAL AND METHOD

Experiment 1

1. Site, experimental design and cultural practices: The field experiment was conducted at Chamchamal plain, 47 km from Kermanshah, west of Iran in 2011-2012 (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 study was conducted as a randomized complete block design (RCBD) with three replications. There were three defoliation levels and three fertilizer rates: D1: Control, no leaf removal; D2: Removal of 1/2 leaves; D3: Removal of all leaves

N1: 0 kg N $ha^{-}1$; N2: 75 kg N ha^{-1}; N3: 150 kg N ha^{-1}

At summer after harvesting the maize (*Zea mays*), the previous crop, the soil was plowed by moldboard plough. Wheat seeds (*Triticum aestivum,* CV Pishtaz) were sown on Oct, 24, 2011 by hand. Seeding rate was 250 kg ha^{-1}. Seed emerged by rain water. 250 $Kgha^{-1}$ of complete fertilizer (NPK) was applied as presowing. Nitrogen source for fertilizer treatments was urea fertilizer (N%=46, $CO (NH_2)_2$), applied as top dressing. The nitrogen fertilizer was used immediately after defoliation. Weeds were controlled by 2, 4-D herbicide.

Plot size was 1 m wide and 1 m long. The distances between plots and between replications were both 1 m. Plants were well-watered during the growth season. Defoliation and fertilizer treatments were imposed at anthesis stage (203 days after sowing).

2. Plant sampling and measurements: Plants were harvested when they yellowed (Jun, 29, 2012, 249 days after sowing). Seed yield, spike weight, leaf and stem weight, total dry matter (biological yield), seed number per spike and seed weight were measured by selecting five plants per plot. Spike length and peduncle length were measured using three plants per plot. Harvest index was computed as the ratio of the grain to the aboveground dry matter at harvest.

Experiment 2

After harvesting seeds from maternal plants, immediately after one week, they were tested for seed germination traits. In the laboratory experiment, germination traits of seed produced from maternal plant under different defoliation treatments and nitrogen rates were tested to study the effect of maternal environment. The study was conducted as a factorial experiment based on a completely randomized design with three replications in 2012.

Before starting the trial, seeds were sterilized using sodium hypochlorite solution (1% active chlorine) for 10 min to avoid fungal contamination. Twenty seeds were then placed in each Petri dish and 10 mL of distilled water was added to them. Temperature during experiment was kept at 25 ± 1°C by a germinator. This germinator was regulated at 15 h lightness and 9 h darkness. Two millimeters growth of coleoptile and radicle was the criterion for germination.

Seed vigor was estimated by these equations (Sharifzadeh *et al*., 2006, Abasian *et al*., 2010): Seed vigor (% cm) = [(Radicle length (cm) + Caulicle length (cm)) * (Germination percentage (%))] Seed vigor (% g) = [(Radicle weight (g) + Caulicle weight (g)) * (Germination percentage (%))] The trial period was 10 days and germination percentage was recorded after 10 days.

Statistical analysis

Analysis of variance (ANOVA) was used to determine significant differences. The Multiple Range Test of Duncan performed the separation of means ($P < 0.05$). Correlation coefficients were calculated for the relationship between several crop parameters. All statistics were performed with the program MINITAB (version 14.0), SAS (version 9.1) and SPSS (version 16.0).

RESULTS AND DISCUSSION

Experiment 1

1. *Stem and leaf weight*: D1N3 had higher stem and leaf weight than D3N1 (Table 1). It shows that nitrogen can have positive effect on aboveground biomass even at reproductive phase. Defoliation had a minor effect on stem and leaf weight. It is probably due to that stem and leaf weight growth was partially completed at heading stage and defoliation at this stage only had a negative effect on seed filling, because seed yield was reduced by increasing defoliation intensity (Table 1). Ahmadi and Joudi (2007) did not observe significant difference among grain yields of wheat (*Triticum aestivum*) under defoliation treatments.

2. Peduncle length and spike length: D2N3 had the highest peduncle length and the difference among other treatments was not significant. Defoliation and nitrogen had no significant effect on spike length (Table 1). It is probably due to that peduncle and spike growth was partially completed at heading stage. Fasae *et al*. (2009) reported that defoliation at 12 and 16 weeks after maize planting had no significant effect on cob length.

3. Seed number per spike and spike weight: Complete defoliation without nitrogen application decreased seed number per spike compared to no leaf removal with nitrogen application (Table 1). So nitrogen availability at heading stage has an important role in seed number per spike. D1N2 had higher spike weight than D2N2 and difference among other treatments was not significant (Table 1). Barimavandi *et al*. (2010) reported that the row numbers per ear only was affected by complete defoliation; it is due to that stem reserves can compensate insufficient photosynthesis from leaves. Seed number per spike had a remarkable effect on seed yield and spike weight (Table 2).

4. Seed yield and seed weight: Seed yield reduced under complete defoliation (Table 1), but application of nitrogen fertilizer can save seed yield even under complete defoliation. This indicates that when plant losses their leaves due to hail storm, farmer can apply nitrogen fertilizer. This practice enables plant to tolerate defoliation. Lower seed yield can be attributed to lower seed number per spike and seed weight. Reduction in leaf area reduces resources for grain filling (Koptur *et al*., 1996). Higher seed number per spike, stem and leaf weight and spike weight can increase seed yield (Table 2). Complete defoliation reduced seed weight compared to control (Table 1). Maposse and Nhampalele (2009) reported that as the intensity of defoliation increased, 100-seed weight decreased. This shows that seed weight as a sink strength parameter can change with assimilate availability.

5. Biological yield and harvest index: There was no significant difference among defoliation and nitrogen treatments in terms of biological yield (Table 1). It is probably due to that stem and leaf weight growth was partially completed at heading stage and defoliation at this stage only had a negative effect on seed filling. The results are in compatible with Ahmadi and Joudi (2007) findings. There was no significant difference among defoliation and nitrogen treatments in terms of harvest index (Table 1). The Results are in compatible with Heidari (2012) findings, but in contrast to Seghatoleslami *et al.* (2005) findings. It is due to that with changing of defoliation and nitrogen treatments, changes in reproductive and vegetative parts had the same rate.

Table 1

Effect of defoliation and nitrogen rate treatments on wheat traits

Treatments	Stem and leaf weight (g/plant)	Peduncle length (cm)	Seed number per spike	Spike length (cm)	Spike weight (g/plant)	Seed yield (g/plant)	Seed weight (g)	Biological yield (g/plant)	Harvest index (%)
D1N1 [a]	0.640 ab	15.7 b	19.5 abc	6.1 a	1.253 ab	0.973 ab	0.053 a	2.01 a	43.0 a
D1N2	0.590 ab	16.5 b	23.65 ab	6.4 a	1.510 a	0.920 ab	0.050 ab	2.28 a	50.3 a
D1N3	0.760 a	17.2 b	26.57 a	6.3 a	1.250 ab	1.107 a	0.043 bc	2.29 a	48.5 a
D2N1	0.600 ab	15.8 b	16.15 bc	7.2 a	0.900 ab	0.680 abc	0.043 bc	1.87 a	51.4 a
D2N2	0.487 ab	17.0 b	14.25 bc	5. 8 a	0.817 b	0.620 bc	0.045 abc	1.39 a	54.1 a
D2N3	0.680 ab	23.4 a	22.15 abc	6.3 a	1.390 ab	1.070 a	0.050 ab	2.07 a	50.5 a
D3N1	0.325 b	15.6 b	12.85 c	5.8 a	0.943 ab	0.485 c	0.040 c	1.80 a	48.9 a
D3N2	0.680 ab	16.2 b	23.55 ab	6.9 a	1.380 ab	1.010 ab	0.040 c	2.06 a	49.3 a
D3N3	0.613 ab	13.6 b	22.15 abc	7.2 a	1.400 ab	0.947 ab	0.043 bc	2.02 a	47.0 a

[a] D1, D2 and D3 are defoliation intensities (0, 1/2 and all leaves per plant, respectively). N1, N2 and N3 are nitrogen rates of 0, 75 and 150 kg ha^{-1}.

[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 wheat under different defoliation and nitrogen treatments

	Stem and leaf weight	Peduncle length	Seed number per spike	Spike length	Spike weight	Seed yield	Seed weight	Biological yield	Harvest index
Stem and leaf weight	1	.281	.857**	.473	.597	.920**	.275	.643	-.243
Peduncle length	.281	1	.183	-.238	.166	.331	.390	.106	.316
Seed number per spike	.857**	.183	1	.456	.849**	.936**	.187	.854**	-.290
Spike length	.473	-.238	.456	1	.466	.396	-.202	.566	-.279
Spike weight	.597	.166	.849**	.466	1	.821**	.358	.824**	-.427
Seed yield	.920**	.331	.936**	.396	.821**	1	.373	.758*	-.404
Seed weight	.275	.390	.187	-.202	.358	.373	1	.217	-.306
Biological yield	.643	.106	.854**	.566	.824**	.758*	.217	1	-.464
Harvest index	-.243	.316	-.290	-.279	-.427	-.404	-.306	-.464	1

*.Correlation is significant at the 0.05 level

**.Correlation is significant at the 0.01 level

Table 3

Effect of defoliation and nitrogen rate treatments on wheat seed traits

[a] Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling weight (mg)	Vigor (% mg)	Vigor (% cm)
D1N1	70.00 a	4.60 bcd	6.29 abc	10.07 ab	8.047 a	12.395 a
D1N2	82.50 a	5.11 bc	9.43 a	8.87 bc	6.600 a	12.630 a
D1N3	81.67 a	5.34 b	6.96 abc	12.00 a	7.450 a	9.893 ab
D2N1	73.33 a	5.14 bc	6.80 abc	8.73 bc	6.467 a	8.810 ab
D2N2	50.00 a	6.90 a	3.87 c	10.30 ab	5.050 a	5.480 b
D2N3	63.33 a	4.78 bcd	5.34 bc	9.00 bc	6.575 a	6.423 b
D3N1	81.67 a	3.98 d	8.08 ab	7.60 c	7.215 a	9.823 ab
D3N2	78.33 a	5.07 bc	7.54 ab	9.60 bc	7.560 a	9.933 ab
D3N3	55.00 a	4.33 cd	5.57 bc	7.73 c	5.100 a	6.693 b

[a] D1, D2 and D3 are defoliation intensities (0, 1/2 and all leaves per plant, respectively). N1, N2 and N3 are nitrogen rates of 0, 75 and 150 kg ha^{-1}.
[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 wheat seed under different defoliation and nitrogen treatments

	Germination percent	Shoot length	Root length	Seedling weight	Vigor (based on weight)	Vigor (based on length)
Germination percent	1	-.402	.904**	.093	.769*	.790*
Shoot length	-.402	1	-.471	.582	-.409	-.362
Root length	.904**	-.471	1	-.200	.542	.808**
Seedling weight	.093	.582	-.200	1	.309	.119
Vigor(based on weight)	.769*	-.409	.542	.309	1	.756*
Vigor (based on length)	.790*	-.362	.808**	.119	.756*	1

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

Experiment 2

1. Seed germination percentage: There was no significant difference among defoliation and nitrogen treatments in terms of seed germination percentage (Table 3). Seed germination percentage had a positive and significant correlation with root length and vigor (Table 4). Galloway (2001) reported that increasing maternal nutrient and light levels decreased seed germination percentage. Luzuriaga *et al*. (2006) also reported similar results. Koptur *et al*. (1996) reported that defoliation treatments on maternal plant had no significant effect on days to germination in the common vetch (*Vicia sativa*). It was expected that seed germination was reduced as defoliation intensity increased, but seed germination did not reduced under defoliation. It is probably due to that under defoliation plant supplies required reserves for seed.

2. Shoot length and root length: Under mild and severe defoliation condition, application of 75 kg N ha $^{-1}$ increased shoot length compared to 0 kg N ha $^{-1}$ (Table 3). Under application of 75 kg N ha $^{-1}$, removal of half leaves increased shoot length compared to untouched leaves. Inverse results were observed for root length. Under application of 75 kg N ha $^{-1}$, removal of half leaves decreased root length compared to untouched leaves (Table 3). Root length had a positive and significant correlation with seed vigor based on length (Table 4). Contreras (2007) reported that severe water stress during lettuce (*Lactuca sativa* L.) seed production on maternal plant increased seedling radical length. Minor effect of defoliation and nitrogen on root length and shoot length may be due to partially even seed weight (Table 1).

3. Seedling weight and vigor: Complete defoliation treatment decreased seedling weight compared to application of nitrogen fertilizer of 150 kg ha $^{-1}$ and untouched leaves treatment (Table 3). Lower seedling weight in complete defoliation is probably due to lower seed weight (Table 1). There was no significant difference among treatment in terms of seed vigor based on weight (Table 3). D3N3, D2N3 and D2N2 had lower seed vigor based on length (Table 3) compared to D1N1 and D1N2. The result are in compatible with Contreras (2007) finding. Lower seed vigor in the experiment may be due to incomplete seed growth especially embryo.

CONCLUSIONS

Seed yield reduced under complete defoliation, but application of nitrogen fertilizer can save seed yield even under complete defoliation. Complete defoliation decreased seed weight compared to control (D1N1). Defoliation and nitrogen fertilizer application on maternal plant had a minor effect on germination traits of produced seed. Regarding few reports about maternal environment effects on seed traits, it is recommended to study effect of other environmental factors such as light and other nutrients on seed germinability and storability.

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REFERENCES

1. Abasian A., I. Hammidi, L. Yari, and A. Dashti (2010). Comparising effect of different doses of Solanum nigrum on germinability and seed vigor of maize, C.V. S.C. 704, under standard germination test and investigating seed vigor under complex stresses. 11th Iranian Crop Science Congress, Environmental Sciences Research Institute, Shahid Beheshti University, Tehran, 24-26 July, 1929-1933.

2. Ahmadi A, and M. Joudi (2007). Effect of timing and defoliation intensity on growth, yield and gas exchange rate of wheat grown under well-waterd and drought conditions. Pakistan Journal of Biological Sciences. 10:3794-3800.

3. Barimavandi A,R, S. Sedaghathoor, and R. Ansari (2010). Effect of different defoliation treatments on yield and yield components in maize (Zea mays L.) cultivar of S.C704. AJCS. 4:9-15.

4. Contreras S.A. (2007). Effects of maternal plant environment on lettuce (Lactuca sativa L.) seed dormancy, germinability, and storability. Ohio state University, USA. Ph.D. Diss,148 p.

5. Fasae O.A., F.I. Adu, A.B.J. Aina, and K.A. Elemo (2009). Effects of defoliation time of maize on leaf yield, quality and storage of maize leafs as dry season forage for ruminant production .Rev Bras Ciênc Agrár Recife. 4:353-357.

6. Galloway L.F. (2001). The effect of maternal and paternal environments on seed characters in the herbaceuose plant Campanula Americana (Campanulaceae). American Journal of Botany. 88:832–840.

7. Heidari H. (2012). Foxtail millet (Setaria italica) mother plants exposure to deficit and alternate furrow irrigation and their effect on seed germination. Annals of Biological Research. 3:2559-2564.

8. Ibrahim U., B.M. Auwalu, and G.N. Udom (2010). Effect of stage and intensity of defoliation on the performance of vegetable cowpea (Vigna unguiculata (L.) Walp). African Journal of Agricultural Research. 5: 2446-2451.

9. IMO (2012) Meteorological data. Iran Meteorological Organization. <accessed 20 Februery 2012>. http://www.weather.ir

10. Koptur S, C.L. Smith, and J.H. Lawton (1996). Effects of artificial defoliation on reproductive allocation in the common vetch Vicia sativa (fabaceae; papilionoideae) American Journal of Bortany. 83:886-889.

11. Luzuriaga A.L., A. Escudero, and F. Perez-Garcia (2006). Environmental maternal effects on seed morphology and germination in Sinapis arvensis (Cruciferae). Weed Research. 46: 163–174.

12. Maposse I.C., and V.V. Nhampalele (2009). Performance of cowpea varieties under different defoliation regimes for multiple uses. African Crop Science Conference Proceedings, vol. 9, pp 279 – 281.

13. Panditharante S., M.C.N. Jayasuriya, W.J.K.V. Ranjith, and S.C. Thrimawithana (1978). A study of the effect of nitrogen fertilization and intensity and frequency of defoliation on yield, chemical composition and feeding value of Guinea A grass. J Natn Sci Coun Sri Lanka. 6:137-144.

14. Seghatoleslami M.J., E. Majidi, M. Kafi, G. Noor Mohammadi, F. Darvish, and S.G. Mousavi (2005). Phenological and morphological response of three millets species to deficit irrigation. Journal of Agricultural Sciences of Islamic Azad University. 3:89-99.

15. Sharifzadeh F., H. Heidari, H. Mohamadi, and M. Janmohamadi (2006). Study of osmotic priming effects on wheat (Triticum aestivum) germination in different temperature and local seed masses. Journal of Agronomy. 5:647-650.

16. Tollenaar M., and T.B. Daynard (1987). Effect of defoliation on kernel development in maize. Can J Plant Sci. 58:207-212.

17. Zhang Y., L.D. Bunting, L.C. Kappel, and J.L. Hafley (1995). Influence of nitrogen fertilization and defoliation frequency on nitrogen constituents and feeding value of annual ryegrass. J Anim Sci. 73:2474-2482.