Effect of Plant Density and Nitrogen Rate on Yield and Yield Components of Wheat in Wild oat-Infested Condition

Mohammd Armin, Hassan gholami and Hamidreaza Miri

ABSTRACT

In order to study the effect of plant density and nitrogen rate on yield and yield components of wheat in wild oat-infested condition an experiment was conducted in 2009 in southern. The treatments were consisted of 4 levels of nitrogen (0, 100, 150 and 200 kg ha) and three crop densities (250, 400 and 550 plants per m²) which arranged in factorial using RCD with four replications. Wild oat densities in weed-infested plots was similar and (about 80 plants per m²). The results showed that wild oat height in all three densities treatments was lower than wheat in early growth stage but in late growth was higher than wheat. Increasing wheat density by 550 plants per m² increased wheat grain yield, biological yield and number of ears. The highest harvest index, tiller number, grain number per ear, ear length and seed weight were obtained in density of 250 plants per m². The highest grain yield, biological yield, harvest index, tiller number, ear number, grain number per ear, ear length and seed weight was observed in the highest levels of nitrogen. In conclusion the results showed that by increasing wheat density and rate of nitrogen application wheat competitiveness increased against wild oat.

Key words: wild oat, plant density, Nitrogen, Competition.

Introduction

About 60% of cultivated land in the world is dedicated to cereal production which wheat and rye constitute 34% and barley and oat constitute 9-11% of this. Weeds are one the main limiting factor in Crop production [27 and 28]. According to Kumar and Singh [10] estimation weed cause considerable yield loss (9.8-13.1%) of wheat all around the world. Introducing modern varieties with less competitive ability and need to receive more fertilizer have been increasing these losses. Wild oat (Avena fatua) is one of the most interfering weed in cereal producing area and has been adapted with wide range of agroclimate conditions, and therefore consider as one of the main constrains in cereal production. Influence of certain weed on wheat depends on species, weed density, cultivar, rate and time of fertilizer consumption, planting date and time and other ecological and agricultural factors.

Fertilization management from view of time and rate of applied fertilizer is an important factor in optimize crop production and weed management. Despite fertilizers application can increase crop yield in weed free condition [29,30,31,32,33,34,35,36, 37,38], but at same time can increase weed biomass and density, which may increase seed production by weed [6,9,17,25,26] reported that ability of wild oat for nitrogen absorption is higher than wheat which can result in higher growth of this weed and therefore may reducing wheat yield at the higher rate. Ahmadvand et al., [1] showed that competitive effect of wild oat on wheat increase with increasing nitrogen rate, so in density of 80 plant/m² applying 50, 75 and 100 kg/ha N resulted in 37, 41.5 and 44.4% reduction in wheat biological yield, respectively. Rastgou et al., [21] evaluate the effect of rate and time of nitrogen application on economic threshold damage of wild mustard and concluded that densities of economic threshold damage of wild mustard in low, medium and high levels of nitrogen was 0.94, 0.79 and 0.14 plant/ m² respectively. Base on this finding economic thrashed of wild mustard is less in higher rate of nitrogen and this means that wild mustard competitiveness increase with higher rate of nitrogen. Dhima, and Eleftherohorinos [3] reported that increasing nitrogen application in wheat in competing with wild oat resulted in increasing weed density and reducing crop yield. Iqbal and Whrgit [7] observed that with increasing soil nitrogen from 20 to 12 mg/kg wild mustard and lambsquater biomass increased substantially and both of these weed respond to applied nitrogen more than wheat. Parchami and Behadvand [18] reported that
wheat grain and biological yield decrease significantly with increase wild oat density. Increase nitrogen rate in without competition situation increase wheat yield but, in competition situation economic loss of wild oat on wheat increase with increasing nitrogen rate. The maximum seed production for wild oat in low, medium and high rate of nitrogen was 38.69, 50.04 and 56.06 million seed/ha which indicate positive effects of nitrogen on wild oat seed production.

Competitive effects of weeds on crop have been affected by both of plants. Results of experiment indicated that with increasing wheat density its competitiveness increase against wild oat. Hasznzade Deloi, [5] evaluate the effects wheat densities of 300, 400 and 600 plants/m² in presence of 0, 20, 40, 60, 80 and 120 wild oat plants/m² and concluded that increasing wheat density reduced leaf area and biomass of wild oat while increase wheat yield and biomass. Martin et al., [13] showed that yield reduction in lower densities of wheat are more severe than higher densities so, in wheat density of 300 plant/m² presence of 5-6 wild oat plant reduced wheat yield by 20% while in wheat density of 700 plant/m² 38 wild oat required for reducing wheat yield by 20%.

Since optimum density and nitrogen requirement for wheat mostly determined in weed free condition and this finding can changed in presence of competition, this study evaluates the effects of wheat density and nitrogen application in situation of wild oat interference with wheat.

**Material and Methods**

The experiment was carried out in 2009 in southern Iran, in Pasargad city (1839 m above from sea level, 53° 08′ altitude, 30° 01′ latitude, average rainfall of 352.4 mm, min temperature of -4 and max of 36 °C). Physiochemical characteristic of experimental soil in 0-30 cm depth was shown in Table-1. Experiment was in Factorial using Randomized Blocks Design with four replications. Treatment consisted of 4 nitrogen level (0, 100, 150 and 200 kg ha) and three wheat densities (250, 400 and 550 plants/m²).

The experimental soil was fallow in previous year. In order to prepare the soil first plowed with a moldboard plow to a depth of 30 cm and then leveling the soil was frozen. Fertilizer application carried out in accordance with the soil test results. Prior to planting seeds were inoculating with Carboxy Tiraman fungicide. The experimental units were 3*4 m which wheat was hand seed according to desired densities. Wild oat seeds were sown in each with density of 80 seed per m². Gibberelic acid treatment was applied for breaking wild oat seed dormancy.

At physiological maturity wheat and wild oat plant were harvested at area of 1.5 m² by hand and below traits were measured. Wheat ear number in square meter, seed number per ear, grain yield, biological yield and harvest index and oat yield and yield components. All data were subjected to analysis of variance using SAS and mean were separated by Duncan multiple range test.

**Results and Discussion**

**Yield Components:**

Wheat density had significant effects on number of wheat tillers (Table 2). Number of tillers decrease by increasing density so, the highest tillers number (3.47 tiller/plant) observed in density of 250 plant/m² and the lowest one (1.17 tillers/plant) observed in 550 (Table 3). In condition of competition nutrients, water and light availability limited and it can reduce number tiller per plant. In this situation some of tillers can not produce ear and therefore number of infertile tillers increased. The main mechanism of reducing tiller number in higher densities is reducing nitrate reductase enzyme activity. This enzyme contributes to nitrogen absorption by plant and therefore reduces plant nitrogen content. With reducing nitrogen absorption, root development and utilization of nutrient resource interrupt which resulted in lower tiller production [23]. Lemrel et al., [11] showed that tillers number is the most important yield component in wheat that reduced in competition with wild oat.

Increase nitrogen level resulted in higher tiller number production, so the highest tiller number (2.78 tiller/plant) obtained in treatment of 200 kg /ha nitrogen application while, no nitrogen application produced the lowest tiller. There is no significant difference between 150 and 200 kg N treatments (Table 4). With application sufficient N higher number of tillers can produce ear and number of fertile tiller increases.

Plant density, nitrogen application and density*nitrogen interaction had significant effect on wheat ear number (Table 2). The highest (650.39 ear/m²) and lowest (607.66 ear/m²) ear number observed in 550 and 250 plant /m² treatment, respectively (Table 3). Ear reduction in low densities is due lower plant per area unit. Although the number of tiller per plant increase in lower plant densities, lowering plant per area can not compensate with tiller number in these densities.

<table>
<thead>
<tr>
<th>Table 1: Physico-chemical properties of soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter (%)</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1.02</td>
</tr>
</tbody>
</table>
Table 2: Analysis of variance table for yield and yield components of wheat.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>tillers</th>
<th>ear number</th>
<th>seed per ear</th>
<th>yield (t.ha(^{-1}))</th>
<th>biological yield (t.ha(^{-1}))</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>rep</td>
<td>2</td>
<td>0.01ns</td>
<td>76.45**</td>
<td>0.012ns</td>
<td>0.0001**</td>
<td>0.01**</td>
<td>0.01**</td>
</tr>
<tr>
<td>nitrogen</td>
<td>3</td>
<td>9.07</td>
<td>9670.42**</td>
<td>21.28</td>
<td>9.07**</td>
<td>4.34**</td>
<td>3.99**</td>
</tr>
<tr>
<td>density</td>
<td>2</td>
<td>18.36</td>
<td>7083.56**</td>
<td>75.77</td>
<td>18.34**</td>
<td>3.49**</td>
<td>7.06**</td>
</tr>
<tr>
<td>nitrogen*density</td>
<td>6</td>
<td>0.11**</td>
<td>2125.47**</td>
<td>1.39**</td>
<td>0.11**</td>
<td>0.02**</td>
<td>0.006**</td>
</tr>
<tr>
<td>Error</td>
<td>22</td>
<td>0.006</td>
<td>23.87</td>
<td>0.01</td>
<td>0.006</td>
<td>0.008</td>
<td>0.00681</td>
</tr>
</tbody>
</table>

ns: not significant; (*) and (**) represent significant difference over control at P < 0.05 and P < 0.01, respectively.

Table 3: Effect of plant density on yield and yield components of wheat.

<table>
<thead>
<tr>
<th>wheat density (plant/ m(^2))</th>
<th>tillers</th>
<th>ear number</th>
<th>seed per ear</th>
<th>seed weight (g)</th>
<th>yield (t.ha(^{-1}))</th>
<th>biological yield (t.ha(^{-1}))</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>3.47 a</td>
<td>607.66 b</td>
<td>33.08 a</td>
<td>37.35 a</td>
<td>7.61 c</td>
<td>18.11 c</td>
<td>37.09 a</td>
</tr>
<tr>
<td>400</td>
<td>2.47 b</td>
<td>609 b</td>
<td>31.31 b</td>
<td>36.23 b</td>
<td>8.19 b</td>
<td>18.58 b</td>
<td>36.22 b</td>
</tr>
<tr>
<td>550</td>
<td>1.17 c</td>
<td>650.39 a</td>
<td>28.12 c</td>
<td>34.88 c</td>
<td>8.68 a</td>
<td>19.61 a</td>
<td>35.07 c</td>
</tr>
</tbody>
</table>

Values followed by the same letter do not differ significantly at p = 1% according to DMRT.

Table 4: Effect nitrogen yield on yield and yield components of wheat.

<table>
<thead>
<tr>
<th>Nitrogen kg/ha</th>
<th>tillers</th>
<th>ear number</th>
<th>seed per ear</th>
<th>seed weight (g)</th>
<th>yield (t.ha(^{-1}))</th>
<th>biological yield (t.ha(^{-1}))</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.67 c</td>
<td>575.03 d</td>
<td>29.17 d</td>
<td>35.18 d</td>
<td>7.36 d</td>
<td>17.98 d</td>
<td>35.33 d</td>
</tr>
<tr>
<td>100</td>
<td>2.22 b</td>
<td>626.86 b</td>
<td>30.30 c</td>
<td>35.65 c</td>
<td>7.91 c</td>
<td>18.50 c</td>
<td>35.83 c</td>
</tr>
<tr>
<td>150</td>
<td>2.67 a</td>
<td>638.87 c</td>
<td>31.03 b</td>
<td>36.27 b</td>
<td>8.37 b</td>
<td>19.04 b</td>
<td>36.34 b</td>
</tr>
<tr>
<td>200</td>
<td>2.78 a</td>
<td>648.64 d</td>
<td>32.84 a</td>
<td>37.50 a</td>
<td>9.01 a</td>
<td>19.52 a</td>
<td>36.99 a</td>
</tr>
</tbody>
</table>

Values followed by the same letter do not differ significantly at p = 1% according to DMRT.

Ear number increase with increasing nitrogen application and the highest ear number (648.64) obtained from application of 200 kg/ha N while, lowest ear number obtained in no N treatment (Table 4). Increasing N availability in high N treatment may result in producing more ears from tillers and therefore increasing number of fertile ear. Khaliq et al., [8] showed that increasing N rate by 175 kg/ha increase ear number and grain yield of maize. In general yield increasing in situation of N application are mainly due to higher ear /area production.

Interaction effect of N*density showed that the highest ear number (667.8 ear/m\(^2\)) were obtained in density of 250 plant/m\(^2\) and application of 200 kg/ha, while the lowest ear number (511.8 ear/m\(^2\)) belonged to 250 plant/m2 density without nitrogen (Figure 1). Fallahi et al., [4] also reported that by increasing plant density number of ear /area increased significantly.

Number of seed per ear were significantly (p < 0.05) affected by density, N rate and interaction of these two treatment (Table 2). With increasing applied N, number of seed/ear increased significantly and the highest seed per ear (32.84) were observed in density of 250 plant/m\(^2\). The lowest seed/ear (29.17) observed in density of 550 plant/m\(^2\) (table 3). Application of 200 kg/ha N produced the highest seed/ear among nitrogen treatment (table 4). Reddi and Patil [20] also showed that with increasing N rate number seed/ear increased which resulted in increasing grain yield in wheat.

Application of 200 kg N in density of 250 plant/m\(^2\) produced the highest number/ear (35.85) among interaction treatments while, in density of 550 plant/m\(^2\) without N the lowest seed number (28.35) were observed (Figure 2). Martin et al., [13] evaluated the effect of weed competition on growth and yield of spring barley and concluded that number of seed/ear are the most susceptible component which affected by competition. Blackshaw, [2] also showed that wheat yield reduction in competition with weed is related to reduction of seed number/ear.

Seed weight also significantly affected by plant density (table 2). Seed weight increased by increase density. The highest (37.35 g) and lowest (34.88 g) 1000 seed weight were observed in 250 and 550 plant/m\(^2\), respectively(table 3). Among nitrogen treatment, applying 200 kg/ha N produced the highest (37.50g) 1000 seed weight (table 4). There different observation that showed seed weight may increase, decrease or remain unaffected by applying nitrogen.

Interaction effect of N*density showed significant effect on seed weight ( table 2). The highest (38.76 g) were observed in 250 plant/m\(^2\) density and 200 kg/ha N while the lowest (33.88 g) were observed in 550 plant/m\(^2\) without N application (Figure 3). Poorazar and Ghadiri [19] showed that seed weight decrease by increasing plant density. Morshita and Thill, [16] concluded that seed weight in barley decrease 9-22% as affected by competition. [14] on the other hand reported that in presence of foxtail and Lolium number of wheat tiller decrease while, seed weight remain unaffected.
Fig. 1: Interaction effect of Nitrogen amount and wheat on ear number. Values followed by the same letter do not differ significantly at $p = 1\%$ according to DMRT.

Fig. 2: Interaction effect of Nitrogen amount and wheat on seed per ear. Values followed by the same letter do not differ significantly at $p = 1\%$ according to DMRT.

Fig. 3: Interaction effect of Nitrogen amount and wheat on seed weight. Values followed by the same letter do not differ significantly at $p = 1\%$ according to DMRT.
Fig. 4: Interaction effect of Nitrogen amount and wheat on grain yield. Values followed by the same letter do not differ significantly at p = 1% according to DMRT.

**Grain Yield, Biological Yield and Harvest Index:**

By increasing plant density grain yield and biological yield increased significantly while harvest index decreased (table 2). Density of 550 plant/m² produced the highest grain (8.68 t/ha) and biological yield (19.61) which showed 12 and 7% increased in comparison to 250 plant/m² treatment, respectively (table 3). The highest harvest index in contrast, were observed in 250 plant/m² treatment which showed 5% increase in comparison to 550 plant/m² treatment. This observation showed that by increasing plant density partitioning of assimilates to grain are more susceptible of vegetative parts. In fact in higher densities allocation pattern have changed. It has been shown that harvest index may increase in competition with other plant but, in some cases increase harvest index may be the main factor contributing in competition tolerance in crops [22]. Lindquist *et al.*, [12] suggested that in competition situation assimilate allocation is more susceptible than dry matter acclimation.

Increase nitrogen rate increase by 200 kg/ha causes a significant increase in grain yield, biological yield and harvest index (table 4). The highest grain yield (9.00 t/ha) observed in 200 kg/ha N treatment which showed 12% increase in comparison with control (zero N) treatment. Mohajeri and Ghadiri [15] reported that in situation of wheat-wild mustard competition wheat grain yield increased by increase N rate by 100 kg/ha. Strong, [24] also observed that by increasing N rate under optimal level wheat growth and grain yield increased while, after this optimum level increase N rate only increase vegetative growth and grain yield remain unaffected. Henson and Jordan [6] in evaluation of wheat and wild oat competition for nitrogen absorption reported that increase N rate cause an increase in wheat dry matter accumulation and grain yield which reduced competition effects of wild oat, in fact nitrogen changes the competitiveness of plants. Biological yield increased from 17.9 t/ha in control N treatment to 19.5 t/ha in 200 kg/ha N treatment. There is no significant differences between 150 and 200 kg/ha N treatments. Harvest index also increased from 35.33 to 36.99% by increasing N rate from zero to 200 kg/ha (table 4). Interaction effect of N*density showed significant effect on grain yield (table 2). The highest grain yield (9.66 t ha⁻¹) were observed in 550 plant/m² density and 200 kg/ha N while the lowest (6.80 t ha⁻¹) were observed in 250 plant/m² without N application (Figure 4).

**Conclusions:**

The overall results indicate, under wild oat infestation. Application of Nitrogen can increase competitive ability in winter wheat. increasing plant density reduces the biomass production of wild oat. wild oat through reducing the number of fertile tillers and that of the spikes per unit area also reduces the economic yield of wheat. We can reduce harmful effects of wild oat (if not controlled) by using high plant density or adequate utilization of nitrogen.

**References**