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PREDICTION OF GRAIN YIELD LOSSES IN WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIFFERENT DENSITIES OF WILD OAT (*AVENA FATUA* L.)

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Abstract

This research aims to determine the yield losses of wheat due to various densities of *Avena fatua*. For this purpose, field experiment was conducted during Fall, 2012 at Agriculture Research Farm, The University of Agriculture Peshawar, Pakistan. Wheat seeds were planted at constant seed rate (125 kg ha^{-1}) and various densities of *A. fatua* (5, 10, 15, 20, 25, 30, 35 and 40 m^{-2}) were maintained in an additive design, and replicated 3 times. Pure stand of wheat was also included in the treatments for comparison. The data recorded showed that the total dry matter yield and grain yield of wheat were linearly decreased with the increasing density of *A. fatua.* It was noted that the highest density of the weed (40 m^{-2}) decreased grain yield of wheat by 76%. The grain yield reduction was in the range of 20-76%, depending on the weed density. The magnitude of yield reduction was weed density dependent. Similarly, the biological yield of wheat was also decreased with the increasing weed density. There was a close relationship between weed biomass and grain yield of wheat. Thus it is suggested that accurate estimates of crop yield losses due to weed interference are required for cost-effective weed management programs.

Keywords: Wheat, Wild oat, *Avena fatua*, Yield losses, Weed density, Threshold level

Introduction

In Pakistan, wheat (*Triticum aestivum* L.) covers an area of over 9.039 million hectares, bringing the country amongst world's top 10 wheat producing countries (Anon., 2013). Wheat is important for our country in all agriculture related policies, economy and trade. Still the average yield in our country is very low as compared to advanced countries. The low yields can be attributed to certain yield reducing factors. Weed infestation is among major factors that needs proper management at proper time. Weed management at proper time should be given importance because weeds use resources that would otherwise be available to the crops (Zimdahl, 2004). Yield loss, harvest problems, threshing difficulties, increasing cost of production are major concerns related to weeds infestation in our country. However, the yield reduction is depending on the weed species, weed population, time of weeds emergence, growing conditions, soil fertility or nutrients status of the soil, duration of weed competition with the crop and stage of weed control in the wheat (Klingman & Ashton, 1982). It has been reported that presence of weeds in crop resulted up to 50% reduction of the crop yield in certain conditions (Nisar *et al*., 1996). But in some cases the yield losses may increase up to 90 % and somewhere a complete failure of the crop depending on the aggressiveness and persistence of the weed species and duration of weed competition and thus has been declared an important biological factor that decreases crop yield (Reddy *et al*., 2003). In our country *A. fatua* is a major weed of wheat in the irrigated and rainfed areas. Therefore, this weed is under extensive studies in many countries of the world including Pakistan. Before maturity of wheat crop, the seeds shattering make this weed more perpetual, successful and problematic in wheat production. Thus the seeds are mixed in the soil and remain dormant in the soil for many years and germinate when the environmental conditions are suitable. Weeds infestation decrease grain yield, as the available resources are shared by the crop plants and weeds (Klingman & Ashton, 1982). Thus, the ultimate effect of weed competition is the stunted growth and yield loss of the crop, but determining the way in which yield reduction occurs is important in understanding the complex phenomenon of crop-weed competition. Weed competition has become a major constraint in limiting yield of any crop. In case of *A. fatua*, it is a major weed of wheat in Pakistan and causes huge losses on national level. Probably the good adaptability characters and prevailing cropping system makes this weed successful under different environmental and ecological conditions.

Weed management at proper time is essential to avoid yield losses (Evans *et al.,* 2003) because application of weed management strategies after critical period of weed competition is a serious problem in developing countries and especially in Pakistan. Farmers control weeds at later growth stages when the weeds have attained maximum growth and have already caused maximum yield losses due to sharing resources. Effect of weed emergence on crop yield has been widely studied. Previous research has suggested that keeping crop plants weed free for first 7 weeks after planting are required to avoid significant yield losses in wheat (Khan *et al*., 2002). The time of weed removal is important as competitiveness of weeds depends upon duration of its interference with the crop (Akhtar *et al*., 2000). Therefore weed control strategies must be aimed at critical period of weed competition and weeding should be done at proper time of weed management to minimize the adverse effects of weed competition on crop yield and quality (Evans *et al.,* 2003). Similarly, the threshold level of individual weeds could be helpful in deciding the weed management program. Although there is always a mixed population of weeds in wheat, however, determining the threshold level of major weeds can greatly help in the successfulness of the weed management program.

In view of the importance of *A. fatua* as a major weed of wheat in our country, this weed was selected for determining the impact of different densities of this weed on grain yield losses of wheat. Determining the competitive ability of this weed can be used as a base for management options. By investigating the competitive ability and threshold level, we can use economical approaches to manage this weed in wheat.

Materials and Methods

The present research study was conducted during Fall, 2012 at Agriculture Research Farm, The University of Agriculture Peshawar, Pakistan. An additive design (constant crop seed rate and varying weed densities) were used with three replications. There were nine treatments and three replications. *Avena fatua* being the major weed of wheat in the province and the country was therefore selected for study. The treatments were 8 densities of *A. fatua* (5, 10, 15, 20, 25, 30, 35 and 40 plants m^{-2}). Control (0 density of *A. fatua*) was maintained for comparison. A field previously occupied by maize/legume intercrop was selected for the experiment and was irrigated. Before sowing of wheat and *A. fatua*, seedbed was prepared by ploughing the field twice at proper moisture conditions, followed by harrowing and leveling. All other cultural practices were kept uniform for all the treatments except for wild oat densities. Nitrogen and phosphorus fertilizers were applied in the form of urea and diamonium phosphate (DAP) @ 120 and 90 kg ha^{-1}, respectively. Half nitrogen and full dose of phosphorus were applied at sowing and remaining nitrogen was applied with second irrigation. All the recommended cultural and agronomic practices were followed throughout the growing season for optimum growth of wheat and the weed. Wheat was planted at seed rate of 125 kg ha^{-1} (recommended rate) and seeds of *A. fatua* were planted as per density mentioned in the treatments. Higher seed rate of *A. fatua* was used and then thinning was done to get the desired density of the weed in the respective treatments. All other weeds were manually removed throughout the crop season. Due to frequent rains the crop was irrigated just once, 40 days after sowing.

Total dry matter yield and grain yield of wheat and total dry matter yield of *A. fatua* were recorded in each treatment after maturity of the crop and subsequently converted into kg ha^{-1}. Similarly, the plants of *A. fatua* were harvested in each treatment and the data were converted to kg ha^{-1}. All agronomic based practices and plant protection measures were followed in each treatment uniformly throughout the season for optimum crop growth.

Statistical analysis

The data collected were analyzed statistically by using Statistix 8.1 package and Least Significant Difference (LSD) test was used for mean separation**.** While for figures and regression analyses (trend lines), MS Excel was used.

Results and Discussion

Total dry matter yield of wheat: Total biomass of wheat is important in developing countries like Pakistan because grain yield is important because grains are principal staple food of the country. While wheat straw is used as animal feed and plastering of roof tops and walls of mud houses. Therefore, total dry matter yield including grains and straw are important for the farmers in the area under discussion. Statistical analysis of the data (Fig. 1) revealed that with the increasing density of *A. fatua*, the total dry matter yield of wheat was significantly ($P \leq 0.05$) decreased (R^2 = 88%). Thus there was a strong correlation between the weed density and total dry matter yield of wheat (Fig. 1). This shows that *A. fatua* is a competitive weed that adversely affects the growth of wheat crop. As *A. fatua* and wheat has similar morphology therefore, this weed is a strong competitor with wheat. It was observed that density of this weed proved detrimental at 25 m^{-2}. While reduction in dry matter yield of wheat was slight behind this density. *A. fatua* produced more number of tillers (data not given) and thus effectively shared the available resources with wheat crop which ultimately decreased the total dry matter yield of wheat. Even low density of *A. fatua* (5 m^{-2}) significantly decreased the dry matter yield of wheat as compared to the pure stand of wheat (0 weed m^{-2}). In light of the present findings, it is suggested that this weed even at low density may prove detrimental and hence should be controlled. Otherwise wheat production on country level can be significantly affected because as this is a major weed in wheat in all ecological zones of the country. Thus by calculating the total area under wheat and the presence of this weed in wheat, the total losses could be in millions of tons. In similar studies, Armin & Asghripour (2011) reported that increase in wild oat density resulted in the reduction of wheat yield through decrease in fertile tiller per plant and spike m^{-2}. Thus it seems that presence of *A. fatua* in wheat even at low density can deprive millions of people of their food and animals of their feed.

Dry matter yield of *A. fatua*: It was observed that dry matter yield of *A. fatua* was significantly ($P \leq 0.05$) and linearly (R^2=98%) increased with the increasing density of this weed (Fig. 2). As *A. fatua* produced tillers therefore higher biomass of this weed was recorded. The present results indicated that higher density of this weed in field can attain higher biomass or dry matter which is inversely proportional to grain yield or biological yield of wheat. Thus all the factors that increase the biomass of weed should be focused in weed management programs. In light of the present studies, it is suggested that *A. fatua* should be controlled in wheat crop even at low density (5 m^{-2}) to avoid yield losses. Regression analysis of the data revealed that there was a strong relationship between weed density and total biomass or dry matter with R^2 value of 98%. As grass killer herbicides have been used in our country for the control of grassy weeds including *A. fatua* therefore, there are chances of resistance development in this weed. There are no such studies that have reported the resistance of this weed in our country. However, there are several complaints by the farmers that

the available grass killer herbicides are no more working to kill this weed. Kim *et al*., (2002) investigated herbicide dose for crop-weed competition and it was reported that dose of herbicide can be changed for weeds and herbicides used. Thus it seems that using higher seed rate of wheat suppresses the weeds and thus less dose of herbicide could be used. In light of the present studies, it is suggested that weeds should be managed before attaining vegetative growth to avoid grain yield loss in wheat. In several areas of the country, the farmers are interested to collect and harvest the wild oats from wheat fields to use as fodder purpose. Therefore this perception results in decreasing grain yield of wheat in those areas.

Loss in grain yield of wheat: Statistical analysis of the data indicated that the grain yield of wheat was found significantly ($p \leq 0.05$) higher under weed free conditions. While with the increasing density of *A. fatua*, the grain yield of wheat was significantly decreased (Fig. 3). Lowest density of the weed (5 m^{-2}) decreased the grain yield of wheat by 20%. While highest weed density (40 plants m^{-2}) decreased the grain yield of wheat by 76% with strong relationship (R^2 = 95%) between weed density and grain yield of wheat. The present results showed that *A. fatua* is highly competitive with wheat even at lowest density. As wheat and *A. fatua* have the same family and similar morphological characters and life cycles therefore, this weed is more dangerous for the wheat. It was observed that *A. fatua* produced more tillers which ultimately increased the dry biomass which consequently decreased the grain yield of wheat. Weed control at the beginning of the crop emergence is difficult for the poor farmers in Pakistan because manual removal is difficult and time consuming. On the other hand, the farmers are always interested to get *A. fatua* plants from wheat fields for fodder at later stages of the crop. These controversial interests support continuous existence of *A. fatua* in wheat, causing significant yield reduction. Similarly, the unwise use of grass killer herbicides in the area under discussion seems to have created resistance in *A. fatua*. Apart from these, the rented wheat threshers are used by the farmers that further spread this weed. As the farmers in these areas do not use certified seeds therefore this weed has taken the shape of noxious and most problematic weed in the country. Our results showed that lowest density of *A. fatua* was capable to significantly decrease the grain yield of wheat. Thus this weed needs to be controlled through joint efforts of the government, local community and farming community. Blackshaw *et al*., (2005) reported that crop-weed competition is affected by other factors like manure and other inorganic fertilizers. Therefore it is suggested that *A. fatua* and wheat competition should be studied under various environmental conditions. While Marwat & Khan (2007) reported that climatic variation can greatly change the overall competition between crop and weed; where some weeds are favored by environmental factors as compared to crop plants. Thus different weeds can become more harmful and cause significant yield losses under different environmental conditions.

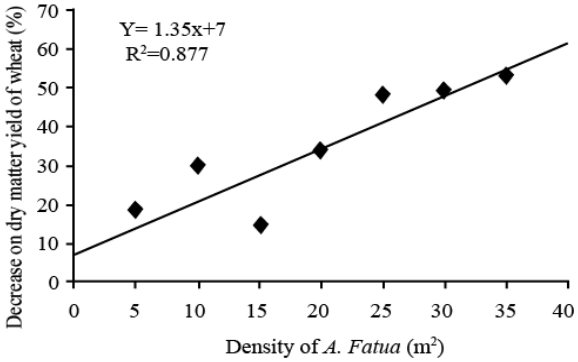

Fig. 1. Dry matter yield reduction of wheat due to *A. fatua*

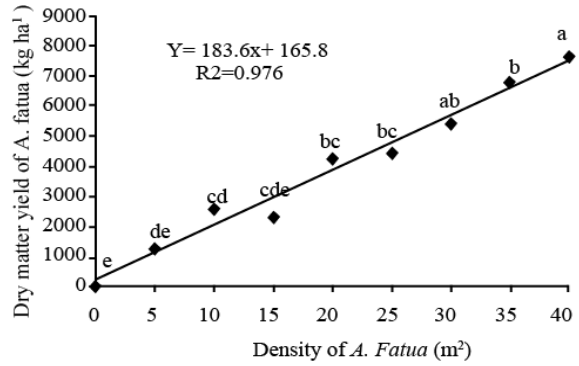

Fig. 2. Total dry matter yield of *A. fatua*

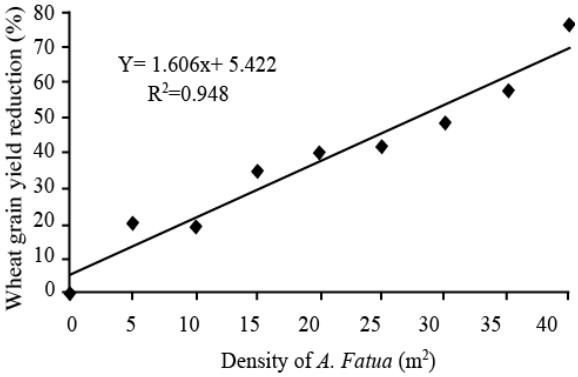

Fig. 3. Grain yield reduction of wheat at different densities of *A. fatua.*

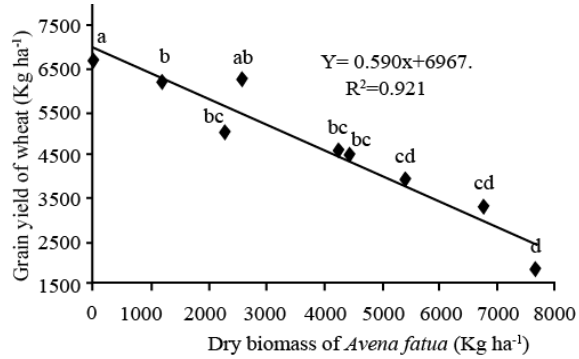

Fig. 4. Relationship between dry weed biomass and grain yield of wheat.

Relationship between dry biomass of *A. fatua* and grain yield of wheat: It is an established fact that with the increasing density of weed, the grain yield and biological yield of wheat is decreased. Data (Fig. 4) showed that there was a strong relationship (R^2=92%) between dry biomass of *A. fatua* and grain yield of wheat. Wheat and *A. fatua* have very close resemblance and thus they have morphologically similar leaf, root, stem and life cycle. Thus the weeds having close resemblance to a particular crop are considered more harmful because they utilize the available resources equally. Thus utilization of resources at the same time of life growth cause more yields losses to the crop. Data presented in Fig. 4 shows that with the increasing dry biomass of *A. fatua*, the grain yield was significantly decreased ($p \leq 0.05$) with R^2 value of 92%. There was a linear relationship between dry weed biomass and grain yield of wheat. In light of the present studies, it is suggested that the focus of all weed management programs should be to decrease the dry biomass of weeds instead of decreasing weed density. Because some weeds have small size while other attain bigger growth. Thus weeds having bigger vegetative growth and with more biomass will be more competitive as compared to the high density with less biomass. Competition between wheat and *A. fatua* was clear as depicted in Figs. 1-4. However, other varieties of wheat may perform differently under the same weed at the same density due to their different tillering capacity, higher biological yield, plant height and competitive ability. Therefore all other varieties should be checked for their competitive ability against different weeds. In a similar study, Khan & Marwat (2006) reported that there was a strong relationship between weed density and grain yield of wheat. They stated that higher weed density and dry biomass of weed significantly decreased the grain yield of wheat. Studies related to crop–weed competition provide useful information to decide weed control measures and the optimal timing for weed control to protect crop yield and quality (Swanton *et al.,* 2015).

Conclusions

The data revealed that by increasing the density of *A. fatua* from 5-40 plants m^{-2}, the total dry matter and grain yield of wheat was decreased in a linear fashion. Highest density ($40m^{-2}$) of *A. fatua* significantly decreased the total dry matter yield and grain yield of wheat. However, this decrease in dry matter yield and grain yield was weed density dependent. Development of prediction models is always helpful to improve the efficiency of weed management programs.

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