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Performance of different herbicides on wheat grain yield and correlation between growth and yield attributes of wheat and weeds

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ABSTRACT

A field experiment was conducted at Siswal, Hisar, Haryana during 2016-17 and 2017-18 to study the effect of different herbicides applied alone or mixtures on weeds and yield of wheat (*Triticum aestivum*). Significantly higher grain yield was obtained in weed free treatment, which was statistically similar with pinoxaden + metsulfuron and pendimethalin *fb* pinoxaden treatments, but significantly higher than all other treatments during both the years. Weed free, pinoxaden + metsufuron and pendimethalin *fb* pinoxaden treatments produced 70.9, 67.7 and 64.9; 69.4, 67.0 and 64.3% higher grain yield as compared to weedy check treatment, respectively during 2016-17 and 2017-18. Statistically similar grain yield was recorded in pyroxasulfone and pyroxasulfone + pendimethalin treatments, it was 54.1 and 51.1; 55.3 and 52.4% higher to weedy check treatment, respectively during 2016-17 and 2017-18. Application of flumioxazin and flumioxazin + pendimethalin provided effective weed control, but grain yield was lower due to crop phytotoxicity after first irrigation in light texture soils. Significant positive correlation between grain yield, growth and yield attributes, per cent control of weeds and weed control efficiency, but negative correlation was observed between grain yield and weed dry weight, panicle length, seeds/panicle, test weight of wild oat and weed index.

INTRODUCTION

Wheat is dominant crop in the temperate countries not only for human food, but also for livestock feed. Its success largely depends on adaptability to environmental conditions and agronomic practices. Productivity of wheat is governed by many factors, but one of the most serious and less noticed causes of low yield is the presence of weeds. Weeds reducing 10-82% yield loss depend upon weed density, weed species, time period of infestation and competitive ability of crop plant to weeds under different agro-ecological conditions (Heyne 1987). A lot of research work has been done on weeds in wheat, some of which support that wild oat (*Avena ludoviciana*) and wild canary grass (*Phalaris minor)* are two most dominant grassy weeds making wheat cultivation very difficult and major reasons for low yields (Singh *et al*. 1995). Wild oat is one of the ten worst annual weeds of temperate agricultural regions in the world (Holm *et al.* 1991) and difficult to control because of initial morphological and physiological similarities to wheat plants and long phase of emergence. While the weeds are a strong competitor for water and nutrients (Gonzaliz-Ponce and Santin 2001) grassy weed competes more vigorously with cereals. Although herbicides have played a vital role in improving crop yield and overall production efficiency, over-reliance and repetitive use of the herbicides belonging to the same site of action can also lead to development of herbicide resistant (HR) weed biotypes.

Wild oat is most susceptible to development of resistance (De Prado and Franco 2004). Wild oat biotypes have high genetic diversity, aggressive nature and respond to high fertility in comparison to wheat plants. Additionally, wild oat controlled with inhibiting acetyl-CoA carboxylase, characterized by single site of action which leads to selection pressure of resistant individuals in weed population. Nature of weed and herbicide mechanism may cause sudden development of Herbicide resistance (HR) in wild oat. Herbicide resistance action committee (HRAC) documented 43 biotypes of wild oat resistant to herbicides in different parts of world (www.weedscience.com). First case of HR was documented in wild oat with the use of herbicides in ACCase inhibitor group in Western Australia in 1985 (Heap 2015) followed by more reports documented

(Beckie *et al.* 2002). Now-a-days, sole dependence on these group of herbicides led to development of many cases of cross resistance (XR) or multiple-resistance (MR) in wild oat worldwide (Uludag *et al.* 2008). A wild oat population from Fatehabad District, Haryana was however found resistant under field and lab evaluation (Singh 2016, Unpublished data) Singh *et al.* (2016) reported poor efficacy of sulfosulfuron against wild oat and resistance against clodinafop and fenoxaprop to a population from farmer's field. Problem of herbicide resistant weeds is more challenging in the developing countries because of less availability of alternate herbicides for efficient control. Hence, study was carried out to manage *A. ludoviciana* resistant population to 'Fops' below threshold level and assess the effect of different herbicides on yield of wheat.

MATERIALS AND METHODS

Field experiment was conducted at farmer's field at village Siswal, (Longitude 29°23"113' and Latitude 75°47"490') district Hisar (Haryana) during *Rabi* seasons of 2016-17 and 2017-18. Fourteen treatments, *viz.* pendimethalin at 1500 g/ha (PE) *fb* pinoxaden at 50 g/ha (PoE), pendimethalin + metribuzin at 1500 g/ha (PE), metribuzin at175 g/ha (PE), pyroxasulfone at 127.5 g/ha (PE), pyroxa-sulfone at 106 g/ha + pendimethalin at 1000 g/ha (PE), flumioxazin at 100 g/ha (PE), flumioxazin at 80 g/ha + pendimethalin at 1500 g/ha (PE), clodinafop at 60 g/ha + metsulfuron at 4 g/ha (PoE), metribuzin at 175 g/ha (PoE), sulfosufuron + metsulfuron 32 g/ha (PoE), pinoxaden at 50 g/ha + metsulfuron at 4 g/ha (PoE), isoproturon at 1000 g/ha (PoE), weedy check and weed free were evaluated in randomized block design having gross plot size 65.0 x 7.7 m and replicated thrice. Wheat cultivar '*WH-1105*' was sown on November 13, 2016 and November 22, 2017 using a seed rate 100 kg/ha in rows at 20 cm apart.

Crop was fertilized with recommended dose of N 150 kg/ha and P_2O_5 60 kg/ha during both the years. Nitrogen was applied in two equal splits *i.e.* ½ at sowing and remaining ½ with first irrigation. Diammonium phosphate at 130 kg/ha was drilled at the time of sowing providing 23 kg N/ha and 60 kg P_2O_5/ha. Rest of N was applied through urea, broadcast at 52 kg N/hajust before sowing of wheat and at 75 kg N/ha immediately before the first irrigation. Pre-emergence (PE) herbicides were sprayed immediately after sowing, post-emergence (PoE) herbicides applied at 35 DAS with the help of knapsack sprayer fitted with flat fan nozzles using 500 lit/ha spray volume for PE herbicides and 300 lit/ha for PoE herbicides. Growth, yield attributes of crop and weeds and yield was recorded at harvest and statistically analyzed by using software SPSS version 7.5.

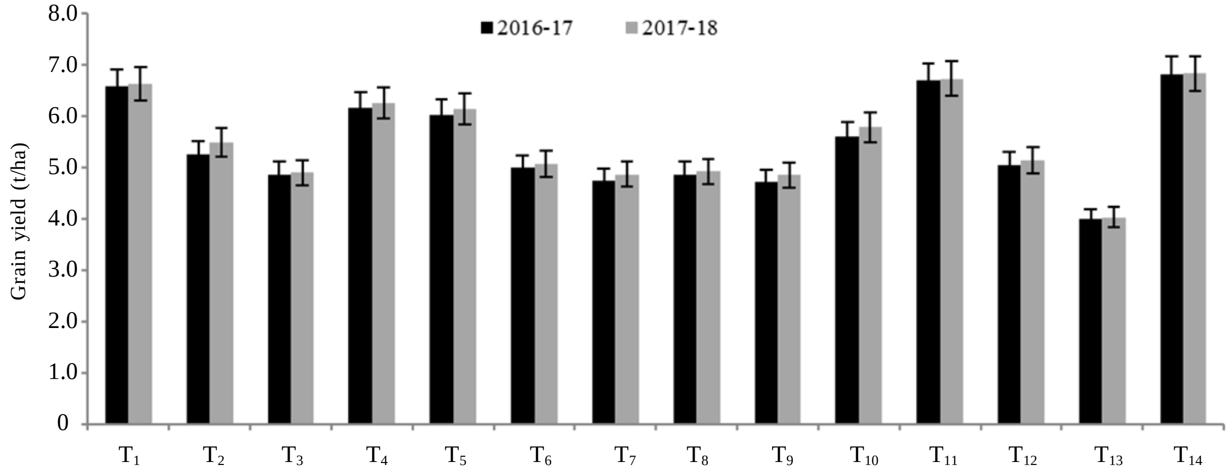
RESULTS AND DISCUSSION

Grain yield

Grain yield was significantly affected with different weed control treatments (**Figure 1**). Significantly higher grain yield in weed free treatment, which was statistically similar with pinoxaden + metsulfuron and pendimethalin *fb* pinoxaden treatments, but significantly higher than all other treatments during both the years. Weed free, pinoxaden + metsufuron and pendimethalin *fb* pinoxaden treatments produced 70.9, 67.7 and 64.9; 69.4, 67.0 and 64.3% higher grain yield as compared to weedy check treatment, during 2016-17 and 2017-18, respectively. Sequential application of herbicides and herbicide mixtures reduced crop-weed competition by killing grassy as well as broad-leaf weeds that helped to wheat for utilization of available nutrients, moisture, light and space more efficiently, thus produced higher tillers, spike length, grains/spike, test weight and hence increase in grain yield and delayed HR in different weed species.

Yadav *et al* (2016) attained wheat grain yields similar to the weed free treatment with sequential application of herbicides as compared to alone herbicides. Pendimethalin + metribuzin and sulfosulfuron + metsulfuron treatments provided statistically similar grain yield, but significantly lower than pinoxaden + metsulfuron and pendimethalin *fb* pinoxaden. Singh *et al*. (2012) reported that sulfosulfuron, pendimethalin + metribuzin and clodinafop was not effective as pinoxaden because all weed cohorts were not killed by alone PE and PoE herbicides, hence weeds were continued to grow and competing with crop plants for the natural resources, thus resulting in poor crop growth in terms of lower dry weight, tillers, grains/spike, 1000 grains weight and finally lower grain yield.

Metribuzin (PE) and (PoE) treatments also provided statistically similar grain yield during both the years but significantly lower than sequential application of pendimethalin *fb* pinoxaden and tank mixture of pinoxaden + metsufuron because alone PE and PoE herbicides did not control all weed cohorts, which resulted in lower grain yield. Statistically similar grain yield was recorded in pyroxasulfone and pyroxasulfone + pendimethalin treatments during



T_1 - Pendimethalin at 1500 g/ha (PE) *fb* pinoxaden at 50 g/ha (PoE); T_2 - Pendimethalin + metribuzin at 1500 g/ha (PE); T_3 - Metribuzin at 175 g/ha (PE); T_4 - Pyroxasulfone at 127.5 g/ha (PE); T_5 - Pyroxasulfone at 106 g/ha + pendimethalin at 1000 g/ha (PE); T_6 - Flumioxazin at 100 g/ha (PE); T_7 - Flumioxazin at 80 g/ha + pendimethalin at 1500 g/ha (PE); T_8 - Clodinafop at 60 g/ha + metsulfuron at 4 g/ha (PoE); T_9 - Metribuzin at 175 g/ha (PoE); T_{10} - Sulfosufuron + metsulfuron 32 g/ha (PoE); T_{11} - Pinoxaden at 50 g/ha + metsulfuron at 4 g/ha (PoE); T_{12} - isoproturon at 1000 g/ha (PoE); T_{13} - Weedy check; T_{14} - Weed free

Figure 1. Grain yield influenced by different weed control treatments

Table 1. Correlation coefficient between different growth and yield attributes of wheat and weeds during 2016-17

Parameter	Grain yield	Plant height	CDW	Spike length	Grains/ spike	Test weight	Mort (%)	WDW	Panicle length	Seeds/ panicle	Test weight	WCE	WI
Grain yield	1												
Plant height	.667**	1											
CDW	.981**	.639*	1										
Spike length	.969**	.611*	.979**	1									
Grains/spike	.986**	.621*	.973**	.985**	1								
Test weight	.981**	.641*	.964**	.956**	.982**	1							
Mortality (%)	.809**	.272	.770**	.780**	.821**	.854**	1						
WDW	-.784**	-.401	-.726**	-.765**	-.827**	-.852**	-.922**	1					
Panicle length	-.937**	-.557*	-.901**	-.914**	-.921**	-.908**	-.839**	.760**	1				
Seeds/panicle	-.865**	-.272	-.844**	-.856**	-.864**	-.851**	-.925**	.797**	.921**	1			
Test weight	-.606*	-.558*	-.632*	-.614*	-.583*	-.621*	-.517	.429	.690**	.559*	1		
WCE	.786**	.401	.727**	.767**	.828**	.854**	.924**	-1.000**	-.762**	-.799**	-.430	1	
WI	-1.000**	-.667**	-.981**	-.970**	-.987**	-.980**	-.809**	.784**	.938**	.866**	.607*	-.786**	1

**Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)
CWD, crop dry weight; WDW, weed dry weight; WCE, weed control efficiency; WI, weed index.

2016-17 and 2017-18. Pyroxasulfone kill only grass weeds especially littleseed canary grass and wild oat, whereas combination of pyroxsulfone + pendimethalin controlled complex weed flora, thus provide more available nutrients, space, moisture and sun light to crop plants so that crop plants flourish well, resulted in higher tillers and ultimately higher yield.However, pendimethalin was not effective against *A. ludoviciana*. Herbicide resistant weeds like *P. minor* and *R. dentatus* were sensitive to PE herbicides such as pendimethalin, trifluralin, metribuzin, pyroxasulfone and flufencet (Singh 2014, Kaur *et al*. 2017, Punia 2017). Application of flumioxazin and flumioxazin + pendimethalin provided effective weed control, but grain yield was lower due to crop phytotoxicity after first irrigation in light texture soils. Statistically lower grain yield recorded in clodinafop + metsulfuron and isoproturon, due to poor control of HR wild oat. Grassy weeds were strong competitor of cereals than broadleaf weeds, thus resulted in reduction in grain yield of wheat. Singh *et al*. (2016) reported that poor efficacy of sulfosulfuron against wild oat and resistance against clodinafop and fenoxaprop to a population from farmer's field.

Correlation studies

Plant height,dry weight, yield attributes of wheat, mortality percentage in weeds and weed control efficiency (WCE) had significantly positive

Table 2. Correlation coefficient between plant height, crop and wild oat dry weight, yield attributes of wheat and weeds during 2017-18

Parameters	Grain yield	Plant height	CDW	Spike length	Grains/ spike	Test weight	Mort (%)	WDW	Panicle length	Seeds/ panicle	Test weight	WCE	WI
Grain yield	1												
Plant height	.662**	1											
CDW	.978**	.636*	1										
Spike length	.956**	.653*	.942**	1									
Grains/spike	.988**	.632*	.984**	.953**	1								
Test weight	.971**	.695**	.950**	.926**	.978**	1							
Mortality (%)	.828**	.271	.806**	.719**	.814**	.788**	1						
WDW	-.796**	-.395	-.749**	-.712**	-.792**	-.831**	-.917**	1					
Panicle length	-.933**	-.537*	-.899**	-.890**	-.910**	-.852**	-.850**	.767**	1				
Seeds/panicle	-.867**	-.298	-.857**	-.765**	-.869**	-.801**	-.939**	.814**	.927**	1			
Test weight	-.570*	-.495	-.658*	-.558*	-.581*	-.520	-.546*	.456	.651*	.573*	1		
WCE	.797**	.395	.751**	.714**	.793**	.832**	.919**	-1.000**	-.770**	-.816**	-.458	1	
WI	-1.000**	-.662**	-.978**	-.956**	-.988**	-.971**	-.827**	.796**	.933**	.867**	.571*	-.797**	1

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)
CWD, crop dry weight; WDW, weed dry weight; WCE, weed control efficiency; WI, weed index.

correlation with grain yield butweed dry weight, panicle length, seeds/panicle, test weight of wild oat were negatively correlated during both the years (**Table 1** and **2**). Highest positive correlation was recorded between grains/spike and grain yield of wheat (0.986**). Grain yield also had positive relationship with crop dry weight (0.981**), test weight (0.981**), spike length (0.969**), mortality percentage in weeds (0.809**), WCE (0.786**), crop growth rate (0.902*) during 1st year. Correlation coefficient was negative between grainyield and weed dry weight(-0.784**), panicle length of wild oat (-0.937**), seeds/panicle (-0.865**), test weight of wild oat (-0.606*) and weed index (-1.000**) during 2016-17. Similar trend was observed in 2017-18.

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