International Scholars Journals

African Journal of Agronomy ISSN 2375-1185 Vol. 4 (10), pp. 280-287, November, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Efficacy of herbicide (pyroxasulfone 85WG) in combination with previously existing herbicides used for weed management

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Accepted 18 October, 2016

A field trial was conducted to evaluate the efficacy of post-emergence application of herbicides on weeds reduction and yield parameters in wheat crop. Treatments comprised of post-emergence application of pyroxasulfone, clodinafop propargyl and pendimethalin alone and in various combinations and also non-treated group of wheat plot was considered as control (weedy check). Results revealed that the diversity of *Phalaris minor* (*P. minor*), *Avena fatua* (*A. fatua*) and *Convolvulus arvensis* (*C. arvensis*) decreased ominously by all the herbicides compared to non-treated control. However, clodinafop propargyl at 60 g a.i ha^{-1} was found to be most effective as it severely reduced the weeds population as well as biomass with maximum mortality. Pyroxasulfone alone or with different combinations showed poor response as compared to weedy check. Maximum spike bearing tillers (354.50), number of grains spike^{-1} (59.50), 1000-grain weight (58.50 g), straw yield (6.52 t ha^{-1}) and grain yield (4.73 t ha^{-1}) were recorded in response of clodinafop propargyl at 60 g a.i ha^{-1} versus other herbicides. Consequently, clodinafop propargyl proved itself a potential herbicide for weed control and better yield in wheat crop.

Keywords: Weed management, herbicides application, weeds dry weight, *Triticum aestivum* L., clodinafop propargyl.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an essential grain food component and is a very important commodity among cereal crops (Montazeri et al., 2005). A 17% world's cropped area is under wheat cultivation which together adds 35% of the staple food and 20% of the calories (Chhokar et al., 2006). In Pakistan, the larger part of the population depends upon wheat for food and its enhanced production is indispensable for food security.

Weeds competition with wheat crop is a key point in yield reduction (Zand et al., 2003; Waheed et al., 2009). The effect of weeds on wheat yield has been reported by the majority of researchers worldwide. Zand et al. (2007) reported 30% wheat yield loss and sometimes complete failure of crop. Weeds compete with crop plants for various resources such as water and nutrients, resulting in low yields (Jarwar et al., 2005; Shehzad et al., 2012a; Shehzad et al., 2012b). Montazeri et al. (2005) reported that *Phalaris minor, Alhagi persarum* (camelthorn), *Avena fatua* (Wild oat), *Cirsium arvense* L.), *Glycyrrhiza glabra* L. (licorice), *Sinapis arvensis* L. (wild mustard), *Convolvulus arvensis* L. (field bindweed), Scop. (*Canada thistle*), (*Descurania sophia* L.) Webb. (flixweed) and *Galium* sp. (bedstraw) are the most harmful and upsetting weeds in wheat crop.

Currently, chemical weed control has emerged as an effective tool for weed management because it is approachable, less time consuming as well as economical (Duke and Lydon, 1987; Jarwar et al., 1999; Baghestani et al., 2007). A 37% increase in wheat yield has been reported by eradication of weeds (Jails and Shah, 1982). Majid and Hussain, (1983) compared the

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Table 1. Mean monthly weather conditions of the experimental site during the year 2010-11

Month	Temperature			R.H.	Rain fall	PAN evaporation	Sun shine	Wind speed	ETo
	Max.	Min.	Avg.						
	ºC	ºC	ºC	%	mm	mm	Hours	Km/h	mm
Nov-10	27.1	10.5	18.8	62.3	00.0	02.5	08.5	02.6	02.1
Dec-10	21.0	05.8	13.4	70.4	00.0	01.3	07.3	03.1	01.1
Jan-11	15.9	04.3	10.1	73.4	0	01.3	05.4	04.3	00.9
Feb-11	20.2	08.7	14.4	73.0	20.6	01.7	05.5	06.2	01.2
Mar-11	26.4	13.1	19.8	59.8	06.8	03.5	08.4	05.8	02.5
Apr-11	32.0	17.2	24.8	47.0	20.9	05.9	09.3	07.2	04.2

Latitude = 31^{O}- 26' N, Longitude = 73^{O}- 06' E, Altitude = 184.4m

efficacy of Dicuran MA 60WP, Stomp 330EC, Buctril M 20% and herbit 20% with hand weeding practice in wheat and revealed that Dicuran MA 60WP controlled 96.8% weeds and increased yield by 37%. Similarly, Pandey et al., (1996) observed that post-emergence application of isoproturon and metaxuron @ 1 kg a.i. ha^{-1} and 2 kg a.i. ha^{-1}, respectively produced best weed control in wheat. Furthermore, Qasem, (2007), Zand et al., (2010) and Naseer-ud-din et al., (2011) suggested the post-emergence application of herbicides for increased yield and significant weed population reduction. On the other hand, weed resistance to herbicide application can pose problems in weed management (Beckie et al., 2000) and with the passage of time their evaluation should be performed (Baghestani et al., 2007) and the introduction of new herbicides is a pre-requisite to eradicate the resistance of weeds.

Therefore, the present study was designed to evaluate the efficacy of new herbicide (pyroxasulfone 85WG) alone and in different combinations with previously existing herbicides being used for weed management as well as their effect on yield attributes in wheat crop native to Punjab, Pakistan.

MATERIALS AND METHODS

Site and soil description

The experiment was conducted at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad (31°.26 N, 73°.06 E) during the Rabi season 2010-11. The soil was of sandy clay loam in texture with total soluble salts 1.4 dSm^{-1}, pH soil 8.1, pH water 6.67, organic matter 0.87 % and electrical conductivity 2.6 dS m^{-1}. The meteorological data regarding rainfall, relative humidity, temperature, wind velocity, sunshine and evapotranspiration etc. were recorded from meteorological observatory in the immediate vicinity of the field during the phase of crop development and is shown in (Table 1). A survey conducted before herbicide application at the experimental site during 2010–11 revealed weed flora comparing of prickly chaff flower (*Achyranthes aspara*), jungle onion (*Asphodelus tenuifolius* L.), lamb's quarters (*Chenopodium album* L.), bitter dock (*Rumex dentatus* L.), canarygrass (*Phalaris minor*), wild oat (*Avena fatua* L.), yellow sweetclover (*Melilotus indica* L.), fumitory (*Fumaria indica* L.), field bindweed (*Convolvulus arvensis* L.), prostrate knotweed (*Polygonum plebejum* L.) wild medic (*Medicago polymorpha* L.), emex species (*Emex spinosa*), swine cress (*Coronopus didymus*) and blue pimpernel (*Anagallis arvensis* L.). However, canarygrass, wild oat and field bindweed (*Convolvulus arvensis* L.) were found to be dominant and present study was focused on management of these three weeds by post-emergence application of herbicides.

Layout and experimental design

The experiment was laid out in randomized complete block design (RCBD) having four replications with a net plot size of 3.0 m × 8.0 m consisting of 8 rows.

Agronomic practices

Before sowing, the soil was prepared for seed bed conditions by two dry plowings, land leveling, soaking irrigation followed by two cross plowings with rotavator plow at the sowing time. The basic NPK fertilizer dose 125-100-0 kg ha^{-1} was applied as diammonium phosphate (DAP) and Urea. Textural class and physico-chemical properties of the field was determined by using the International Textural Triangle (Brady, 1990). The wheat cultivar Sahar-2006 was sown during the third week of November-2010. The seeds were hand drilled using seed rate 125 kg ha^{-1} keeping 25 cm rows apart. Threshing for each plot was done separately and manually when the green color from the glumes and kernels disappeared completely in first week of April.

Herbicides application

The following treatments of herbicides as post-emergence application was applied; I) pyroxasulfone 85WG (75 g a.i ha^{-1}), II) pyroxasulfone 85WG (100 g a.i ha^{-1}), III) clodinafop propargyl 15 WP (60 g a.i ha^{-1}), IV) pyroxasulfone + pendimethalin (75+683 g a.i ha^{-1}), V) pyroxasulfone + pendimethalin (100+683 g a.i ha^{-1}), VI) pyroxasulfone + pendimethalin (75+910 g a.i ha^{-1}), VII) pyroxasulfone + pendimethalin (100+910 g a.i ha^{-1}) pyroxasulfone + clodinafop propargyl (75+60 g a.i ha^{-1}). A non-treated (weedy check) considered as control. The herbicides were applied after 1st irrigation at wheat tillering stage by "Knapsack" hand sprayer fitted with T-jet nozzle. Volume of spray was determined by calibration method and water was used at 250 L ha^{-1}.

Data recording

Visual weed damage was rated after 15, 30, 45 and 60 days from 1 m^2 quadrate in each plot. Weed population was measured separately for each weed species by counting the number of weeds within two randomly dropped 1 m^2 quadrates in each plot. Percent weed biomass reduction was measured using two 0.25 m^2 quadrates. All weeds were then cut at the ground level, separated and oven-dried at 75°C for 72 h for the measurement of dry weight. Data on plant height, number of spike bearing tillers, number of grains per spike, 1000-grain weight, straw and grain yield were also recorded at physiological maturity of wheat crop as precisely described by (Zand et al., 2007). Ten plants were selected at random from each plot and their height was measured by using measuring tape from soil surface to the final growing point and the average was calculated accordingly. A unit area of 1 m^2 was selected at random from two different sites for each plot. The number of spike bearing tillers was counted and average number of productive tillers m^{-2} calculated. Ten spikes selected at random from each experimental unit, were threshed manually. Grains were counted and average number of grains per spike was calculated. Two samples, each of 1000-grains, were taken from the produce of each plot. These samples were weighed on an electric balance and average 1000-grain weight was calculated. The crop was harvested, sun dried and allowed to threshing in respective plots. Wheat biomass of the sun dried and threshed samples were recorded for each treatment by using a spring balance. Straw yield per plot was converted to tones per hectare (t ha^{-1}). The harvested and sun dried crop was threshed manually. The grain weight for each treatment was recorded in kilogram and later expressed in tones per hectare (t ha^{-1}).

Statistical analysis

The data thus obtained was analyzed according to Fisher's analysis of variance technique (Steel et al., 1997). The assumptions of variance analysis were tested by ensuring that the residuals as random and homogenous with a normal distribution about a mean of zero. Means were separated by using Least Significant Difference (LSD) test at 5% probability.

RESULTS AND DISCUSSION

Weed population reduction (%)

A considerable reduction was observed in weed density after 15 days of herbicides application (DAHA) as compared to weedy control (Table 2). Clodinafop propargyl (60 g a.i ha^{-1}) reduced the *P. minor* density (92.41%) DAHA. The lowest weed control (1.08%) was recorded in plots treated with pyroxasulfone (75 g a.i ha^{-1}) versus non-treated control. The reduction of *A. fatua* (wild oat) density of 60.65% was observed as a result of pyroxasulfone + pendimethalin (75 + 683 g a.i ha^{-1}) application. However, clodinafop propargyl (60 g a.i ha^{-1}) reduced the *A. fatua* population up to 81.42% (Table 2). Similarly, the highest reduction in *C. arvensis* density was observed of 78.77% in response to clodinafop propargyl (60 g a.i ha^{-1}) application. The effect of clodinafop propargyl on weed reduction was found be in the order of *P. minor* > *A. fatua* > *C. arvensis*. According to Barros et al. (2005) the efficiency of a single herbicide for different weeds may differ according to weed species. The results indicated that clodinafop propargyl (60 g a.i ha^{-1}) controlled the weeds in better way as compared to pyroxasulfone alone and in different combinations with pendimethalin and clodinafop propargyl. These results are in analogy with the results of Tunio et al., (2004) and Jarwar et al. (2005) who indicated that clodinafop propargyl is most effective for weed control and hence recommended for controlling grassy weeds and maximizing of wheat yield. Furthermore, it was observed that the new herbicide pyroxasulfone at different doses and in combination failed to control the weed populations as compared to other herbicides (Table 3). The results indicate that maximum percent reduction of *P. minor*; *A. fatua* and *C. arvensis* was 93.04%, 86.53% and 82.80% respectively, achieved by the application of clodinafop propargyl (60 g a.i ha^{-1}) that assuring better efficacy for weed control after 30 DAHA and findings are in accordance with Stagnari et al. (2006).

After 45 DAHA, reduction in *P. minor* density was observed as; 81.70% for pyroxasulfone (75 g a.i ha^{-1}), 81.06% for pyroxasulfone (100 g a.i ha^{-1}), 81.06% for pyroxasulfone + pendimethalin (75 + 910 g a.i ha^{-1}) and 81.70% for pyroxasulfone + clodinafop propargyl (75 + 60 g a.i ha^{-1}) (Table 4). However, the reduction in *P. minor* density was maximum (93.19%) in response of clodinafop propargyl treatment (60 g a.i ha^{-1}). These results are in conformity with the findings of Barros et al. (2005) and

Table 2. Effect of different POST application herbicide treatments on percent weed populations at 15 (DAHA**) during 2010-11

Treatments	Visual weed injury		
	Phalaris minor	*Avena fatua*	*Convolvulus arvensis*
	Weed population reduction (%)	Weed population reduction (%)	Weed population reduction (%)
Pyroxasulfone @ 75 g a.i ha^{-1}	01.08 a	33.60 b	46.40 cd
Pyroxasulfone @ 100 g a.i ha^{-1}	58.57 e	33.88 b	48.20 de
Clodinafop propargyl @ 60 g a.i ha^{-1}	92.41 f	81.42 e	78.77 g
Pyroxasulfone + Pendimethalin @ 75 + 683 g a.i ha^{-1}	54.88 d	60.65 d	53.24 f
Pyroxasulfone + Pendimethalin @ 100 + 683 g a.i ha^{-1}	53.36 cd	36.06 bc	51.07 ef
Pyroxasulfone + Pendimethalin @ 75 + 910 g a.i ha^{-1}	52.27 c	36.88 c	45.32 cd
Pyroxasulfone + Pendimethalin @ 100 + 910 g a.i ha^{-1}	36.00 b	37.15 c	12.58 b
Pyroxasulfone + Clodinafop propargyl @ 75 + 60 g a.i ha^{-1}	34.70 b	38.25 c	44.24 c
Non-treated control	0.00 a	0.00 a	0.00 a
LSD (*P* = 0.05)	2.17	2.35	2.56

Means in the respective columns followed by different letters are significantly different by LSD test at *P*= 0.05

*DAHA= Days after herbicide application

Table 3. Effect of different POST application herbicide treatments on percent weed populations at 30 (DAHA) during 2010-11

Treatments	Visual weed injury		
	Phalaris minor	*Avena fatua*	*Convolvulus arvensis*
	Weed population reduction (%)	Weed population reduction (%)	Weed population reduction (%)
Pyroxasulfone @ 75 g a.i ha^{-1}	70.88 d	49.57 b	63.63 e
Pyroxasulfone @ 100 g a.i ha^{-1}	71.09 de	48.99 b	50.17 c
Clodinafop propargyl @ 60 g a.i ha^{-1}	93.04 g	86.53 e	82.80 f
Pyroxasulfone + Pendimethalin @ 75 + 683 g a.i ha^{-1}	70.04 d	59.59 d	55.78 d
Pyroxasulfone + Pendimethalin @ 100 + 683 g a.i ha^{-1}	65.18 c	48.42 b	55.08 d
Pyroxasulfone + Pendimethalin @ 75 + 910 g a.i ha^{-1}	72.99 ef	47.56 b	48.77 c
Pyroxasulfone + Pendimethalin @ 100 + 910 g a.i ha^{-1}	59.49 b	47.56 b	20.00 b
Pyroxasulfone + Clodinafop propargyl @ 75 + 60 g a.i ha^{-1}	74.47 f	47.85 b	47.36 c
Non-treated control	0.00 a	0.00 a	0.00 a
LSD (*P* = 0.05)	2.36	1.77	1.85

Means in the respective columns followed by different letters are significantly different by LSD test at *P*= 0.05

Table 4. Effect of different POST application herbicide treatments on percent weed populations at 45 (DAHA) during 2010-11

Treatments	Visual weed injury		
	Phalaris minor	*Avena fatua*	*Convolvulus arvensis*
	Weed population reduction (%)	Weed population reduction (%)	Weed population reduction (%)
Pyroxasulfone @ 75 g a.i ha^{-1}	81.70 e	47.42 c	50.57 b
Pyroxasulfone @ 100 g a.i ha^{-1}	81.06 e	69.90 e	49.03 b
Clodinafop propargyl @ 60 g a.i ha^{-1}	93.19 f	89.96 g	74.51 c
Pyroxasulfone + Pendimethalin @ 75 + 683 g a.i ha^{-1}	78.08 d	77.50 f	51.35 b
Pyroxasulfone + Pendimethalin @ 100 + 683 g a.i ha^{-1}	75.32 c	72.34 e	49.80 b
Pyroxasulfone + Pendimethalin @ 75 + 910 g a.i ha^{-1}	81.06 e	72.20 f	50.96 b
Pyroxasulfone + Pendimethalin @ 100 + 910 g a.i ha^{-1}	62.97 b	59.57 d	49.42 b
Pyroxasulfone + Clodinafop propargyl @ 75 + 60 g a.i ha^{-1}	81.70 e	32.83 b	48.26 b
Non-treated control	0.00 a	0.00 a	0.00 a
LSD (*P* = 0.05)	2.15	2.25	2.37

Means in the respective columns followed by different letters are significantly different by LSD test at *P*= 0.05

Tucker et al. (2006) who reported that clodinafop propargyl has high efficacy on weed control which subsequently resulted in better crop yield. After 60 DAHA, the control of *P. minor* populations was also found to be significant in clodinafop propargyl treatment. The least percentage reduction on *P. minor* was 64.85% and 76.77% in response to pyroxasulfone + pendimethalin (100+910 g a.i ha^{-1}) treatment and pyroxasulfone + pendimethalin (100 + 683 g a.i ha^{-1}), respectively, while for *A. fatua* was 52.14% in pyroxasulfone + clodinafop propargyl treatment (75 + 60 g a.i ha^{-1}) (Table 5). These results are in line with the findings of Saini and Singh, (2001) and El-Metwally et al., (2010) who revealed that clodinafop propargyl is very efficient in reducing weed population and dry weight and in increasing yield attributes. These results are also in accordance with findings of Anwar-ul-Haq et al. (1981) and Saini, (2000) who reported that dry weights of weed species were significantly reduced under chemical treatments.

Wheat yield and yield attributes

The data showed that the post emergence herbicides application had no significant effect on plant height (Table 6). The maximum plant height (95.55cm) was observed in weedy check plant (control), while minimum (81.92 cm) was in clodinafop propargyl (60 g a.i ha^{-1}) treated plant. These results are in agreement with the previous findings of Marwat et al., (2005) and Arif et al., (2011) who indicated that the post-emergence herbicides had no significant effect on plant height. This may be attributed to the competition among weeds and wheat which compelled plant height increase and weed competition.

The spike bearing tillers of wheat increased considerably as a result of post emergence herbicides application. The higher spike bearing tillers (354.50) was recorded in clodinafop propargyl (60 g a.i ha^{-1}) treated plots, while lowest (192.50) was observed in non-treated plots (weedy control) (Table 6). These results are in agreement with the Ijaz et al., (2008) who observed that better weed control increased the nutrients availability to the crop which ultimately increased the spike bearing tillers. The number of grains/spike is an important characteristic in determining the wheat yield. The results showed that the grains/spike increased significantly versus weedy control, however, the differences among the herbicide treatments was found to be non-significant (Table 6). Maximum number of grain/spike was recorded in clodinafop propargyl treated plots. A 59.50 grains/spike was observed in clodinafop propargyl treated plants as compared with 43.75 grains/spike in non-treated plants (control). These results are in line with those reported by Ali et al., (2004) that number of grains per spike increase increased as a result of post-emergence herbicide application. Similarly , the data regarding 1000- grain weight indicated that there was significant increase in grain weight (Table 6). The maximum 1000-grain weight observed was 58.50 g versus control (46.15 g) as a result of clodinafop propargyl (60 g a.i ha^{-1}) application. The increase in 1000-grain weight was possibly due to better growth and development of crop plants which resulted in more grain weight assimilation. The results regarding 1000-grain weight is in agreement with Qureshi et al., (2003); Mishra (2006) and Naseer-ud-din et al. (2011) who observed significantly higher 1000-grain weight with chemical weed control in wheat. Statistical analysis of the data revealed significant differences among the herbicide treatments as well as weedy control (Table 6). The straw yield of 6.52 t ha^{-1} was recorded with clodinafop propargyl (60 g a.i ha^{-1}) followed by pyroxasulfone + pendimethalin (100 + 910 g a.i ha$^{-1,}$ 6.02 t ha^{-1}). Of all the herbicides, pyroxasulfone + pendimethalin (75 + 683 g a.i ha^{-1}) gave the lowest straw yield of 3.92 t ha^{-1}. These findings are in agreement with that of Dixit and Singh, (2008) who reported that post-emergence herbicides have significant effect on straw yield. In the case of grain yield, results indicated that post-emergence treatment significantly affected the crop grain yield. The grain yield of 4.73 t ha^{-1} was obtained from clodinafop propargyl (60 g a.i ha^{-1}) (Table 6). Pyroxasulfone applied alone and in different combinations resulted in the lowest grain yields, since control of grass and broadleaf weeds was not affected by this new herbicide. Chhokar et al., (2008) found that post-emergence clodinafop propargyl was very effective in controlling weeds and improving grain yield.

Economic and marginal analysis

The post emergence herbicide treatments increased the net benefit significantly as compared to non-treated control (weedy check) (Table 7). Maximum net income of Rs. 11974 (1376 US$) was obtained in response to clodinafop propargyl (60 g a.i ha^{-1}) followed by pyroxasulfone (Rs. 95470), pyroxasulfone + clodinafop propargyl (Rs. 94920) and so on. The marginal analysis seems to be dependent on weed management because the benefit was found to be highest for clodinafop propargyl (6460.76 %). These findings are in accordance with previous studies that herbicides might be lower cost and very effective for timely weed control. Marwat et al., (2006) also reported a excellent marginal rate of return by performing a cost benefit ratio for clodinafop propargyl, 2, 4-D 70 SL, bromoxynil + MCPA, isoproturon, chlorfluazuron, triasulfuron + terbutryn and fenoxaprop-p-ethyl herbicides. Similarly, Naseer-ud-din et al., (2011) and Shahzed et al., (2012b) reported similar marginal analysis for pyroxasulfone, terbutryn + triasulfuron, flufenacet + pyroxasulfone, flufenacet, carfentrazone ethyl + isoproturon, bromoxynil + MCPA herbicides.

Table 5. Effect of different POST application herbicide treatments on percent weed populations and biomass reductions at 60 (DAHA) during 2010-11

Treatments	Visual weed injury				
	Phalaris minor		*Avena fatua*		
	Population reduction (%)	Biomass reduction (%)	Population reduction (%)	Biomass reduction (%)	P re
Pyroxasulfone @ 75 g a.i ha^{-1}	83.26 f	52.67 d	53.74 b	20.69 b	
Pyroxasulfone @ 100 g a.i ha^{-1}	82.42 ef	64.81 e	75.93 c	27.27 d	
Clodinafop propargyl @ 60 g a.i ha^{-1}	93.72 g	80.25 f	94.11 f	71.74 e	
Pyroxasulfone + Pendimethalin @ 75 + 683 g a.i ha^{-1}	79.91 d	50.92 d	81.28 e	26.29 cd	
Pyroxasulfone + Pendimethalin @ 100 + 683 g a.i ha^{-1}	76.77 c	61.72 e	78.07 cd	25.17 cd	
Pyroxasulfone + Pendimethalin @ 75 + 910 g a.i ha^{-1}	83.05 f	43.20 c	78.87 de	22.37 bc	
Pyroxasulfone + Pendimethalin @ 100 + 910 g a.i ha^{-1}	64.85 b	55.04 d	54.81 b	20.27 b	
Pyroxasulfone + Clodinafop propargyl @ 75 + 60 g a.i ha^{-1}	81.17 de	34.15 b	52.14 b	23.77 bcd	
Non-treated control	0.00 a	0.00 a	0.00 a	0.00 a	
LSD (P = 0.05)	1.72	0.41	2.55	2.82	

Means in the respective columns followed by different letters are significantly different by LSD test at P= 0.05

Table 6. Effect of different POST application herbicide treatments on wheat (*Triticum aestivum* L.) yield during 2010-11

Treatments	Parameters			
	Plant height (cm)	Spike bearing tillers	No. of grains spike^{-1}	1000-grain weight (g)
Pyroxasulfone @ 75 g a.i ha^{-1}	94.85 ab	296.25 e	47.50 c	47.62 d
Pyroxasulfone @ 100 g a.i ha^{-1}	94.67 ab	298.50 e	48.50 c	47.02 de
Clodinafop propargyl @ 60 g a.i ha^{-1}	81.92 f	354.50 a	59.50 a	58.50 a
Pyroxasulfone + Pendimethalin @ 75 + 683 g a.i ha^{-1}	92.25 c	310.50 c	53.75 b	55.17 b
Pyroxasulfone + Pendimethalin @ 100 + 683 g a.i ha^{-1}	89.32 d	311.50 c	54.00 b	56.07 b
Pyroxasulfone + Pendimethalin @ 75 + 910 g a.i ha^{-1}	85.80 e	305.50 d	53.75 b	51.77 c
Pyroxasulfone + Pendimethalin @ 100 + 910 g a.i ha^{-1}	87.42 de	312.25 bc	54.00 b	55.10 b
Pyroxasulfone + Clodinafop propargyl @ 75 + 60 g a.i ha^{-1}	93.00 bc	314.50 b	53.25 b	47.55 d
Non-treated control	95.55 a	192.50 f	43.75 d	46.15 e
LSD (P = 0.05)	2.25	2.55	1.62	1.24

Means in the respective columns followed by different letters are significantly different by LSD test at P= 0.05

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