Pak. J. Weed Sci. Res., 19(2): 217-230, 2013

INTEGRATED WEED MANAGEMENT STRATEGIES IN WHEAT

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ABSTRACT

An experiment to study the impact of integrated weed management strategies in wheat was carried out at the Agronomic Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan, during the year 2010-11. The experiment was laid out in a randomized complete block design with three replications and ten treatments. The treatments included were one hoeing with kasola (after 1st irrigation), two hoeing with kasola (after 1st and 2nd irrigation), Puma Super (fenoxaprop-p-ethyl) @500 mL ha^{-1} after 1st irrigation, weed free (hand pulling throughout the season), weedy check (control), 3-hoeing with khurpa (after 1st, 2nd and 3rd irrigation), Sonic @ 100 g ha^{-1} after 1st irrigation, Puma Super @ 500 mL ha^{-1} after 2nd irrigation, 3-hoeing with kasola (after 1st, 2nd and 3rd irrigation) and Buctril super (bromoxynil+MCPA) @500 mL ha^{-1} at 60 days after sowing. The results revealed that application of herbicides and hoeing significantly affected weed biomass (g m^{-2}), number of tillers (m^{-2}), spike length (cm), 1000-grain weight (g), grain yield (t ha^{-1}) and biological yield (t ha^{-1}). Weed free crop throughout the season gave the highest grain yield (6.167 t ha^{-1}) and biological yield (11.42 t ha^{-1}). Among the herbicides used, Buctril super produced maximum grain yield (4.767 t ha^{-1}) and biological yield (9.953 t ha^{-1}). From the results obtained, it is concluded that both chemical and manual weed control methods gave excellent control of weeds but chemical control was found to be the easiest, time saving and effective method.

Key words: Herbicide, mechanical control, weed management, wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the basic component of human diet. It is the most widely grown cereal grain crop in the world, except in the rice-eating regions of Asia. Globally, it ranks second in total production as a cereal crop behind maize, the third being rice. It is

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also a staple food of the people of Pakistan and serves as backbone in the economy of the country.

Among all cereals, wheat is the most preferred food for human being. Yields of wheat continued to increase, as new land came under cultivation and with improved agricultural husbandry involving the use of fertilizers, threshing machines and reapers (the combine harvester) and tractor-drawn cultivators (Vaughan and Judd, 2003).

The yield per unit area obtained in our country is far less than the yield of developed countries of the world. Besides various causes of low grain yield per unit area, presence of weeds is a key limiting factor towards higher wheat yields. Weeds compete with crop for light, nutrient, water and carbon dioxide. Rao (2000) reported that reduction in crop yield has a direct correlation with weed competition, while Friesen *et al*. (2000) mentioned that herbicides would continue to be a key component in weed management in wheat. Moreover, they observed that weeds consume three to four times more nitrogen, potassium and magnesium than weed free crop.

The annual losses to wheat crop due to weed infestation in Pakistan and in Khyber Pakhtunkhwa (KPK) province is amounting to Rs. 28 billions and Rs. 2 billions, respectively (Pervaiz and Qazi, 1992). These enormous figures warrant an efficient control of weeds for lucrative economic returns. The eradication of weeds from the cropped field is, therefore, very essential for obtaining good crop stand and high economic returns.

From the start of settled agriculture up to the middle of the 20th century, the plough and hoe had been the main direct methods of weed control although fire, hoeing, mowing and smothering had also been applied. Conventional methods of weed control are weather-dependent, tedious, laborious, time consuming and costly. Crop mimicry (resemblance) by grassy weeds like wild oats and canary grass complicates the success of manual weed control strategies. Now weed technology has entered a scientific phase and chemical weed control is being more emphasized in modern agriculture. Chemical weed control is less dependent on weather and hence more practicable for use during the critical period of weed crop competition. The use of chemicals is usually easy, time saving, highly effective and most economical approach to weed control. However, it may not be environmentally safe as manual, mechanical and biological methods of weed control.

Integrated weed management (IWM) is the careful consideration of all available weed control techniques and subsequent integration of appropriate measures that discourage the development of weed and keep herbicides and other intervention to levels that are economically justified and reduce or minimize risks to human health and the environment (Ferrell *et al*., 2001). Integrated weed management emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. Integrated weed management takes into account all relevant control tactics and methods available locally, evaluating their potential cost effectiveness. It does not, however, consist of any absolute or rigid criteria. Implementation of IWM lies with farmers, who adopt those elements of IWM, which are seen to be practical and added value to their activities (Dumka *et al*., 2004).

Keeping this in view, the present study was initiated to determine the impact of different weed management strategies on weeds, yield and economics of wheat.

MATERIALS AND METHODS

The experiment was initiated at the Agronomic Research Area, Faculty of Agriculture, Gomal University, Dera Ismail Khan, KPK during winter 2010-11. It was laid out in a randomized complete block design with ten treatments and three replications. The net plot size was kept 5m x 2m. Wheat variety Hashim-8 was sown on a well prepared seedbed with single row hand drill. Seed rate @ 100 kg ha^{-1} was used. Urea, Diammonium Phosphate (DAP) and Sulphate of Potash (SOP) @ 150 kg N, 120 kg P_2O_5 and 60 kg K_2O ha^{-1} were applied, respectively. Full dose of phosphorus, potash and half dose of nitrogen were applied at seedbed preparation while the remaining half of nitrogen was applied at first irrigation.

The treatments included were T_1: one hoeing with kasola (after 1st irrigation), T_2: two hoeing with kasola (after 1st and 2nd irrigation), T_3: Puma Super (fenoxaprop-p-ethyl) @500 mL ha^{-1} after 1st irrigation, T_4: weed free (hand pulling throughout the season), T_5: weedy check (control), T_6: 3-hoeing with khurpa (after 1st, 2nd and 3rd irrigation), T_7: Sonic @ 100 g ha^{-1} after 1st irrigation, T_8: Puma Super @500 mL ha^{-1} after 2nd irrigation, T_9: 3-hoeing with kasola (after 1st, 2nd and 3rd irrigation) and T_{10}: Buctril Super (bromoxynil+MCPA) @500 mL ha^{-1} 60 days after sowing.

The data on fresh weed biomass (g m^{-2}), dry weed biomass (g m^{-2}), plant height at maturity (cm), number of tillers (m^{-2}), spike length (cm), number of grains (spike^{-1}), 1000-grain weight (g), grain yield (t ha^{-1}) and cost benefit ratio were recorded and analyzed using analysis of variance techniques (Steel *et al*., 1997) and differences between means was separated through MSTATC computer software (MSTATC, 1991).

RESULTS AND DISCUSSION

Fresh weed biomass (gm^{-2}) 60 days after sowing

The broadleaved weeds predominantly germinated in the field were *Convolvulus arvensis* (filed bind weed), *Chenopodium album* (common lambs-quarters), *Medicoago denticulata* (Bur Colver), *Melilotus indica* (White melilot), *Rumex dentatus* (Prickly dock) and *Angallis arvensis* (pimpernel). Among narrow leaved weeds, *Avena fatua* (Wild oat) and *phalaris minor* (Canary grass) were dominant in the experimental area. The data given in Table-1 indicated that the maximum fresh weed biomass (FWB) of 109 gm^{-2} was recorded in T5 (control) while the rest of the treatments including T1 (one hoeing with kasola), T2 (two hoeing with kasola), T7 (sonic), T9 (3-hoeing with kasola) and T6 (3-hoeing with khurpa) were found statistically at par with T5. The lowest FWB (97.88 gm^{-2}) was recorded in T4 (weed free) but was statistically at par with the remaining two treatments i.e. T10 (Buctril Super) and T3 (Puma Super after 1st irrigation). The highest FWB in T5 (control) was due to the presence of weeds in this treatment as no weed control measure was adopted while the lowest was recorded in T4 where weeding was done from time to time to keep the field weed free. The application of Puma Super and Buctril Super effectively controlled weed population and resulted in lower FWB.

Qureshi *et al*. (2002) studied the efficiency of various weed management practices in wheat and reported the highest (85.47%) weed control under hand weeding for full season and it was statistically at par with Buctril Super alone and its combination with different planting geometries. Our results are also in agreement with the finding of Mountazaari (2000) and Deshmukh and Atale (2006) who reported that application of herbicides and hand weeding controlled the number of weeds significantly by decreasing weed biomass.

Dry weed biomass (gm^{-2}) 60 days after sowing

The data regarding dry weed biomass are given in Table-1. It is revealed from the data that dry weed biomass (DWB) was significantly affected by various weed management strategies. The highest DWB (18.65 gm^{-2}) was recorded in weedy check (T5) followed by T1, T2, T9, T8 and T6 which were statistically similar. The lowest DWB (14.29 gm^{-2}) was recorded in T4 (weed free) which was statistically at par with T3 and T10. As far as the use of herbicides is concerned, Buctril Super reduced DWB substantially due to presence of broadleaved weeds in the experimental area, which were killed by this weedicide. Harbir *et al*. (2000) and Singh *et al*. (2002) noted efficacy of herbicides and manual weeding and reported that hand weeding reduced weeds DWB than other treatments. Similarly, Pandey *et al.* (2002) evaluated the efficacy of weedicides on wheat and reported that weed population and weed dry weight were significantly lower under weed control treatments than the weedy control.

Fresh weed biomass (g m^{-2}) 120 days after sowing

The data showed the maximum FWB (55.17 gm^{-2}) in control (T5) that differed significantly from all other treatments (Table-1). It was followed by T1 and T3 with FWB of 29.38 and 27.27 gm^{-2}, respectively and both treatments were statistically similar. The minimum FWB (9.333 gm^{-2}) was found in T4 where experimental field was kept weed free throughout the season. Application of Buctril Super (T10) also reduced FWB (16.23 gm^{-2}) suggesting that chemical treatment is the best alternative if the labour is a limiting factor in proper and timely weed management. Mishra and Kewat (2002) studied the effect of weed control treatments on weed density and reported that weed population and biomass were significantly reduced with hand weeding, chemical treatment and chemical plus cultural treatments in rice; hand weeding and chemical treatment in wheat; and hand weeding as well as chemical plus cultural treatment in mungbean. Similarly, O'Donovan (2005) reported that different weed control practices when applied alone may not be sufficient to provide adequate weed management. However, combining these practices and integrating them with herbicides use can result in long-term and more cost-effective weed management.

Dry weed biomass (gm^{-2}) 120 days after sowing

The data showed the highest DWB (9.183 gm^{-2}) in T5 (weedy check) that differed significantly from all other treatments. The lowest DWB (3.140 gm^{-2}) was recorded in T4 (weed free). It was followed by T1 and TT3 and both were statistically similar. Among various herbicides, the maximum DWB (5.767 gm^{-2}) was recorded in T3 (Puma Super) while the lowest DWB (3.267 gm^{-2}) was found in T10 where Buctril Super was applied. It is clear from the data that weed control throughout the season (T4) resulted in lowest DWB while higher DWB in weedy check was due to the presence of unchecked weeds. O'Donovan (2005) reported that different weed control practices when applied alone were not sufficient to provide adequate weed management. However, combining these practices and integrating them with herbicides use resulted in long term and more cost-effective weed management.

Plant height at maturity (cm)

The results revealed that significantly taller plants (121.0cm) were recorded in T4 (weed free) which differed significantly from all other treatments. It was followed by T6 (3-hoeing with khurpa) and T9 (3-hoeing with kasola) with plant height of 118.5 and 117.5cm, respectively. The presence of taller plants in weed free and 3-hoeings treatments suggested that weeds in these treatments were properly eliminated and the crop was safe from weeds competition for nutrients, light and space. Moreover, hoeing improved soil condition and made soil environment conducive for plant growth. The short statured plants (106.6cm) were measured in T5 (control) that differed significantly from all other treatments. Deshmukh and Atale (2006) conducted field trials to compare 2,4-D and Isoproturon with hand weeding and found that hand weeding increased weed control efficiency (80%) and promoted plant growth and wheat grain yield over control. Among herbicides treatments, the maximum plant height (113.9cm) was recorded in Buctril Super (T10) followed by Puma Super at 2nd irrigation (111.5cm) while the short statured plants (109.2cm) were observed in Sonic applied treatment (T7). It showed that Buctril Super effectively controlled all prevailing weeds and promoted plant growth due to lesser weeds competition with crop plants for available resources.

Number of tillers (m^{-2})

The data regarding the number of tillers m^{-2} as affected by various weed management strategies are presented in Table-2. Among treatments, weedicides application and manual weeding resulted in more tillers than weedy check (control). The maximum number of tillers (492) was recorded in T4 (weed free) followed by T6 (3-hoeing with khurpa) giving 482.7 tillers m^{-2} and both treatments were statistically at par with each other. The minimum number of tillers (273.3) was noted in weedy check (T5). Among herbicidal treatments Buctril Super application produced 422.0 tillers m^{-2} followed by Sonic and Puma Super producing 410 tillers m^{-2} each. The maximum number of tillers m^{-2} produced in weed free and 3-hoeing with khurpa plots might be due to complete eradication of weeds and sufficient availability of nutrients to crop plants and *vice-versa* in weedy check treatment.

Spike length (cm)

The length of spikes is an important economic and yield contributing trait of wheat. The data regarding spike length of wheat showed that the maximum spike length of (12.22cm) was recorded in T4 (weed free) followed by T6 (3-hoeing with khurpa) with spike length of 11.82cm and both treatments were statistically similar to each other (Table-2). The minimum spike length (6.810cm) was found in T5 (weedy check) which differed significantly from all other treatments. Application of Buctril Super (T10) was found better than Puma Super at 1st and 2nd irrigation. The maximum spike length in weed free and 3-hoeing treatments could be due to effective weeds eradication and improvement of soil environment conducive for crop growth. Herbicides application enhanced spike length due to timely and efficiently weeds management which resulted in higher nutrients availability to crop plants. Mushabar *et al*. (2000) and Nadeem (2003) conducted trials to evaluate the efficiency of chemical and manual weed control measures on weed density and yield contributing traits of wheat and observed that hand weeding and herbicides significantly increased the number of fertile tillers, spike length, number of grains (spike^{-1}), 1000-grain weight and grain yield.

Number of grains (spike^{-1})

The potential of spike is measured in terms of its number of grains that is an important yield component. The data showed that the maximum number of grains (73.00) were recorded in T4 (weed free) followed by T6 (3-hoeing with khurpa), T10 (Buctril Super), T9 (3-hoeing with kasola) and T8 (Puma Super at 2nd irrigation) with 72.33, 72.00 and 71.33 grains spike^{-1} respectively (Table-2). However, all the four treatments were statistically at par with each other. Similarly T8 was also statistically similar to T3 (Puma Super at 1st irrigation) producing 68.00 grains spike^{-1}. The minimum number of grains spike^{-1} (49.00) was recorded in T5 (weedy check). The maximum number of grains spike^{-1} in wed free and 3-hoeing with khurpa as well as kasola treatments might be due to eradication of weeds and provision of greater amount of nutrients which produced larger spikes. Mushabar *et al*. (2000) and Shahid *et al*. (2005) also reported greater number of fertile tillers, spike length and number of grains by adopting manual and chemical weed control practices.

1000-grain weight (g)

The data pertaining to 1000-grain weight (g) as affected by various weed management strategies are presented in Table-3. The heaviest grains (37.01g) were recorded in T4 (weed free) followed by T6 (3-hoeing with khurpa) with grain weight of 36.76g and both the treatments were statistically at par with each other. The minimum grain weight was noted in control (35.53g). The heavier grains in weeds free treatment and 3-hoeing as well as herbicides application might be attributed to availability of more resources in terms of nutrients and favourable soil environment. Mushabar *et al*. (2000), Ahmad *et al*. (2001) and Shahid *et al*. (2005) also found heavier grains of wheat in treatments where manual and chemical weed control practices were adopted.

Grain yield (t ha^{-1})

The data given in Table-3 revealed the maximum grain yield (6.167 t ha^{-1}) in T4 (weed free) that differed significantly from all other treatments. It was followed by T6 (3-hoeing with khurpa) and T9 (3-hoeing with kasola) with grain yields of 5.757 and 5.733 t ha^{-1} respectively. However, both treatments produced statistically similar grain yields. The minimum grain yield (2.877 t ha^{-1}) was recorded in T5 (weedy check). Amongst different weed management strategies, weeding through out crop season (T4: weed free) and three hoeing with khurpa as well as kasola resulted in higher grain yields as compare to herbicides application. Among herbicides, Buctril Super (T10) and Puma Super at 2nd irrigation (T8) produced statistically similar grain yields whereas Puma Super at 1st irrigation (T3) and Sonic (T7) were statistically at par with each other. Mushabar *et al*. (2000) and Nadeem (2003) also reported increased biological yield and grain yield while evaluating the efficiency of chemical and manual weed control measures on wheat yield and yield contributing traits.

Cost-benefit ratio (%)

The financial feasibility of adapting appropriate weed management strategies is determined by economics of weed management practices and calculating cost-benefit analysis. Computing the economics of weed management practices, the data revealed the maximum CBR (0.58) in T5 (Table-4). The minimum CBR (0.33) was recorded in Buctril Super @ 500 mL ha^{-1} (T10) followed by T3 (Puma Super at 1st irrigation). While, Sonic (T7) and Puma Super at 2nd irrigation (T8) had similar CBR of 0.36. The data suggest that investing in weed management practices is a financially viable option at current costs and production prices and the most economical weed management strategy is using Buctril Super. Although the higher grain and biological yields were obtained in manual weed control practices yet the cost incurred in those treatments were higher which resulted in higher CBR as compare to herbicides application. Singh *et al*. (2002), in a field experiment on wheat, observed that among the weed control treatments, hand weeding gave the highest grain yield and was significantly superior to both herbicide treatments but the highest net return of per rupee investment was recorded in case of Isoporturon followed by hand weeding and Pendimethalin applications.

Table-1. Fresh & dry weed biomass (FWB and DWB) at 60 DAS and Fresh & dry weed biomass (g m^{-2}) at 120 DAS of wheat as affected by different weed management strategies

No.	Treatments	FWB 60 DAS	DWB 60 DAS	FWB 120 DAS	DWB 120 DAS
T_1	One hoeing with kasola	108.8 a	17.83 b	29.38 b	6.287 b
T_2	Two hoeing with kasola	108.6 a	17.72 ab	21.58 c	4.320 c
T_3	Puma Super (after 1st irrigation)	100.6 bc	16.39 bc	27.27 b	5.767 b
T_4	Weed free	97.88 c	14.29 c	9.333 f	3.140 d
T_5	Control (weedy check)	109.0 a	18.65 a	55.17 a	9.183 a
T_6	3-hoeing with khurpa	102.8 b	16.90 ab	17.49 e	4.310 c
T_7	Sonic	108.3 a	17.36 ab	21.22 cd	4.223 cd
T_8	Puma Super (after 2nd irrigation)	104.7 ab	17.10 ab	18.14 de	3.983 cd
T_9	3-hoeing (with kasola)	108.3 a	17.31 ab	18.81 cde	3.730 cd
T_{10}	Buctril Super	98.91 bc	16.16bc	16.23 e	3.267 cd
	LSD0.05	6.704	2.237	3.255	1.133

Means followed by different letters are significantly different at 5% level of probability.

Table-2. Plant height (PH) at maturity (cm), number of tillers (m^{-2}), Spike length (SL) (cm) and number of grains $spike^{-1}$ (GPS) of wheat as affected by different weed management strategies

No.	Treatments	PH	Tillers m^{-2}	SL	GPS
T_1	One hoeing with kasola	108.0 e	380.0 d	8.45 f	61.33 e
T_2	Two hoeing with kasola	109.1 e	396.0 cd	8.95 e	63.33 de
T_3	Puma Super (after 1st irrigation)	110.5 d	410.0 bcd	9.91 d	68.00 bc
T_4	Weed free	121.0 a	492.0 a	12.22 a	73.00 a
T_5	Control (weedy check)	106.6 f	273.3 e	6.81 g	49.00 f
T_6	3-hoeing with khurpa	118.5 b	482.7 a	11.82 a	72.33 a
T_7	Sonic	109.2 e	410.0 bcd	9.02 e	66.33 cd
T_8	Puma Super (after 2nd irrigation)	111.5 d	408.7 bcd	10.14 cd	70.33 ab
T_9	3-hoeing (with kasola)	117.5 b	436.0 b	11.25 b	71.33 a
T_{10}	Buctril Super	113.9 c	422.0 bc	10.45 c	72.00 a
	LSD0.05	1.249	32.01	0.413	3.219

Means followed by different letters are significantly different at 5% level of probability.

Table-3. 1000-grain weight (TGW) (g) and grain yield (GY) of wheat as affected by different weed management strategies

No.	Treatments	TGW	GY
T_1	One hoeing with kasola	35.58 de	3.213 e
T_2	Two hoeing with kasola	36.28 bc	4.693 c
T_3	Puma Super (after 1st irrigation)	36.133 cd	4.240 d
T_4	Weed free	37.01 a	6.167 a
T_5	Control (weedy check)	35.53 e	2.877 f
T_6	3-hoeing with khurpa	36.76 ab	5.757 b
T_7	Sonic	36.10 cd	4.207 d
T_8	Puma Super (after 2nd irrigation)	36.22 bc	4.727 c
T_9	3-hoeing (with kasola)	36.28 bc	5.733 b
T_{10}	Buctril Super	36.40 bc	4.767 c
	$LSD_{0.05}$	0.594	0.287

Means followed by different letters are significantly different at 5% level of probability.

Table-4. Cost-Benefit Ratio of wheat as affected by different weed management strategies

Treat	Weed Management Strategies	Yield (t ha^{-1})	Income from Grains (Rs. ha^{-1})	Income from Straw (Rs. ha^{-1})	Gross Income (Rs. ha^{-1})	Total Expenditure (Rs. ha^{-1})	Net Income (Rs. ha^{-1})	CBR
T_1	One hoeing with kasola	3.213	76308	9850	86158	47080	39078	0.54
T_2	Two hoeing with kasola	4.693	111459	11150	122609	49680	72929	0.40
T_3	Puma Super (1st irrig)	4.240	100700	11632	112332	39316	67052	0.35
T_4	Weed free	6.167	146466	13132	159598	63839	107318	0.40
T_5	Control (weedy check)	2.877	68329	7915	76244	44480	31764	0.58
T_6	Three hoeing with khurpa	5.757	136729	13132	149861	57480	92381	0.38
T_7	Sonic	4.207	99916	11190	111106	39998	66326	0.36
T_8	Puma Super (2nd irrig)	4.727	112266	13040	125306	45110	80026	0.36
T_9	Three hoeing with kasola	5.733	136159	13092	149251	59700	96970	0.40
T_{10}	Buctril Super	4.767	113216	12965	126181	41639	80901	0.33

Wheat grain: Rs.23750/t Wheat straw: Rs. 2500/t

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