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Efficacy of Different Herbicides for Control of Weeds in Srghum (*Sorghum bicolor* L.) under Rainfed Conditions

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Abstract: Sorghum variety PARC-SS-2 was subjected to five different herbicides with different levels of active ingredients for control of weeds in comparison with hand-weeded and un-weeded check during summer seasons of 1997 and 1998 at the National Agricultural Research Centre Islamabad. Weed population significantly reduced from 73.79 to 90.04 percent due to the application of various herbicides and by 78.69 percent due to hand weeding over the un-weeded check. Reduction in weed population per unit area was more in the increased levels of herbicides. All treatments gave significantly higher grain yields than the unweeded check in both the years. The grain yield of the plots treated with Metolachlor + Atrazine at 1.00 kg ha^{-1} was significantly more than the plots treated with either dose of other herbicides or hand weeded in both the years. At the two levels of herbicides the increase in yield ranged from 845 to 1144 kg ha^{-1} through Metolachlor + Atrazine at 1.00 kg ha^{-1}, 328 to 1144 kg ha^{-1} by hand weeding and 665 to 1750 kg ha^{-1} by Metolachlor + Atrazine at 0.75 kg ha^{-1}, as compared to no weeding. As such, increase in the levels of herbicides increased the yield. It was found that the yield from hand-weeded plots was more than all the herbicides at either level. However, Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai), higher level resulted significantly higher yields than the hand weeded ones. The effect of the lower level of Metolachlor + Atrazine at 0.75 kg ha^{-1} (ai), was at par with hand-weeded plots. Though the difference was there, but it was non-significant statistically. The higher doses of these herbicides which have resulted significant grain yield, could be considered for higher return. The economic analysis revealed that there was increased net income from the plots treated with herbicides or hand weeded over the unweeded check. The highest marginal rate of return (MMR) of 404.16 percent was obtained from T3 (the plots treated with Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai) followed by T6 (Metolachlor + Atrazine at 0.75 kg ha^{-1} (ai) with MRR of 297.22 percent while that of hand weeded treatment the MRR was 229.54 percent.

Key Words: Herbicides; efficacy; weed control; sorghum bicolor Rainfed conditions.

Introduction

There are many factors which hinder the increase in crop production per unit area. One of the factors which causes low production, is weeds infestation. Weeds not only use a portion of water and plant nutrients but also compete for sun light resulting in poor growth of the crop. Sorghum seedlings are relatively weak and cannot compete with weeds. Most of the farmers control weeds mechanically or manually. Herbicides could be useful in barani areas where mechanical weed control is precluded by frequent rains in July and August and weeding can not be carried out in time. Therefore chemical weed control could be the alternative in such a situation. A number of herbicides are available for control of different weeds. Some are used for control of annual grasses while there are others which are used for control of broad leaved weeds (Da Silva *et al*., 1986).

Lee and Choi (1989) have reported that simazine did not control grasses, but controlled broad-leaved weeds. Alachlor controlled all grasses but did not control *Acalypha australis* and *Chenopodeum album*. A combination of simazine and alachlor controlled weeds more effectively than either herbicide alone.

Simazine at 1.5 to 3.0 kg ha^{-1} when applied post sowing, gave significant weed control during the early developmental stages of sorghum crop and highly significant weed control was however reported at a highest herbicide rate. Grain yield increased by 14-24 percent when treated with simazine + 2 hoeings (Tanchev 1989). Balyan and Singh (1986) have reported that nitrofen and hand weedings effectively controlled weeds and gave similar increases in yield and nitrogen uptake compared with unweeded check. In another study on weed control in sorghum Balyan and Singh (1987) have reported that hand weeding 3 times in combination with application of 2 litres nitrofen ha^{-1}, enhanced N uptake by the crop and increased dry matter (DM) production of the crop and weeds.

Bishnoi *et al.* (1990) have reported significant effects of chemical weed control on weed population and grain yield with conventional tillage practices. Gopal and Kondap (1986) have reported that atrazine stimulated the availability and uptake of nutrients by sorghum at low as well as high fertility levels. Latehanna (1987) has reported that at rates above 1.0 kg ha^{-1} (ai), atrazine caused significantly higher crop mortality than lower rates. The present study was carried out to evaluate the efficacy of different herbicides for control of weeds in sorghum.

Materials and Methods

The trials were carried out during kharif (monsoon) seasons of 1997 and 1998 at the National Agricultural Research Centre Islamabad (located at 33 ^{0}N and 518 m above sea level where the annual rainfall ranges from 500 to 1500 mm and the soil is clay-loam with a pH of 7.8 to 8.2). Sorghum variety PARC-SS-2 was subjected to five different herbicides with different levels of active ingredients and hand-weeded and an un-weeded check. A randomized complete block design with three replications was used to conduct the trial. The treatments were:

T1 Pendimethalin at 1.00 kg ha^{-1} ai (pre-emergence).
T2 Oxadiazon at 0.35 kg ha^{-1} ai (pre-emergence).
T3 Metolachlor + Atrazine at 1.00 kg ha^{-1} ai (pre-emergence)
T4 Pendimethalin at 0.75 kg ha^{-1} ai (post-emergence).
T5 Oxadiazon at 0.25 kg ha^{-1} ai (post-emergence).
T6 Metolachlor + Atrazine at 0.75 kg ha^{-1} ai (post-emergence).
T7 Topogard at 0.50 kg ha^{-1} ai (post-emergence).
T8 Dicuron-MA at 0.90 kg ha^{-1} ai (post-emergence).
T9 Hand weeding (twice)
T10 Unweeded Check

Planting was done with rotary hand dibler on ridges 75 cm apart with 15 cm plant to plant distance. Urea and DAP fertilizers were applied at 60 kg ha^{-1} nitrogen and 30 kg ha^{-1} P_2 O_5. Half of N

with full dose of P_2 O_5 was applied at sowing time and the remaining half N as side dressing when the crop was at knee-high stage. Seedlings were rated for herbicide injury two weeks after crop emergence. Weed control ratings were scored 3 and 8 weeks after planting the crop. Weed control ratings were made by comparing the weed-free and unweeded check assigning zero to 'no weed control'. Data on the green and dry weight of weeds per plot, number of weeds per 1.5 m^2, and yield of grain (kg ha^{-1}) and stover (t ha^{-1}), were recorded; total income from grain and stover, total cost incurred, net benefit and percentage marginal rate of return (MRR) over the control (check) were calculated, following Fisher and Yates (1983).

Results and Discussion

Weeds density: The data on weeds population showed significantly reduced from 73.79 to 90.04 percent due to the application of various herbicides and by 78.69 percent due to hand weeding over the un-weeded check (Table 1). The reduction in weeds population per unit area was observed in the increased levels of herbicides. It ranged from 75.73 to 79.13 percent in Pendimathelin, 73.79 to 75.97 percent in Oxadiazone and 86.89 to 90.04 percent in Metolachlor + Atrazine. In Topogard and Dicuran the population density of weeds was control by 83.98 and 84.95 percent, while in the hand weeded plots it was recorded 78.64 percent. Dowler *et al.* (1983) have reported that the use of atrazine alone or in combination with metolachlor or pendimethalin as early postemergence treatments was the most promising method for control of weeds in sorghum. Greer and Denman (1983) were of the opinion that the use of herbicides along with good cultural practices would help control weeds and make crop production more profitable.

Dry matter from weeds: The dry matter accumulation from weeds was found to decrease with increase in the levels of herbicides (Table 1). The dry matter of weeds from the control plots was significantly more than all the treatments in the two years study. Amongst the herbicides, Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai), showed the maximum efficacy giving only 533 kg ha^{-1} dry matter of weeds as against 5247 and 1033 kg ha^{-1} from the un-weeded and hand weeded plots, respectively. The dry matter obtained from the lower levels of herbicides ranged from 747 to 467 kg ha^{-1} and at the highest levels of herbicides it was from 533 to 1313 kg ha^{-1}. The dry matter of weeds of hand weeded plots was significantly more than the plots treated with Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai). The difference with other treatments was non-significant. Though there were differences among the hand weeded and chemically treated plots in the following year, but these were non-significant. The overall results showed that herbicides with Atrazine as an active ingredient, were more effective for weed control and the crop plants fully utilized enough moisture and nutrients from the soil for which the weeds compete. Balyan and Singh (1986) have reported that nitrofen and hand weedings effectively controlled weeds and gave similar increases in yield and nitrogen up-take compared with unweeded check. In another study on weed control in sorghum. Balyan and Singh (1987) have reported that by hand weeding three times and application of 2 litres nitrofen ha^{-1} enhanced N uptake by the crop and increased DM production.

Grain Yield: The grain yield was proportionate to the control of weeds either by herbicide or by hand weeding (Table 1). All treatments gave significantly higher grain yields than the unweeded check in both the years. The grain yield of the plots treated with Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai) was significantly more than the plots treated with either dose of other herbicides or hand weeded in both the years. Though the difference was non-significant statistically but the two levels of

Table 1: Efficacy of different herbicides for control of weeds in sorghum under rainfed conditions (NARC Islamabad).

		Treatments										
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	LSD at 5%
Weed density 1.5 m^2 area	1997	39	46	18	47	51	23	26	34	37	193	335.76
	1998	47	53	23	53	57	31	40	28	51	219	446.53
	Mean	43	49	20	50	54	27	33	31	44	206	
% mean weed control over check		79	76	90	76	74	87	84	85	79	-	
Weight dry matter of weeds kg ha^{-1}	1997	1162	1336	488	700	1100	723	1036	1150	866	4760	74.22
	1998	1000	1290	578	966	1234	467	1200	1482	1200	5658	117
	Mean	1081	1313	533	833	1167	747	1118	1316	1033	5209	
Grain yield kg^{-1}	1997	1678	1310	1931	1507	1129	1878	1004	991	1693	1009	7.1
	1998	1422	1156	2166	1633	1078	1622	1156	1289	1733	800	-
	Mean	1550	1233	2049	1570	1104	1750	1080	1140	1713	905	
Grain yield increase over check kg ha^{-1}		645	328	1144	665	199	845	175	235	808	-	
Stover yield kg ha^{-1}	1997	9.3	8.9	15.1	8.0	6.2	12.7	7.6	8.8	11.5	7.6	
	1998	12.4	7.9	121.0	8.9	10.2	10.8	8.6	8.5	10.4	6.3	
	Mean	10.9	8.4	13.6	8.5	8.2	11.7	8.1	8.6	10.9	6.9	
Stover yield increase over check kg ha^{-1}		4.0	1.5	6.6	1.5	1.3	4.8	1.2	1.7	4.0	-	

Table 2: Economics of different herbicides for control of weeds in sorghum under rainfed conditions (NARC, Islamabad).

Treatment	Total income (Rs/ha)	Total cost (Rs/ha)	Net benefit (Rs/ha)	Marginal rate of return (%) over check
T1	18218	8576	9642	215.82
T2	14424	8472	5952	94.95
T3	23878	8486	15392	404.16
T4	17814	8363	9451	209.56
T5	13091	8255	4836	58.40
T6	20423	8296	12127	297.22
T7	12817	8440	4377	43.37
T8	13553	8476	5077	66.30
T9	19868	9807	10061	229.54
T10	10779	7726	3053	-

Herbicides	Rate/unit/per kg
Pendimethalin	Rs. 650/=
Oxadiazon	Rs. 670/-
Metolachlor	Rs. 600/-
Atrazine	Rs. 600/-
Topogard	Rs. 714/-
Dicuran	Rs. 750/-
Primextra	Rs. 660/-

Grain price = Rs. 10/- per kg.
Stover price = Rs. 10/- per 40 kg
Hand weeding = 28 man days at Rs.75/= per man day (Rs.2081/ha).

herbicides, the increase in yield ranged from 845 to 1144 kg ha^{-1} with application of Metolachlor + Atrazine at 0.50 kg ha^{-1}; 328 to 1144 kg ha^{-1} by hand weeding and 665 to 1750 kg ha^{-1} by Metolachlor + Atrazine at 1.00 kg ha^{-1}, as compared to no weeding. As such, increase in the levels of herbicides increased the yield. The hand-weeded plots also yielded significantly more grain yield than the unweeded plots. Comparing the yield from hand-weeded plots with the herbicide treated plots, it was found that the yield from hand-weeded plots was more than all the herbicides at either level. However, Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai) at higher levels resulted significantly higher yields than the hand weeded ones. These results are partially in agreement with Bishnoi *et al.* (1990). Gopal and Kondap (1986) have reported that atrazine stimulated the availability and uptake of nutrients by sorghum at low and specially at high fertility levels. Latehanna (1987) has reported that at rates above 1.0 kg ha^{-1} (ai), atrazine caused significantly higher crop mortality than lower rates. The effect of the lower level of Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai) was at par with hand-weeded plots. Though the difference is there, but it was non-significant statistically. The higher doses of these herbicides which have resulted significant grain yield, could be considered for higher return. It may be pointed out that the percentage weed control by lower levels of Metolachlor + Atrazine at 1.00 kg ha^{-1} (ai), was not up to the extent as observed in case of hand weeding, but still, their ultimate effect upon crop yield was encouraging. The reason might be the differential weed-complex and weed growth per unit area and the differential affectivity of the herbicide towards the most competitive weed flora which were responsible for the crop yield.

The economic analysis presented in Table 2 reveled that there was increased net income from the plots treated with herbicides or hand weeded over the unweeded check. The increase in net benefit still the yield was high. In the following year, yield from the plots treated with Metolachlor + Atrazine at 1.00 kg ha^{-1}(ai) was again significantly higher than rest of the treatments. At ranged from 58.40 to 404.16 percent. The highest MRR of 404.16 percent was obtained from T3 (the plots treated with Metalachlor + Atrazine at 1.00 kg ha^{-1} (ai) followed by T6 (Metalachlor + Atrazine at 0.75 kg ha^{-1} (ai) with MRR of 297.22 percent while that of hand weeded treatment the MRR was 229.54 percent.

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