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Response of Weeds and Wheat Yield to Tillage and Weed Management

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ABSTRACT

Weed flora and yield attributes of wheat in two tillage systems (conventional and minimum tillage) with five weed management systems (unweeded control, handweeding one, post emergence application of sulfosulfuron @ 28 g ai/ha, post emergence application of fenoxaprop-P-ethyl @ 100g ai/ha, and rice straw mulch @ 4 t/ha + sulfosulfuron @ 26 g ai/ha) were evaluated in Khumaltar, Nepal from 2001-02 to 2002-03 winter season. The most common narrowleaf weed species were *Alopecuros aequalis* and *Phalaris minor* and broadleaf dicot were *Chenopodium album, Coronopus didymus, Rumex crispus, Stellaria media,* and *Soliva anthemifolia*. The population of *A. aequalis, P. minor, R. crispus,* and *S. media* was more in conventional tillage at 4 weeks after sowing compared to minimum tillage. The total population of narrowleaf weeds was higher in conventional tillage than in minimum tillage at 4 and 8 weeks after sowing. Sulfosulfuron gave broader spectrum of weed control than fenoxaprop-P- ethyl. Sulfosulfuron has suppressed both narrowleaf and broadleaf weeds. Fenoxyprop-P-ethyl suppressed only narrowleaf weeds, but broadleaf weeds like *C. album, C. didymus, R. crispus, S. anthemifolia,* and *S. media* were not suppressed. Among the weed management treatments, sulfosulfuron, handweeding one, and straw mulch + sulfosulfuron were the best in terms of weed suppression and yield attributes. There was no impact of conventional tillage and minimum tillage on grain yield of wheat.

Key words: conventional tillage, minimum tillage, weed flora, weed management, wheat

INTRODUCTION

Wheat is the third important cereal crop after rice and maize. It is grown in terai, mid-hills and inner terai of Nepal. The area, production and productivity of wheat are 667,077 ha, 125,8045 Mt, and 1886 kg/ha respectively (Statistical information, 2001/02). It is a winter season crop grown mainly under rainfed condition after rice, being rice–wheat a major cropping system which is about 550,000 ha.

Weeds are important biotic factor in the production of wheat. They tend to shift with the change in the tillage, management, and cropping system although there are other factors that govern the changes in the weed flora. Weeds account for 10-80 percent yield reduction depending upon the weed species and infestation and caused depletion of soil water up to 6.5 cm (Mehra and Gill, 1988; Khera *et al*., 1995; Afentouli and Eleftherohorinos, 1996; Ranjit *et al*., 1998). With time, in the absence of tillage, populations of grassy annual weeds increased in maize/soybean rotation and wind dispersed weed increased in wheat - soybean rotation (Tuesca *et al*., 2001).

The common weeds of wheat crop are

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Alopecuros spp., C. album, C. didymus, Fumaria sp., Lathyrus aphaca, P. minor, Polypogon fugox, Polygonum spp, Rumex spp., and S. media. *P. minor* is an important weed in the rice – wheat crop rotation. However, this weed is more common in the sorghum-wheat and soybean-wheat rotation and it tends to be surface rooting (Okerke *et al*., 1981).

Herbicides Isoproturon, 2,4-D Na-salt, pendimethalin, fenoxaprop-P-ethyl, sulfosulfuron, clodinafop, tralkoxydim, metribuzin and diclofop were found to be effective in controlling grassy weeds including *Elymus repens* and isoproturon resistant *P. minor* ranging from 72-98 % as well as broadleaf weeds *Gallium aparine, Sinnapis arvensis, S. media* (Parrish *et al*., 1995; Malik *et al*., 1998; Rainbolt *et al*., 1999; Ranjit, 1999; Hamal *et al*., 2000). The rice straw mulch increased the wheat yield and suppressed the weeds (Roy, 1989; Ning and Hu, 1990). Paddy straw mulch was more effective than the stubble of the preceding crop under rainfed wheat. *Lantana camera* mulch in minimum tillage and conventional tillage maintained higher values of leaf area index (LAI) of wheat (Verma and Acharya, 1996).

Many herbicides have been tested in the past to control narrowleaf and broadleaf weeds in wheat. Reduced and zero tillage system for growing wheat in low cost has been under the way to its popularity. Not only the tillage system but also the rotation of herbicides and other weed control methods to avoid the risk of developing herbicide resistant weeds in the future is of great concerned. However, this instance has not been reported in Nepal. Hence, considering all the above reasons, the present study has been initiated in the Nepalese soil to find out the feasible tillage systems and weed management methods for controlling common weeds in wheat after rice.

MATERIALS AND METHODS

This experiment was conducted in the lowland field in Agronomy farm, Khumaltar, Nepal during the winter season of 2001/02 and 2002/03 in a split plot design replicated 4 times. The main plot and sub plot comprises of tillage and weed management respectively. The plot size was 4m × 5m (20m^2) and row spacing 20 cm. The field is located at 27° 40’N latitude and 85° 20’E longitude with an elevation of 1360m above mean sea level. Soil samples were collected and bulked to record the fertility status before and after the experiments. Soil analysis, carried out before and after the first and second wheat crop, showed the following results:

Nutrient	First Crop	Second Crop	Remarks
percent organic matter	2.28 to 2.55	3.08-3.75	medium
Percent nitrogen	0.086-0.144	0.094-0.196	low to medium
Phosphorus	176-221 kg/ha	122-202 kg/ha	medium
Potassium	263-409	190-444 kg/ha	medium to high

The soil type is silty clay with soil moisture content of 30-40 percent. The mean of minimum temperature was 0°C in January to 14.3°C in May while mean maximum temperature was 15.8°C in January to 29.7°C in May. The total mean rainfall was 240 mm with 32 rainy days.

The field was ploughed and harrowed twice in case of conventional tillage (CT). About 5 –7cm deep ploughing (one pass) by Chinese seed drill was done for the minimum tillage (MT). Planting was on 14 November 2001 and 18 November in 2002 by making a line with hand hoe for both the tillage systems. Chemical fertilizer was applied at the rate of 100 kg nitrogen, 50 kg phosphorus and 30 kg potash per hectare. Nitrogen was splitted in two halves. The first half was applied during wheat planting and other half during top dressing 45 days after planting. The variety used was Pasang-Lhamu at the seed rate of 120 kg/ha. Irrigation was applied after 24 days of wheat seeding. Chopped rice straw @ 4t/ha was used for the mulch treatment one day after wheat seeding.

There were 5 weed management treatments:

W_1 = unweeded control
W_2 = hand weeding once
W_3 = post emergence application of sulfosufuron {trade name = Leader® 75WG, chemical name = (1-(2-ethylsulfonylimidazo [1,2-a] pyridin-3-ylsulfonyl)-3-(4,6-dimethoxypyramidin-2-yl)urea)} @ 28 g ai/ha
W_4 = post emergence application of fenoxaprop-P-ethyl {trade name = Puma super® 10 EC, chemical name = Ethyl: (±) -ethyl-2[4-(6-chloro-2benzoxazolyl)oxy] phenoxy] propanoate} @ 100 g ai/ha
W_5 = rice straw mulch @ 4t/ha + sulfosulfuron @ 26 g ai/ha

One gram of sulfosulfuron was mixed with 37ml cationic surfactant (Leadermix®) before the spray. The spray volume was 500 l/ha. The type of the sprayer used was Aspee Knapsack with 4 flat fan nozzles. The sky during the herbicide spray was clear sunny with mild cold wind. To control aphids, dimethoate (Roger® 30 EC) @ 3 ml/2l water was sprayed during the flag leaf initiation stage of wheat.

Weeds were counted from 0.50 m^2 area by randomly placing 0.25 m^2 quadrant at 2 places in each plot. Weed count was performed 3 times, the first at 4 weeks after wheat seeding (4WAS), the second at 8 weeks after wheat seeding (8WAS) and the third at milking stage of wheat (MSW). The first and second weed counts were carried out from the same spot in each plot but the third count was done from the different spot in each plots to see the changes in the weed flora during the reproductive stage of wheat. Individual weed species were counted. Weeds were pulled during the second count and third count and biomass was recorded after separating and cutting the roots of the narrowleaf and broadleaf weeds

Yield parameters such as plant height (cm), tillers per meter square, seeds per panicle, thousand seed weight (g), and grain yield (kg/ha) were recorded. Plant height was recorded from the average of 5 plants in each plot. Tillers per meter square were recorded by placing 0.25m^2 quadrate in 4 places in each plot. Harvesting was done from 13. 44 meter square (3.20m × 4.20m). Grain yield was adjusted at 14% moisture content. Harvesting was done on 11 May 2002 and 13 May 2003.

RESULTS AND DISCUSSION

A number of narrowleaf and dicot broadleaf weed species were recorded in the experimental field (Table 1). However, the dominant species were only few such as *A. aequalis, C. album, C. didymus. P. minor, R. crispus, S. media, and S. anthemifolia.*

Response of weed population to tillage

Weed density was not significantly affected by the tillage. Probably it might need many years of rotations to see its effect on weed density and shift. Reduced tillage may influence weed frequency through changes in the microenvironments of weeds. Wicks and Somerhalder (1971) reported that reduced tillage concentrates weed seeds at the soil surface resulting in increased weed pressure. In the present study, the total number of broadleaf weeds was comparatively less than the narrowleaf weeds in both tillage systems (Table 2). The population of *A. aequalis*, *P. minor,* and *S. media* was low at 4WAS (Figure 1a, b, d). The population of *P. minor* was comparatively lower than *A. aequalis* (Figure 1b and a). The annual dicot weed including *C. album* was reported to be more common in tilled systems (Buhler and Daniel, 1988; Teasdale *et al*., 1991; Blackshaw *et al*., 1994; Anderson *et al*., 1998; Yenish *et al*., 1992). Association of wind dispersed species in reduced tillage and summer annual dicots in conventional tillage have been reported by Derksen *et al*. (1993). The number of *S. anthemifolia* has been reported to be higher in minimum tillage (Ranjit, 1999).

Table 1 Weed species recorded in wheat crop.

Weed species	Family	Weed species	Family
Narrowleaf weeds			
Alopecuros aequalis Sobol.	Poaceae	*Oxalis corniculata* L.	Oxalidaceae
Cynodon dactylon (L.) Pers.	Poaceae	*Polygonum hydropiper* L.	Polygonaceae
Phalaris minor Retz.	Poaceae	*Polygonum* spp.	Polygonaceae
Broadleaf weeds (Dicot)		*Ranunculus* sp.	Ranunculaceae
Anagalis arvensis L.	Primulaceae	*Rorripa indica*	Brassicaceae
Alternanthera philoxeroides (L.)DC.	Amaranthaceae	*Rumex crispus* L.	Polygonaceae
Bothiospermum sp.	Boraginaceae	*Senicio vulgaris* L.	Compositae
Capsella-bursa-pastories Medic.	Brassicaceae	*Soliva anthemifolia*	Compositae
Cardamine pratense	Brassicaceae	*Stellaria media* Villars	Caryophyllaceae
Chenopodium album L.	Chenopodiaceae	*Stellaria aquatica* Scop.	Caryophyllaceae
Chenopodium ambrosoides L.	Chenopodiaceae	*Stellaria alsine* Grimm.	Caryophyllaceae
Coronopus didymus Smith.	Brassicaceae	*Trifolium repens* L.	Leguminosae
Gnaphalium affine D. Don.	Compositae	*Vicia hirsuta* S.F.Gray	Lequminosae
Lactuca sp.	Compositae		
Mazus sp.	Scrophulariaceae		

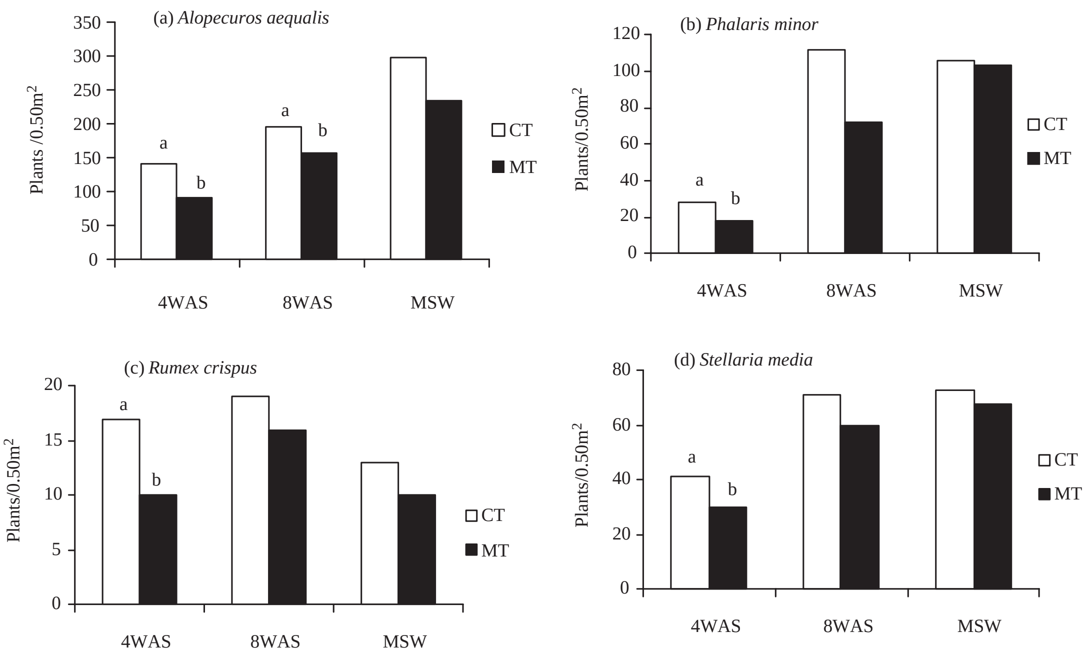

Figure 1 (a-d) Response of some important weeds to conventional tillage (CT) and minimum tillage (MT) at 4 weeks after seeding (4 WAS), 8 weeks after seeding (8WAS), and maturity stage of wheat (MSW). Values in the bars with the same letters above are not significantly different at the 0.05 level. Bars without letter are not significantly different (average of 2 years).

The interaction of tillage and weed management was not significantly different although the total number of narrowleaf weeds was less in minimum tillage than in conventional tillage at 4 and 8 WAS. The two years combined data of total narrowleaf weeds showed the significant impact of tillage at 4 and 8 WAS but not on the broadleaf weeds (Table 2).

Response of weed population to management practices

Significantly less narrowleaf and broadleaf weed was recorded due to straw mulch at 4WAS (before application of sulfosulfuron (Table 2). Weeds like *A. aequalis and C. album* were affected by the straw mulch at 4 WAS (Figure 2a and b). Lee *et al*. (1991) reported that rice straw inhibits germination of *P. minor*. In this experiment, straw mulch suppressed narrowleaf weeds up to 23%, and broadleaf weeds up to 36% compared to unweeded control at 4WAS (Table 2). But after 4WAS, other flush of weed seeds emerged. The reason is not clear but it might be that the suppressing ability of straw mulch after few weeks has gone down and the second flush of weed started germination. One glasshouse experiment in Taiwan showed that phytotoxins are present in the soil during the 1st month of straw decomposition (Chou and Lin, 1976). With the application of sulfosulfuron, narrowleaf and broadleaf weeds were suppressed from 41-72% and 61-80% at 8WAS, respectively (Table 2). Weeds like *A. aequalis, C. album, S. anthemifolia*, and *S. media* were reduced with the application of sulfosulfuron after straw mulch, which was comparable to hand weeding treatment W_2 (Figure 2a, b, e, and f). This showed that an additional weed control is essential to suppress the weeds that emerged after 4-5 WAS in case of straw mulch.

The effects of weed management to some

Table 2 Effect of tillage and weed management on number of narrowleaf and broadleaf weeds in wheat (average of 2 years).

Treatments	Narrowleaf			Broadleaf		
	4WAS	8WAS	MSW	4WAS	8WAS	MSW
Tillage	---------- Plants /0.50m^2 ----------					
Conventional tillage (CT)	168[1]	308	403	153	176	161
Minimum tillage (MT)	110	230	346	94	161	166
Weed Management						
Unweeded Control (W_1)	141 a	520 a	748 a	134 a	252 b	119 bc
Hand weeding one (W_2)	145 a	198c	290 c	128 a	86 cd	139 b
Sulfosulfuron (W_3)	154 a	147 c	205 d	123 a	45 d	44 c
Fenoxaprop-P-ethyl (W_4)	147 a	177c	261 cd	147 a	361 a	469 a
Straw mulch + sulfosulfuron (W_5)	108 b	303 b	371 b	86 b	99 c	47 c
Tillage (T)	*[2]	**	NS	NS	NS	NS
Weed management (W)	**	**	**	*	**	**
T x W	NS	NS	NS	NS	NS	NS

1) Means within the same column and grouping followed by the same letter are not different according to Fisher's protected test P=0.05.

2) Treatments effects and interactions were significant at 5% (*), significant at 1% (**) or nonsignificant (NS).

common weed species are shown in Figure 2. The population of these species was above 10 plants per 0.50m^2 compared to rest of other species. Post emergence application of sulfosulfuron alone suppressed *A. aequalis, C. album P. minor, R. crispus, S. anthemifolia,* and *S. media* at 8WAS (Figure 2). Fenoxaprop-P-ethyl has good effect on grassy weeds at 8WAS but not on the broadleaf weeds in both years.

It has been reported that fenoxaprop-P-

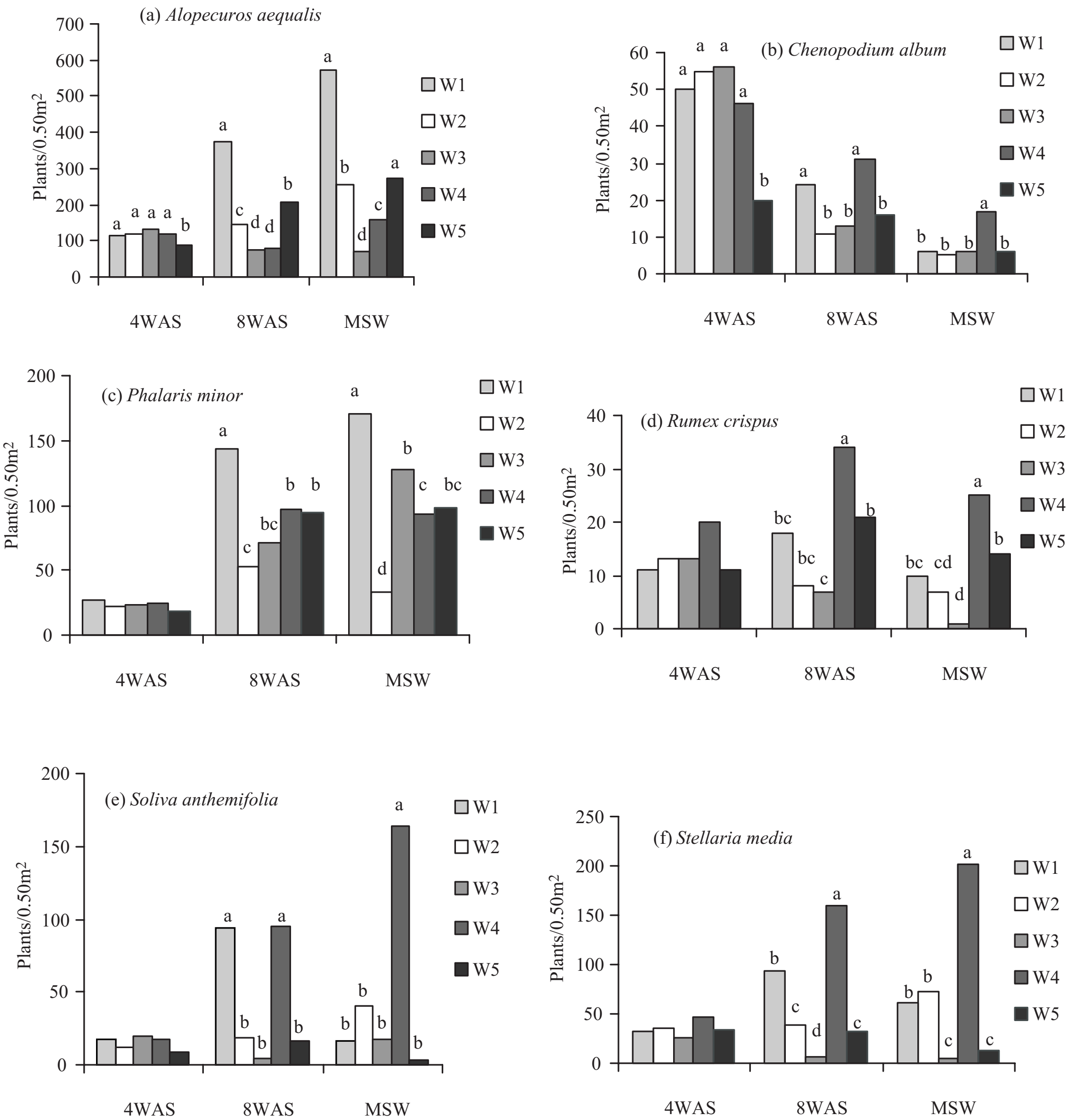

Figure 2 (a-f) Response of some important weeds to different weed management W1 (unweeded control), W2 (handweeding 1), W3 (sulfosulfuron), W4 (fenoxaprop), and W5 (straw mulch + sulfosulfuron) at 4 weeks after seeding (4WAS), 8 weeks after seeding (8WAS), and maturity stage of (MSW). Values in the bars with the same letters above are not significantly different at the 0.05 level. Bars without letter are not significantly different (average of 2 years).

ethyl (50 g/ha) applied in late November at the 2-3-leaf stage of wheat gave good control of grasses including *A japonicus*. However the best control of grasses and broadleaf weeds was obtained with a mixture of fenoxaprop-P-ethyl and fluroxypyr (Fan *et al*., 1992). Control of broadleaf and grassy weeds was achieved by tank mixed combination of amidosulfuron and fenoxaprop-P-ethyl that applied in wheat, barley, rye, and triticale (Adamczeweski *et al*., 1994).

The number of *P. minor* was higher in the second year (2002-03) at 4WAS, 8WAS, and MSW. *S. media* was more at 8WAS in the second year. But *S. anthemifolia* increased at MSW in the second year. *A. aequalis* was less in the second year in all the counts than in the first year (2001-02). Interaction of year and tillage showed that *A. aequalis* and total narrowleaf weeds were more in the first year in both tillage systems at 4WAS. But in contrast *P. minor* increased in both tillage in the second year at 8WAS (data not presented).

Response of weed biomass to tillage and weed management

Dry weed biomass was different in different weed management treatments in both years. All the weed management treatments have suppressed the narrowleaf weed biomass compared to control. Sulfosulfuron has suppressed both narrow and broadleaf weed biomasses showing better performance in controlling the weeds. Fenoxaprop showed better suppression to grassy weed biomass but failed to suppress the broadleaf weed biomass. Broadleaf weed biomass was even higher in fenoxaprop than in unweeded control. It might be due to less competition of broadleaf weeds to narrowleaf weeds resulting to more for prolific growth. Both the herbicides performed better than the unweeded control. Straw mulch + sulfosulfuron showed better effect on weed biomass at the maturity stage of wheat than at 8 WAS. Tillage did not significantly suppress both weed biomasses (Table 3).

Table 3 Dry narrowleaf and broadleaf weed biomass as effected by tillage and weed management at 8 weeks after seeding (WAS) and maturity stage of wheat (MSW).

Treatments	8WAS		MSW	
	Broadleaf	Narrowleaf	Broadleaf	Narrowleaf
Tillage	------------------------ ght ($g/0.50m^2$) ------------------------			
Conventional tillage (CT)	3.3[1]	9.6	13.5	71.2
Minimum tillage (MT)	3.5	9.4	14.3	66.0
Weed Management				
Unweeded Control (W_1)	4.9 b	18.0 a	12.1 b	132.0a
Hand weeding one (W_2)	1.4 c	5.8 c	14.6 b	55.0 b
Sulfosulfuron (W_3)	1.2 c	4.9 c	1.9 c	57.8 b
Fenoxaprop-P-ethyl (W_4)	7.4a	7.3 c	38.2 a	44.5 b
Straw mulch + sulfosulfuron (W_5)	2.1 c	11.7 b	2.8 c	53.6 b
Tillage (T)	NS[2]	NS	NS	NS
Weed management (W)	**	**	**	**
T x W	NS	NS	NS	NS

1) Means within the same column and grouping followed by the same letter are not different according to Fisher's protected test P=0.05.

2) Treatments effects and interactions were significant at 5% (*), significant at 1% (**) or nonsignificant (NS)

Response of yields and yield components to tillage

Yield parameters such as plant height, tillers/m^2, seeds/panicle, thousand seed weight and grain yield was not different between both tillage systems (Table 4). Hammel (1995); Shrestha *et al*. (2002) have reported similar results.

Response of yields and yield components to weed management

Plant height was different in both the years. Plants were taller in the treatments W_2, W_3, and W_5 compared to W_1. Number of tiller per square meter was also higher in W_2, W_3, and W_5 compared to W_1.The number of tiller ranged from 184/m^2 in W_1 to 359/m^2 in W_3 and 412/m^2 in W_5. However, tiller/m^2 in W_2 was at par with W_4. With the increase in weed population, the number of tillers/m^2 decreased (Table 2 and 4).

The number of seeds per panicle was higher in W_2 and lowest in W_1 showing the impact of weed management. But the seeds per panicle in W_5 was comparable to $W_{1,}$ the higher number of tillers must have attributed to higher grain yield than in W_1 **(**Table 4 and Figure 3). Significantly different grain yield was recorded in both the years. The grain yield was low in 2002-03 compared to 2001-02. Other yield parameters such as tillers/m^2 and plant height were also less in 2002-03 than in 2001-02. The reason behind this might be the occurrence of rainfall after the irrigation was applied in the field.

Treatments W_2, W_3 and W_5 gave higher yield 2914 kg/ha, 2906 kg/ha, and 2647 kg/ha respectively than W_4 (2194 kg/ha) and W_1 (1383 kg/ha) (Figure 3).

Increase in wheat grain yield with the application of sulfosulfuron and fenoxaprop herbicides was also reported by the other researchers (Brar *et al*., 1998; Singh *et al*., 1998; Shukla *et al*., 1998). The grain yield has also shown the same type of trend (Figures 3 and 4).

Table 4 Effect of tillage and weed management on yield parameters of wheat.

Treatments	Plant height	Tillers	Seeds/panicle	1000 seed weight
	(cm)	Plants/ m^2	Number	(g)
Tillage				
Conventional tillage (CT)	105.6[1]	310	44	37.3
Minimum tillage (MT)	105.8	329	41	37.6
Weed Management				
Unweeded Control (W_1)	101.6 b	225 d	40 c	35.0 c
Hand weeding one (W_2)	106.6 a	312 c	46 a	37.9 b
Sulfosulfuron (W_3)	109.0 a	359 b	42 bc	38.0 b
Fenoxaprop-P-ethyl (W_4)	103.4 b	287 c	45 ab	37.0 b
Straw mulch + sulfosulfuron (W_5)	107.8 a	412 a	39 c	39.3 a
Tillage (T)	NS[2]	NS	NS	NS
Weed management (W)	**	**	**	**
T x W	NS	NS	NS	NS

1) Means within the same column and grouping followed by the same letter are not different according to Fisher's protected test P=0.05.

2) Treatments effects and interactions were significant at 5% (*), significant at 1% (**) or nonsignificant (NS)

The present result showed that the both narrowleaf and broadleaf weeds affected on the wheat grain yield. Figures 3 and 4 showed that both weeds have contributed to the reduction of grain yield.

The low yield in W_4 might be due to higher number of broadleaf weeds although the narrowleaf weeds were less compared to W_5. Other treatments W_2, W_3 and W_5 reduced the broadleaf weeds. The weed density of both narrowleaf and broadleaf weeds increased during the maturity stage so it is essential to control in order to minimize the weed seed bank in the consecutive years. Sulfosulfuron alone increased wheat grain yield compared to unweeded control.

Plant height, tillers per square meter, thousand seed weight and grain yield were higher in the first year than in the second year. It might be due to increased number of *P. minor* as well as rainfall pattern (data not presented).

CONCLUSION

No specific weed species were associated with the tillage systems in the present study. Both tillage systems have same type of weed species but with different intensities. There were more

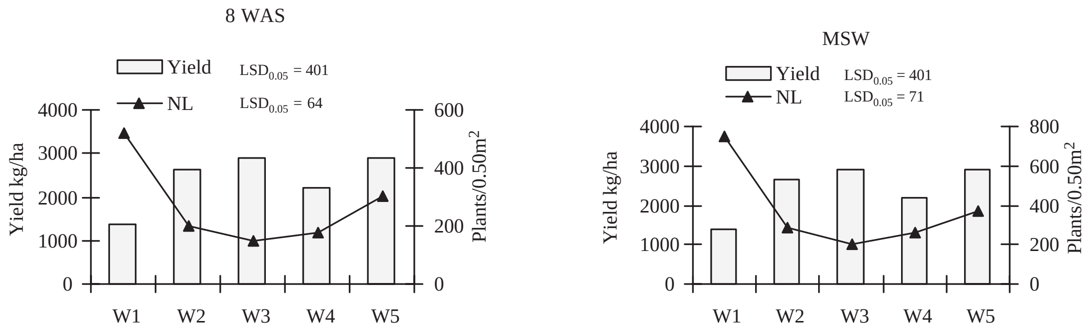

Figure 3 Response of wheat grain yield and narrowleaf weeds (NL) to different weed management W1 (unweeded control), W2 (handweeding 1), W3 (sulfosulfuron), W4 (fenoxyprop), and W5 (straw mulch + sulfosulfuron) at 8 weeks after seeding (8WAS) and maturity stage of wheat (MSW).

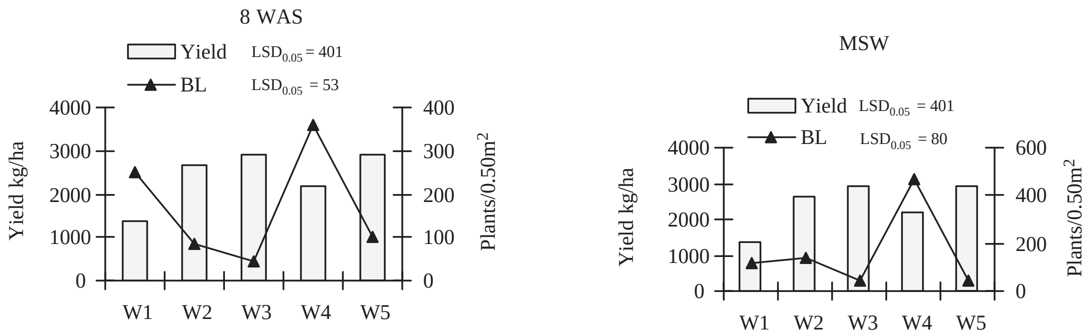

Figure 4 Response of wheat grain yield and broadleaf weeds (BL) to different weed management W1 (unweeded control), W2 (handweeding 1), W3 (sulfosulfuron), W4 (fenoxaprop), and W5 (straw mulch + sulfosulfuron) at 8 weeks after seeding (8WAS) and maturity stage of wheat (MSW).

Narrowleaf than broadleaf weeds in both tillage systems. The most common narrowleaf weed species were *A. aequalis* and *P. minor*, while broadleaf dicot was *C. album, C. didymus, R. crispus S. media*, and *S. anthemifolia*. The population of *A. aequalis, P. minor, R. crispus*, and *S. media* was higher in conventional tillage than in minimum tillage. Total population of narrowleaf weeds was higher in conventional tillage than in minimum tillage at 4 and 8 WAS. Among the weed management treatments, sulfosulfuron, hand weeding one and straw mulch + sulfosulfuron performed best in terms of weed suppression and yield attributes. Sulfosulfuron has suppressed both narrowleaf and broadleaf weeds. Although fenoxaprop suppressed narrowleaf weeds, broadleaf weeds like *C. album, C. didymus, R. crispus, S. media,* and *S. anthemifolia* were not suppressed. Straw mulch alone suppressed the first flush of weeds until 4-5 WAS. But with the application of sulfosulfuron suppressed the weeds that emerged in the later stage. It showed that the straw mulch needs an additional weed control method to reduce the weeds in the later stage.

So from this study it can be concluded that depending on the weed flora even in the straw mulch, selective herbicides can be applied. If farmers can identified the weeds and use proper herbicide, it will help to increase efficiency of weed control. Fenoxaprop might not be advisable when the broadleaf weeds dominate the weed flora. Since yield was not different between conventional and minimum tillage, wheat can be planted with minimum tillage and proper weed management. Sulfosulfuron gave broader spectrum of weed control than fenoxaprop-P- ethyl. From this study it showed that there is no need of straw mulch because sulfosulfuron alone gave effective weed control with high yield.

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