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Response of Weeds and Yield of Dry Direct Seeded Rice to Tillage and Weed Management

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ABSTRACT

The study was initiated to assess the performance of rice (*Oryza sativa*) under dry direct seeded environment with two tillage systems of conventional tillage and minimum tillage and five weed management treatments namely unweeded control, handweeding twice 25 and 45 days after seeding, anilophos + one handweeding, bispyribac-sodium, and straw mulch + bispyribac-sodium as an alternate method of transplanting in the mid-hill ecology. Both anilophos and bispyribac–sodium were found to reduce narrowleaf and broadleaf weeds compared to unweeded control. However, anilophos reduced *Cyperus difformis, C. sanguinolentus, and C. iria* 4 weeks after seeding (WAS) but not *Ammania* sp. and *Dopatrium junceum* 8 WAS. Bispyribac–sodium and straw mulch + bispyribac-sodium reduced the population of *Alternanthera philoxeroides, Ammania* sp., *Commelina diffusa, C. difformis, C. iria,* and *D. junceum* 8 WAS. No phytotoxic effect on the rice plants was observed due to both herbicides. Yield and yield attributes were not affected by the tillage systems. The weed managements were found to affect the numbers of tiller per square meter and grain yield. The increasing number of weed did not affect the plant height of rice (Khumal-4). The numbers of tiller and grain yield highly affected the increasing number of weed population. Anilophos plus one handweeding, straw mulch plus bispyribac-sodium, handweeded twice and bispyribac–sodium alone gave higher yield compared to unweeded control. Promising grain yield could be achieved with the anilophos or bispyribac-sodium with additional physical or mechanical control methods in dry direct seeded rice.

Key words: dry direct seeded rice, bispyribac-sodium, anilophos, tillage, weed flora

INTRODUCTION

Transplanting is the popular rice establishment practice throughout Nepal with very little in direct seeding in some pocket areas. But with the ascending problem of labor and time, alternate method of rice culture may be beneficial in the future. However, direct seeding will be an alternate option to transplanting. Puddling for rice transplanting also makes land preparation difficult for wheat crop in rice–wheat rotation resulting in cloddy soil structure, loss of soil moisture, delayed and inadequate seed soil contact (Sharma and De Datta, 1985). Weeds are one of the limiting factors in direct seeded rice in reducing the yield. Weeds account for 50-80% yield reduction in rainfed uplands (Ranjit *et al*., 1989; Sinha *et al*., 1996). Yield reduction in rice is even higher (97%) due to competition of *Echinochloa crusgalli* (Kurchania *et al*., 1991). However, *Echinochloa* spp. was reported to be more competitive causing greater loss in growth and yield of rice compared to *C.*

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difformis, *Eclipta alba*, *Marsilia minuta*, and *Paspalum distichum* (Srinivasan and Palaniappon, 1994). The yield losses caused by different weeds depends on the type of rice culture, weed infestation, density and weed species prevalence.

Hand weeding is the most popular method of weed management in Nepal as well as in many parts of the world. Besides hand pulling and hand weeding, a number of herbicides have been developed and tested for the direct seeded rice around the world. Herbicides such as butachlor, thiobencarb, pendimethalin, oxyfluorfen, propanil, quinclorac, ioxynil, 2,4-D, piperophos + sulfonylurea, bentazone, molinate and bispyribac-sodium have been tested in direct seeded rice in the past research (Biswas *et al.*, 1992; Chin, 1999; Crawford and Jordan, 1995; Im, *et al.*, 1999; Ranjit *et al.*, 1989). Many factors affected cause the change of weed communities. Weed flora in the rainfed ecosystem has been reported to be the most complex compared to irrigated rice, but the weed management is the most important and can fill up at least 15% yield gap in different growing conditions (Moody, 1982). This study aimed to assess the responses of weed and yield attributes of dry direct seeded rice to tillage and weed management with bispyribac-sodium and anilophos herbicide and straw mulch in the mid-hill ecology.

MATERIALS AND METHODS

This experiment was conducted in the lowland field at Agronomy farm, Khumaltar, Nepal in a split plot design with RCBD replicated 4 times during the summer season of 2002. The main plots and sub plots were compiled of tillage and weed management respectively. The plot size was 4m × 5m (20m^2) and row spacing 20 cm. The field was located at an elevation of 1360 m above mean sea level on 27° 40'N latitude and 85° 20'E longitude.

Land preparation was done with 2 ploughing and 2 harrowing in case of conventional tillage (CT). But, for minimum tillage (MT), about 5-7 cm deep ploughing (only one time) was undertaken by the Chinese Seed Drill. Rice seeding was done after wheat harvest.

Planting was carried out after making a line with hand hoe for both tillage systems. Planting and harvesting were conducted in June and October respectively.

The variety used was Khumal-4. Seed rate was 90 kg/ha. Chemical fertilizer was applied at 100 kg nitrogen, 50 kg phosphorus, and 30 kg potash per hectare. Nitrogen was splitted in two halves. The 1st half was given as basal dose during planting and 2nd half during top dressing 45 days after planting. Chopped rice straw at 4 t/ha was used for the mulch treatment one day after rice seeding.

Weed count was initiated from 0.50 m^2 placing 50 cm by 50 cm quadrat at 2 places in each plot. Weed count was performed 3 times first 4 weeks after rice seeding (WAS), the second one 8 WAS and the 3rd at milking stage of rice (MSR). The first and second weed counts were carried out from the same spots in each plot but the third count was done from the different spot in each plot to see the changes in weed flora during the reproductive stage of rice. Individual weed species was counted. Weeds were pulled during the second and third counts and biomass was recorded after separating and cutting the roots of the narrowleaf and broadleaf weeds.

Chopped rice straw @ 4t/ha was used for the mulch treatment one day after rice seeding. There were 5 weed management treatments namely unweeded control (W_1), twice hand weeding 25 and 45 days after sowing (DAS) (W_2), preemergence application of anilophos [S[N(4-chloro-phenyl-)-N-isopropyl-carbamoyl-methyl-]-o, o-dimethyl-dithiophosphate, trade name = Arozin® 30EC] @ 0.4kg ai/ha (W_3), postemergence application of bispyribac-sodium [2,6-bis{(4,6-dimethoxypyrimidin-2-yl) oxy}benzoate, trade name = Nominee®10 EC] @

50 g ai (W_4), and rice straw mulch @ 4 t/ha + postemergence application of bispyribac-sodium @ 40 g ai /ha 40 days after seeding (DAS) (W_5).

Bispyribac-sodium was applied after mixing with 1/1 v/v surfactant. Anilophos was applied one day after rice sowing. Aspee backpack sprayer with 4 flat fan nozzles (8002) was used for herbicide spray. The spray volume was 500 l/ha. The weather during herbicide spray was sunny sky with patches of cloud and mild wind.

Plant height (cm), tillers per square meter, seeds per panicle, thousand seed weight (g) and grain yield (kg/ha) were recorded. Plant height was recorded from the averages of 5 plant in each plot. Tillers were recorded from one square meter in each plot. Harvesting was done from 9.60 square meter (3m × 3.20m). Grain yield was adjusted at 14 percent moisture contents.

The mean minimum temperature during the rice crop ranged from 20.3°C (June) to 12.8°C (October) and the maximum temperature ranged from 28.5°C (June) to 24.7°C (October). The total rainfall was 993.5 mm from June to October. The percent soil moisture during the rice crop was 40-53.

RESULTS AND DISCUSSION

Weeds were categorized in narrowleaf (grass and sedge), broadleaf (monocot and dicot) and pteridophyte. The important species were *A. philoxeroides, C. diffusa, C. difformis, C. iria, C. sanguinolentus, Ceratopteris thalictroides, E. colona, F. miliacea, Lindernia procumbens, and P. distichum* (Table1).

Response of weeds and weed biomass to tillage and management

Both narrowleaf and broadleaf weeds and their biomass were found not to be different due to tillage in all counts. However, *P. distichum* was noticed to be more in minimum tillage 8 WAS and

Table 1 Weed species recorded in the experimental field at different stages of direct seeded rice.

Weeds species	Family	Weeds species	Family
Narrowleaf weeds :		*Alternanthera philoxeroides* (Mart) Griseb.	Amaranthaceae
		Ammania baccifera L.	Lythraceae
Cynodon dactylon L. Pers	Poaceae	*Dopatrium junceum* Hamilt.	Scrophulariaceae
Cyperus difformis L.	Cyperaceae	*Lindernia procumbens* Philcox	Scrophulariaceae
C. dilutus L	Cyperaceae	*Polygonum hydropiper* L.	Polygonaceae
C. iria L	Cyperaceae	*Rotola indica* Koehne	Lythraceae
C. sanguinolentus Vahl.	Cyperaceae	*Rorrippa indica*	Brassicaceae
Echinochloa colona L. (Link)	Poaceae	*Vandellia angustifolia* Benth.	Scrophulariaceae
E. crusgalli (L) P. Beauv.	Poaceae		
Eriocaulan sp.	Eriocaulaceae	Broadleaf weeds (Monocot) :	
Eriocaulan sieboldtianum Sieb.et Zucc	Eriocaulaceae		
Fimbristylis miliacea Vahl.	Cyperaceae	*Commelina diffusa* Burm.f	Commelinaceae
Paspalum distichum L.	Poaceae	*Murdania* sp.	Commelinaceae
Panium sp.	Poaceae	*Monochoria vaginalis* Presl.	Pontederiaceae
Scirpus juncoides Roxb.	Cyperaceae	*Sagittaria guayanensis* H.B.K	Alismataceae
Broadleaf weeds (Dicot) :		Pteridophyte :	
Ageratum conyzoides L.	Asteraceae	*Ceratopteris thalictroides* (L) Brongn	Parkeriaceae
Eclipta prostrata L.	Asteraceae		
Erigeron sp.	Asteraceae		

MSR although the population was not high. But the number of *C. sanguinolentus* was less in minimum tillage 8 WAS (Figure 1).

It has been reported that different tillage systems have different rates of weed suppression. Reduced tillage (one round tillage + leveling) resulted in heavy infestation of *F. miliacea*. But conventional tillage increased the amount of *M. vaginalis.* A seeding rate of 100 kg/ha significantly reduced sedges and broadleaf biomass 60 days after planting but not *E. crusgalli* (Azmi and Mortimer, 1999). However, the tillage did not affect the total populations of weed in the study. It might need a few years to see the change in weed population and species (Table 2).

Total number of weed was different due to weed management treatments in all counts except broadleaf weeds 4 WAS. Preemergence application of anilophos + handweeding, straw mulch + bispyribac-sodium and bispyribac-sodium alone reduced the narrowleaf weeds in all counts (Table 2). Among the individual species, anilophos and straw mulch suppressed more amount of *C. difformis and C. sanguinolentus* than the unweeded control 4 WAS (Figure 2). All weed control treatments were found to suppress both narrowleaf and broadleaf weeds 8 WAS, and MSR (Table 2).

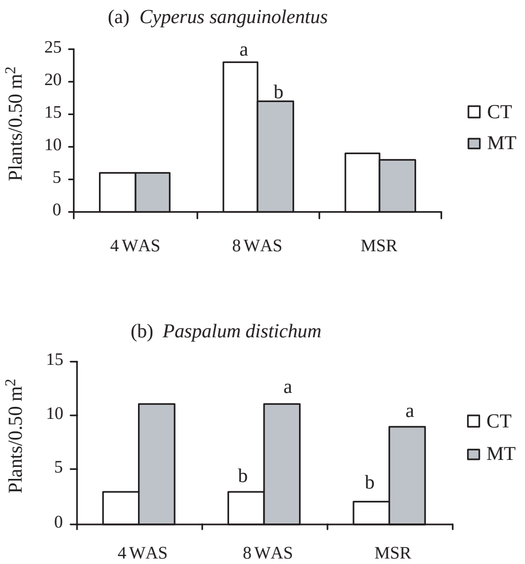

Figure 1 Weed species response to conventional tillage (CT) and minimum tillage (MT) at 4 WAS, 8 WAS, and MSR. Values in the bars with the same letters above are not significantly different at the 0.05 level. Bars without letter are not significantly different.

Post-emergence application of bispyribac-sodium alone and straw mulch + bispyribac-sodium were found to suppress both types of weed namely *Ammania* sp. and *D. junceum*, but both of them were not suppressed by anilophos when compared to the unweeded control 8 WAS (Figure 2). The number of these weeds decreased during the maturity stage of rice. Weeds like *Cyperus* spp., *C. diffusa*, and *D. junceum* were suppressed by bispyribac-sodium alone and in combination with straw mulch (Figure 2).

Narrowleaf and broadleaf weed biomasses were significantly different due to weed management 8 WAS and MSR. Higher weed biomass was recorded in the unweeded control. The rest of the weed management treatments lowered the weed biomass in the same range. The herbicide application was also equally effective as twice handweeding (Table 3).

Earlier researches also reported that bispyribac–sodium controlled many narrowleaf and broadleaf weeds such as *C. diffusa*, *C. iria*, *E. crusgalli*, *Fimbristyllis* spp., *Leersia oryzoides*, *Murdania* sp., *P. distichum*, *Polygonum* sp., *Sagittaria* spp., *Scirpus* spp., and *Sphenoclea zeylanica* (Han, 2001; Kobayashi *et al*., 1995; Shinohara *et al*., 1994; Tachikawa *et al*., 1997; Yokohama *et al*., 1993). *A. philoxiroides*, *Aeschenomene indica*, *Ammania coccinea*, and *Heteranthera limosa* were also controlled by KIH 2023 (bispyribac–soduim) (Braverman and Jordan, 1996). Anilophos + ethoxysulfuron or anilophos alone controlled the most dominant weed *Cyperus* sp., *F. miliacia* and also *Saccolepis interrupta* (Moorthy *et al*., 1999; Screedevi and Thomas, 1993).

Table 2 Narrowleaf and broadleaf weeds as affected by tillage and weed management.

Treatment	Narrowleaf weeds			Broadleaf weeds		
	4 WAS	8 WAS	MSR	4 WAS	8 WAS	MSR
	----------------------- (Plants/0.50 m^2)-----------------------					
Tillage :						
Conventional tillage (CT)	92[1]	65	31	23	45	11
Minimum tillage (MT)	145	79	43	36	45	11
Weed management :						
Unweeded control (W_1)	172 ^{a}	117 ^{a}	58 ^{a}	27	25 ^{c}	30 ^{a}
Handweeding twice (W_2)	161 ^{a}	90 ^{ab}	48 ^{ab}	32	56 ^{b}	7 ^{b}
Anilophos + handweeding one (W_3)	63 ^{b}	59 ^{bc}	34 ^{bc}	28	107 ^{a}	7 ^{b}
Bisbyribac-sodium (W_4)	127 ^{ab}	55 ^{c}	21 ^{c}	35	12 ^{c}	5 ^{b}
Straw mulch + bisbyribac-sodium (W_5)	70 ^{b}	40 ^{c}	23 ^{c}	24	25 ^{c}	7 ^{b}
Tillage (T)	NS[2]	NS	NS	NS	NS	NS
Weed management (W)	**	**	**	NS	**	**
T x W	NS	NS	*	NS	NS	NS

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

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

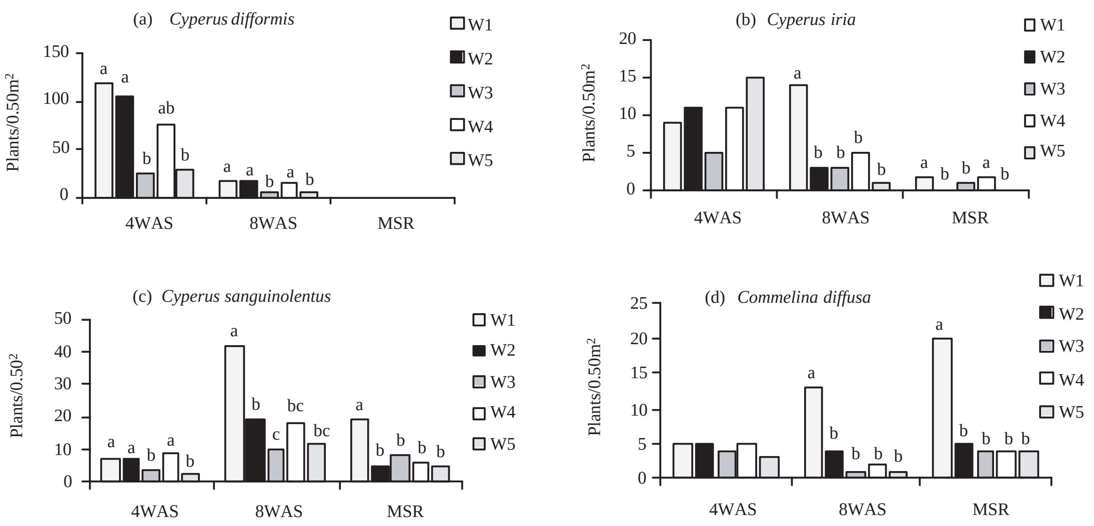

Figure 2 Weed species responses to different weed managements of W1 (unweeded control), W2 (handweeded twice), W3 (anilophos + one weeding), W4 (bispyribac-sodium), and W5 (straw mulch + bispyribac-sodium) at 4 WAS, 8 WAS, and MSR. Values in the bars with the same letters above are not significantly different at 0.05 level. Bars without letters are not significantly different.

Table 3 Effects of weed management on dry weed biomass at different stages of rice.

Treatments	8 Weeks after sowing (WAS)		Maturity stage of rice (MSR)	
	Narrowleaf	Broadleaf	Narrowleaf	Broadleaf
	--------------------------------(g/0.50 m^2)------------------------------			
Tillage :				
Conventional tillage (CT)	35.6[1]	5.8	30.5	13.4
Minimum tillage (MT)	48.7	8.2	43.9	13.7
Weed management :				
Unweeded control (W_1)	113.1 a	18.1 a	88.3a	50.8 a
Handweeding twice (W_2)	20.9 b	4.6 b	11.1 b	2.4 b
Anilophos + handweeding one (W_3)	14.5 b	4.5 b	24.4 b	3.7 b
Bisbyribac-sodium (W_4)	38.4 b	2.3 b	35.5 b	5.3 b
Straw mulch + bisbyribac-sodium (W_5)	24.0 b	5.6 b	26.8 b	5.5 b
Tillage (T)	NS[2]	NS	NS	NS
Weed management (W)	**	**	**	**
T × W	NS	NS	NS	NS

1 Means within the same column and grouping followed by the same letters are not different according to Fisher's protected test P=0.05.
2 Treatment effects and interactions were significant at 5% (*), significant at 1% (**) or nonsignificant (NS).

Response of yield attributes of rice to tillage

There were no significant differences on plant height, tillers per square meter, thousand seed weight and grain yield due to tillage. It showed that dry direct seeding rice in conventional and minimum tillage did not affect the yield attributes and could be planted in both tillage systems (Table 4). Hobbs *et al.* (2002) also reported that rice yield was in the same range in both puddled and unpuddled rice cultures. This might be due to the condition under the unpuddled rice culture where the weeds were more properly controlled, since, in general, weeds in unpuddled rice culture were more serious problem than in puddled rice culture.

Response of yields attributes to weed management

Tillers per square meter, grain yield and dry straw weight were significantly different due to weed management, but not plant height, number of seeds per panicle, and thousand seed weight. It showed that higher numbers of weed did not affect plant height because the plant height in other weed management treatments was in the same range of the unweeded control. Number of tillers per square meter ranged from 205 in unweeded control to 335 in straw mulch + bispyribac-sodium. Higher yield (6,708 kg/ha) was recorded in handweeding twice, straw mulch + bispyribac-sodium (6,445 kg/ha), and anilophos + one handweeding (6,416 kg/ha) which were at par to each other. Bispyribac-sodium alone yielded 5,469 kg/ha which was higher than that in unweeded control (2,136 kg/ha) (Table 4). All weed management treatments except unweeded control in this experiment gave promising yields up to 670 kg/ha. In the study, both herbicides did not show any phytotoxic effect on rice plants. However, the phytotoxic effect of these herbicides on different agroecological rice cultivars needs to

Table 4 Effects of tillage and weed management on plant height, tillers, seeds/panicle, thousand seed weight, grain yield and dry straw weight of dry direct seeded rice.

Treatments	Plant height	Tiller	Seed/panicle Filled	Seed/panicle Unfilled	1000 seed wt.	Grain yield	Straw biomass
	(cm)	(no./ m^2)	----(no./panicle)----		(g)	(kg/ha)	(kg/ha)
Tillage :							
Conventional tillage (CT)	127.6[1]	281	146	12	18.7	5630	7395
Minimum tillage (MT)	127.8	256	126	11	19.4	5239	6432
Weed management :							
Unweeded control (W_1)	127.4	205[c]	106	11	19.1	2136[c]	3989[b]
Handweeding twice (W_2)	127.2	258[ab]	138	11	19.3	6708[a]	7701[a]
Anilophos + handweeding one (W_3)	128.5	277[ab]	170	11	18.9	6416[a]	7541[a]
Bisbyribac-sodium (W_4)	127.5	270[abc]	128	10	19.2	5469[b]	7195[a]
Straw mulch + bisbyribac-sodium (W_5)	128.0	335[a]	139	15	18.8	6445[a]	8140[a]
Tillage (T)	NS[2]	NS	NS	NS	NS	NS	NS
Weed management (W)	NS	NS	*	NS	NS	**	**
T × W	NS	NS	NS	NS	NS	NS	NS

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

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

be assessed in the future. The rotational effect of these herbicides to wheat herbicides should be studied in depth in different agroecological environments to find the effect on crop and weed shifts in the future.

With the increasing number of narrowleaf weed population, both tillers per square meter and grain yield decreased (Table 2, 4, and Figure 3). In this study *Cyperus* spp. were the found to be dominant narrowleaf weed. Broadleaf weed like *D. junceum* did not affect the rice yields (Figure 3). Because the yield in anilophos treatment was higher, even the broadleaf weeds was not suppressed. The yield reduction might be depended on weed species.

However, the low yield in bispyribac-sodium alone compared to other treatments W2, W3 and W5 was actually not known although it suppressed both narrowleaf and broadleaf weeds (Figure 3). This herbicide might need to be assessed with regard to time, rate and the cultivar in different agroecological environments for more seasons.

CONCLUSION

Most common weeds associated with dry direct seeded rice were *A. philoxiroides*, *C. difformis*, *C. iria*, *C. sanguinolentus*, *C. diffusa*, *D. junceum*, *E. colona*, and *Lindernia* sp. Both narrowleaf and broadleaf weeds were not significantly different due to tillage, but was significantly different due to weed management. Both narrowleaf and broadleaf weeds were reduced by bispyribac-sodium. Weeds like *A. philoxiroides*, *Cyperus* spp., and *D. junceum* were significantly reduced. However, *Ammania* sp. and *D. junceum* were not suppressed by anilophos. No phytotoxic effect on rice plants has been observed due to both herbicides. This study showed that both herbicides could be applied in dry direct seeded rice culture in the mid hill ecology. The weed managements showed significant impact on tillers and grain

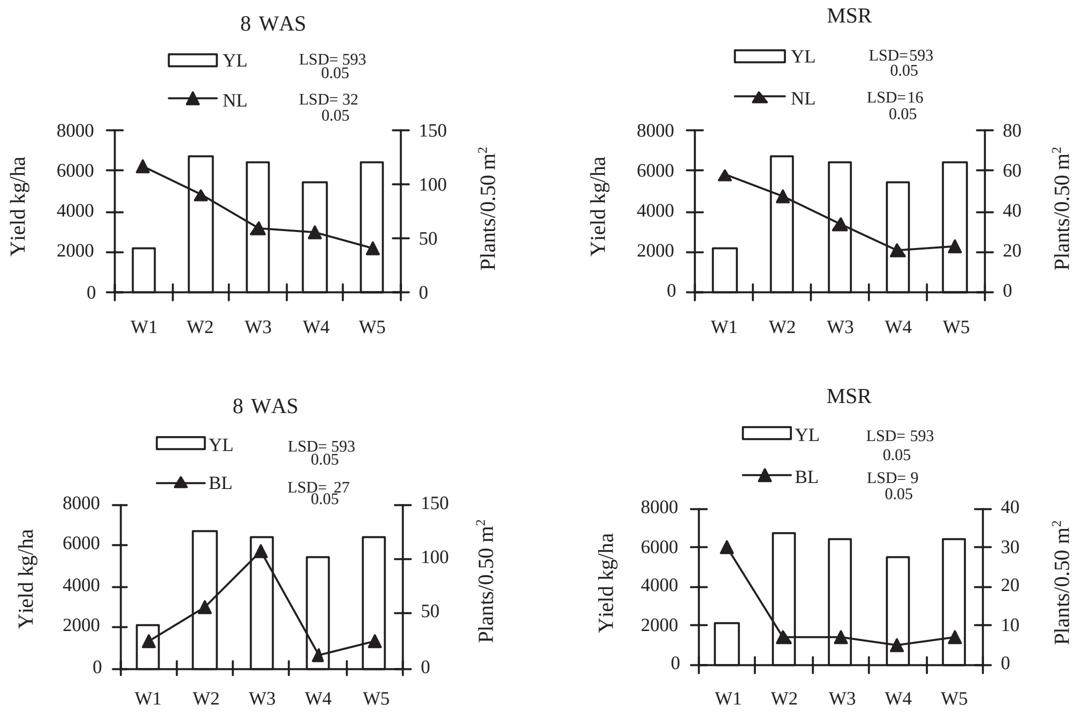

Figure 3 Grain yields of rice as affected by narrow leaf (NL) and broadleaf weed (BL) under different weed managements of W1 of (unweeded control), W2 (handweeded twice), W3 (anilophos + 1 weeding), W4 (bispyribac-sodium), and W5 (straw mulch + bispyribac-sodium) 8 WAS and MSR.

yield. With the increasing number of weed population, the numbers of tiller and grain yields decreased. All weed management gave comparable yields to twice handweeding. With the proper weed management 150-200 percent rice yield could be increased so that the drudgery operation like seedbed preparation and transplanting could be avoided in dry direct seeded rice culture.

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