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Performance of Penoxsulam for Weed Control in Transplanted Rice

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ABSTRACT

The efficacy of penoxsulam on weed control was evaluated in field experiments during the 2006 and 2007 *kharif* seasons at the research farm of Punjab Agricultural University, Ludhiana, India. There were seven treatments consisting of two doses of penoxsulam (22 and 25 g/ha) applied at 3 and 12 days after transplanting (DAT), butachlor (1500 g/ha) applied at 3 DAT, hand weeding (twice at 20 and 40 DAT) and weedy check (untreated control). The main dominant weeds in the field were *Echinochloa crus-galli* and *Cyperus iria*. Maximum weed control efficiency (90%) was attained with penoxsulam (25 g/ha) applied at 12 DAT followed by the hand weeding treatment (76%). The plots treated with penoxsulam (25 g/ha) applied at 12 DAT resulted in highest grain yield (7.95 t/ha) and this treatment increased yield to about 104% and 13% more than weedy check and butachlor (1500 g/ha) treatments, respectively. Penoxsulam applied at 12 DAT was superior in terms of increasing grain yield and reducing weed dry matter when compared to its application at 3 DAT. The hand weeding treatment was found to be as effective in reducing weed dry matter as butachlor at 1500 g/ha and both treatments resulted in a similar yield. This study identifies an alternate herbicide to butachlor in transplanted rice, and this may reduce the development of resistance in weeds against widely used butachlor.

Keywords: Butachlor, *Oryza sativa*, Penoxsulam, sedges, transplanted rice, weed control efficiency

INTRODUCTION

Rice is the major food staple for approximately 60% of the world's population (FAO 2006). Globally, this crop is grown on an area of 132 million ha. Of the total rice acreage under cultivation, it is estimated that 70% (about 92.7 million ha) area is under transplanted rice culture, and the remaining 30% is under direct-seeded rice culture including drill-seeded, broadcast-sown, puddle-seeded, water-seeded and upland (Maclean *et al*. 2002). In India alone, rice occupies 45 million ha; however, the average yield of rice is quite low (2.9 t/ha) as compared to China (6.3 t/ha), Japan (6.4 t/ha) and Indonesia (4.6 t/ha) and weeds are considered as the major yield limiting factor in rice production (Yaduraju and Mishra 2004; FAO 2006). The loss in grain yield caused by weeds varies from 30 to 50% (Singh *et al*. 2004; Reddy *et al*. 2006).

Weed control in India is primarily achieved through the use of herbicides and hand weeding, but the latter is becoming less common because of migration of farm workers to the cities. It has been estimated that 300 to 400 man hours per hectare are required to remove weeds from transplanted rice fields (Singh *et al*. 2004). Thus, due to increasing labor shortage problem, herbicide-based weed management system is becoming the most popular method of weed control in rice.

The use of herbicides offers selective and economic control from the beginning of the crop, giving the advantage of a good head start and competitive superiority to the crop. However, a single herbicide application does not control all kinds of weeds, thereby provokes a weed shift of tolerant species. Butachlor, for example, is being used widely for weed control in transplanted rice (Labrada 2002). It provides effective control of annual grasses but not of sedges and non-grass species (Katherisan 2001), which compete with the crop and cause heavy yield losses (Singh *et al*. 2004). There is also a need to restrict continuous use of herbicides with a similar mode of action to avoid undesirable weed shift and herbicide resistance (Sangakkara *et al*. 2004). In other parts of the world, the long-term use of butachlor in transplanted rice has led to resistance development in barnyardgrass (Huang and Lin 1993). Given that herbicide resistance is likely to increase, research is needed to evaluate the efficacy of alternate herbicides, which may provide wide weed control spectrum with wide application window.

Penoxsulam is a post-emergence herbicide, acts by inhibiting the acetolactate synthase enzyme, and is registered for weed control in rice in the southern USA (Lassiter *et al*. 2006). In India, however, little information is available on its application timing and efficacy in transplanted rice. Therefore, the present study was undertaken to evaluate the performance of penoxsulam against various weeds in transplanted rice.

MATERIALS AND METHODS

Experiment description

A field experiment was conducted at the experimental farm of Punjab Agricultural University, Ludhiana (30° 56′ N and 75° 52′ E), India during the 2006 and 2007 summer seasons. The climate of the experimental site is broadly classified as semiarid subtropical, characterized by very hot summers and cold winters. The average annual rainfall is 750 mm, 75 to 80% of which is received through the northwest monsoon during July to September. The experimental soil was sandy loam in texture. The surface soil (0 to 15 cm) had a total organic nitrogen 218 mg kg^{-1}, phosphorus 8.4 mg kg^{-1}, pH of 7.6 and EC 0.19 ds m^{-1}. Seven treatments consisting of two doses of penoxsulam (22 and 25 g/ha) applied at 3 and 12 days after transplanting (DAT), butachlor (1500 g/ha) applied at 3 DAT, hand weeding (twice at 20 and 40 DAT) and weedy check (un-

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Short Communication

Table 1 Effect of weed control treatments on weed density (species wise) and their dry weight (DM) at harvest.

Treatment	Dose (g/ha)	Application time (DAT)	Weed density (No./m²) Grasses	Sedges	Broad leaf	DM (kg/ha)
Butachlor	1500	3	3.90 (14.3)	2.44 (5.00)	3.02 (8.33)	406 (1549)
Penoxsulam	22	3	4.97 (23.8)	2.00 (3.50)	3.07 (8.50)	558 (3023)
Penoxsulam	25	3	4.54 (19.7)	1.82 (2.83)	2.76 (6.67)	503 (2440)
Penoxsulam	22	12	3.58 (11.8)	1.24 (0.66)	2.45 (5.17)	375 (1365)
Penoxsulam	25	12	2.86 (7.33)	1.07 (0.17)	2.13 (3.67)	253 (552)
Hand weeding	-	20 and 40	3.98 (14.8)	1.81 (2.50)	1.66 (2.00)	373 (1307)
Weedy check	-	-	6.10 (36.5)	2.79 (6.83)	5.43 (28.7)	744 (5503)
LSD (0.05)	-	-	0.62	1.03	0.84	13

Figures in parentheses are the means of original value. Data subjected to square root transformation.
DAT: Days after transplanted, DM: Dry matter of weeds

Table 2 Effect of treatments on plant height, weed control efficiency (%), yield components and yield of rice.

Treatment	Dose (g/ha)	Application stage (DAT)	Weed control efficiency (%)	Panicles (No./sqm.)	Panicle weight (g)	Grain yield (t/ha)
Butachlor	1500	3	71.8	332	3.81	7.02
Penoxsulam	22	3	45.0	292	3.41	6.26
Penoxsulam	25	3	55.7	291	3.73	6.97
Penoxsulam	22	12	75.2	317	3.97	7.57
Penoxsulam	25	12	90.0	326	4.13	7.95
Hand weeding	-	20 and 40	76.2	314	4.01	7.47
Weedy check	-	-	-	256	2.87	3.89
LSD (0.05)	-	-	-	36.6	0.13	0.46

treated control) were laid out in a randomized block design with three replications. Herbicides were sprayed using a knapsack sprayer fitted with a flat fan nozzle at a spray volume of 500 L/ha. Thirty days old seedlings of rice were transplanted in the second fortnight of June during both the years, at a spacing of 20 × 15 cm. In both years, 120 kg N/ha was applied uniformly through urea fertilizer in three equal split doses (1/3rd basal, 1/3rd at 21 DAT, and 1/3rd at 42 DAT). Irrigation comprised of continuous flooding for 15 days after transplanting followed by intermittent irrigation at 3 days interval up to 14 days before harvest. Other agronomic and plant protection measures were adopted as recommended during the crop growth.

Density and dry matter (DM) of weeds

The efficacy of different treatments on weeds was evaluated at crop maturity. Two quadrats (0.5 × 0.5 m) were placed in each plot at random to determine the weed density. Weed seedlings within these quadrats were counted, and the efficacy of weed control treatments was evaluated by comparing the density with the untreated control. Weeds were cut at ground level, washed with tap water, oven dried at 70°C for 48 h and then weighed for dry matter (DM). The weed control efficiency (WCE) was calculated using the following formula (Tawaha *et al*. 2002):

$$\text{WCE} = \frac{\text{weed DM in untreated plot - weed DM in treated plots}}{\text{weed DM in untreated plot}} \times 100$$

Growth and grain yield of rice

The panicles of rice were counted at maturity by randomly placing two quadrats (0.5 m by 0.5 m) in each plot. Panicle weight was determined by randomly sampling five panicles. Grain yield was determined at maturity by harvesting the net plot of size 2 × 3 m.

Statistical analysis

The data from the two years were combined for analysis as in each case there were no interaction effects of treatment and year. CROPSTAT version 7.2.3 (IRRI) was used for statistical analysis of data, and means were separated using LSD at P = 0.05. The data on weeds were transformed by angular transformation before being subjected to ANOVA.

RESULTS AND DISCUSSION

Effect on weeds

The main grassy weeds present in the field were *Echinochloa crus-galli*, *E. colona* and *Ischaemum rugosum*, while *Eclipta prostrata* and *Caesulia axillaries* were amongst the main broad-leaf weeds. In sedges, *Cyperus iria* was the predominant weed. Application of penoxsulam (25 g/ha) at 12 DAT resulted in a significantly lower weed density than weedy check and caused 90% reduction in mean dry weight of weeds over the weedy check (**Table 1**). This treatment also reduced 64% dry matter of weeds when compared with the application of butachlor at 1500 g/ha. The superiority of penoxsulam (25 g/ha) at 12 DAT over the application of butachlor (1500 g/ha) was mainly due to the better control of sedges and some broad-leaf weeds. The application of penoxsulam (22 or 25 g/ha) proved more superior in terms of weed control when applied at 12 DAT than at 3 DAT. The WCE was highest (90%) with the application of penoxsulam (25 g/ha) at 12 DAT followed by the hand weeding treatment (76%), while it was 72% with the application of butachlor (1500 g/ha) (**Table 2**).

Our results conform with those of previous studies where penoxsulam effectively controlled many weed species, including *Echinochloa* spp., *Cyperus* spp., *Alternanthera philoxeroides* (Mart.) Griseb.], ducksalad [*Heteranthera limosa* (Sw.) Willd.], eclipta [*Eclipta prostrata* (L.) L.], hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A.W. Hill], northern jointvetch [*Aeschynomene virginica* (L.) B.S.P.], *Polygonum* spp., spreading dayflower (*Commelina diffusa* Burm. f.), and Texasweed [*Caperonia palustris* (L.) St. Hil.] (Larelle *et al*. 2003; Strahan 2004; Lap *et al*. 2005; Walton *et al*. 2005; Lassiter *et al*. 2006; Williams and Burns 2006; Willingham *et al*. 2006). Similarly in another study, post-emergence application of penoxsulam (25 g/ha) effectively controlled major weeds in transplanted rice and proved superior over butachlor (Singh *et al*. 2007).

Effect on crop

There was no phytotoxic effect on the crop due to application of penoxsulam at any of the doses applied at 3 or 12 DAT. All weed control treatments increased grain yield over the untreated control. This was due to better control of weeds, which ultimately increased the number of panicles, panicle weight and grain yield over the control (**Table 2**).

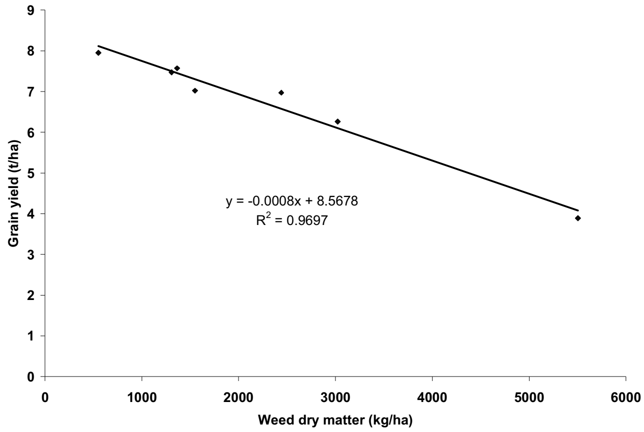

Fig. 1 Relationship between mean weeds dry matter and grain yield of rice.

Grain yield of rice was negatively correlated with the dry matter of weeds (**Fig. 1**). An R^2 value of 0.96 indicates that dry matter of weeds alone accounted for 96% of variation in grain yield of rice. The highest yield was observed in the plot treated with penoxsulam (25 g/ha) at 12 DAT. Penoxsulam applied at 12 DAT resulted in 13 and 104% increase in grain yield over the application of butachlor (1500 g/ha) and weedy check, respectively (**Table 2**). The application of penoxsulam (22 g/ha) at 3 DAT proved to be most inferior among all the weed control treatments in terms of grain yield, which was due to poor control of weeds provided by this treatment. It was observed that many weeds, especially sedges and broad-leaf weeds, emerged after the application of penoxsulam when applied at 3 DAT so that these weeds were not controlled when penoxsulam was applied at 3 DAT.

Penoxsulam kills weeds by inhibiting acetolactase synthase, an enzyme which ultimately reduces the transport of photosynthate from source leaves to roots, resulting in root growth inhibition (Devine 1989; Devine *et al.* 1990; Shaner 1991). Since, most of the weeds emerged late they escaped the mechanism of transport of photosynthate from source leaves to roots. It was noticed that grain yield remained statistically similar when penoxsulam (22 g/ha and 25 g/ha) was applied at 12 DAT. These results are in agreement with those of Bond *et al.* (2007), who also reported higher paddy yield following post emergence application of penoxsulam due to superior weed control.

It was concluded from the experimental study that penoxsulam provided excellent control over weeds in rice and could be use as an alternative herbicide to butachlor for weed control in rice. Due to its pre- and post-emergence activity, it provides more flexibility to farmers in terms of its time of application, if the farmers fail to apply pre-emergence herbicide in time.

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