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POST EMERGENCE CHEMICAL WEED CONTROL IN DIRECT SEEDED FINE RICE

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ABSTRACT

Direct seeding of rice is a promising resource conservation technology for rice-wheat cropping system but its adoption is impeded due to heavy weed infestation. A field study was conducted during summer 2008 to evaluate the efficacy of post emergence herbicides in three fine rice cultivars viz. Super Basmati, Basmati 385 and Shaheen Basmati under direct seed rice culture at Agronomic Research Area, University of Agriculture, Faisalabad. Bispyribac sodium, ethoxysulfuron ethyl and penoxuslam were used as early post emergence (15 days after sowing; DAS) at label dose of 30, 30 and 15 g a.i. ha^{-1}, respectively. A weedy check and manual weeding (15 and 25 DAS) were maintained for comparison. Bispyribac sodium suppressed both weed density (75%) and dry weight (80%) over control that was highest among all herbicides. Higher rice grain yield and maximum marginal rate of return was also associated with this herbicide in all rice cultivars. Despite of its effectiveness against weeds and scoring higher rice yields, manual weeding was uneconomical primarily due to higher costs involved. Post emergence application of bispyribac sodium appeared to be a viable strategy for weed control in direct seeded rice with higher economic returns.

Keywords: weed control, herbicides, basmati, grain yield, bispyribac sodium.

INTRODUCTION

Weed infestation in direct seeded rice (DSR) fields remains the single largest constraint limiting their productivity. A DSR crop generally lacks a "head start" over weeds due to dry tillage, absence of flooding and alternate wetting and drying conditions making it particularly vulnerable to weed competition during early part of its growth (Rao *et al*., 2007). As the weeds and rice emerge simultaneously in DSR, the proper time and method of weed control remains a complex phenomenon (Khaliq and Matloob, 2011). Timing of weed emergence and the pressure exerted to the crop through interference are highly correlated so that resultant yield losses are usually higher when weeds emerge earlier or simultaneously with crop (Aldrich, 1987). An effective early weed management tactic is imperative for any DSR production technology aiming at achieving higher productivity and profitability (Jaya Suria *et al*., 2011).

Rao *et al*. (2007) described various weed management strategies practiced in DSR in Asia. These include agronomic practices as land preparation, seeding rates, fertilizer application, water management, competitive cultivars, as well as manual, mechanical, and chemical weed control. The choice of the weed management methods depends upon climatic conditions, soil type, technology available, type of rice culture, the farmer's economic situation and yield target, and is evaluated in terms of the cost of weed control in comparison with the estimated value of the resulting yield increase. Manual weeding, although efficient in controlling weeds, has been restricted due to several economical and technological factors (Khaliq *et al*., 2011a).

Over the years, chemical weed control in DSR has emerged as promising solution of weed problem and expanded manifold as it is easy, quick, economical and feasible. Several pre-emergence herbicides applied either alone or supplemented with hand weeding have been reported to provide fairly adequate weed suppression in DSR (Pellerin and Webster, 2004; Baloch *et al*., 2005). However, limited application time window (0-5 days after sowing; DAS), a critical water regime and toxicity to main crop are associated challenges. In this scenario, post-emergence herbicides appear to offer alternate possibility. Crop cultivars with variable stature, canopy structure and maturity periods may also differ in their ability to compete with weeds. Degree of competition offered by a crop can influence the herbicide performance (Khaliq and Matloob, 2011). Many of the issues related to DSR still remain unaddressed and a lot of work remains to be done to develop technologies which are site-specific, effective and economically viable. Large scale adoption of DSR in Pakistan is restricted largely due to unavailability of a potential weed control strategy available locally (Khaliq *et al*., 2011b). The present work is intended to explore the weed control through post emergence herbicides in three fine rice cultivars of Pakistan.

MATERIALS AND METHODS

Seed source: Seeds of rice cv. Super Basmati and Basmati-385 were obtained from Rice Research Institute, Kala Shah Kaku, while Shaheen Basmati seeds were collected from Soil Salinity Research Institute, Pindi Bhattian. For all cultivars, healthy and disease free seeds were used.

Site description: The study was conducted at Agronomic Research Farm, University of Agriculture Faisalabad (184 m above sea level). The soil of experimental site belongs to Lyallpur soil series (Aridisol-fine-silty, mixed, hyperthermic Ustalfic, Haplargid in USDA classification and Haplic Yermosols in FAO classification). The pH of saturated soil paste was 7.6 and total soluble salts were 0.79 dS m^{-1}. Organic matter, total nitrogen, available phosphorus and potassium were 0.71%, 0.062%, 13.1 ppm, and 179 ppm, respectively. Due to high evapo-transpiration, Faisalabad features an arid climate with mean annual rainfall of about 200 mm.

Experimentation: A field vacated by wheat was selected and previous field history reveals the presence of diversified weed flora of summer season. The experiment was conducted during summer 2008 and laid out in randomized complete block design (RCBD) under split plot arrangement with four replications. The net plot size was 6 m x 2.70 m. The seed of fine rice cultivars were osmo-hardened with 2.2 % $CaCl_2$ prior to sowing (Farooq *et al*., 2007). The rice crop was sown in the first week of July with single row hand drill, using a seed rate of 75 kg ha^{-1} and maintaining 22.5 cm distance between crop rows. A basal fertilizer dose of 125 kg N, 55 kg P_2O_5 and 40 kg k_2O ha^{-1} was applied. Fertilizers used were urea (46% N), diammonium phosphate (18% N, 46% P_2O_5) and sulphate of potash (50% K_2O). The whole phosphorus and potassium and half of nitrogen were applied at the time of sowing. The remaining half nitrogen was applied in two splits at tillering and panicle initiation, respectively. All varieties were placed in main plots. Label doses of the bispyribac sodium, ethoxysulfuron ethyl and penoxuslam were used at 30, 30 and 15 g a.i. ha^{-1}, respectively as sub plot treatments. Herbicides were applied as an early post emergence (15 DAS) using a knapsack spray fitted with a flat fan nozzle. Volume of spray (320 L ha^{-1}) was determined after calibration. For manual weeding hoeing was done twice at 15 and 25 DAS with *Kasola* to kill inter row weeds while intra row weeds were rouged out by hand pulling. A weedy check was maintained for each cultivar.

Data on weed dynamics (density, dry biomass) were recorded at 35 DAS from two randomly selected quadrats (100 x 100 cm) from each experimental unit. Weeds were clipped from ground surface, and dried in an oven at 70 ºC for 48 h for determining dry weed biomass. Data on rice yield attributes were recorded from 15 randomly selected plants taken from each plot and computing their average. Productive tillers (m^{-2}) were counted from two randomly selected sites from each plot and averaged. A random sample of kernels was taken from the produce of each plot, 1000-kernels were counted manually and weighed on an electric balance. Crop was harvested and tied into bundles in respective plots. Each experimental plot was manually threshed to determine grain yield and is presented as t ha^{-1}.

Statistical analysis: The data collected were subjected to Fisher's analysis of variance technique (Steel *et al*., 1997) using "MSTATC" statistical package (Freed and Scott, 1986) and HSD Tukey's test at $p \leq 0.05$ probability was applied to compare the differences among treatments' means.

RESULTS AND DISCUSSION

Weed growth: Weed flora of the experimental site comprised of grasses (*Echinochloa crus-galli*, *E. colona*, *Dactyloctenium aegyptium, Leptochloa chinensis*, *Elusine indica*), sedges (*Cyperus rotundus*, *C. iria*) and broad leaved (*Trianthema portulacastrum, Ipomoea aquatic*, *Portulaca oleracea*) species. Weed dynamics (density and dry biomass) did not vary significantly ($p \leq 0.05$) among different rice cultivars in these studies (Figure 1a and b). The interactive effect of cultivars and weed control treatments was also non-significant in this regard. Weed density and dry biomass varied significantly under different weed control treatments. Manual weeding was the most effective and recorded 88% suppression of weed density as compared with control plots. Bispyribac sodium realized 75% reduction in weed density, while ethoxysulfuron ethyl and penoxsulam followed with similar ($p \leq 0.05$) level of weed suppression. The same trend as of weed density was observed for weed dry biomass (Figure 1b). Manual weeding scored >90% suppression of weed dry biomass while bispyribac sodium came up with 80% inhibition as the second best weed control treatment. Ethoxysulfuron ethyl reflected a dry biomass reduction of 64% that was similar ($p \leq 0.05$) with that achieved with penoxsulam (61%).

Our data showed effectiveness of manual weeding in limiting weed density and dry biomass merely owing to physical removal of the weeds as an effective tool for their management. Nonetheless, during later part of the growing season weeds were also suppressed by shading effect of rice in manually weeded plots due to quick and dense canopy closure (Baloch *et al*., 2005). Herbicides differed in respect of their efficacy and bispyribac sodium emerged as promising one in averting both density and dry matter accumulation by weeds. The performance of this herbicide could be attributed to reasonable suppression of both narrow and broad-leaved weeds and selectivity to rice crop as well. It is a member of pyrimidinyloxy benzoic chemical family and inhibits acetolactate synthase enzyme in susceptible plants thus retarding the synthesis of branch chain amino acids (Darren and Stephen, 2006). The effectiveness of bispyribac sodium as a post emergence herbicide for DSR is also reported elsewhere (Mahajan *et al*., 2009; Khaliq *et al*., 2011b). Penoxulam proved inferior in suppressing weeds particularly grasses as repeated and higher flushes of *D. aegyptium* and *E. indica* were observed during period of crop growth. Similarly, though highly effective against sedges, ethoxysulfuron ethyl exhibited poor suppressive activity against grass as well as broad-leaved weeds (data not shown). The findings of present study corroborate the previous findings of Ashraf *et al*. (2006), Hussain *et al.* (2008), Jaya Suria *et al.* (2011), Khaliq *et al*. (2011a,b) and Akbar *et al*. (2011) who concluded that herbicides are an effective mean of securing yield loss against weed infestation during critical period. However, Khaliq and Matloob (2011) reported variation in total weed dry biomass in some other rice cultivars after season long weed competition in DSR.

Rice yield components: Similar yield attributes and grain yield was recorded in these studies (Figure 2) so that cultivars and their interaction were non-significant. Differences in yield attributes and yield were apparent only under weed control treatments. Season long weed competition in weedy check reduced rice yield and yield related parameters. Unattended weed growth drastically reduced rice grain yield (>80% less than manually weeded plots). Rice remains a poor weed competitor (Saito, 2010) and is particularly vulnerable to yield loss by weeds particularly during initial stage of development (Khaliq and Matloob, 2011). Such yield losses tend to intensify manifold when rice crop is directly sown (Rao *et al*., 2007). Number of panicle bearing tillers, grains per panicle, 1000-grain weight and grain yield were highest where weeds were controlled by manual weeding. Bispyribac sodium appeared at par with manual weeding for most of the yield attributes and yield as well. These treatments lessened weed crop competition during the crucial phase of rice crop establishment that was manifested as more panicles per unit area, increased kernel number and kernel weight over control. Higher rice yield in response to efficient weed control are reported elsewhere (Mahajan *et al*., 2009; Khaliq *et al*., 2011a,b; Akbar *et al*., 2011; Jaya Suria *et al*., 2011).

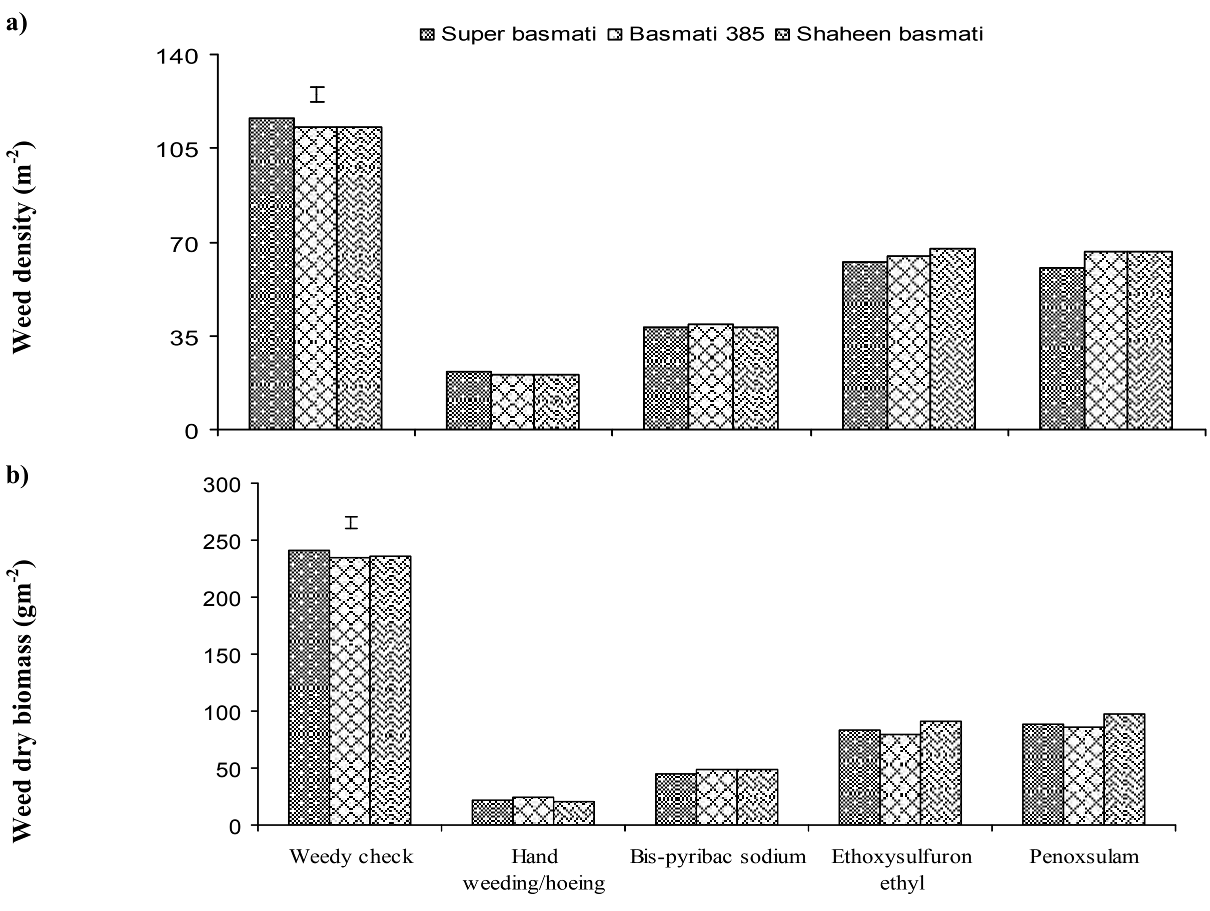

Figure 1. Influence of different weed control treatments on weed density and biomass in three fine rice cultivars. Capped bars denote HSD ($p \leq 0.05$).

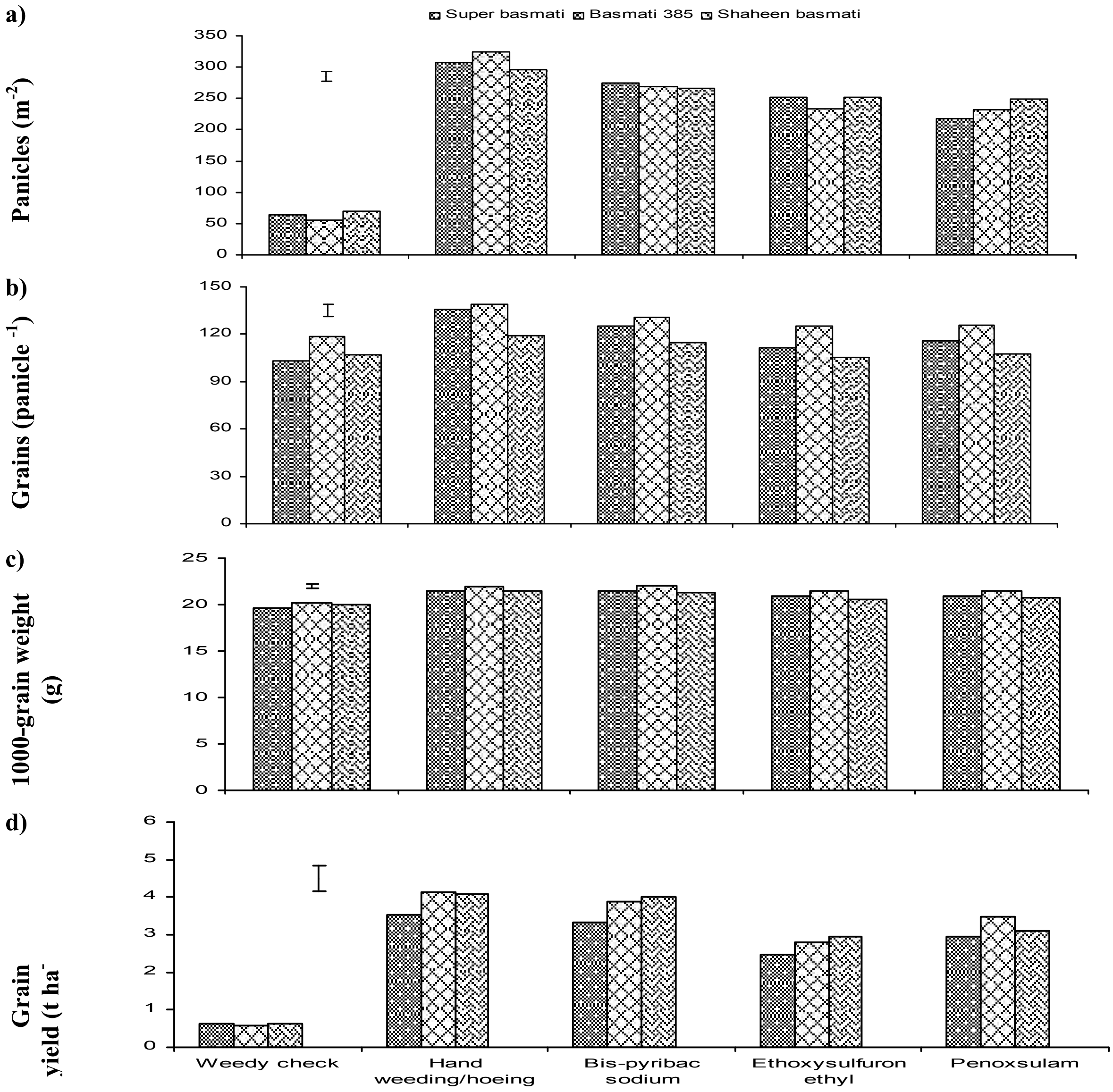

Figure 2. Influence of different weed control treatments on yield and yield components of three fine rice cultivars. Capped bars denote HSD ($p \leq 0.05$).

Economic and marginal analysis: The effectiveness of any production system is ultimately evaluated on the basis of its economics. Economic analysis is the basic consideration in determining which treatment gives the highest return while marginal analysis indicates the relative contribution of additional expenditures. A perusal of data revealed that there was an overall increase in net income in different weed control treatments over the control (Table 1). This indicates that with appropriate weed control DSR production can be a profitable venture. Highest net benefits in all cultivars were realized by manual weeding. Bispyribac sodium was the second effective treatment regarding net befits. Marginal and dominance analyses (Table 2) showed that maximum marginal rate of return (11037-28250%) was obtained by the application of bispyribac sodium. It was followed by penoxsulam in Super (6649%) and Basmati 385 (9632%) and by ethoxysulfuron in Shaheen basmati (5603%). Although effective in eradicating weeds and scoring higher grain yields, manual weeding exhibited lowest MRR (35-548%) which is understandable due to higher labor costs involved in this practice. The cost-effectiveness of bispyribac sodium as a post emergence herbicide for weed management in aerobic rice is in line with Mahajan *et al*. (2009). Studies concluded that use of herbicides was an efficient and cost-effective method for weed control in DSR. Manual weeding can be adopted where cheap labor is available.

Table 1. Economic analysis of different weed control treatments in three fine rice cultivars

	Super basmati					Basmati-385					Shaheen basmati					Remarks
	Control	Manual weeding	Bispyribac sodium	Ethoxysulfuron	Penoxsulam	Control	Manual weeding	Bispyribac sodium	Ethoxysulfuron	Penoxsulam	Control	Manual weeding	Bispyribac sodium	Ethoxysulfuron	Penoxsulam	
Total yield	0.63	3.53	3.33	2.48	2.96	0.59	4.13	3.87	2.79	3.48	0.64	4.08	4.02	2.96	3.09	t ha^{-1}
Adjusted yield	0.56	3.18	2.99	2.23	2.66	0.52	3.72	3.48	2.51	3.13	0.57	3.67	3.62	2.66	2.78	To bring at farmer's level (10%)
Gross income	18900	107325	100912	75263	89775	17550	125550	117450	84713	105638	19238	123863	122175	89775	93825	Rs. 33750 t^{-1}
Cost of herbicides/ manual weeding	0	2800	1200	885	1100	0	2800	1200	885	1100	0	2800	1200	885	1100	Manual weeding (200 per man, 7 man day^{-1} ha^{-1}) Total price of herbicide ha^{-1}
Sprayer rent	0	0	100	100	100	0	0	100	100	100	0	0	100	100	100	Rs. 100 per spray
Spray application cost	0	0	250	250	250	0	0	250	250	250	0	0	250	250	250	Rs. 250/man, one man day^{-1} ha^{-1}
Cost that vary	0	2800	1550	1235	1450	0	2800	1550	1235	1450	0	2800	1550	1235	1450	Rs. ha^{-1}
Net field benefit	18900	104525	99362	74028	88325	17550	122750	115900	83478	104188	19238	121063	120625	88540	92375	Rs. ha^{-1}

Table 2. Marginal analysis of different weed control treatments in three fine rice cultivars

Treatments	Total cost that vary	Net benefits	Marginal cost	Marginal net benefits	Marginal rate of return (%)
	(Rs ha^{-1})				
Super Basmati					
Weedy check (control)	0	18900	-	-	-
Ethoxysulfuron	1235	74028	1235	55128	4463
Penoxsulam	1450	88325	215	14297	6649
Bispyribac sodium	1550	99362	100	11037	11037
Manual weeding	2800	104525	1250	5163	413
Basmati-385					
Weedy check (control)	0	17550	-	-	-
Ethoxysulfuron	1235	83478	1235	65928	5338
Penoxsulam	1450	104188	215	20710	9632
Bispyribac sodium	1550	115900	100	11712	11712
Manual weeding	2800	122750	1250	6850	548
Shaheen Basmati					
Weedy check (control)	0	19238	-	-	-
Ethoxysulfuron	1235	88540	1235	69203	5603
Penoxsulam	1450	92375	215	3835	1784
Bispyribac sodium	1550	120625	100	28250	28250
Manual weeding	2800	121063	1250	438	35

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