Pak. J. Weed Sci. Res., 20(4): 519-529 , 2014

EFFECTIVE WEED MANAGEMENT IN DRY DIRECT SEEDED RICE FOR SUSTAINABLE PRODUCTIVITY

Rana Inayat Ali[1]*, M.U. Saleem, Nadeem Iqbal and M. Akhter

ABSTRACT

A field experiment was conducted at Rice Research Institute, Kala Shah Kaku, Pakistan during 2011 to identify appropriate herbicides for effective weed control in dry direct seeded rice. Randomized Complete Block Design (RCBD) was used with three replications. The major weeds identified with dry direct seeded rice were Echinochloa colona, Echinochloa cruss-galli, Diplachne fusca, Cyperus iria, Cyperus difformis, Scirpus meritimus, Cyperus rotundus, Marsilia minuta and Conyza stricta. Twelve pre and post emergence herbicidal treatments were tested and compared with weedy check. A pre-emergence herbicide was applied just after seeding and the post-emergence herbicides were applied at 21 and 40 days after seeding (DAS). Weed density m^{-2} was recorded at 20 and 45 days after seeding. The best weed control (94.8 - 98.1%) was achieved with two sprays (21 & 40 DAS) of post emergence herbicide (bispyribac sodium) followed by single application (21 DAS) of the same herbicide which gave weed control of 77.5 to 82.3 %. orthosulphuron, phenoxulum and ethoxysulphuron as post emergence herbicides were found more effective against broad leaf weeds and sedges than grasses. As regards paddy yield, it was found to be maximum (3.97 - 4.14 t ha^{-1}) with the twice application of bispyrabic sodium (Clover 20% SC or Nominee 20% SC) whereas, the lowest paddy yield was recorded in case of weedy check (0.41 t ha^{-1}). Number of productive tillers m^{-2}, number of filled grains $panicle^{-1}$ and 1000-grain weight (g) were also higher in the plots having twice application of bispyribac sodium than other herbicidal treatments and weedy check.

Key words: Dry direct seeding, herbicides, paddy yield, percent weed control, rice, weed density, yield components.

Citation: Ali, R.I., M.U. Saleem, N. Iqbal and M. Akhter. 2014. Effective weed management in dry direct seeded rice for sustainable productivity. Pak. J. Weed Sci. Res. 20(4): 519-529.

INTRODUCTION

[1]Rice Research Institute, Kala Shah Kaku, Pakistan
*Corresponding author's email: nadeemaro@yahoo.co.uk

The growth of world's population is expected to exceed up to 8.5 billion by the year 2020 and subsequently, this will require increased rice (*Oryza sativa* L.) and other food crops production. This could be satisfied, either by increasing areas of crops or by achieving higher crop yields. The first option may not be feasible due to various economic and environmental reasons. In Asia during the past decade, rice area in most of the countries has remained static or even declined. Therefore, production should be increased by increasing the yield per unit area (Maan *et al.,* 2007). In Pakistan, rice is grown on an area of 2.57 million hectares with annual production of 6.16 million tones and an average yield of 2396 kg ha^{-1} (Anon., 2012) which is much lower than many other rice growing countries. There exists a good scope of increasing rice production as present yield level is much lower than the potential of our existing varieties. Less plant population per unit area is one of the major causes of low rice yield because transplanting is done manually in the extremely hot season and farm labour does not transplant required number of seedlings per acre despite vehement efforts of crop specialists, media publicity and farmers themselves. This issue has compelled the researchers to explore the new resource conservation production technologies by which required number of plants per unit area can be maintained.

Direct rice seeding or mechanized transplanting are the only alternate technologies where plant population can be increased but mechanized transplanting is very costly and difficult. The only way left is the adoption of direct seeded rice (DSR) which can reduce the water and labour demand ultimately decreasing the cost of production. In South Asia, direct seeded rice is being practiced on terraced and sloppy lands of Bangladesh, along the coast and western Himalayan region of India (Gupta *et al.,* 2006; Hussain *et al.*, 2008). The productivity of direct seeded rice is often reported to be lower, mainly due to problems associated with weed management which cause yield loss of 50-91% (Elliot *et al.*, 1984; Fujita*,* 1996). Singh *et al.* (2005) reported good success with dry seeded rice production technology in large scale farmer participatory trials in the Tevai of Uttaranchal, India where the seed bed technique was combined with the application of pendimethalin within two days after seeding. Thus, timely weed control is of vital importance to increase rice productivity (Akhtar *et al.,* 2010). Moreover, the development of new and improved herbicides for dry seeded rice is essentially needed (Gupta *et al.*, 2003). Several pre and post emergence herbicides have been reported to provide a fair degree of weed control in direct seeded rice (Moorthy and Mittra, 1992; Pellerin and Webster, 2004). Thus, it is crucial to upgrade the direct seeded rice technology along with effective weed management and make it more cost effective, environment and farmer's friendly.

MATERIALS AND METHODS

A field experiment was conducted at Rice Research Institute, Kala Shah Kaku, Pakistan (31°45'35N 73°50'16E with altitude 205 m) during the year 2011 using Randomized Complete Block Design (RCBD) with three replications having plot size of 5m x 10m ($50m^2$). Six pre and post emergence herbicides (Table-2) were tested and compared with weedy check (no weeding). The physico-chemical properties of experimental site are given in Table-3 whereas the metreological data is presented in Fig. 1. Soil was prepared thoroughly after "rauni" (soaking irrigation) by giving two ploughings followed by plankings. Seeding of dry seed of variety Super Basmati at the rate of 35 kg ha^{-1} was done on 25th June 2011 using rabi drill. First irrigation was applied just after seeding and subsequently field was irrigated repeatedly after every 5 days to keep the soil in saturation condition till the completion of tillering phase. Later on irrigation was done at 75% soil moisture level and in total 18 irrigations was applied. Application of fertilizer was made at the rate of 133:85:62 kg N: P: K ha^{-1} in the form of Urea, DAP and SOP, respectively. All P and K while one third of N fertilizer was added to the soil before seeding during seed bed preparation. The remaining nitrogen fertilizer was applied in two equal splits i.e. at 35 days after seeding and at panicle initiation stage. Pre-emergence herbicide application was made just after seeding while post-emergence herbicides application was done at 21 and 40 days after seeding. The following weeds were found infesting the experimental area.

The data on weed density m^{-2} before and after herbicide application was recorded. The crop was harvested on 12th November 2011 and the data on number of productive tillers m^{-2}, number of filled grains per panicle, 1000-grains weight (g) and paddy yield (t ha^{-1}) was recorded. The data for each trait was individually subjected to ANOVA technique by using M-Stat C software and means were separated by using Fisher's protected LSD test (Steel and Torrie, 1997).

Table-1. List of weeds found in dry direct seeded rice crop

Broad leaf weeds		
Botanical Name	English Name	Common Name
Sphenoclea zeylancia	Goose weed	Mirchi booti
Marsilea minuta	Water clover	Chaupatti
Conyza stricta	Bitter weed	Daryai booti
Sedges		
Cyperus rotundus	Purple nut sedge	Morke
Cyperus defformis	Umbrella plant	Ghooin
Scirpus meritimus	Bulrush	Deela
Cyperus iria	Flat sedge	Bhoin
Fimbristylis dichotoma	Globe frigerush	Chooti bhoin
Grasses		
Paspalum distichum	Water grass	Naru
Echinochloa crus-galli	Barnyard grass	Dhiddon
Echinochloa colona	Jungle rice	Swanki
Diplachne fusca	Sprangle top	Kallar grass
Cynodon dactylon	Creeper grass	Khabbal
Dactyloctenium aegyptium	Egyptian finger grass	Madhana

Table-2. Herbicidal treatments

Trade Name	Common Name	Time of application/ Spray	Dose ha^{-1}
Stomp 330 E	Pendimethalin	0 DAS	2500 ml
Nominee 20 % SC	bispyribac sodium	21 DAS	250 ml
Nominee 20 % SC	bispyribac sodium	21 and 40 DAS	250 ml
Clover 20 % SC	bispyribac sodium	21 DAS	200 g
Clover 20 % SC	bispyribac sodium	21 and 40 DAS	200 g
Ryzelon 240 SC	Phenoxulum	21 and 40 DAS	125 ml
Sunstar gold 60 % WG	ethoxy sulphuron	21 and 40 DAS	50 g
Kelion 50 WG	orthosulphuron	21 and 40 DAS	120 g
Stomp 330E + Nominee 20%SC	pendimethalin and bispyribac sodium	0 and 21 DAS	2500 ml + 200 ml
Stomp 330E + Ryzelon 240SC	pendimethalin and phenoxulum	0 and 21 DAS	2500 ml + 125 ml
Stomp 330E + Sunstar gold 60%WG	pendimethalin and ethoxy sulphuron	0 and 21 DAS	2500 ml + 50 g
Stomp 330 E + Kelion 50 WG	pendimethalin and orthosulphuron	0 and 21 DAS	2500 ml + 120 g

Table-3. Physical and chemical properties of soil used for study

Parameter	0-6" soil depth	6-12" soil depth
EC (dsm^{-1})	1.31	0.94
Soil pH	8.19	8.29
Organic matter (%)	0.39	0.27
Nitrogen (%)	0.48	0.31
Available phosphorus (ppm)	5.1	4.9
Available potash (ppm)	91	78
Saturation (%)	44	38
Texture	Clay loam	Clay loam
SAR (m mol L^{-1})	7.01	7.25

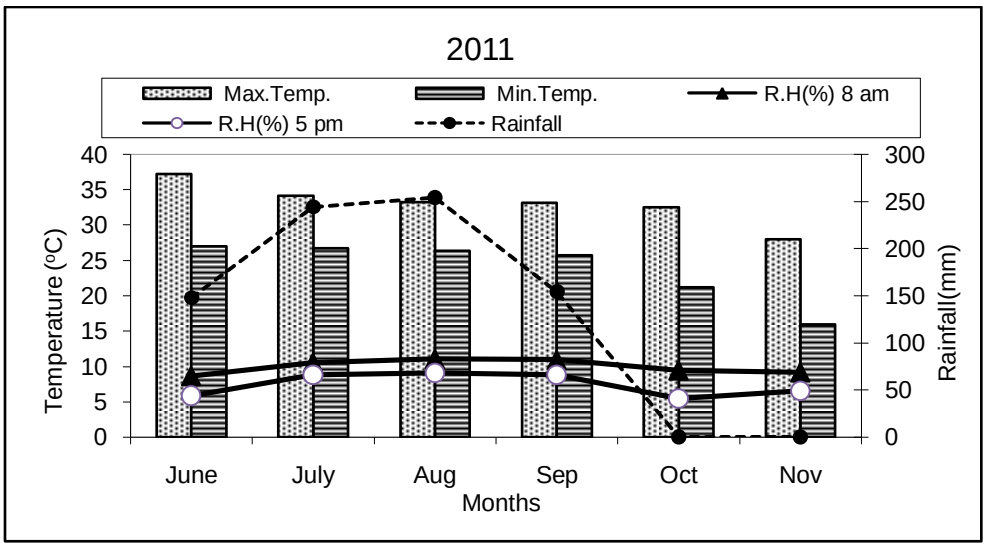

Figure 1. Meteorological data of experimental site during the crop growth season 2011

RESULTS AND DISCUSSION

Weed density m^{-2}

The weed species infesting the experimental field are given in Table-1. The results indicated that the herbicide treatments significantly ($P<0.05$) affected the weed density (Table-4). Thus, significantly the minimum post treatment weed density (6.4 m^{-2}) at 45 days after sowing was achieved with two applications of Nominee 20 % SC; first at 21 days after sowing and the 2nd 40 days after sowing. It was followed by the twice application of Clover 20 % SC and these two treatments remained statistically at par with each other. Whereas, the highest number of weeds (251.2 m^{-2}) was counted in the weedy

check (control) plots. It was also observed that Stomp 330E alone as a pre-emergence herbicide was not much effective to control early flush of weeds while in combination with Bispyribac sodium, Phenoxulum and Orthosulphuron it gave better weed control than the sole application of these herbicides. Similar results were reported by Hess and Rose (1995) and Nagappa *et al.* (2002). In terms of percent weed control twice application of Nominee 20%SC and Clover 20%SC herbicides containing Bispyribac sodium as gamma isomer gave the best weed control over all types of weeds which was 98.1% and 94.8%, respectively and these were found statistically at par with each other; whereas, single application of these herbicides was not as effective as twice application. Ryzelon (phenoxulum), Kelion (orthosulphuron) and Sunstar gold (ethoxysulphuron) as post-emergence treatments were found more effective against broadleaf weeds and sedges than in case of grasses. The results are in conformity with Fujita (1996) and Jinhao *et al.* (1999) who reported that use of post-emergence herbicides gave better weed control in direct seeded rice.

Number of productive tillers per m^2

The comparison of mean values regarding number of productive tillers m^{-2} (Table-6) indicated that productive tillers were maximum in the plots treated with post-emergence herbicide Nominee (418.2 m^{-2}) followed by Clover (390.6 m^{-2}) and these two treatments were statistically at par with each other. The other herbicide treatments gave comparatively lower number of productive tillers. The lowest number of productive tillers was counted in weedy check plots. The results are in line with the findings of Fang and Wang (1990) who reported that yield and yield components decreased in case of herbicide untreated plots.

Number of filled grains per panicle

The effect of herbicide treatments on number of filled grains $panicle^{-1}$ were found to be highly significant ($P<0.01$). Thus, the highest number of filled grains $panicle^{-1}$ (116.3) was recorded from the plots sprayed with Nominee 20%SC on 21 and 40 DAS (T_3) and it was followed by T_5 (Clover 20% SC sprayed at 21 & 40 DAS) which produced 107.1 filled grains $panicle^{-1}$ and these treatments were statistically at par with each other (Table-6). The lowest number of filled grains per panicle was found in case of weedy check plots (43.6). The results are in conformity with that of Nagappa *et al.* (2002) who reported higher number of filled grains $panicle^{-1}$ in case of herbicides treated plots than untreated plots.

Table-4. Weed density m^{-2} at 20 and 45 days after sowing

Herbicidal Treatments	Pre-treatment weed density (20 DAS)				Post-treatment weed density 45 DAS			
	Grasses	Sedges	Broad Leaves	Total	Grasses	Sedges	Broad Leaves	Total
Stomp 330 E (Spray at 0 DAS)	98.0 a	81.3 c	61.3 e	240.6 a	87.7 a	78.0 a	54.7 b	220.3 b
Nominee 20 % SC (Spray at 21 DAS)	77.3 d	88.4 b	90.2 b	255.9 a	19.8 d	17.4 b	9.7 d	36.9 f
Nominee 20 % SC (21 & 40 DAS)	88.7 b	78.7 c	53.7 c	221.1 b	3.4 e	1.3 d	1.7 c	6.4 h
Clover 20 % SC (Spray at 21 DAS)	80.6 c	81.1 c	77.4 c	239.1 a	23.4 d	19.3 b	11.2 d	43.9 f
Clover 20 % SC (21 & 40 DAS)	75.0 d	82.0 c	72.7 d	229.7 b	5.3 e	3.7 e	2.8 e	9.8 h
Ryzelon 240 SC (21 & 40 DAS)	68.7 d	105.7 a	39.3 b	213.7 bc	36.0 c	25.7 b	19.1 c	100.8 d
Sunstar gold 60 % WG (21 & 40 DAS)	100.7 a	75.3 d	54.0 e	230.0 b	80.7 a	16.3 b	27.4 c	135.3 c
Kelion 50 WG (21 & 40 DAS)	80.0 c	93.3 b	97.4 a	270.7 a	32.0 c	24.7 b	47.0 b	103.7 d
Stomp 330E + Nomine 20%SC (0 + 21 DAS)	74.7 d	53.0 b	85.7 b	210.4 c	10.0 e	13.0 e	2.0 c	25.1 f
Stomp 330E + Ryzelo 240 SC (0 & 21 DAS)	84.2 c	80.1 c	71.3 d	235.6 a	31.6 c	26.3 b	19.7 c	57.6 f
Stomp 330E + Sunstar 60WG (0 & 21 DAS)	71.4 d	82.3 c	79.4 c	232.8 b	57.0 b	16.9 b	17.3 c	96.7 d
Stomp 330E + Kelion 50WG (0 & 21 DAS)	81.1 c	70.3 e	80.4 c	231.8 b	34.7 c	18.6 b	17.1 c	70.4 e
Weedy Check	82.7 c	79.0 c	78.1 c	239.8 a	85.8 a	82.0 a	83.4 a	251.2 a
LSD	5.29	8.17	6.24	34.72	9.68	11.31	10.51	12.23

Means followed by different letters in the respective columns are significantly different by Fisher's Protected LSD test at $p \leq 0.05$.

1000-grain weight (g)

The results indicated that herbicide treatments had a significant ($P<0.05$) effect on grain weight. The highest 1000-grains weight of 21.92 g was recorded with the treatment T_3 where Nominee was applied twice (21 & 40 DAS) and it was followed by Clover treated plots (T_5) which gave 21.73 g weight of 1000 grains and the differences between these two treatments were found to be non-significant statistically (Table-6). The data showed that sole application of Nominee or Clover (21 & 40 DAS) proved to be superior to the combination of Nominee with Stomp. Whilst the lowest 1000-grains weight of 20.11 g was recorded in case of weedy check.

Paddy yield (t ha^{-1})

All herbicide treatments except sole application of Stomp 330E gave significantly ($P<0.05$) higher paddy yield than weedy check (Table-6). Thus, the maximum paddy yield (4.14 t ha^{-1}) was achieved with the treatment T_3 where Nominee 20%SC was applied twice (21 & 40 DAS) and it was followed by T_5 (Clover 20%SC sprayed on 21 & 40 DAS) which produced 3.97 t ha^{-1} paddy however, these two treatments remained statistically at par with each other. Amongst the combined application of different herbicides, T_9 (Stomp 330E + Nominee 20%SC sprayed at 0 & 20 DAS) expressed significantly ($P<0.05$) higher paddy yield than all other herbicide combinations by producing 3.78 t ha^{-1} paddy. Whereas, the lowest yield of 0.41 t ha^{-1} was recorded with treatment of weedy check that remained statistically at par with that of T_1 where pre-emergence application of Stomp 330 E was made. Our findings get support from the work of other scientists who reported that effective weed control with herbicide application improved grain yield in transplanted rice (Bhowmick and Ghosh, 2002) as well as in direct wet-seeded rice (Saini and Angiras, 2002; Ashraf *et al.*, 2006). Increased grain yield through effective weed control was also reported by Lourens *et al*. (1989).

Table-5. Percent weed control of pre and post-emergence herbicides

Herbicidal Treatments	Percent Weed Control			
	Grasses	Sedges	BL	Average
Stomp 330 E (0 DAS)	10.5 g	4.0 d	10.7 e	8.4
Nominee 20SC (21 DAS)	74.3 c	80.3 b	89.2 b	82.3 b
Nominee 20SC (21 & 40 DAS)	96.4 a	98.3 a	99.6 a	98.1 a
Clover 20SC (21 DAS)	70.9 c	76.2 b	85.5 b	77.5 c
Clover 20SC (21 & 40 DAS)	92.9 a	95.4 a	96.1 a	94.8 a
Ryzelon 240SC (21 & 40 DAS)	47.6 e	75.6 b	51.3 d	58.2 d
Sunstar gold 60WG (21 & 40 DAS)	19.8 f	78.3 b	49.2 d	49.1 e
Kelion 50 WG (21 & 40 DAS)	60.0 d	73.5 b	51.7 d	61.7 d
Stomp 330E+Nomine 20SC (0 & 21 DAS)	86.6 b	75.4 b	97.6 a	86.5 b
Stomp 330E+Ryzelon 240SC (0&21 DAS)	62.4cd	67.2 c	72.3 c	67.3 d
Stomp 330E + Sunstar gold 60 WG (0 & 21 DAS)	20.2 b	79.3 b	78.6 c	59.4 d
Stomp 330E + Kelion 50WG (0 & 21 DAS)	57.2 d	73.5 b	78.7 c	69.8 cd
Weedy Check	-	-	-	-
LSD	6.94	8.71	8.13	7.52

Means followed by different letters in the respective columns are significantly different by Fisher's Protected LSD test at $p \leq 0.05$.

Table-6. Effect of herbicides on paddy yield and yield components

Herbicidal Treatments	No. of tillers m^{-2}	No. of filled grains $panicle^{-1}$	1000 grain weight (g)	Paddy yield (t/ha)
Stomp 330 E (0 DAS)	57.0 e	46.7 d	20.41 b	0.62 e
Nominee 20SC (21 DAS)	406.7 a	105.7 a	21.09 a	3.57 b
Nominee 20SC (21 & 40 DAS)	418.2 a	116.3 a	21.92 a	4.14 a
Clover 20SC (21 DAS)	373.4 a	103.4 a	20.91 a	3.36 c
Clover 20SC (21 & 40 DAS)	390.6 a	107.1 a	21.73 a	3.97 a
Ryzelon 240 SC (21 & 40 DAS)	231.2 bc	76.3 bc	20.62 b	1.76 d
Sunstar gold 60WG (21 & 40 DAS)	187.1 d	68.2 c	20.21 b	1.42 de
Kelion 50 WG (21 & 40 DAS)	214.3 c	74.1 bc	20.61 b	1.66 d
Stomp 330 E + Nominee 20 SC (Spray at 0 + 21 DAS)	412.3 a	107.3 a	20.97 a	3.78 b
Stomp 330 E + Ryzelon 240 SC (Spray at 0 & 21 DAS)	266.2 b	84.6 b	20.49 b	1.83 d
Stomp 330 E + Sunstar gold 60 WG (Spray at 0 & 21 DAS)	234.8 bc	76.7 bc	20.31 b	1.71 d
Stomp 330 E + Kelion 50 WG (Spray at 0 & 21 DAS)	267.3 b	82.3 bc	20.67 b	2.11 d
Weedy Check	46.0 e	43.6 d	20.11 b	0.41 e
LSD	49.65	17.79	1.49	0.4167

Means followed by different letters in the respective columns are significantly different by Fisher's Protected LSD test at $p \leq 0.05$.

CONCLUSION

It can be concluded from these studies that in dry direct seeded rice an effective control of weeds (i.e. grasses, broad leaf weeds and sedges) and ultimately a higher paddy yield could be achieved with twice application of bispyribac sodium (POE) at 21 and 40 days after sowing. However, in fields where broad leaf weeds and sedges predominate, ethoxysulphuron or orthosulphuron are more appropriate herbicides to be used. Selection and timely application of suitable herbicides based on prevailing weed flora would enable the rice growers to harvest better paddy yield at comparatively lower cost.

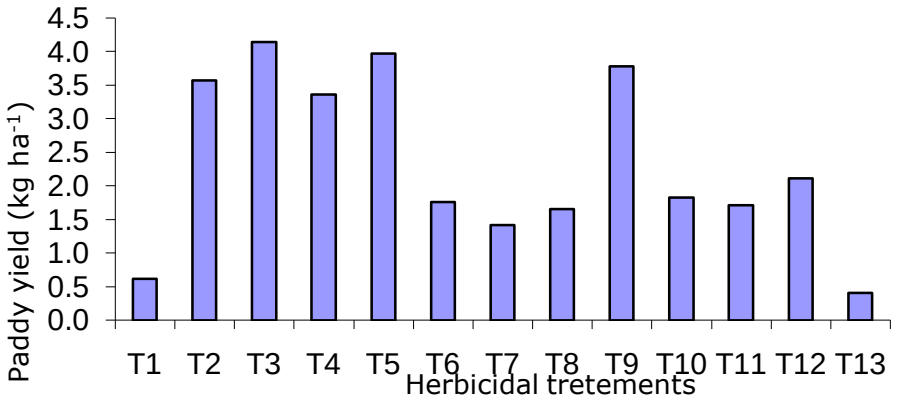

Figure 2. Effect of the herbicidal treatments on paddy yield

REFERENCES CITED

Akhtar, M., I. Ali and M.U. Saleem. 2010. Harmful insects, diseases, weeds of rice and their control. p. 14-20.

Anonmymous. 2012. Economic Survey of Pakistan. Govt. of Pakistan. Finance Division Economic Advisory Wing, Islamabad. Pp.

Ashraf, M.M., T.H. Awan, Z. Manzoor, M. Ahmad and M.E. Safdar.2006. screening of herbicides for weed management in transplanted rice. J. Anim Pl. Sci. 16(1-2): 92-95.

Bhowmick, M.K. and R.K. Ghosh. 2002. Relative efficacy of herbicides against weed incidence in summer rice. Adv. Plant Sci. 15(2): 499-503.

Elliot, P.C., D.C. Navarez, D.B. Estario and K. Moody. 1984. Determining suitable weed control practices for dry – seeded rice. Philip. J. Weed Sci. 11:70-82.

Fang, Z.Y. and S.X. Wang. 1990. Preliminary study on weed control in dry seeded rice (DSR) after winter wheat. Intl. Rice Res. Newslet. 15(6): 26-27.

Fujita, K. 1996. Effect of several herbicides application on growth of shoots and roots of rice seedlings at the nursery stage. Weed Res. 41: 44-54.

Gupta, R.K., J.K. Ladha, S. Singh, R.J. Singh, M.L. Jat, *et al*. 2006. Production technology for direct seeded rice. Rice Wheat Consortium Technical Bulletin 8. New Delhi, India. Rice Wheat Consortium for the Indo-Gagetic Plains. pp. 16.

Gupta, R.K., R.K. Naresh, P.R. Hobbs, Z. Jiaguo and J.K. Ladha. 2003. Sustainability of post-green revolution agriculture: the rice-wheat cropping system of the Indo-Gangetic Plains and

China. Improving the productivity and sustainability of rice-wheat systems: Issues and impacts, improving the pro 1-25.

Hussain, S., M. Ramzan, M. Akhter and M. Asalam. 2008. Weed management in direct seeded rice. J. Anim. Pl. Sci. 18: (2-3): 86-88.

Hess, M. and E. Rose. 1995. HOE 095404: a new herbicide for broadleaf weed and sedge control in rice. In Brighton Crop Protection Conference Weeds, vol. 2, pp. 763-768. Brit Crop protection Council.

Jinhao, H., S. Yujian, Z. Xiaojun and B. Huanzheng. 1999. Occurrence of weeds in arid seedling nursery of early rice and their control. ACTA Agriculturae-Zhejiangensis 5, 002.

Lourens, J.H., M.B. Arceo and F.S. Datud. 1989. Fenoxyprop ethyl (Whip) and fenoxaprop-p-ethyl (Whip-S) for grass control in direct seeded rice under rainfed conditions in the Philippines. Proc. 12th Asian Pacific Weed Sci. Soc. Conf., Manila, Philippines, pp. 291-301.

Maan, R.A, S. Ahmad, G. Hassan and M.S. Baloch. 2007. Weed management in direct seeded rice crop. Pak. J. Weed Sci. Res. 13(3-4): 219-226.

Moorthy, B.T.S. and B.N. Mittra. 1992. Reduction of herbicide phytotoxicity on upland rice by use of protectants. Inter. J. Pest Manage. 38(3): 295-297.

Nagappa, N., D. Naresh and D.P. Biradar. 2002. Efficiency of different herbicides to control weeds and its impact on yield in direct seeded rice of Tunga Bhadra project area. Karnataka J. Agric. Sci. 15: 359-361.

Pellerin, K.J. and E.P. Webster. 2004. Imazethapyr at different rates and timings in drill and water seeded imidazolinone-tolerant rice. Weed Technol. 18:23–227.

Saini, J.P. and N.N. Angrias. 2002. Evaluation of ethoxysulphuron against broad leaved weeds and sedges in direct seeded puddled rice. Indian J. Weed Sci. 34:36-38.

Singh, V.P., G. Singh, S.P. Singh, A. Kumar, Y. Singh, D.E. Johnson and M. Mortimer. 2005. Effect of rice wheat establishment methods and weed management in irrigated rice-wheat production system. In Workshop on Direct Seeded Rice in the Rice-wheat System of the IGP, 1-2 Feb.2005, G.B. Pant University of Agric & Technol., Uttaranchal, India, pp. 12.

Steel, R.G.D. and J.H. Torrie. 1997. Principles and procedures of statistics. Mc Graw Hill Book Co. Inc. Singapore, p. 172-177.