Indian Journal of Agronomy **61** (3): 326–330 (September 2016)

Research Paper

Effect of crop-establishment methods and weed-management options on weed dynamics and productivity of rice (*Oryza sativa*)

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Received : August 2015; Revised accepted : July 2016

ABSTRACT

A field experiment was conducted at the Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during the rainy (*kharif*) seasons of 2011 and 2012, to study the effect of crop-establishment methods and weed-management options on weed dynamics and productivity of rice (*Oryza sativa* L.). The lowest density and dry matter of total weeds 60 days after sowing/days after transplanting was recorded under transplanted rice. This treatment resulted in the highest number of effective tillers/m^2 (218.36) and grain yield (4.01 t/ha) of rice. Among the weed-management options, application of bispyribac sodium 20 g/ha at 15 DAS/DAT followed by 1 hand-weeding (HW) at 35 DAS/DAT being at par with the application of penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds, followed by 1 HW at 35 DAS/DAT recorded the minimum population and dry-matter of total weeds and the highest weed control efficiency. This treatment resulted in significantly higher number of panicles/m^2, grains/panicle and grain yield than rest of the treatments. Crop-establishment methods and weed-management options interacted significantly; and significantly higher grain yield was recorded with transplanted rice in combination with the application of bispyribac sodium 20 g/ha at 15 DAS/DAT followed by 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds followed by (fb) 1 HW at 35 DAS/DAT. The highest net returns (₹1,380/ha) and benefit: cost ratio (1.09) were recorded with application of penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT.

Key words **:** Crop-establishment methods, Productivity, Rice, Weed-management

Rice is the staple cereal crop of India plays a key role in food security. The country has to produce approximately 130 million tonnes of rice by 2025 to feed the ever-increasing growing population (Hugar *et al.,* 2009). The productivity of rice in India is quite low (2.2 t/ha) compared to China (6.2 t/ha) and Japan (6.5 t/ha). There are various factors responsible for low productivity of rice, in which weeds are predominant ones. In India, transplanting is the most common method of rice cultivation. However, owing to its several limitations, viz. more labour and time-consuming and requiring a lot of expenditure on raising nursery, its uprooting and transplanting. In wet seeding, sowing of pre-germinated or sprouted seeds on to puddled soil substantially reduces the cost of labour, as it eliminates the use of seedlings and related operations such as seedling nursery operation, care of seedlings, pulling, bundling, transportation and transplanting (Serrano, 1975). Besides numerous advantages it has been accompanied by an increase in weed problems. Sometimes farmers do not get chance for weeding at appropriate time due to pre-occupation. Hand- weeding in wet-seeded rice is more time-consuming, cumbersome and not as easy as in transplanted rice (Moody, 1983).

Direct dry-seeded rice (DSR) which excludes puddling and drudgery of transplanting the young rice seedlings provides an option to resolve the edaphic conflict and enhances the sustainability of rice–wheat cropping system. Transplanted rice has deleterious effects on the soil environment for the succeeding wheat and other upland crops. Puddling requires lot of scarce water, destroys soil structure and adversely affects soil productivity. Non-development of ground-water in *kharif*, late onset of monsoon and drudgery of operations often delays rice transplanting which leads late vacation of fields, forcing farmers to sow wheat after the optimum time. The DSR facilitates timely establishment of rice and succeeding winter crops. Unlike

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puddled fields, DSR fields do not crack and thus help in saving irrigation water (Kumar, 2009).

Farmers growing direct-seeded rice are, however, likely to encounter greater problems related to weed management in absence of standing water. The transition to direct seeding of rice can, therefore, be successful only if accompanied by effective weed management practices (Singh *et al*., 2003). Weeds cause 50–60% reduction in grain yield under puddled conditions and 91% in un-puddled conditions (Ali and Sankaran, 1984). Use of weeding tools damage the rice as they move through the field, especially during early crop growth, and they also fail to remove some of the grassy weeds. Keeping these facts in view, present investigation was under taken to study the effect of crop-establishment methods and weed management options on weed dynamics and productivity of rice.

MATERIALS AND METHODS

The field experiment was conducted Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, during the rainy (*kharif*) seasons of 2011 and 2012. The soil was loam, high in organic carbon (0.87%), low in available nitrogen (262.0 kg/ha), medium in available phosphorus (21.8 kg/ha) and potassium (259.0 kg/ha) contents, neutral *p*H (7.2). An experiment was conducted in a split-plot design with 3 replications; keeping rice-establishment methods, viz. direct-dry seeded rice (DSR), wet-seeded rice (WSR-sprouted seeds) and transplanted rice (TPR) in main plots and 6 levels of weed-management options, viz. penoxsulam 22.5 g/ha at 2–3 leaf stage of weeds (W_1), penoxsulam 22.5 g/ha at 2–3- leaf stage of weeds followed by (fb) 1 hand-weeding (HW) at 35 DAS/DAT (W_2), bispyribac sodium 20 g/ha at 15 DAS/DAT (W_3), bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 hand- weeding at 35 DAS/DAT (W_4), weed-free (W_5) and weedy check (W_6) in subplots.

In direct dry-seeded rice, seeds were sown in lines, 20 cm apart, by using 40 kg/ha seed rate and covered by soil, while sprouted seeds were sown in rows, 20 cm apart, in wet-seeded rice using manually operated drum seeder. Twentyone day-old-seedlings were used in transplanting method. Rice cultivar 'Sarju 52' was used in the experiment. In direct dry-seeding rice, seed was sown on 11 June 2011 and 21 June 2012. Crop was fertilized uniformly with 150, 60 and 40 kg/ha of N, P_2O_5 and K_2O, respectively, through NPK mixture (12 : 32 : 16), urea (46 : 0 : 0) and muriate of potash (0 : 0 : 60). Full amount of phosphorus and potassium and half of nitrogen were applied basal just before sowing of rice seed/transplanting of rice seedling. Remaining nitrogen was top-dressed through urea in 2 splits–first at active tillering and second at panicle-initiation stage-in all methods of rice establishment.

Density and dry matter of weeds were recorded at 60 DAS/DAT with the help of quadrate (0.5 m × 0.5 m) and then converted in per square meter. Data on weeds were subjected to square-root transformation before statistical analysis to normalize their distribution. Data were analyzed by using ANOVA and critical difference (CD) value at 5% level of significance were calculated and used to test significant differences between treatment means.

RESULTS AND DISCUSSION

Effect on weeds

The major weed species recorded in weedy plots were: *Echinochloa colona*, *Leptochloa chinensis, Echinochloa crus-galli* among grasses; *Cyperus rotundus, C. iria* and *C. difformis* among sedges; and *Caesulia axillaris, Alternanthera pheloxeroides*, *Trianthema monogyna* among broad-leavf weeds. These results are in accordance with the studies of Yadav *et al*. (2010a) and Mukherjee and Maity (2011). The lowest density and dry weight of weeds was observed with transplanted rice (Table 1). The highest density and dry matter of weeds were observed under DSR. It might be due to better conditions for weeds emergence and its survival. Transplanted and wet-seeded rice resulted in lower density and dry-matter of weeds mainly because of puddling which gave lesser emergence of deeply placed seeds. These results confirm the findings of Baloch *et al.* (2006) and Sanjay *et al.* (2010). Lowest density and dry-matter of weeds were found with the post-emergence application of bispyribac sodium at 20 g/ha fb 1 HW at 35 DAS/DAT, which was at par with pre-post-emergence application of penoxsulam at 22.5 g/ha + 1 HW at 35 DAS/DAT. These results confirm the findings of Revathi *et al.* (2010).

Different rice-establishment methods did not influence weed-control efficiency significantly; however, the highest weed-control efficiency was noticed under TPR and the lowest under DSR. Amongst weed-management options, the highest weed-control efficiency was seen with weed-free treatment which was closely followed by application of either bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT. This might be attributed to the control of all categories of weeds. Kiran *et al.* (2010) also reported similar results.

Yield attributes

Crop-establishment methods and weed-management options affected the yield attributes of rice (Table 2). Transplanted rice produced the highest number of panicles/m^2. Crop raised through wet seeding also pro-

Table 1. Weed density, dry matter and weed-control efficiency at 60 DAS/DAT as influenced by crop-establishment methods and weed management options on rice (pooled data of 2 years)

Treatment	Weed density (Nos./m^2)	Weed dry-matter (g/m^2)	Weed-control efficiency (%)
Rice-establishment method			
Direct-seeded rice	3.7 (126.0)	3.5 (169.3)	75.95
Wet-seeded rice	3.3 (73.1)	3.0 (83.9)	76.35
Transplanted rice	2.8 (51.7)	2.6 (59.4)	76.95
SEm±	0.08	0.06	0.50
CD (P=0.05)	0.33	0.21	NS
Weed-management option			
Penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds	4.4 (84.3)	4.4 (86.8)	80.00
Penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT	2.6 (16.0)	1.6 (4.6)	99.00
Bispyribac sodium 20 g/ha at 15 DAS/DAT	4.4 (89.4)	4.4 (85.7)	80.25
Bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT	2.6 (15.6)	1.6 (4.3)	99.05
Weed-free	0.0 (0.0)	0.0 (0.0)	100.00
Weedy check	5.7 (297.8)	6.0 (444.2)	0.00
SEm±	0.14	0.09	0.66
CD (P=0.05)	0.40	0.24	1.87

Original values given in parentheses; DAS, days after sowing; DAT, days after transplanting; fb, followed by; HW, hand-weeding; NS, non-significant

duced significantly more panicles/m^2 compared to direct dry-seeding of rice. The highest number of panicles/m^2 was counted under weed-free condition which was closely fb the application of either bispyribac sodium 20 g/ha fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha fb 1 HW at 35 DAS/DAT. Application of bispyribac sodium 20 g/ha or penoxsulam 22.5 g/ha alone being at par with each other recorded significantly higher number of panicles/m^2 than the weedy check. Differences in panicle length due to different rice-establishment methods and weed-management options were found non-significant. However, the longest panicle was observed of transplanted rice and the shortest in direct dry-seeded rice. Similarly, longest panicle was recorded under weed-free condition and shortest one in the crop kept under the weedy check. This might be owing to transplanting of young seedlings which might have resulted in better availability of nutrients, light and space during growth stages; production of more number of shoots per unit area. Ali *et al.* (2012) also reported similar results.

The effect of rice-establishment methods on grains/panicles was not significant. However, the maximum grains/panicles were produced with transplanted rice compared to DSR. It was because of more density and dry weight of weeds in direct dry-seeded rice and the least in TPR and wet-seed rice (WSR) during the reproductive stage. This result is in line with the finding of Ali *et al.* (2012). Among weed-control options, weed-free treatment being at par with the application of either bispyribac sodium 20 g/ha with 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha with 1 HW at 35 DAS/DAT resulted in the highest number of grains/panicles. The 1,000-grain weight did not differ significantly due to crop-establishment methods and weed management options. However, the highest grain weight was recorded in transplanted rice. It might be owing to lower weed population and dry weight of weeds which may have enhanced N, P and K uptake. The results confirm the findings of Kumar *et al.* (2007) and Yadav *et al.* (2010b).

Grain yield

Transplanted rice gave the highest grain yield. Crop raised through wet seeding also gave significantly higher grain yield than that of direct dry-seeded rice. The highest grain yield was obtained under with weed-free condition, though it was almost similar with the application of either bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3 leaf stage of weeds fb 1 HW at 35 DAS/DAT. Among the herbicidal treatments, application of bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT being at par to each other recorded significantly higher grain yield than their sole application (Table 2).

Enhanced grain yield is a resultant of yield attributes and therefore, maximum expression of yield attributes, viz. panicles/m^2, panicle length, grains/panicle and 1,000-grain weight, owing to reduced crop-weed competition in weed-free plots resulted in higher grain yield by 78.4% than weedy check. The results are in close conformity to

Table 2. Effect of crop-establishment methods and weed-management options on yield attributes and grain yield of rice (pooled data of 2 years)

Treatment	Effective tillers/m^2	Panicle length (cm)	Grains/ panicle	1,000-grain weight (g)	Grain yield (t/ha)	Net return (× 10^3₹/ha)	Benefit: cost ratio
Rice-establishment method							
Direct-seeded rice	174.4	25.0	154.4	23.4	3.30	19.27	0.50
Wet-seeded rice	197.4	25.1	156.3	23.6	3.61	23.12	0.61
Transplanted rice	218.3	25.4	158.7	23.7	4.01	26.14	0.64
SEm±	2.05	0.2	0.82	0.13	0.06		
CD (P=0.05)	8.02	NS	3.21	NS	0.22	NA	NA
Weed management option							
Penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds	157.3	24.7	152.3	23.3	2.90	13.84	0.40
Penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT	262.0	25.8	162.3	23.9	4.86	41.38	1.09
Bispyribac sodium 20 g/ha at 15 DAS/DAT	159.5	24.7	152.1	23.6	2.91	13.31	0.37
Bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT	264.2	25.6	163.6	23.9	4.92	41.33	1.07
Weed-free	277.8	26.0	167.7	24.0	5.14	41.76	1.01
Weedy check	59.4	24.3	139.6	22.9	1.11	-14.56	-0.45
SEm±	5.5	0.50	1.98	0.21	0.09		
CD (P=0.05)	16.10	NS	5.71	NS	0.25	NA	NA

DAS, Days after sowing; DAT, days after transplanting; fb, followed by; HW, hand-weeding; NS, non-significant

those of Ramana *et al*. (2007).

The interaction effect of rice-establishment methods and weed-management options with respect to grain yield was significant (Fig. 1). Transplanted rice gave the highest grain yield under weed-free condition, followed by application of either bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT. The WSR also gave significantly higher grain yield under weed-free condition which was closely fb application of either bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT or penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT as compared to direct dry-seeded rice.

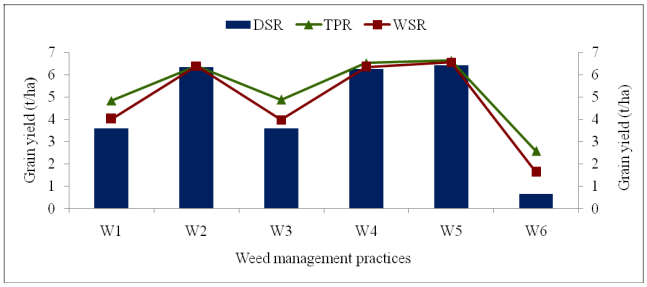

Fig. 1. Interaction between crop-establishment methods and weed-management options on grain yield (t/ha) (DSR, Direct seed rice; WSR, wet-seeded rice; TSR, transplant rice; details of weed-management options are given under Materials and Methods)

Economics

The total cost of cultivation, gross returns, net returns and benefit: cost ratio were obtained maximum and minimum under establishment methods of transplanted and direct-dry seeded rice respectively. Amongst the weed-management options, the highest cost of cultivation, gross returns and net returns were recorded in crop kept with weed-free (Table 2). However, among chemical weeding, bispyribac sodium @ 20 g ai/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT was recorded the highest cost of cultivation (₹38,840/ha) and gross returns (₹80,170/ha), while the highest net returns (₹1,380/ha) and benefit: cost ratio (1.09) was recorded under application of penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT and minus in weedy check during experimentation. Prasad *et al*. (2001) also documented similar findings.

Hence it may be concluded from this study that transplanting method of crop establishment and post-emergence application of bispyribac sodium 20 g/ha at 15 DAS/DAT fb 1 HW at 35 DAS/DAT could be found optimum, as it has resulted in the highest productivity. However, transplanting method of crop-establishment and early post-emergence application of penoxsulam 22.5 g/ha at 2–3-leaf stage of weeds fb 1 HW at 35 DAS/DAT resulted in the highest net returns and benefit: cost ratio.

REFERENCES

Ali, M.A. and Sankaran, S. 1984. Crop-weed competition in direct seeded low land and upland bunded rice. *Indian Journal of*

Weed Science **16**(2): 90–96.

Ali, R.A., Iqbal, N., Saleem, M.U. and Akhtar, M. 2012. Effect of different planting methods on economics, yield and grain quality of rice. *International Journal of Agricultural and Applied Science* **4**(1): 28–34.

Baloch, M.S., Awan, I.U., Hassan, G. and Khakwani, A.A. 2006. Effect of establishment methods and weed management practices on some growth attributes of rice. *Rice Science* **13**(2): 131–140.

Hugar, H.Y., Chandrappa, H., Jaydeva, H.M., Satish, A. and Mallikarjun, G.B. 2009. Comparative performance of different rice establishment methods in Bhadra command area. *Karnataka Journal of Agricultural Science* **22**(5): 992–994.

Kiran, D.Y., Subramanyam, D. and Sumathi, V. 2010. Growth and yield of transplanted rice (*Oryza sativa*) as influenced by sequential application of herbicides. *Indian Journal of Weed Science* **42**(3, 4): 226–228.

Kumar, A., Shivay, Y. S. and Pandey, J. 2007. Effect of crop establishment methods and weed control practices on weed dynamics, productivity and nutrient removal by weeds *vis-a-vis* crop and quality of aromatic rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **77**(3): 179–183.

Kumar, R. 2009-http://agropedia.iitk.ac.in/?q=content/direct-seeded-rice (submitted by Shukla, Rajeew on Tue, 30/06/2009–16:57).

Moody, K. and Vardova, V.G. 1983. The status of weed control in rice in Asia. (In) *Proceedings of Women in Rice Farming System,* 26–30 September 1983, International Rice Research Institute, Los Banos, Laguna, Philippines, pp. 467–480.

Mukerjee, P.K. and Maithy, S.K. 2011. Weed control in transplanted and wet seeded rainy season rice. *Indian Journal of Agricultural Sciences* **81**(2): 134–139.

Prasad, S., Mishra, S.S. and Singh, S.J. 2001. Effect of establishment methods, fertility levels and weed management practices on rice (*Oryza sativa* L.). *Indian Journal of Agronomy* **46**(2) : 216–221.

Ramana, A.V., Naidu, G.J. and Murthy, K.R.V. 2007. Integrated weed-management in rainfed upland rice. *Indian Journal of Agronomy* **52**(4): 311–314.

Revathi, M., Prabhakaran, N.K. and Chinnusamy, C. 2010. Establishment techniques and weed management practices in puddle low land rice. (In) *Proceedings Biennial Conference on Recent Advances in Weed Science Research*, held during 25–26 February 2010 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur, pp. 71–72.

Sanjay, M.T., Prasad, T.V.R., Dinesh, G.R., Ravi Kumar, H.S., Lokesh, D.S., Ananda, N. and Basavaraj, M.K. 2010. Productivity and economics of rice as influenced by weed management practices under different crop establishment techniques. (In) *Proceedings Biennial Conference on Recent Advances in Weed Science Research*, held during 25–26 February 2010 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur, pp. 55.

Serrano, F.B. 1975. *Twenty-six Years of Rice Research and Development,* pp. 122. National Research Council of the Philippines, Diliman, Quezon City, Philippines.

Singh, S., Singh, H., Narwal, S. and Malik, R.A. 2003. Performance of herbicides in transplanted rice. *Indian Journal of Weed Science* **35**(1 and 2): 114–116.

Yadav, D.B., Punia, S.S. and Yadav, A. 2010a. Efficacy of bispyribac-sodium, azimsulfuron and penoxsulam for post-emergence weed control in transplanted rice. (In) *Proceedings Biennial Conference on Recent Advances in Weed Science Research*, held during 25–26 February 2010 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur, pp. 75.

Yadav, V., Singh, L. and Singh, R. 2010b. Effect of crop establishment methods and weed management practices on protein content, nutrient uptake and yield of rice (*Oryza sativa* L.). *Pakistan Journal of Weed Science Research* **16**(4): 379–385.