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Effect of planting geometries and weed-management practices on weeds, crop performance and economics of direct-seeded aerobic rice (*Oryza sativa*)

NEESHU JOSHI[1], V.P. SINGH[2], V.C. DHYANI[3] AND S.P. SINGH[4]

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145

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ABSTRACT

A field experiment was conducted in a factorial randomized block design during the rainy (*kharif*) season of 2013 at Pantnagar, Uttrakhand, to study the influence of different planting geometry and weed-management practices on weed and crop dynamics in direct seeded aerobic rice (*Oryza sativa* L.). Continuous drilling at 20 cm with pendimethalin as pre-and bispyribac-Na as post emergence herbicide supplemented with 1 hand-weeding 45 days after sowing provided excellent results. *Echinochloa colona* (2.04 ±0.71) recorded the maximum summed dominance ratio. Among the planting geometries, continuous drilling at 20 cm and among weed-control practices, pendimethalin (1,000 g a.i./ha) + bispyribac-Na (25 g a.i./ha) + 1-hand-weeding 45 days after sowing (DAS) provided the higher weed-control efficiency (87.4%), productivity (₹4.79 t/ha) and net benefit (₹40,633/ha).

Key words : Aerobic rice, Net benefit, Planting geometry, Summed dominance ratio, Weed control practices

Currently, sustainability of water resources is of major concern (Juraimi *et al.,* 2010), and declining water availability threatens the sustainability of traditional flood-irrigated rice ecosystems. The per hectare yield of rice (3.37 t/ha) in India, though increasing marginally, 4.31 t/ha. It is no longer feasible to flood rice fields for better crop establishment and weed but is still well below world's average yield of control (Johnson and Mortimer, 2005). Among different water-saving approaches, aerobic rice cultivation has come up with huge success in different parts of the world. But weed menace continues to be a severe problem in aerobic rice systems resulting in up to 90% reduction in grain yield (Gowda *et al.,* 2009). Therefore, effective weed management in aerobic rice has become a serious challenge for researchers and farmers (Rao *et al.,* 2007). Proper weed-management technologies can result in an additional rice production (Singh *et al*., 2012). Herbicides are considered to be an alternative/ supplement to hand-weeding. Planting density is another important factor which influence the crop performance as narrow row spacing improves a crop's competitiveness with weeds by developing a faster canopy cover and allowing less light penetration through its leaves. The study was carried out to see the relative species composition, crop performance and economics under different weed-control treatments and planting geometry.

The field study was conducted at the Norman E. Borlaug Crop Research Centre of the GBPUAT, Pantnagar, during the rainy (*kharif*) season of 2013. The soil (0–15 cm) was loamy in texture and neutral in reaction (pH 7.3) with 1.29 g/cc bulk density, 5.2 g/kg organic carbon and 18.9 Milli equivalent (me) 100/g soil cation-exchange capacity (CEC). Soil contained 0.1% total N, 22.8 kg/ha available P and 245.5 kg/ha available K. The experiment was laid out in factorial randomized complete-block design 3.0 m × 1.5 m net plot size, involving 4 replications. Twelve treatments comprised 3 planting geometry (continuous drilling at 20 cm, 20 cm × 10 cm, 25 cm × 25 cm) and 4 weed-management practices [pendimethalin (1,000 g/ha 3 DAS) + 1 hand-weeding at 30 DAS, pendimethalin (1,000 g a.i./ha 3 DAS) + bispyribac-Na (25 g a.i./ha 20 DAS) + 1 hand-weeding at 45 DAS and bispyribac-Na (25 g/ha 28 DAS) + 1 hand-weeding at 45 DAS and weedy check], were included in the trial. Rice variety 'Pant Dhan 12' was taken. Each plot

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[2]**Corresponding author Email**: neeshu.joshi@gmail.com

[1]M.Sc. (Agriculture) Student, [2]Professor (Agronomy), [3,4]Assistant Professor (Agronomy), College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145

was fertilized with NPK (12: 32: 16) mixture (187.5 kg) and rest through urea (212 kg) with recommended dose of 120: 60: 40 of NPK/ha. Half dose of N and full dose of P and K were applied basal. Remaining N was applied in 2 equal splits at 30 and 60 days after sowing (DAS). The soil samples were analysed for *p*H, electrical conductivity, organic carbon, available N, P and K following standard methods. Dominant weed species were identified using the summed dominance ratio (SDR) computed as follows (Janiya and Moody, 1989):

SDR of a weed species = ½ [(Relative density (RD) + Relative dry weight (RDW)].

where, RD (%) = (Density of a given weed species/ Total weed density) × 100 and RDW (%) = (Dry weight of a given weed species/Total weed dry weight) × 100.

Weed-control efficiency (WCE) of different treatments was calculated as follows (Hasanuzzaman *et al*., 2008):

WCE (%) = (DWC – DWT)/DWC × 100

where, DWC=dry weight of weeds in weedy check plots and DWT=dry weight of weeds in treated plots.

Weed community was mostly dominated by broad-leaf weeds and grasses (Table 2). Based on the summed dominance ratio (SDR) values, grassy weed *Echinochloa colona* (SDR 2.04) was predominant; among the broad-leaf species *Ammania baccifera* (SDR 0.84) was predominant and *Cyperus rotundus* (SDR 1.08) among the sedges (Table 1). The variation in the weed composition and dominance might be due to the differences in the agro-climatic conditions, cropping systems, growing season, cultural practices and weed seed bank composition and periodicity of germination pattern of different weed species among the experimental sites (Juraimi *et al.,* 2010).

All treatments exhibited significant effects on weed dry weight and weed density in different plots (Table 2). Integration of both pre- and post-emergence herbicide application supplemented with 1 hand-weeding decreased weed biomass by 82% and weed density by 90% compared with untreated weedy plots. Weed-control efficiency based on the weed dry matter at harvesting varied significantly among the planting geometry and herbicidal treatments (Table 2). Reduction in weed dry-matter due to application of different herbicides ranged from 21 to 90%; weed density, on the other hand, was reduced within the range of 70–91%. These results might be due to effective weed control, resulting in lower weed density in the respective weed-management treatments. The results confirm the findings of Tiwari *et al*. (2013). Continuous drilling at 20 cm (78%) with pendimethalin (1,000 g/ha) + bispyribac-Na (25 g/ha) + 1 hand-weeding at 45 DAS (87.4%) pro-

Table 1. Weed composition with summed dominances ratio followed by standard error in rainy (*kharif*) season of 2013 at 60 days after sowing

Scientific name	Family	Summed dominance ratio
Grasses		
Echinochloa colona	Poacea	2.04 ± 0.71
Leptochloa chinensis	Poacea	1.53±0.58
Broad leaf weed		
Ammania baccifera	Lythracea	0.84±0.19
Sedge		
Cyperus rotundus	Cyperacea	1.08±0.32

*±indicates variation in relative dry weight)

Table 2. Effect of agronomic practices on weed density, weed dry weight and weed-control efficiency and growth attributes at 60 days after sowing in direct seeded rice

Treatment	Weed density (no./m^2)	Weed dry weight (g)	Weed-control efficiency (%)	Plant height (cm)	Shoots/m^2	Crop dry matter (g/m^2)
Planting geometry (cm×cm)						
Continuous drilling at 20 cm inter-row spacing	5.00	2.30	72.30	93.10	264.30	596.10
20 × 10	5.50	1.80	68.20	89.30	259.30	566.40
25 × 25	5.50	1.90	62.40	79.70	216.70	506.60
SEm±	0.03	0.01	3.20	1.80	12.60	55.80
CD (P=0.05)	0.09	0.03	NS	NS	36.30	NS
Weed control practice						
Pend + 1 HW at 30 DAS	5.10	2.10	88.40	87.70	277.90	594.60
Bispy + 1 HW at 45 DAS	4.90	1.90	93.00	89.80	292.60	671.30
Pend + bispy + 1 HW at 45 DAS	4.80	1.80	89.10	95.70	306.80	743.00
Weedy	6.50	2.80	0.00	92.60	110.00	216.70
SEm±	0.03	0.01	3.70	2.10	14.50	64.40
CD (P=0.05)	0.10	0.30	10.70	NS	41.90	185.40

Pend, Pendimethalin; Bispy, bispyribac; HW, hand-weeding

Table 3. Effect of agronomic practices on yield attributes and yield and economics in direct-seeded rice

Treatment	1,000-grain weight (g)	Panicle (no./m^2)	Grains/ panicle	Grain yield (t/ha)	Harvest index	Net returns (₹/ha)	Benefit: cost ratio
Planting geometry (cm×cm*)*							
Continuous drilling at 20 cm inter-row spacing	25.8	191.8	204.3	3.47	34.7	40,576	1.70
20 × 10	26.6	204.0	213.0	3.41	32.9	38,215	1.60
25 × 25	25.9	152.7	211.0	2.90	34.6	32,048	1.50
SEm±	0.20	8.40	2.90	0.14	1.10	-	-
CD (P=0.05)	0.60	24.30	NS	0.40	NS	-	-
Weed control practice							
Pend +1 HW at 30 DAS	26.0	196.3	216.0	3.62	33.2	30,498	1.40
Bispy + 1 HW at 45 DAS	25.7	205.9	218.0	3.77	34.9	32,135	1.50
Pend + bispy + 1 HW at 45 DAS	26.3	238.1	227.0	4.78	36.7	40,633	1.80
Weedy	26.4	91.1	176.1	0.86	28.8	2,073	0.11
SEm±	0.20	9.70	3.40	0.16	1.30	-	-
CD (P=0.05)	NS	28.10	9.80	0.46	3.70	-	-

Pend, Pendimethalin; Bispy, bispyribac; HW, hand-weeding

vided satisfactory weed control with weed-control efficiency (WCE) of 88%. Our findings confirm the results of Mishra and Singh (2012).

Continuous drilling at 20 cm and application of pendimethalin (1,000 g/ha) + bispyribac-Na (25 g/ha) + 1 hand-weeding at 45 DAS, recorded the maximum plant height and higher number of shoots and crop dry matter (Table 2). The removal of competitive effect of weeds reduced inter-specific competition for resources and enabled the crop plants to utilize available resources more efficiently throughout the growth cycle, which in turn positively influenced crop yield and biomass production (Gowda *et al*., 2009).

Panicles/m^2 were significantly affected by different planting geometry, while 1,000-grain weight, grains/ panicle and harvest index were found to be significantly influenced by weed-control practices. Rice grain yield was significantly influenced by planting geometry and weed control practices (Table 3). The increase in rice grain yield over the weedy check owing to different treatments was attributed to reduced weed density and biomass of weeds, which resulted in increased dry-matter production of crop, panicles/m^2, grains/panicle and 1,000-grain weight (Ganie *et al*., 2014). Economic analysis revealed that the highest net returns and benefit: cost ratio were observed in treatment receiving pendimethalin (1,000 g/ha) + bispyribac-Na (25 g/ha) + 1 hand-weeding at 45 DAS in continuous drilling rice seeds at 20 cm.

Thus, continuous drilling with 20 cm along with pendimethalin (1 kg/ha) + bispyribac-Na (25 g/ha) + 1 hand-weeding at 45 DAS increased weed-control efficiency, crop growth parameters and yield and yield attributes and proved to be the most cost effective weed-management option in direct- seeded aerobic rice.

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