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Rice productivity under different weed management and establishment methods

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ABSTRACT

Field experiment was conducted to find out alternative tillage practices with appropriate weed management opportunities to increase the yield potential of rice crop. Major associated weeds were *Echinochloa colona, E. crus-galli, Leptochloa chinensis* among grasses, *Caesulia axillaris, Alternanthera sessilis, Ammania baccifera* among broad-leaved weeds and *Cyperus rotundus, C. iria, C. difformis* and *Fimbristylis miliaceae* among sedges at 60 DAS. Adoption of conventional transplanted rice (TPR) with *Sesbania* inclusion as green manure along with integrated approaches of weed management using bispyribac-sodium 20 g/ha supplemented with one hand weeding at 45 DAS was found effective and profitable alternative than conventional transplanted rice and hand weeding to attain higher productivity of rice crop. However, the benefit cost ratio was higher when the crop was grown under zero-till situation (ZTR) along with retention of crop (wheat) residues followed by *Sesbania* as brown manure due to less cost involved under zero-till situation.

Key words: Bispyribac-sodium, Conventional tillage, Establishment method, Rice producivity, *Sesbania*, Zero tillage

Rice (*Oryza sativa*) is the most important cereal crop of the world, forming staple diet of 70% of world's population (Sahu *et al.* 2014). It is the widely cultivated crop in the India, with production of 104.80 million tonnes (Anonymous 2015). India ranks second in production and consumption of rice in the world. India need to produce about 130 million tonnes of rice by 2025 to feed the ever growing population (Hugar *et al.* 2009), which is a challenging task.

Traditionally, rice is grown by transplanting in puddled situation which has weakened the natural resource base, which also hampers the crop yield. It is associated with various constraints like labour availability, weeds, water, insects *etc*. Among the several production constraints, weeds are most important with great genetic diversity (Singh *et al.* 2003). More than one third of the total loss (33%) is caused by weeds alone (Mukherjee 2006). Crop losses due to weed competition throughout the world as a whole, are greater than those resulting from combined effect of insect pests and diseases (Hassan *et al.* 2005). Weeds reduce the crop yield, deteriorate quality and reduce market value of grains. Further, the question arises with the conventional cultivation of rice due to ever increasing energy prices for pumping water and running tractors, required for puddling and other operations, limited water and labour availability for the transplanting, sequential use of herbicides for weed control *etc*. Weed management also increases the cost of cultivation and thus farmers need technologies that can reduce their costs of cultivation and improve their returns. Conventional method of weed control is weather dependent, laborious, and expensive.

So, there is need to find an alternative production system, which could reduce cost of production, conserve natural resources, save time and labour, effectively control weeds, enhance productivity and ensure environmental safety. But, current production system can hardly compensate the food demand of increasing population with a fatigue natural resource base (Saharawat *et al.* 2010). Therefore, to sustain and improving the production system of rice, it is essential to adopt resource conserving technologies like direct seeding, zero-till with residue retention. Crop residue retention is a good option which increases the yield and profitability, while decreasing weed pressure. Manuring of the crop with *Sesbania* has dual advantage of adding biomass to soil, acting as mulch and smothering the weeds. Singh *et al.* (2009) reported that application of wheat residue mulch at 4 t/ha and *Sesbania* intercropping for 30 days were equally effective in controlling weeds in dry-seeded

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rice. Therefore, present work was undertaken to find out alternative tillage practices with appropriate weed management opportunities to increase the yield potential of rice crop.

MATERIALS AND METHODS

A field experiment was conducted at NEB Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand, India) during *Kharif* 2015 and 2016. The soil of the experimental plot was high in organic carbon (0.76%), low in available nitrogen (212.6 kg/ha), medium in available phosphorus (17.2 kg/ha) and available potassium (203.1 kg/ha) with slightly alkaline pH (7.86). The experiment was laid out in strip plot design with 15 treatments, comprising 5 establishment methods of rice in vertical strip, *viz.* conventional transplanted rice (TPR-CT), TPR-CT followed by *Sesbania* as green manure, direct-seeded rice (DSR) *fb Sesbania* incorporation, zero-till direct-seeded rice (ZT-DSR) *fb Sesbania* as brown manure and ZT-DSR with retention of residues of previous wheat crop along with *Sesbania* as brown manure and 3 weed control measures in horizontal strip *viz.*, unweeded control, recommended herbicide *i.e.* bispyribac-sodium 20 g/ha as post-emergence and integrated weed management *i.e.* herbicide application *fb* one hand weeding at 45 DAS/DAT, replicated thrice in clay loam soil. Under ZT-DSR condition, the *Sesbania* was knocked down by the application of 2,4-D at 30 days after sowing and used as brown manure.

Variety '*Pant dhan-18*' was sown with recommended fertilizer dose (150:60:40 kg N:P:K/ha) through urea (46% N) and NPK mixture (12:32:16% N, P and K). Zinc at 25 kg/ha was applied only in rice as $ZnSO_4$ (23.5% zinc). Full dose of phosphorus, potassium and zinc and half of nitrogen fertilizer was applied as basal while remaining nitrogen was top dressed in two split doses at the time of tillering and panicle initiation stage. Plant protection measures and irrigations were provided as and when required. After sowing of the crop, residue of the previous crop (wheat residue in rice) was applied manually in the plots according to the treatments. Bispyribac-sodium 20 g/ha was applied after 25 days of sowing by using 500 litre volume of water/ha with knapsack sprayer fitted with flat fan boom nozzle. Data of density of complex weed flora (no./m^2) were collected from each individual plot from one side of the plot, leaving the two border rows with the help of a quadrate. For weed biomass (g/m^2), weeds were removed from the sampling rows above the ground with the sickle, sun dried then kept in hot air oven at 60±10 °C till constant dry weight is obtained. Different yield attributes parameters and yield were recorded at crop harvest. Economics was calculated on the basis of prevailing market prices of input used and output obtained. Weed population data were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis, adapted in statistical package CPCS-1, designed and developed by Punjab Agricultural University, Ludhiana (Cheema and Singh 1991).

RESULTS AND DISCUSSION

Weed flora

Major weed flora in the experimental fields was grouped into grasses, broad-leaved and sedges. Different weed spectrum observed during *Kharif* 2015 and 2016 were *E. colona, E. crus-galli, L. chinensis* among grasses; *C. axillaris, A. sessilis, A. baccifera* among broad- leaved weeds (BLW) and *C. rotundus, C. iria, C. difformis* and *F. miliaceae* among sedges at 60 DAS. The composition of grassy, BLWs and sedges in weedy plot under TPR-CT was 48.6, 31.1 and 20.3% during *Kharif* 2015 and 57.4, 18 and 24.6% during *Kharif* 2016; followed by *Sesbania* as green manure, which was 45.9, 17.3 and 36.7% and 66.1, 2.6 and 31.3%, respectively during *Kharif* 2015 and 2016; however it was found to be 15.5, 29.0 and 58.6% during *Kharif* 2015 and 21.0, 11.7 and 67.3% during *Kharif* 2016 under DSR *fb Sesbania* incorporation; under ZT-DSR *fb Sesbania* as brown manure, it was recorded as 16.1, 68.9 and 15.0% and 14.1, 39.3 and 46.0%, respectively during *Kharif* 2015 and 2016; while ZT-DSR with retention of residues of previous wheat crop along *fb Sesbania* as brown manure, recorded grassy weeds composition with 60.1 and 67.4%, respectively during *Kharif* 2015 and 2016, while BLWs and sedges was 22.1 and 17.8%, respectively during *Kharif* 2015 and 20.9 and 11.6%, respectively during *Kharif* 2016 (**Figure 1**).

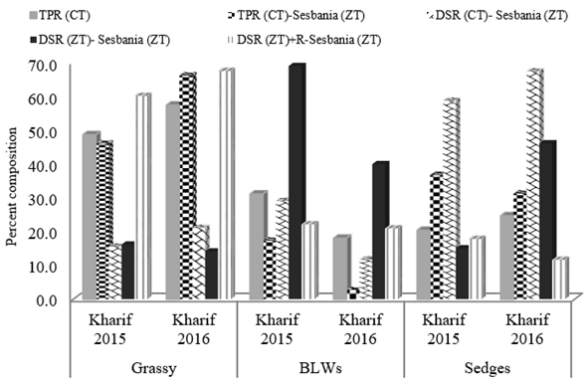

Figure 1. Composition of grassy, BLWs and sedges in weedy plot under differenet establishment methods of rice during *Kharif* 2015 and 2016

Effect on weeds population

Establishment methods significantly reduced the density and biomass of weeds in rice during both the years of study (**Table 1**). Among establishment methods, the lowest density of grassy weeds and biomass was recorded under zero-till direct-seeded rice without residue retention *fb Sesbania* as brown manure,which was at par with conventional direct-seeded rice followed by *Sesbania* incorporation in *Kharif* 2015, while during *Kharif* 2016, conventional DSR *fb Sesbania* incorporation recorded lowest grassy weed biomass being significantly at par with zero-till direct-seeded rice without residue retention *fb Sesbania* as brown manure in reducing the grassy weed density. The density of grassy weeds was low under zero-till direct- seeded rice without residue retention *fb Sesbania* as brown manure due to compaction of the soil surface which suppresses the emergence of grassy weeds which have narrow sized seeds. However, conventional transplanted rice with *Sesbania* as green manure significantly reduced the density and biomass of BLWs during both the years of experimentation, might be due to weed suppression by manuring of *Sesbania.* The density and biomass of sedges was recorded lowest under zero-till direct seeded rice with residue retention and *Sesbania* as brown manure during both the years of *Kharif* 2015 and *Kharif* 2016, which was at par with conventional transplanting TPR (CT), due to the residue retention, which act as mulch and control the sedges density. Sapre *et al.* 2015 also reported weed control by retention of residues under zero-till condition. Different weed management practices significantly influenced weed density and biomass of grassy, BLWs and sedges, recording lowest density including biomass under integrated approaches (bispyribac-sodium 20 g/ha *fb* one hand weeding at 45 DAS/DAT) followed by sole herbicidal application over the unweeded situation (**Table 1**). This might be due to adoption of integrated approaches of weed management, *viz.* herbicidal application supplemented with one hand weeding then other weed control treatments. The highest weed density and biomass was recorded under weedy situation.

Effect on crop yield

The yield and yield attributing characters of rice was significantly influenced by establishment system during *Kharif* 2015 and *Kharif* 2016 (**Table 2**). The number of panicles/m^2 was significantly highest under conventional system of rice TPR (CT) during both the years, being at par with conventional transplanted rice *fb Sesbania* inclusion as green manure during *Kharif* 2015. Similar results were noticed with number of grains/panicle. Conventional transplanted rice *fb Sesbania* inclusion as green

Table 1. Effect of establishment methods and weed management on weed density and biomass of weeds at 60 DAS of rice during *Kharif* 2015 and 2016

Treatment	Weed density (no./m^2)						Weed biomass (g/m^2)					
	Grassy		BLWs		Sedges		Grassy		BLWs		Sedges	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Establishment system												
TPR (conventional tillage)	6.3 (40.7)	6.2 (41.4)	4.4 (20.2)	3.7 (13.8)	2.8 (9.8)	3.6 (15.1)	8.8 (81.9)	8.4 (76.5)	3.6 (13.2)	3.1 (9.9)	2.9 (10.5)	3.9 (16.8)
TPR (conventional tillage)- *Sesbania* (zero tillage)	6.0 (36.9)	5.6 (34.3)	3.3 (11.3)	2.0 (4.0)	4.2 (21.3)	4.3 (19.4)	8.4 (77.5)	7.7 (62.4)	2.7 (7.4)	1.7 (2.4)	4.3 (22.7)	4.5 (21.3)
DSR (conventional tillage)- *Sesbania* (zero tillage)	3.2 (11.4)	3.8 (18.1)	4.9 (27.1)	3.8 (15.4)	5.4 (44.9)	4.7 (48.0)	4.5 (23.5)	5.2 (34.3)	4.0 (18.8)	3.3 (11.7)	5.4 (44.7)	4.8 (50.4)
DSR (zero tillage)- *Sesbania* (zero tillage)	2.9 (9.3)	4.1 (16.1)	6.6 (46.3)	5.6 (32.0)	3.3 (10.7)	4.2 (23.2)	3.8 (15.2)	5.8 (33.3)	5.6 (33.1)	4.7 (23.1)	3.4 (11.8)	4.4 (26.1)
DSR (zero tillage) + residue - *Sesbania* (zero tillage)	6.0 (43.8)	6.0 (47.1)	4.1 (20.9)	3.2 (13.8)	2.7 (10.4)	2.9 (9.8)	9.3 (117.4)	8.0 (82.9)	3.5 (14.8)	2.6 (8.7)	2.9 (11.7)	2.9 (10.2)
LSD (p=0.05)	0.3	0.5	0.2	0.4	0.2	0.4	0.7	0.2	0.3	0.2	0.3	0.1
Weed management												
Recommended herbicide (bispyribac- Na 20 g/ha)	4.6 (22.7)	4.4 (19.3)	4.4 (19.7)	3.9 (16.3)	3.0 (8.5)	3.2 (10.7)	6.1 (39.9)	6.2 (39.0)	3.6 (13.2)	3.2 (10.6)	3.2 (9.7)	3.2 (11.2)
IWM (recommended herbicide *fb* one hand weeding)	3.0 (9.7)	3.2 (10.0)	2.6 (7.3)	2.0 (4.3)	1.5 (1.3)	1.6 (2.1)	4.2 (19.6)	4.6 (22.0)	2.2 (5.0)	1.7 (2.5)	1.5 (1.4)	1.7 (2.5)
Unweeded	7.1 (52.9)	7.8 (64.9)	6.9 (48.5)	5.0 (26.9)	6.6 (48.4)	7.1 (56.5)	9.5 (129.8)	10.3 (112.6)	5.8 (34.2)	4.4 (20.4)	6.7 (49.7)	7.4 (61.1)
LSD (p=0.05)	0.3	0.5	0.04	0.5	0.2	0.4	1.0	0.2	0.4	0.1	0.2	0.1

Original data is indicated in parentheses; Data transformed to square root transformation; TPR- Transplanted rice; DSR- Direct seeded rice; IWM- Integrated weed management

Table 2. Effect of establishment methods and weed management on yield and yield attributes of rice during *Kharif* 2015 and 2016

Treatment	Panicles (no./m^2)		No. of grains/ panicle		1000- grain weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Establishment system										
TPR (conventional tillage)	222.8	244.9	127.1	123.0	26.9	26.4	5.1	4.6	7.4	9.2
TPR (conventional tillage)- *Sesbania* (zero tillage)	204.8	209.9	124.5	121.5	27.5	26.7	5.2	5.4	7.5	10.3
DSR (conventional tillage)- *Sesbania* (zero tillage)	171.7	144.6	107.4	82.3	26.0	17.9	3.7	3.0	5.4	6.6
DSR (zero tillage)- *Sesbania* (zero tillage)	124.4	100.6	96.4	71.7	26.3	18.1	2.9	2.3	4.2	6.0
DSR (zero tillage) + residue - *Sesbania* (zero tillage)	143.9	138.4	104.2	93.4	25.8	21.8	3.7	3.4	5.4	7.3
LSD (p=0.05)	23.2	4.2	16.6	4.4	0.9	1.7	0.4	0.7	0.5	1.6
Weed management										
Recommended herbicide (bispyribac- Na 20 g/ha)	197.7	191.3	125.2	114.6	26.6	26.2	4.8	4.5	7.1	9.8
IWM (recommended herbicide *fb* one hand weeding)	225.0	231.9	128.3	123.8	26.9	26.8	5.4	4.8	7.5	9.9
Unweeded	97.8	79.9	82.3	56.7	26.0	13.5	2.1	2.0	3.3	4.0
LSD (p=0.05)	12.3	5.7	11.6	5.0	0.4	1.5	0.3	1.1	0.3	2.2

Table 3. Effect of establishment methods and weed management on economics of rice during *Kharif* 2015 and 2016

Treatment	Cost of cultivation (x10^3 `/ha)		Gross return (x10^3 `/ha)		Net return (x10^3 `/ha)		B:C	
	2015	2016	2015	2016	2015	2016	2015	2016
Establishment system								
TPR (conventional tillage)	35.64	36.64	101.64	104.13	66.00	67.48	1.8	1.8
TPR (conventional tillage)-*Sesbania* (zero tillage)	35.64	36.64	103.05	119.87	74.59	79.33	1.9	2.3
DSR (conventional tillage)- *Sesbania* (zero tillage)	25.94	26.44	73.90	70.31	47.96	43.88	1.7	1.5
DSR (zero tillage)- *Sesbania* (zero tillage)	21.27	21.77	57.44	58.13	36.17	36.36	1.6	1.6
DSR (zero tillage) + residue - *Sesbania* (zero tillage)	20.94	21.44	73.52	78.69	52.59	57.25	2.4	2.5
Weed management								
Recommended herbicide (bispyribac- Na 20 g/ha)	27.84	28.54	96.47	104.32	68.62	75.77	2.6	2.8
IWM (recommended herbicide *fb* one hand weeding)	30.39	31.09	105.81	109.21	75.42	78.11	2.6	2.6
Unweeded	25.42	26.12	43.45	45.14	18.03	19.02	0.5	0.3

manure recorded highest 1000-grain weight, grain and straw yield followed by conventional TPR (CT) during both the years. Different weed management practices significantly influenced yield and yield attributing characters of rice recording highest grain yield (5.4 and 4.8 t/ha) and yield attributes under integrated approaches (bispyribac-sodium 20 g/ha *fb* one hand weeding at 45 DAS/DAT) followed by sole herbicidal application (bispyribac-sodium 20 g/ha) over the unweeded situation during both the years of study (**Table 2**). Similar results were also reported by Gaire *et al.* 2013. Number of grains/panicle was found at par with sole application of recommended herbicide (125.2) during *Kharif* 2015. However, during *Kharif* 2015 and *Kharif* 2016, 1000-grain weight was also at par with sole herbicidal application being superior over the unweeded situation. While, grain and straw yield was at par with sole herbicidal application (bispyribac-sodium 20 g/ha) only during *Kharif* 2016. This might be due to effective control of weeds with herbicidal application of bispyribac-sodium, which offers broad spectrum weed control (Parthipan *et al.* 2013) and integrated approach, thereby increasing the yield attributes and yield. The lowest grain and straw yield was recorded in unweeded situation due to severe weed competition evident from higher weed density and dry biomass (**Table 1**).

Economics

Among different establishment system, highest net return of ` 74591.00 and ` 79335.00, was recorded in the plots where rice was planted in the conventional transplanted rice with *Sesbania* as green manure, during *Kharif* 2015 and *Kharif* 2016, respectively, while zero-till direct seeded rice with residue retention followed by *Sesbania* (ZT) as brown manure attained highest benefit cost ratio as 2.4 and 2.5, during *Kharif* 2015 and *Kharif* 2016, respectively (**Table 3**). This result was attained due to less cost of cultivation under zero tilled direct seeded rice with residue retention along with *Sesbania* used as brown manure. Within weed management practices, IWM (bispyribac-sodium 20 g/ha *fb* 1 hand weeding at 45 DAS/DAT) practice recorded the highest net return (` 75417.00 and ` 78114.00), during *Kharif* 2015 and *Kharif* 2016, respectively, while benefit cost ratio was highest with integrated

approach (2.6) of weed control during *Kharif* 2015 and with sole herbicidal application (2.8) followed by integrated approach (2.6) of weed control during *Kharif* 2016. This resulted due to less difference attained in net returns compared to the cost of cultivation among the two treatments.

It was concluded that adoption of conventional transplanted rice *fb Sesbania* inclusion as green manure along with integrated approaches of weed management (bispyribac-sodium 20 g/ha supplemented with one hand weeding at 45 DAS) was found effective and profitable alternative with respect to conventional tillage practices and hand weeding to attain higher productivity of rice crop under rice-wheat cropping system. However, the benefit cost ratio was higher with zero-till direct seeded rice along the retention of residues followed by *Sesbania* used as brown manure due to less cost of cultivation involved under zero-till situation.

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