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Influence of Various Crop Establishment Methods and Weed Management Approaches on Weed Dynamics in Rice Crop

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A B S T R A C T

A field experiment was conducted at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttarakhand) during *kharif* seasons of 2011and 2012 to study the effect of crop establishment methods and weed management practices on weed dynamics and productivity of rice. The results revealed that the lowest density and dry matter of total weeds at 60 days after sowing/days after transplanting was obtained with transplanted rice. This treatment produced the highest number of panicles/m^2 and rice grain yield (4145 and 3879 kg/ha). Among the weed management practices, application of bispyribac sodium 20 g/ha at 15 DAS/DAT followed by (fb) one HW at 35 DAS/DAT being on par to the application of penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds fb one HW at 35 DAS/DAT recorded the minimum population and dry matter of total weeds and recorded the highest weed control efficiency. This treatment produced the significantly higher number of panicles/m^2, grains/panicle and grain yield. Crop establishment methods and weed management practices 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 fb one HW at 35 DAS/DAT or penoxsulam22.5 g/ha at 2-3 leaf stage of weeds fb one HW at 35 DAS/DAT.

Introduction

Rice is the staple cereal crop of India plays a key role in food security. The country has to produce about 130 million tonnes of rice by 2025 to feed the ever growing population (Swaminathan, 2009). The productivity of rice in India is quite low (2.2 t/ha) as 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, it uprooting and transplanting. In wet seeding, sowing of pre germinated or sprouted seeds on to puddled soil reduce substantially 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 preoccupation. 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 provide an option to resolve the edaphic conflict and enhance 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 at a time when there is little water in the reservoirs, 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 to late vacation of fields, forcing farmers to sow wheat after the optimum time. DSR facilitates timely establishment of rice and succeeding winter crops. Unlike 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 per cent grain yield reduction in puddled conditions and 91 per cent in un-puddled conditions (Ali and Sankaran 1984). The 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, the present investigation was under taken to study the effect of crop establishment methods and weed management practices on weed dynamics and productivity of rice.

Materials and Methods

The field experiments was conducted in Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttarakhand) during *kharif* seasons of 2011and 2012. The soil of the experimental field was loam in texture. The soil was found 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) content with neutral pH (7.2). An experiment was conducted in split plot design with three replications; keeping rice establishment methods *viz.*, direct dry seeded rice (DSR), wet seeded rice (WSR-sprouted seeds) and transplanted rice (TPR) in main and six levels of weed management practices *viz.*,penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds, penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds followed by (fb) one hand weeding (HW) at 35DAS/DAT, bispyribac sodium 20 g/ha at 15DAS/DAT, bispyribac sodium 20 g/ha at 15DAS/DAT fb one hand weeding at 35DAS/DAT, weed free and weedy check in sub plot.

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 by using manually operated drum seeder. Twenty one day old seedlings were transplanted in transplanting method and

cultivar Sarju-52 was used in experiment. In direct dry seeding rice seed was sown on 11 June, 2011 and 21 June, 2012 during first and second year respectively. Seed was water soaked for wet seeding and nursery raising for transplanting to same date of seed sown in direct dry seeding. Crop was fertilized uniformly with 150:60:40 kg/ha of N, P_2O_5 and K_2O, respectively through the use of NPK mixture (12:32:16), urea (46:0:0) and muriate of potash (0:0:60). Total amount of phosphorus was applied through NPK mixture while, nitrogen through NPK mixture and urea and potassium through NPK mixture and muriate of potash. The full amount of phosphorus and potassium and half dose of nitrogen were applied as basal just before sowing of rice seed/transplanting of rice seedling. Remaining half of the nitrogen was top dressed through urea in two 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 days after seeding with the help of quadrate (0.5 x 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. All the data were analyzed by using ANOVA, and the least significant difference (LSD) value at 5% level of significance were calculated and used to test significant differences between treatment means.

Results and Discussion

Weed survey

Weed flora of the experimental field was collected, identified and classified as grassy, non grassy weeds and sedges (Table 1). During experimentation, population of grassy weeds dominated over non-grassy weeds. Among grassy weeds, *Echinochloa colona*, *Leptochloa chinensis*, *Echinochloa crus-galli*, and *Ischaemum rugosum* were most dominated weeds. However, among non-grassy weeds *Caesulia axillaris*, *Alternanthera pheloxeroides* and *Trianthem amonogyna* and among sedges *Cyperus rotundus*, *C. iria*, and *C. difformis* were contributed maximum per cent to the total weed density. *Echinochloa colona* with the highest relative density, was the most dominant weed throughout the crop growth in weedy check at all the rice establishment methods. Prasad *et al.,* (2010) and Sarawgi *et al.,* (2010) also noted similar result.The contribution in weedy check as *E. colona* to total weed density was 47.42, 41.38, 40.98, 37.36 and 41.62, 36.18, 34.49, 25.62 per cent respectively, *Caesulia axillaris* was the major non grassy weed in rice crop which contributed 6.19, 7.68, 8.24 and 9.48 per cent respectively. Those results are in line with Singh *et al.,* (2004) and Singh *et al.,* (2005). *Cyperus rotundus* was the major weed among sedges in rice field. The relative density of this weed was 11.12, 8.87, 6.86 and 3.74 and 9.62, 8.89, 5.66 and 3.94 per cent respectively, during 2011 and 2012 at 30, 60, 90 DAS/DAT and at harvest stage, respectively (Table 2). Result found by Avudaithai and Vurabadran (2000) was similar.

Total weed density

All the rice establishment methods had significant effect on the population of total weeds at all the stages of crop growth (Table 3). The overview of data in Table 1 showed that maximum density of total weeds was recorded at 30 DAS/DAT stage during experimentation in all the rice establishment methods and reduced thereafter at subsequent stages. Like Nevase *et al.,* (2010) in this experiment at all the stages total weed population was the lowest under transplanted rice (TPR) except at harvest stage, where the

density of total weeds under this treatment was almost similar to that of crop grown through WSR. Transplanted and wet seeded rice resulted in lower density and dry matter of individual weeds mainly because of puddling which gave lesser emergence of deeply placed weed seeds. Sowing of sprouted seeds through drum seeder under puddled condition (WSR) also proved superior over DSR with respect to control of total weeds. The highest density of total weeds was observed under DSR. The results are in agreement with the findings of Singh *et al.,* (2005) and Singh *et al.,* (2005).

The population of total weeds influenced significantly due to execution of weed management practices at various stages of crop growth during both the years. The maximum density of total weeds was recorded in weedy check at 30 DAS/DAT and declined subsequently at later stages. All the herbicidal treatments observed significantly lower density over un-weeded control during both the years. At 30 DAS/DAT stage, all the herbicidal treatments had almost equal effect on the control of total weeds during both the years except during 2011, where penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds being at par to penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds followed by (FB) one hand weeding (HW) at 35 DAS/DAT, noted the lowest density of total weeds. These results are in conformity with those of Rathore *et al.,* (1994) and Ganesh (1999). At later stages, the application of bispyribac sodium 20 g/ha at 15 DAS/DAT FB one HW at 35 DAS/DAT being at par with penoxsulam 22.5 g/ha at 2-3 leaf stage of weeds FB one HW at 35 DAS/DAT recorded the lowest density of total weeds during both the years.

Total dry matter accumulation by weeds

The data pertaining to dry matter production of total weeds (g/m^2) taken at various stages are presented in Table 4. Irrespective of rice establishment methods, the differences in dry weight of total weeds were significant at all the stages during both the years.

The observations showed that maximum dry matter of total weeds in rice establishment methods was recorded at 90 DAS/DAT stage during both the years. At all the stages, during both the years, the lowest dry matter of total weeds was recorded under transplanted rice (TPR). Crop raised through WSR also caused significant reduction in dry matter accumulation of total weeds in comparison to growing of crops through DSR at all the stages during both the years. Crop raised through DSR was least effective for lowering the dry matter of total weeds at all the stages during both the years.

Similar to rice establishment methods, the dry matter accumulation of total weeds increased upto 90 DAS/DAT stage of crop under weedy check. All the weed management practices significantly reduced the total dry matter than weedy check at all the stages during both the years. At 30 DAS/DAT stage during both the years, the application of penoxsulam 22.5 g/ha alone or in combination with one HW at 35 DAS/DAT, bispyribac sodium 20 g/ha alone or in combination with one HW at 35 DAS/DAT being at par to each other recorded significantly lower total weed dry matter when compared with weedy check.

These results are supported by Deshmukh *et al.,* (1987) also noted that herbicides with one hand weeding resulted in lower weed density, dry weight and gave higher weed control efficiency compared to chemical weeding alone and untreated control.

At later stages, the application of bispyribac sodium 20 g/ha FB one HW being on par with penoxsulam 22.5 g/ha FB one HW observed the lowest dry weight of total weeds during both the years.

Table.1 Weed flora of the experimental field

Botanical Name	Family	Common Name	Local name
Grassy weeds			
***Dactyloctenium aegyptium*(L) P. Beaur**	Poaceae	Crow foot grass	Makra
***Digitaria sanguinalis*(L.) Scop.**	Poaceae	Large carbgrass	Seur
***Echinochloa colona*(L.) Link**	Poaceae	Jungle rice	Sai/Chhotisanwa
***Echinochloa crus-galli*(L.) Beauv.**	Poaceae	Barnyard grass	Sanwa/Daura
***Eleusine indica*(L.) Gaertn.**	Poaceae	Goose grass	Junglimandua
***Ischaemum rugosum*Salisb**	Poaceae	Wrinkle grass	Mutmur
***Leptochloa chinensis*(L.) Nees**	Poaceae	Red sprangle top	-
***Panicum repens*L. Jacq.**	Poaceae	Torpedo grass/Panic grass	Jangli guinea grass
***Paspalum scrobiculatum*L.**	Poaceae	Kodo millet	Hadda
Non-grassy weeds			
Alternanthera pheloxeroides	Amaranthaceae	Alligator weed	Gadani
***Caesulia axillaris* Roxb.**	Compositeae	Pink node flower	Hukuwa
***Celosia argentea* L.**	Amaranthaceae	White cock's comb	Safedmurgkaphool/Salara
***Commelina benghalensis*L.**	Commelinaceae	Spreading day flower	Kena/kankauwa
***Eclipta alba* (L.) Hassk.**	Compositeae	False daisy	Bhangra/Bhrangraj
***Trianthema monogyna*(L.)**	Aizoaceae	Giant pigweed, Horse purslane	Patherchatta
Sedges			
***Cyperus difformis* Linn.**	Cyperaceae	Small flower umbrella sedge	Jalmotha
***Cyperus iria* Linn.**	Cyperaceae	Flatsedge/Yellow sedge	Galmotha
***Cyperus rotundus* Linn.**	Cyperaceae	Purple nutsedge	Motha

Table.2 Major weed species (per cent of total weeds) in weedy plot at various crop growth stages

Weed species	*Echinochloa colona*	*Leptochloa Chinensis*	*Echinochloa crus-galli*	*Caesuliamma xillaris*	*Alternantheraph eloxeroides*	*Trianthemam onogyna*	*Cyperusro tundus*	*Cyperus iria*	*Cyperusdiffor mis*	Other weeds
	2011									
30 DAS/DAT	47.4	8.7	5.3	6.2	2.8	2.0	11.1	4.3	4.0	8.2
60 DAS/DAT	41.4	8.2	6.5	7.7	4.2	1.1	8.9	6.5	4.4	11.2
90 DAS/DAT	41.0	8.8	7.5	8.2	4.7	0.0	6.9	6.3	4.5	12.2
At harvest	37.4	10.3	6.9	9.5	5.5	0.0	3.7	6.9	5.5	14.4
	2012									
30 DAS/DAT	41.6	15.0	6.5	6.5	2.2	2.1	9.6	5.3	4.0	7.2
60 DAS/DAT	36.2	13.7	8.1	7.6	3.5	0.9	8.9	6.5	5.0	9.8
90 DAS/DAT	34.5	15.3	9.1	8.8	3.8	0.0	5.7	6.9	5.7	10.2
At harvest	25.6	18.5	10.8	10.8	4.2	0.0	3.9	7.6	6.4	12.1

Table.3 Density of total weeds (no. m-2) at various stages of crop growth

Treatment	Growth stage (DAS/DAT)							
	30		60		90		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
Rice establishment method								
Direct seeded rice	4.16 (152.89)	4.32 (176.11)	3.65 (116.89)	3.71 (135.11)	3.25 (87.78)	3.36 (105.56)	2.67 (58.89)	2.74 (75.33)
Wet seeded rice	3.60 (79.33)	3.84 (96.67)	3.29 (69.33)	3.28 (76.89)	2.76 (51.11)	2.69 (58.89)	2.03 (32.44)	2.23 (43.33)
Transplanted rice	3.26 (53.11)	3.57 (70.89)	2.74 (47.33)	2.87 (56.00)	2.13 (33.78)	2.28 (40.67)	1.67 (20.89)	1.93 (29.56)
SEm±	0.03	0.02	0.08	0.08	0.02	0.09	0.10	0.08
LSD (P=0.05)	0.12	0.09	0.33	0.32	0.09	0.36	0.37	0.30
Weed management practice								
Penoxsulam 22.5 g/ha	4.01 (60.88)	4.37 (85.33)	4.21 (71.56)	4.51 (96.89)	3.84 (50.22)	4.25 (77.78)	3.34 (31.56)	3.92 (56.89)
Penoxsulam 22.5 g/ha FB one HW	4.03 (61.78)	4.36 (84.44)	2.76 (18.11)	2.43 (13.78)	1.73 (7.11)	1.38 (5.78)	0.60 (1.78)	0.42 (1.33)
Bispyribac sodium 20 g/ha	4.17 (72.44)	4.51 (97.78)	4.30 (78.67)	4.55 (100.00)	3.92 (55.56)	4.28 (78.67)	3.42 (35.11)	3.94 (56.89)
Bispyribac sodium 20 g/ha FB one HW	4.19 (73.78)	4.50 (97.33)	2.65 (17.78)	2.56 (13.33)	1.40 (5.78)	1.31 (4.44)	0.42 (1.33)	0.36 (0.89)
Weed free	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Weedy check	5.62 (301.78)	5.70 (322.44)	5.58 (283.56)	5.68 (312.00)	5.36 (226.67)	5.42 (243.56)	4.96 (154.67)	5.14 (180.44)
SEm±	0.05	0.06	0.15	0.13	0.17	0.18	0.16	0.15
LSD (P=0.05)	0.14	0.16	0.42	0.38	0.49	0.53	0.46	0.44

Original values given in parentheses, DAS- Days after sowing, DAT- Days after transplanting, fb- followed by, HW- hand weeding

Table.4 Total weed dry matter (g m-2) at various stages of crop growth

Treatment	Growth stage (DAS/DAT)							
	30		60		90		At harvest	
	2011	2012	2011	2012	2011	2012	2011	2012
Rice establishment method								
Direct seeded rice	2.93 (41.00)	3.06 (45.07)	3.37 (161.82)	3.45 (176.74)	3.36 (165.11)	3.49 (196.64)	2.88 (117.20)	3.01 (150.33)
Wet seeded rice	2.34 (19.79)	2.51 (21.96)	2.92 (78.89)	2.95 (88.90)	2.90 (87.78)	2.83 (103.29)	2.29 (60.34)	2.51 (82.34)
Transplanted rice	2.00 (12.86)	2.20 (15.30)	2.49 (54.89)	2.60 (63.87)	2.35 (61.71)	2.51 (73.80)	2.00 (40.00)	2.25 (58.77)
SEm±	0.04	0.005	0.05	0.06	0.012	0.09	0.06	0.07
LSD (P=0.05)	0.15	0.02	0.19	0.22	0.048	0.34	0.25	0.28
Weed management practice								
Penoxsulam 22.5 g/ha	2.46 (12.06)	2.72 (15.62)	4.20 (72.08)	4.55 (101.43)	4.35 (83.98)	4.80 (135.81)	3.96 (58.70)	4.58 (108.94)
Penoxsulam 22.5 g/ha FB one HW	2.51 (12.60)	2.71 (15.42)	1.65 (5.03)	1.47 (4.15)	1.27 (3.39)	1.07 (3.26)	0.40 (1.04)	0.36 (0.95)
Bispyribac sodium 20 g/ha	2.56 (13.69)	2.81 (17.32)	4.22 (74.39)	4.50 (97.00)	4.38 (87.37)	4.76 (128.46)	3.97 (60.36)	4.48 (98.84)
Bispyribac sodium 20 g/ha FB one HW	2.55 (13.62)	2.80 (17.10)	1.61 (4.84)	1.45 (3.67)	1.20 (3.32)	0.96 (2.31)	0.36 (0.76)	0.27 (0.52)
Weed free	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Weedy check	4.46 (95.32)	4.50 (99.19)	5.97 (435.52)	6.02 (452.77)	6.03 (451.15)	6.09 (477.62)	5.66 (314.21)	5.86 (373.65)
SEm±	0.05	0.04	0.09	0.08	0.10	0.14	0.13	0.12
LSD (P=0.05)	0.14	0.12	0.25	0.23	0.28	0.41	0.37	0.35

Original values given in parentheses,DAS- Days after sowing, DAT- Days after transplanting, fb- followed by, HW- hand weeding

Table.5 Weed control efficiency (%) at various stages of crop growth

Treatment	Growth stage (DAS/DAT)					
	60		**90**		**At harvest**	
Rice establishment method						
Direct seeded rice	77.75	76.06	76.71	73.61	76.53	72.90
Wet seeded rice	76.66	75.17	76.25	73.83	76.80	74.45
Transplanted rice	77.14	75.57	77.38	74.69	77.97	75.62
SEm±	0.63	0.39	0.66	0.93	0.59	0.75
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management practice						
Penoxsulam 22.5 g/ha	82.78	77.21	81.24	71.97	81.84	71.67
Penoxsulam 22.5 g/ha FB one HW	98.85	99.12	99.29	99.43	99.67	99.82
Bispyribac sodium 20 g/ha	82.42	78.07	80.76	73.29	81.16	74.59
Bispyribac sodium 20 g/ha FB one HW	98.89	99.20	99.38	99.59	99.51	99.87
Weed free	100.00	100.00	100.00	100.00	100.00	100.00
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00
SEm±	0.79	0.49	0.77	1.11	0.96	1.21
LSD (P=0.05)	2.27	1.42	2.21	3.20	2.78	3.50

Original values given in parentheses, DAS- Days after sowing, DAT- Days after transplanting, fb- followed by, HW- hand weeding

Weed control efficiency

The data pertaining to weed control efficiency at various stages of crop growth are presented in Table 5. The differences in weed control efficiency were found non-significance due to different rice establishment methods at all the stages during both the years. However, among all establishment methods at 90 DAS/DAT and at harvest stages, the highest weed control efficiency was noticed under TPR and lowest under DSR though the differences were non-significant.

Weed management practices had significant effect on weed control efficiency at all the stages of crop growth during both the years. At all these stages, the highest weed control efficiency was noted with weed free treatment which was closely followed by either application of bispyribac sodium 20 g/ha FB one HW or penoxsulam22.5 g/ha FB one HW. Among the herbicidal treatments, application of bispyribac sodium 20 g/ha FB one HW at 35 DAS/DAT or penoxsulam22.5 g/ha FB one HW at 35 DAS/DAT being on par to each other recorded the highest weed control efficiency. Revathi *et al.*, (2010) reported the similar result. Application of penoxsulam or bispyribac sodium alone at par to each other, recorded the lowest weed control efficiency at all the stages of crop growth during both the years.

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