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Sowing time and weed management to enhance productivity of direct-seeded aromatic rice

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ABSTRACT

Field experiments were conducted during *Kharif* 2012 and 2013 sandy clay loam soil to study the effect of times of planting and weed management in direct-seeded aromatic rice in foot hills J&K Himalayas. Results revealed that direct-seeded basmati rice sown on 15th June and 10th July recorded non-significant results with respect to grain and straw yield. Among herbicidal weed management, post-emergence application of bispyribac at 30 g/ha recorded significantly higher grain and straw yield which was at par with post-emergence application of cyhalofop-butyl + 2, 4-D 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron at 375 g/ha + 15 g/ha with B:C ratio of 2.98 and 3.95 during *Kharif* 2012 and 2013, respectivly. It was owing to higher number of panicles/m^2, grains/panicle and 1000-grain weight along with lowest weed density, weed dry matter, higher weed control efficiency and lowest weed index.

Key words: Aromatic rice, Direct-seeded, Sowing time, Weed control, Yield

Basmati rice has occupied a prime position in national and international markets because of their excellent quality characters. Traditionally, basmati rice is grown by hand transplanting of 25-30 day old seedlings after puddling. Basmati rice being a relatively long duration crop needs early establishment to avoid lodging and lower seed setting. Growing rice under direct-dry-seeded can be an option for reducing water losses to a great extent (Rao *et al.* 2007). Hence, direct-seeding instead of conventional transplanting is gaining impetus in India. The low productivity of basmati rice can be attributed to several limiting factors and all but one important factor amongst those has been the poor weed management which becomes more relevant under direct-seeding rice where weeds achieve an advantageous position owing to upland conditions (Shan *et al.* 2012). Aerobic soil condition and dry tillage practices besides alternate wetting and drying conditions are conductive for germination and growth of highly competitive weeds. According to Mamun *et al.* (1993), weed growth reduced the grain yield by 68-100% for direct-seeded rice, 22-36% for modern 'boro' rice and 16-48% for transplanted 'aman' rice. Therefore, keeping weeds below threshold level, herbicides provide the cheapest and most effective tool through which excessive weed population can be controlled before crop-weed competition. The time of sowing being a non–monetary input have noticeable impact on weed intensity and on yield also. Delay in sowing results in slow growth of crop and increased infestation of competing weeds. Therefore, the present investigation was undertaken to assess the times of sowing and weed control measures for improving the productivity in direct-seeded aromatic rice in foot hills of J&K Himalayas.

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MATERIALS AND METHODS

A field experiment was conducted at the research farm of Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *Kharif* 2012 and 2013. The experimental soil was sandy clay loam in texture medium in organic carbon, available phosphorus and potassium, low in available nitrogen. The experiment was conducted in spilt plot design with three replications. The main plot treatments consisted of two times of sowing, (i) 15th June (ii) 10th July while the sub-plot treatments were comprised of seven methods of weed control practices (i) azimsulfuron 35 g/ha post-emergence (20 DAS) (ii) cyhalofop-butyl + 2,4-D 90 g/ha + 500 g/ha post-emergence (30 DAS) (iii) bispyribac at 30 g/ha post-emergence (30 DAS) (iv) anilophos + ethoxysulfuron 375 g/ha + 15 g/ha post-emergence (15 DAS) (v) oxadiargyl 100 g/ha pre-emergence (vi) weedy check and (vii) weed free. Rice cultivar '*Basmati-370*' was sown at row to row spacing of 20 cm using 40 kg seed/ha. The crop was fertilized with NPK at 30, 20 and 10 kg/ha. Full dose of phosphorus and potassium along with one third of nitrogen were applied as basal dose at the time of sowing and remaining one third of nitrogen was applied in two equal spilts, one third at tillering stage and the one third was applied at panicle initation stage. Pre-emergence and post-emergence herbicides were sprayed by knapsack sprayer fitted with flat fan nozzle using a spray volume of 500 l/ha. Weedy check plots remained infested with native population of weeds till harvest. Data on weed population and dry matter, crop growth and yield were recorded. The data on weeds were subjected to square root transformation $(\sqrt{x+1})$ to normalize their distribution.Weed indices like weed control efficiency was calculated as suggested by Mishra and Mishra (1997) and weed index was calculated as suggested by Raju (1998).

RESULTS AND DISCUSSION

Weed population, weed dry matter, weed control efficiency and weed index

The major weeds in the experimental field were *Cynodon dactylon* (18.72%), *Echinochloa crusgalli* (17.38%), *Commelina benghalensis* (12.50%), *Cyperus rotundus* (16.46%), *Cyperus difformis* (15.94%) and *Ammania baccifera* (13.03%) and other minor species were *Eclipta alba* and *Solanum nigrum*. The grassy weeds dominated the weed flora throughout the crop growth seasons during both the years.

Among times of sowing, crop sown on 15th June had significantly lowest density of weeds at 60 DAS and at harvest as compared to 10th July sown crop (Table 1). Consequently, weed dry matter at 60 DAS and at harvest in 10th July sown crop was significantly higher than 15th June sown crop. This might have happened due to the fact that relatively conducive environment for ensuring better germination and initial plant stand with development of greater amount of foliage providing better smothering capacity to crop plants leading to enhanced weed suppression which provided an opportunity to crop plants to better utilize the natural resources in the vicinity with lower light transmission ratio at the ground level which inhibited the germination of weed seeds and growth of weed. This confirms the findings of Jadhav (2013) and Chalka and Singh (2013).

Among weed management practices, significantly lowest total weed density at 60 DAS and at harvest were recorded with application of bispyribac 30 g/ha as post-emergence followed by post-emergence cyhalofop-butyl + 2,4-D 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron as post-emergence at 375 g/ha + 15 g/ha. Further application of bispyribac as post-emergence at 30 g/ha also recorded significantly lowest weed dry matter followed by cyhalofop-butyl + 2,4-D post-emergence at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron post-emergence at 375 g/ha + 15 g/ha. Better efficacy and prolonged effectiveness of applied herbicides which did not allow the weeds to germinate and even resulted in rapid depletion of carbohydrate reserves of weeds already germinated through rapid respiration, senescence of leaves, reduction in leaf area and diminution of photosynthesis process (Singh *et al*. 2013).

Table 1. Effect of times of sowing and weed management practices on total weed count, total weed dry weight, weed control efficiency and weed index of direct seeded aromatic rice

Treatment	Total weed count at 60 DAS (no./m^2)		Total weed dry weight at 60 DAS (g/m^2)		Weed control efficiency at harvest (%)		Weed index at harvest (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
Time of sowing								
15th June	10.6 (113)	10.5 (110)	11.4 (129)	11.4 (128)	59.2	60.5	-	-
10th July	12.6 (157)	12.5 (155)	12.4 (154)	12.4 (154)	51.3	52.4	-	-
LSD (P=0.05)	1.93	1.79	1.58	1.67	-	-	-	-
Weed management								
Azimsulfuron 60 g/ha	12.4 (153)	12.4 (152)	12.9 (166)	12.9 (165)	57.3	58.3	35.9	35.6
Cyhalofop-butyl + 2,4-D 90 g/ha + 500 g/ha	10.7 (113)	10.4 (108)	11.5 (131)	11.4 (129)	70.1	71.3	21.9	23.0
Bispyribac 30 g/ha	10.5 (110)	10.3 (106)	11.4 (129)	11.3 (128)	71.8	72.8	15.8	19.6
Anilophos + ethoxysulfuron 375 g/ha + 15 g/ha	10.7 (113)	10.5 (109)	11.5 (131)	11.5 (131)	68.5	70.1	25.2	26.1
Oxadiargyl 100 g/ha	12.5 (156)	12.5 (155)	13.0 (169)	12.9 (165)	56.5	58.1	39.7	41.1
Weedy check	17.3 (298)	20.9 (299)	16.4 (268)	16.4 (269)	0.0	0.0	52.7	56.4
Weed free	1(0.0)	1(0.0)	1(0.0)	1 (0.0)	100	100	0.0	0.0
LSD (P=0.05)	0.78	0.96	0.65	0.98	-	-	-	-

Figures in parentheses are original values

Table 2. Effect of times of sowing and weed management practices on crop and yield attributes of direct seeded aromatic rice

Treatment	Plant height at harvest (cm)		No of panicles/m²		No. of grains/panicle		1000-grain weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
Time of sowing								
15th June	117.8	118.6	144.3	145.1	75.1	76.3	20.8	21.5
10th July	115.6	116.5	142.2	143.9	73.6	75.5	20.0	20.6
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
Azimsulfuron 60 g/ha	112.2	114.2	142.2	143.1	71.7	73.8	20.0	21.1
Cyhalofop-butyl + 2, 4-D 90 g/ha + 500 g/ha	119.4	120.2	146.3	147.8	76.1	77.8	21.8	22.9
Bispyribac 30 g/ha	121.0	121.6	147.8	148.6	76.6	78.7	22.0	22.9
Anilophos + ethoxysulfuron 375 g/ha + 15 g/ha	118.7	119.6	146.1	147.2	75.1	77.1	21.1	22.4
Oxadiargyl 100 g/ha	110.3	112.1	141.5	143.0	70.2	73.2	20.0	21.0
Weedy check	104.9	103.5	137.3	136.8	66.8	65.9	18.2	18.0
Weed free	130.4	132.3	151.1	153.8	85.9	88.7	23.0	24.1
LSD (P=0.05)	2.48	2.32	3.29	3.34	2.82	3.01	1.05	1.19

Basmati rice direct-seeded on 15th June recorded highest weed control efficiency (59.23%) at harvest as compared to 10th July sowing. Among weed control methods, post-emergence application of bispyribac at 30 g/ha (71.76%) was superior followed by post-emergence application of cyhalofop-butyl + 2,4-D at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron at 375 g/ha + 15 g/ha. Lowest weed index was recorded with the post-emergence application of bisypyribac 30 g/ha followed by post-emergence application of cyhalofop-butyl + 2,4-D 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron 375 g/ha + 15 g/ha in the increasing order. Kumar *et al*. (2013) reported similar findings.

Crop growth, yield attributes and yield

Times of planting on 15th June and 10th July failed to show any significant impact on plant height at harvest and yield attributes during both the years registered (Table 2). However, 15th June sowing recorded numerically higher plant height at harvest and yield attributes as compared to 10th July planting. All the weed control treatments recorded significantly more number of panicles/m² as compared to weedy check. Application of bispyribac as post-emergence at 30 g/ha recorded significantly highest number of panicles/m² which was statistically at par with application of cyhalofop-butyl + 2,4-D as post-emergence at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron as post-emergence at 375 g/ha + 15g/ha. Number of grains/panicle and 1000-grain weight was significantly highest with the application of bispyribac post-emergence at 30 g/ha and was statistically at par with application of cyhalofop-butyl + 2, 4-D post-emergence at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron post-emergence at 375 g/ha + 15g/ha. The enhanced yield attributes recorded might be due to lowest density and dry weight of weeds and higher weed control efficiency which resulted in better growth of rice crop.

Economics

Statistically non-significant results were observed with respect to grain and straw yield of rice crop among different times of sowing during both the crop seasons (Table 3). However, 15th June sowing recorded slightly highest grain and straw yields as compared to 10th July sowing.

The increase in yield under various weed-management treatments may be attributed to significant reduction in weed dry matter (Table 3), thereby reduction in crop weed competition which provided congenial environment to the crop for the better expression of vegetative and reproductive potential. The lowest grain yield and straw yield of basmati rice was noticed in weedy check as a consequence of stiff competition imposed by weeds resulting in poor source and sink development with poor yield contributing characters and higher weed index. These results corroborated with the findings of Subhas and Jitendra (2007). Amongst the herbicidal treatments, application of bispyribac as post-emergence at 30 g/ha recorded significantly highest grain and straw yields which was statistically at par with cyhalofop-butyl + 2, 4-D post-emergence at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron post-emergence at 375 g/ha + 15g/ha due to superiority in yield attributes of crop components as a result of reduced crop-weed competition and increased water and nutrient availability (Kumar *et al* 2013).

Table 3. Effect of time of sowing and weed management practices on yield and B:C ratio of direct-seeded aromatic rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		B:C ratio	
	2012	2013	2012	2013	2012	2013
Time of sowing						
15th June	2.07	2.18	3.86	4.05	2.46	3.05
10th July	1.96	2.05	3.76	3.95	2.34	3.02
LSD (P=0.05)	NS	NS	NS	NS	-	-
Weed management						
Azimsulfuron 60 g/ha	1.77	1.91	3.40	3.50	2.41	2.88
Cyhalofop-butyl + 2,4-D 90 g/ha + 500 g/ha	2.16	2.29	4.09	4.29	2.93	3.62
Bispyribac 30 g/ha	2.33	2.39	4.20	4.40	2.98	3.95
Anilophos + ethoxysulfuron 375 g/ha + 15 g/ha	2.07	2.20	3.96	4.17	2.87	3.61
Oxadiargyl 100 g/ha	1.67	1.75	3.27	3.43	2.45	2.72
Weedy check	1.31	1.30	2.95	2.76	1.49	1.92
Weed free	2.77	2.97	4.96	5.42	1.69	2.52
LSD (P=0.05)	0.28	0.28	0.40	0.36	-	-

Among the times of sowing, 15th June sowing recorded highest B: C ratio as compared to 10th July sowing. All the weed control treatments recorded considerably higher benefit: cost ratio over weedy check (Table 3). Higher benefit:cost ratio was obtained with the application of bispyribac as post-emergence at 30 g/ha which was closely followed by cyhalofop-butyl + 2, 4-D at 90g/ha + 500 g/ha and anilophos + ethoxysulfuron as post-emergence at 375 g/ha + 15 g/ha.

It was concluded that application of bispyribac as post-emergence at 30 g/ha, cyhalofop-butyl + 2,4-D as post-emergence at 90 g/ha + 500 g/ha and anilophos + ethoxysulfuron as post-emergence at 375 g/ha + 15 g/ha was found effective in reducing weed population, resulted in higher benefit:cost ratio irrespective of whether rice was sown at 15th June and 10th July under subtropical agro eco-systems of Jammu region.

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