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Influence of date of sowing, crop geometry and weed control methods on weed control and productivity of direct seeded rice

N.N. Angiras, Suresh Kumar and S.S. Rana
Department of Agronomy, Forages and Grassland Management
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 062, India.

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Abstract

A field investigation was carried out during *kharif* 2004, 2005 and 2006 at Palampur with eighteen treatment combinations of two seeding times (early and late), three planting geometries (E-W orientation, bidirectional seeding and broadcast seeding) and three weed control methods [farmer's practice, butachlor 1.50 kg/ha followed by (*fb*) *halod* and cyhalofop butyl 90 g/ha (15 DAS) *fb* 2, 4-D 1.0 kg/ha (30-35 DAS)] for their effect on weeds in direct seeded rice under upland conditions. Delayed sowing resulted in significantly lower *Echinochloa colona, Panicum dichotomiflorum, Ageratum conyzoides* and total weed count and had comparable yield as early seeding in two out of the three years. Bidirectional sowing significantly reduced the population of *Digitaria sanguinalis* and *Cynotis sp.* Bidirectional seeding increased rice grain yield by 7.11% over broadcasting and 8.36% over E-W direction. Cyhalofop butyl *fb* 2, 4-D resulted in significantly lower count of *Echinochloa colona, Cyperus sp., Digitaria sanguinalis, Panicum dichotomiflorum* and total count and dry weight of weeds. Cyhalofop butyl *fb* 2,4-D and butachlor *fb halod* increased rice grain yield by 15.9 and 8.6 per cent, respectively over the farmer's practice of *halod fb* hand weeding.

Key words: Date of sowing, crop geometry, butachlor, cyhalofop butyl, rice.

Introduction

Weeds inflict major losses in upland rice culture sometimes resulting in total crop failures. Direct seeding of rice will only be successful provided there is good crop establishment as well as adequate weed control methods are available to keep the crop free from weeds (Rao *et al.* 2007; Rao and Nagamani, 2007). In absence of adequate weed control, rice yield is reduced by 35-100 per cent (Kumar *et al.* 2008). Manual removal of weeds is labour intensive, tedious, back breaking and does not ensure weed removal at critical stage of crop-weed competition. In rainfed areas of Himachal Pradesh, the time of sowing is primarily controlled by the onset of monsoons. When delayed, with a few exceptions most of the varieties suffer to a large extent. Similarly, row orientation has a considerable influence on tillering capacity and yield of the crop which directly correlated with net assimilation rate. The rice herbicides presently used are mainly pre emergence and weeds coming at later stages of crop growth are not controlled as effectively as at emerging stage. Hence, the present investigation was carried out to study the effect of date of sowing, row orientation and weed control methods (pre and post emergence herbicides) alone and in integration, in controlling weeds in direct seeded upland rice.

Materials and Methods

A field experiment was conducted during the three consecutive *kharif* seasons of 2004, 2005 and 2006 at the Research farm of Department of Agronomy, Forages and Grassland Management, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.6) and medium in available N (326 kg N ha^{-1}), P (19.8 kg ha^{-1}) and K (214.8 kg ha^{-1}). Eighteen treatment combinations of 2 dates of sowing (Early and late) and 3 row orientation (East-west direction, bidirectional and broadcast sowing) in main plot and 3 weed control methods (farmer's practice, butachlor 1.50 kg ha^{-1} (pre) *fb* halod and cyhalofop butyl 90 g ha^{-1} *fb* 2, 4 –D 1.0 kg ha^{-1}) in subplots, were tested in split plot design with three replications. Rice variety 'HPR 957' was sown on June 10, 22 and 7 (D_1) and June 25, July 8 and June 24 (D_2) during 2004, 2005 and 2006, respectively, using 100 kg seed/ha. Application of herbicide was made with power sprayer using 700 L water per hectare. Except weed control treatments, the crop was raised in accordance with the recommended package of practices. The crop was fertilized with 90 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha. Half N and whole of the P_2O_5 and K_2O were applied as basal. The remaining half N was topdressed in two equal splits at tillering and

panicle initiation stages of the crop growth. Weed count and dry weight were recorded at 60 and 90 DAS from two randomly selected spots (0.25 m^2) in each plot and expressed as number/m^2 and g m^{-2}, respectively. The data on count and dry weight of weeds were subjected to $\sqrt{x+1}$ (square root transformation) for statistical analysis. Yields were harvested from net plot.

Results and Discussion

The predominant weed flora which infested the experimental plots by 60 DAS consisted of *Echinochloa colona* (14.9%), *Digitaria sanguinalis* (7.7%), *Panicum dichotomiflorum* (7.2%), *Cyperus sp.* (2.5%), *Ageratum conyzoides* (61.4%) and *Cynotis sp.* (6.3%). At harvest *Echinochloa colona, Panicum dichotomiflorum, Cyperus sp., Ageratum conyzoides* and *Cynotis* constituted 28.8, 12.0, 13.1, 19.5 and 8.5%, respectively.

Date of sowing

Delayed sowing resulted in significantly lower count of *Echinochloa colona* as compared to early sowing both at 60 and 90 DAS during 2006 (Table 1). Similarly delayed sown plots had significantly lower count of *Panicum dichotomiflorum* at 60 DAS during 2006. Count of *Ageratum conyzoides* was also significantly lower due to delayed sowing at 60 DAS during 2004 and 90 DAS during 2006. However, the population of *Cyperus sp., Digitaria sanguinalis* and *Cynotis* was not significantly affected in all the years due to seeding time of rice (Table 2).

Total weed count was significantly affected owing to seeding time during 2004 and 2006 and was significantly lower with late seeding than with early seeding. However, contrary to this total weed dry weight (Table 3) was not significantly influenced due to sowing time in any year showing phenotypic plasticity that fewer weeds accumulate more dry matter due to comparatively less intra-specific competition.

Rice grain yield owing to timely and late seeding was comparable during 2004 and 2006 (Table 3) indicating that farmers can go for late seeding without any loss. But this has only 2/3 probability as rice yield during 2005 under late seeding was below $1/6^{th}$ than under normal seeding time. This had happened owing to mid season drought when young crop under late sowing treatment was severely affected as compared to that under normal seeding. On an average, rice grain yield under normal sowing time was 38.0% higher than under late seeding time.

Row orientation

Row orientation has considerable influence in harnessing solar radiation and micro-climate which likely affect crop growth and associated factors such as weeds, insect pests, diseases etc. During 2004, population of *Digitaria sanguinalis* at 60 DAS was significantly lower in rice fields when it was sown on E-W direction or followed with bidirectional seeding as compared to broad cast seeding (Table 1). E-W and bidirectional seeding were at par with each other in influencing the count of *Digitaria sanguinalis*. Similarly bidirectional sowing was superior to broadcast as well as E-W direction in reducing the number of *Cynotis* sp at 90 DAS during 2006. The count of other weeds was not significantly affected under row orientation treatments at any time in all the years (Table 2). The total weed count and dry weight (Table 3) were also not significantly affected due to row orientation treatments. Row orientation treatments resulted in significant variation in rice grain yield during 2006 only (Table 3). Bidirectional seeding resulted in significantly higher rice grain yield over E-W direction and broadcasting. Bidirectional seeding increased the rice grain yield by 7.1% over broadcasting and by 8.36% over E-W direction.

Weed control methods

Weed control methods brought about significant variation in the population of *Echinochloa colona* at 60 and 90 DAS during 2005 and 2006 (Table 1). Cyhalofop butyl 90 g/ha *fb* 2, 4-D gave significantly lower count of *Echinochloa colona* than farmer's practice and butachlor 1.50 kg/ha *fb halod*. The later two treatments were statistically at par with each other in influencing the count of *Echinochloa colona*. Cyhalofop butyl *fb* 2,4-D significantly reduced the count of *Cyperus sp.* over farmer's practice at 60 DAS during 2005 and 2006 and 90 DAS during 2006; but was not significantly different from butachlor *fb halod* at 60 DAS during 2005 and 2006 and 90 DAS during 2006. Butachlor *fb halod* was also significantly superior to farmer's practice in reducing the count of *Cyperus sp.* at 60 DAS during 2005 and at 90 DAS during 2005 and 2006 (Table 2). Cyhalofop butyl *fb* 2, 4-D gave significantly lower count of *Digitaria sanguinalis*

Table 1. Effect of different treatments on count of grassy weeds in direct seeded rice

Treatment	*Echinochloa*					*Digitaria*			*Panicum*				
	60 DAS			At harvest		60 DAS			60 DAS			At harvest	
	2004	2005	2006	2005	2006	2004	2005	2006	2004	2005	2006	2005	2006
Date of sowing													
D_1 (Early)	3.9(16.3)	3.5(13.1)	5.3(28.7)	4.5(21.7)	4.6(21.3)	3.6(17.0)	3.8(15.5)	1.6(2.9)	1.9(5.5)	2.5(7.1)	3.3(11.8)	2.1(4.7)	3.4(12.4)
D_2 (Late)	4.0(16.1)	3.3(13.3)	3.8(16.1)	3.8(17.6)	2.8(9.3)	3.8(16.8)	3.7(14.9)	1.4(1.6)	2.2(5.2)	1.8(3.8)	2.2(5.6)	2.1(4.7)	3.0(9.4)
CD (P=0.05)	NS	NS	0.32	NS	0.35	NS	NS	NS	NS	NS	0.83	NS	NS
Row orientation													
E-W	4.3(18.7)	3.5(14.2)	4.7(23.7)	4.2(18.6)	3.4(12.4)	3.8(16.4)	3.9(16.5)	1.1(0.6)	2.0(4.4)	1.9(4.4)	2.2(6.0)	2.0(4.2)	3.0(9.3)
Bi-directional	3.5(13.1)	3.5(13.7)	4.2(19.5)	4.2(21.7)	4.0(17.1)	4.3(22.6)	3.5(12.2)	1.7(3.1)	1.8(4.2)	2.3(6.0)	2.9(9.3)	2.3(5.7)	3.6(12.8)
Broadcast	4.0(16.9)	3.3(11.7)	4.7(24.0)	4.1(18.6)	3.7(16.4)	5.3(11.7)	3.9(16.7)	1.7(3.1)	2.3(7.30	2.2(6.0)	3.1(10.8)	2.0(4.2)	3.1(10.6)
CD (P=0.05)	NS	NS	NS	NS	NS	0.84	NS	NS	NS	NS	NS	NS	NS
Methods of weed control													
Farmer's practice	4.3(18.7)	4.3(18.8)	5.2(28.4)	4.9(24.6)	4.2(18.2)	5.3(29.5)	4.2(18.9)	1.9(4.2)	2.2(6.6)	2.8(8.6)	3.2(10.8)	2.8(7.7)	3.4(12.0)
Butachlor 1.50 kg/ha *fb halod*	3.9(16.20)	4.0(16.2)	5.0(25.5)	4.4(20.6)	3.8(16.0)	4.0(17.3)	3.9(16.2)	1.1(0.6)	2.0(4.7)	1.8(4.0)	2.6(8.2)	2.2(4.8)	3.3(11.7)
Cyhalofop butyl 90 g/ha *fb* 2,4-D 1.0 kg/ha	3.7(13.8)	2.0(4.6)	3.4(13.3)	3.3(13.7)	3.1(11.7)	1.8(4.0)	3.2(10.4)	1.5(2.0)	1.9(4.6)	1.3(3.7)	2.4(7.1)	1.3(1.5)	3.0(9.1)
CD (P=0.05)	NS	0.8	0.7	1.0	0.5	0.6	0.8	0.4	NS	NS	NS	0.8	NS

Values given in the parentheses are the original means

Table 2. Effect of treatments on count of sedges and broad-leaf weeds in direct seeded rice

Treatment	*Cyperus*				*Ageratum*					*Cynotis*				
	60 DAS		At harvest		60 DAS			At harvest		60 DAS			At harvest	
	2004	2005	2005	2006	2004	2005	2006	2005	2006	2004	2005	2006	2005	2006
Date of sowing														
D_1 (Early)	1.3(1.2)	2.7(10.6)	2.9(10.5)	3.7(4.6)	10.7(117.7)	3.4(15.2)	2.3(8.4)	3.6(17.7)	2.3(6.5)	1.7(3.1)	2.9(9.7)	3.1(10.8)	2.3(6.3)	2.8(8.5)
D_2 (Late)	1.6(2.2)	3.1(13.7)	3.9(18.3)	3.1(10.6)	7.3(58.8)	6.8(57.4)	2.1(5.7)	4.5(25.4)	2.0(4.8)	1.6(2.2)	1.7(3.2)	3.0(9.9)	1.8(3.4)	3.0(9.4)
CD (P=0.05)	NS	Ns	NS	NS	0.79	NS	NS	NS	0.21	NS	NS	NS	NS	NS
Row orientation														
L-W	1.2(0.6)	2.6(9.5)	3.0(12.0)	3.6(14.0)	8.5(82.6)	4.9(32.0)	2.0(5.7)	4.2(22.6)	2.6(7.7)	1.6(2.4)	2.4(7.1)	3.2(10.6)	1.9(4.0)	3.0(10.0)
Bi-direction	1.5(2.0)	3.2(14.6)	4.2(20.8)	3.5(12.8)	9.5(98.6)	4.7(31.3)	2.2(7.3)	4.2(21.7)	2.0(4.8)	1.8(3.3)	2.4(6.6)	2.9(10.2)	2.2(5.5)	2.4(6.4)
Broadcast	1.6(2.4)	2.9(12.4)	2.9(10.4)	3.2(11.1)	9.1(83.5)	5.7(45.7)	2.5(8.2)	3.8(20.4)	2.0(4.4)	1.5(2.2)	2.2(5.7)	2.9(10.2)	2.0(4.8)	3.1(10.6)
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.6
Methods of weed control														
Farmer's practice	1.7(3.1)	4.2(22.4)	4.1(18.8)	4.2(17.5)	9.2(86.6)	5.7(44.4)	1.3(1.5)	4.5(23.7)	2.3(6.8)	1.1(0.4)	2.7(9.1)	4.4(19.1)	2.2(5.3)	3.0(8.8)
Butachlor 1.50 kg/ha *fb halod*	1.5(1.7)	2.6(9.1)	2.1(6.6)	3.1(10.6)	9.3(92.9)	5.0(32.4)	2.2(6.6)	4.1(24.4)	2.2(5.5)	2.6(6.4)	1.7(3.5)	2.5(6.6)	2.2(5.3)	3.7(14.2)
Cyhalofop butyl 90 g/ha *fb* 2,4-D 1.0	1.1(0.2)	1.9(5.1)	4.0(17.7)	3.0(9.7)	8.5(85.3)	4.5(32.4)	3.1(13.1)	3.6(16.6)	2.1(4.6)	1.3(1.1)	2.5(7.1)	2.2(5.3)	1.8(3.5)	2.0(4.0)
CD (P=0.05)	0.5	1.5	1.1	0.8	0.6	NS	1.0	NS	NS	0.5	1.8	0.7	NS	0.6

Values given in the parentheses are the original means

Table 3. Effect of different treatments on weed count and weed dry weight of total weeds at harvest and grain yield of direct seeded rice

Treatments	Total weed count (No m^{-2})			Total dry weight (gm^{-2})			Grain yield (kg ha^{-1})			Average
	2004	2005	2006	2004	2005	2006	2004	2005	2006	
Date of sowing										
D_1 (Early)	12.3(153.4)	8.2(73.9)	8.2(68.8)	6.7(46.8)	4.5(21.2)	2.7(7.4)	1714	2615	2136	2155.0
D_2 (Late)	10.1(104.1)	8.5(76.0)	7.0(50.3)	7.0(51.6)	4.7(22.8)	2.1(4.0)	1780	418	2487	1561.7
CD (P=0.05)	0.99	NS	1.12	NS	NS	NS	NS	150	NS	-
Row orientation										
E-W	11.2(128.1)	8.1(70.0)	7.6(59.7)	7.1(52.7)	4.5(20.7)	2.4(5.5)	1693	1509	2200	1800.7
Bi-direction	11.5(136.7)	9.2(90.0)	7.7(60.6)	6.6(44.4)	5.0(25.7)	2.3(5.0)	1757	1545	2552	1951.3
Broadcast	10.9(121.4)	7.7(64.8)	7.5(58.4)	6.9(50.6)	4.3(19.6)	2.5(6.7)	1789	1495	2181	1821.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	201.3	-
Methods of weed control										
Farmer's Practice	11.4(134.6)	9.2(87.7)	8.3(69.7)	6.4(42.4)	5.1(25.7)	2.7(7.4)	1639	1388	2127	1718.0
Butachlor 1.50 kg/ha *fb halod*	11.3(128.8)	8.0(70.2)	7.7(61.3)	6.7(47.0)	4.5(21.0)	2.4(5.7)	1710	1554	2331	1865.0
Cyhalofop butyl 90 g/ha *fb* 2,4-D 1.0 kg/ha	10.9(122.6)	7.9(66.8)	6.8(47.7)	7.5(58.2)	4.3(19.3)	2.1(4.0)	1890	1607	2476	1991.0
CD (P=0.05)	NS	0.5	0.7	0.7	0.7	0.4	117	162	182	-

Values given in the parentheses are the original means

at 60 DAS during 2004, 2005 and 2006 over farmer's practice. Butachlor 1.50 kg/ha *fb halod* was also superior to farmer's practice at 60 DAS during 2004 and 2006 in influencing the count of *Digitaria sanguinalis*. Cyhalofop butyl *fb* 2, 4-D gave significantly lower count of *Panicum dichotomiflorum* than farmer's practice and butachlor *fb halod* at 90 DAS during 2005. *Ageratum conyzoides* usually appeared late in rice fields and trends in its count as affected due to weed control methods were not very conspicuous. At 60 DAS, when cyhalofop butyl *fb* 2, 4-D was superior to other two treatments during 2004, farmer's practice had lower count of this weed over other treatments during 2006. Effect of weed control treatments on count of *Cynotis* sp. during different years varied widely and the trends were not very conspicuous, therefore, concluded nothing.

Cyhalofop butyl *fb* 2,4-D resulted in significantly lower count and dry weight of weeds (Table 3) over farmer's practice during 2005 and 2006. It was also superior to butachlor *fb halod* in reducing the total weed count during 2006. However, during 2004 both farmer's practice and butachlor *fb halod* had significantly lower total weed dry weight than cyhalofop butyl *fb* 2,4-D. Whereas total weed count was not affected significantly due to weed control methods.

Owing to superior weed control, cyhalofop butyl *fb* 2,4-D resulted in significantly higher rice grain yield over farmer's practice during all the three years. These findings are in close conformity with the findings of Attri and Angiras (2001). However, it did not significantly increase rice grain yield over butachlor *fb halod* during 2005 and 2006. Butachlor *fb halod* also brought about significant increase in rice grain yield over farmer's practice during 2005 and 2006. Cyhalofop butyl *fb* 2,4-D and butachlor *fb* 2, 4-D on an average increased rice grain yield to the tune of 15.9 and 8.6 per cent, respectively, over the farmer's practice of halod *fb* one hand weeding.

It may be inferred from the present investigation that bidirectional sowing in first fortnight of June and cyhalofop butyl 90 g/ha *fb* 2,4-D 1.0 was the best option for managing weeds and increasing grain yield of rice.

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