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Crop establishment and weed management effect on weed parameters and rice yield under temperate zone of Kashmir

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ABSTRACT

A field experiment was conducted during *Kharif* (rainy) seasons of 2017 and 2018 at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Jammu and Kashmir. The treatments comprised of three crop establishment methods, *viz.* transplanting, direct seeding (DSR), System of Rice Intensification (SRI) in main plots and seven weed management practices, *viz.* butachlor (1500 g/ha), penoxsulam (22.5g/ha), pyrazosulfuron-ethyl + pretilachlor (15 and 600g/ha), bensulfuron methyl + pretilachlor (60 and 600 g/ha), twice conoweeding/hand weeding, weed free and weedy check in sub-plots replicated thrice in a split plot design. The results revealed that significantly lowest weed density and weed dry weight were recorded with transplanted method as compared to SRI and DSR. Application of penoxsulam 22.5 g/ha recorded significantly the lowest weed population and weed dry matter depicting higher weed control efficiency. SRI had resulted in significantly higher yields over DSR and transplanted rice. Penoxsulam (22.5 g/ha) produced significantly higher grain and straw yields. SRI proved to be better method of crop establishment than transplanting and DSR whereas, application of penoxsulam 22.5 g/ha proved superior to other herbicide treatments used.

INTRODUCTION

Rice is the primary food source for more than half of the world's population and is cultivated globally over an area of about 158.8 million hectares with a production of 751.9 million tonnes annually (FAO, 2017). India, the largest rice growing country of the world after China, contributes 21.5% to global rice production. Transplanting is the most dominant method of rice establishment in Kashmir valley, however the shortage of labour and water are pressing farmers to explore the alternatives of conventional transplanting. The area under transplanted rice in world is decreasing due to scarcity of water and labour. So, there is need to search for alternate crop establishment methods to increase the productivity of rice (Farooq *et al.* 2011). Direct seeding reduces labour requirement, shortens the crop duration by 7-10 days and can produce as much grain yield as that of transplanted crop. The system of rice intensification (SRI) was recently promoted as an alternative technology and resource management strategy for rice cultivation that offers the opportunity to boost rice yields with less external inputs. The SRI consists of a set of management practices that were mainly developed in areas with scarcity of water and labour.

Weed management is major prerequisite for improved rice productivity in all the rice establishment methods. Although a number of pre-emergence herbicides provide good control of grassy weeds but due to continuous use of such herbicides, a shift in weed flora and evolution of herbicide resistant weeds has been observed. Crop selective, new generation low dose micro-herbicides like sulfonylureas (bensulfuron-methyl, metsulfuron-methyl, chlorimuron-ethyl, pyrazosulfuron-ethyl, bispyribac-sodium *etc.*) are gaining popularity among farmers for their promising role in weed control. Penoxsulam (acetolactate synthase (ALS) inhibitor) is also a new promising herbicide for effective control of annual grasses, sedges and broad-leaf weeds whereas pyrazosulfuron-ethyl was found effective for complex weed flora in rice (Maiti *et al.* 2003). The present study was planned to evaluate the performance of low dose herbicides as influenced by rice establishment methods.

MATERIALS AND METHODS

The field experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Faculty of Agriculture, Wadura, Jammu and Kashmir during *Kharif* (rainy) seasons 2017 and 2018. The experimental site falls in mid altitude temperate zone with an average annual precipitation of 812 mm. The total rainfall received during the experimentation period (May to September) was 339.4 and 352.5 mm during *Kharif* 2017 and 2018, respectively. The soil of experimental field was silty clay loam in texture, neutral in reaction (pH 6.9), medium in available N, P and K with medium organic carbon content. The treatments consisted of three crop establishment methods, *viz*. transplanting, direct seeding and SRI in main plots and seven weed management practices, *viz*. butachlor (1500 g/ha), penoxsulam (22.5 g/ha), pyrazosulfuron-ethyl + pretilachlor (15 and 600 g/ha), bensulfuron-methyl + pretilachlor (60 and 600 g/ha), twice conoweeding/hand weeding, weed free and weedy check in sub plots. The treatments were replicated thrice in a split plot design. For SRI method, 12-day old seedlings of variety '*Shalimar Rice 4*' were transplanted in last week of May at a spacing of 25 x 25 cm. For direct-seeded rice (DSR), pre-germinated seeds were sown in rows 20 cm apart in well prepared plots on 17th May while for transplanting, nursery sowing was done with same pre-germinated seeds on the same date and then 25 day old seedlings were transplanted at a spacing of 20 x 10 cm. Well decomposed farm yard manure 10 t/ha was incorporated in treatment plots uniformly during land preparation. The entire quantity of phosphorus (60 kg/ha) and potassium (30 kg/ha) and half of nitrogen (60 kg/ha) was applied as basal at the time of transplanting while remaining N was applied in two equal splits at active tillering (30 kg/ha) and panicle initiation stage (30 kg/ha). Under SRI method all the principles were followed. Water management in both SRI and DSR was done in such a way that there was no continuously standing water during the vegetative growth phase while thin film of water was maintained during flowering to soft dough stage. Under transplanting method, plots were flooded with water. Herbicides in liquid formulation were applied with knapsack sprayer fitted with flat-fan nozzle using 300 liters of water per ha whereas the granular herbicides were mixed with sand and applied uniformly across the plot. Weed density (no. of weeds/m^2) was recorded at 45 days after transplanting (DAT) using a quadrate 0.25 m^2 (0.5 x 0.5 m). The weeds falling in the quadrate randomly at two points from each plot in all replications were identified and grouped. The samples collected for the weed density were sun dried first and then dried in oven to determine the dry weight of weeds. Weed control efficiency (WCE) of different treatments was determined by using the following formula:

$$\text{WCE } (\%) = \frac{Wc - Wt}{Wc} \times 100$$

Where, Wc = weed dry weightin weedy (control) plot and

Wt = weed dry weight in herbicide treated plot.

Weed index (WI) of different treatments was determined using the following formula:

$$\text{WI} = \frac{\text{YWF - YT}}{YWF} \times 100$$

Where, YWF = crop yield in weed free plot and

YT= crop yield in treated plot

RESULTS AND DISCUSSION

Effect on weeds

The prominent grassy weeds were *Echinochloa crusgalli, Echinochloa colona* and *Cynodon dactylon*. Broad-leaved weeds were *Ammania baccifera, Marsilea qudrofolia, Monochoria vaginalis* and *Potamogeton distinctus* while the prominent sedges included *Cyperus iria, Cyperus defformis* and *Fimbristylis.*

Significantly lower density was recorded with transplanted method at 30, 45 and 60 DAT/DAS and at harvest over SRI and DSR (**Table 1**). The superiority exhibited by transplanted rice in reducing weed densities over SRI and direct-seeded rice at 60 DAT/DAS were 11.03 and 41.09% during 2017 and the corresponding figures were 11.87 and 42.74%, respectively during 2018. Weed dry matter was significantly reduced under transplanted rice over SRI and DSR, SRI in turn was significantly superior to direct-seeded rice at all growth stages of crop. Superiority exhibited by transplanted rice in reducing the weed dry matter over SRI and DSR at 60 DAT/DAS was 8.55 and 42.11% during 2017 and 8.96 and 43.34% during 2018, respectively (**Table 2**). Continuous submergence of the transplanted crop effectively suppressed the weed population and weed seed germination under transplanted rice. The results was in agreement with the findings of Subramanian *et al*. (2007). SRI recorded significantly a lower weed index of 3.55 during both the years while as transplanted and DSR recorded a weed index of 3.67 and 3.63 and 3.92 and 3.89 during 2017 and 2018, respectively (**Table 3**). Continuous submergence of the transplanted crop effectively suppressed the weed population and weed seed germination under transplanted rice. The results were in agreement with the findings of Subramanian *et al*. (2007); Bhat *et al*. (2011) and Saha and Bharti (2010).

Effective weed control was observed with the application of penoxsulam 22.5 g/ha during both the years. The superiority exhibited by penoxsulam 22.5 g/ha at 60 DAT/DAS over weedy check and butachlor (1500 g/ha) was 54.31 and 32.68% during 2017, and 56.0 and 34.48% for 2018, respectively (**Table 1**). Application of penoxsulam 22.5 g/ha significantly reduced the weed dry matter over weedy check at 30, 45, 60 DAT/DAS and at harvest. Reduction in weed dry matter at 60 DAT/DAS by penoxsulam 22.5 g/ha over weedy check and butachlor 1500 g/ha was 50.22 and 24.32 during 2017 and the corresponding figures for 2018 were 51.44 and 25.44, respectively (**Table 2**). This might be due to the fact that herbicides not only exhibited significantly lesser toxicity to rice seedling but controlled the weeds very efficiently. This has established that penoxsulam is an effective post-emergence herbicide against a wider weed flora and selectivity to rice crop as well. Penoxsulam is a member of the triazolopyrimidine sulphonamide chemical family with ALS (acetolactate synthase) inhibition as its mode of action. It has a

Table 1. Effect of different crop establishment methods and weed management practices on weed density (no./m^2)

Treatment	30 DAT/DAS		45 DAT/DAS		60 DAT/DAS		Harvest	
	2017	2018	2017	2018	2017	2018	2017	2018
Crop establishment method								
Transplanting	2.78(9.1)	2.56(8.1)	3.33(13.4)	3.18(12.5)	3.87(17.6)	3.71(16.4)	3.12(11.9)	2.90(10.7)
Direct-seeding	5.01(28.5)	4.91(27.4)	5.6(36.5)	5.52(35.5)	6.57(50.0)	6.48(48.8)	6.02(41.9)	5.93(40.7)
System of rice intensification (SRI)	2.99(11.0)	2.79(9.9)	3.68(16.5)	3.54(15.6)	4.35(22.5)	4.21(21.3)	3.73(16.8)	3.56(15.6)
LSD(p=0.05)	0.03	0.04	0.03	0.03	0.04	0.06	0.09	0.08
Weed management practice								
Butachlor (1500 g/ha)	5.16(26.9)	5.04(25.7)	5.67(33.1)	5.54(31.7)	6.21(39.3)	6.09(37.9)	5.56(31.1)	5.45(30.0)
Penoxsulam (22.5 g/ha)	2.80(8.0)	2.53(7.2)	3.47(13.0)	3.22(11.6)	4.18(18.4)	3.99(17.0)	3.35(11.8)	3.16(10.7)
Pyrazosulfuron-ethyl + pretilachlor (15 and 600 g/ha)	2.89(8.9)	2.63(7.7)	3.71(15.1)	3.48(13.7)	4.52(21.3)	4.35(19.9)	3.58(13.2)	3.41(12.1)
Bensulfuron-methyl + pretilachlor (60 and 600 g/ha)	3.04(9.8)	2.80(8.6)	3.83(16.0)	3.61(14.6)	4.62(22.2)	4.45(20.8)	3.7(14.0)	3.54(12.9)
Twice cono weeding/ hand weeding (15 and 30 DAS/DAT)	3.35(11.7)	3.14(10.5)	4.08(17.9)	3.88(16.5)	4.82(24.2)	4.66(22.8)	3.95(16.0)	3.80(14.9)
Weed free	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)
Weedy check	6.89(47.8)	6.81(46.6)	8.26(69.4)	8.17(68.0)	9.15(85.0)	9.07(83.6)	8.27(68.9)	8.20(67.8)
LSD(p=0.05)	0.09	0.08	0.08	0.09	0.10	0.15	0.18	0.20

DAS/DAT: days after transplanting sowing; Figures in parentheses are original values; Data subjected to $(\sqrt{x+1})$ transformation

Table 2. Effect of different crop establishment methods and weed management practices on dry weed biomass (g/m^2)

Treatment	30 DAT/DAS		45 DAT/DAS		60 DAT/DAS		Harvest	
	2017	2018	2017	2018	2017	2018	2017	2018
Crop establishment method								
Transplanting	3.76(17.7)	3.57(16.4)	4.44(23.2)	4.28(21.9)	4.92(28.0)	4.77(26.5)	4.33(21.8)	4.12(20.0)
Direct-seeding	6.33(51.2)	6.23(49.9)	7.43(67.0)	7.35(65.6)	8.5(85.5)	8.42(84.0)	7.61(69.4)	7.50(67.6)
System of rice intensification (SRI)	4.34(23.4)	4.19(22.1)	4.94(29.0)	4.80(27.6)	5.38(33.8)	5.24(32.3)	4.77(26.8)	4.58(25.0)
LSD(p=0.05)	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.04
Weed management practice								
Butachlor (1500 g/ha)	5.87(35.3)	5.73(33.8)	6.65(45.8)	6.53(44.2)	7.36(56.8)	7.23(55.0)	6.69(46.7)	6.52(44.6)
Penoxsulam (22.5 g/ha)	3.38(11.6)	3.12(10.1)	4.61(22.1)	4.42(20.5)	5.57(33.0)	5.39(31.2)	4.82(24.5)	4.57(22.4)
Pyrazosulfuron-ethyl + pretilachlor (15 and 600 g/ha)	3.81(14.7)	3.59(13.2)	4.94(25.2)	4.76(23.6)	5.85(36.2)	5.68(34.4)	5.04(26.8)	4.81(24.7)
Bensulfuron-methyl + pretilachlor (60 and 600 g/ha)	4.33(18.8)	4.14(17.3)	5.35(29.3)	5.19(27.7)	6.20(40.2)	6.04(38.4)	5.24(28.7)	5.02(26.6)
Twice cono weeding/ hand weeding (15 and 30 DAS/DAT)	5.03(25.2)	4.87(23.7)	5.93(35.7)	5.79(34.1)	6.72(46.6)	6.57(44.8)	5.75(34.2)	5.56(32.1)
Weed free	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)
Weedy check	10.27(110)	10.19(108)	10.74(120)	10.66(118)	11.19(131)	11.10(129)	10.45(114)	10.34(112)
LSD(p=0.05)	0.11	0.11	0.098	0.10	0.09	0.09	0.10	0.10

DAS/DAT: days after transplanting sowing; Figures in parentheses are original values; Data subjected to $(\sqrt{x+1})$ transformation favourable toxicological and environmental profile. The results were in conformity with Bhat *et al.* (2011). At harvest penoxsulam 22.5 g/ha recorded weed control efficiency of 80.15 during 2017 and 82.01% during 2018 (**Table 3**). Reduction in weed biomass due to effective weed control measures resulted in higher weed control efficiency.

Among the weed management practices, penoxsulam 22.5 g/ha recorded minimum weed index of 2.09 and 2.08 during 2017 and 2018, respectively which was significantly superior to all other weed control treatments (**Table 3**). The data further revealed that the losses in grain yield of rice due to weeds were 49.94 and 42.22%. This might be due to lower weed densities that resulted in increased uptake of nutrients and thus increased grain yield (Bhat *et al.* 2011).

Effect on yield

Grain and straw yields of rice differed significantly due to various treatments during both the years of experimentation. SRI recorded significantly higher grain yield (7.92 and 8.17 t/ha), followed by normal transplanting (7.09 and 7.17 t/ha) whereas the lowest grain yield of 6.01 and 6.24 t/ha was observed in DSR (**Table 3**). The crop established by SRI method provided a yield advantage of 24.11 and10.47% during 2017 and 23.62 and 12.23% during 2018, over DSR and transplanting. SRI also recorded significantly higher straw yield than direct-seeded rice and transplanting. The higher grain and straw yield realized with SRI was probably due to transplanting of seedlings at younger age which preserves a potential for more tillering and rooting. Further, wider spacing in square pattern (25 x 25 cm) provided more room for both canopy and root growth and for subsequent grain filling. The increase in the grain yield under SRI method was attributed to larger root volume, profuse and strong tillers with longer panicles, more and well filled spikelets with higher grain weight. Comparable yields in rice through different systems of crop establishment with that of transplanting has been reported by Mahajan *et al.* (2012).

Among the weed control treatments, penoxsulam 22.5 g/ha provided significantly higher grain (8.19 and 8.28 t/ha) and straw (10.13 and 10.44 t/ha) yield over weedy check and other weed control treatments (**Table 3**). Penoxsulam 22.5 g/ha realized 26.25 and 22.34%, 7.32 and 6.15%, 11.23 and 10.02%, 13.79 and 13.76 % and 49.93 and 46.98% more grain yield as compared to butachlor (1500 g/ha), pyrazosulfuron-ethyl + pretilachlor (15 and 600 g/ha) bensulfuron-methyl + pretilachlor (60 and 600 g/ha), twice conoweeding/hand weeding and weedy check during 2017 and 2018, respectively. This could be possibly due to reduction in weed growth with the herbicide application which allowed the crop to get adequate nutrient supply resulting in higher leaf-area index and thus more production and assimilation of photosynthates contributing to higher grain and straw yield (Shan *et al.* 2012).

Among the different crop establishment methods and weed management practices, weed density and weed dry matter showed significantly negative correlation with grain yield. The regression value for grain yield with weed density (0.856 and 0.859) and weed dry matter (0.758 and 0.761), was significant during 2017 and 2018, respectively. The variations in weed density and weed dry matter could be explained to the extent of 85.6 (**Figure 1**) and 85.9% (**Figure 2**) and 75.8 (**Figure 3**) and 76.1% (**Figure 4**) during 2017 and 2018, respectively.

Table 3. Effect of different crop establishment methods and weed management practices on yield (t/ha) of rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Biological yield (t/ha)		Weed control efficiency (%)		Weed index (%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Crop establishment method										
Transplanting	7.09	7.17	8.88	9.21	15.97	16.38	67.02	68.42	16.50	16.15
Direct-seeding	6.01	6.24	8.00	8.32	14.01	14.56	64.29	64.83	18.40	18.09
System of rice intensification (SRI)	7.92	8.17	9.60	10.17	17.52	18.34	67.77	69.47	14.89	14.82
LSD(p=0.05)	0.75	0.84	0.79	0.87	1.02	1.06	0.06	0.08	0.12	0.15
Weed management practice										
Butachlor (1500 g/ha)	6.04	6.43	8.23	8.67	14.27	15.10	59.84	61.21	29.64	29.19
Penoxsulam (22.5 g/ha)	8.19	8.28	10.13	10.44	18.32	18.71	80.15	82.01	3.55	3.51
Pyrazosulfuron-ethyl + pretilachlor (15 and 600 g/ha)	7.59	7.77	9.31	9.51	16.90	17.29	78.10	79.95	7.20	7.10
Bensulfuron-methyl + pretilachlor (60 and 600 g/ha)	7.27	7.45	9.03	9.37	16.30	16.83	76.02	77.81	11.10	10.93
Twice cono weeding/ hand weeding (15 and 30 DAS/DAT)	7.06	7.14	8.72	8.96	15.78	16.11	70.42	72.04	14.73	14.53
Weed free	9.00	9.29	10.75	11.19	19.74	20.47	100	100	0.00	0.00
Weedy check	4.10	4.39	6.06	6.50	10.15	10.88	0.00	0.00	49.94	42.22
LSD(p=0.05)	0.72	0.84	0.69	0.61	0.78	0.70	0.15	0.21	0.30	0.29

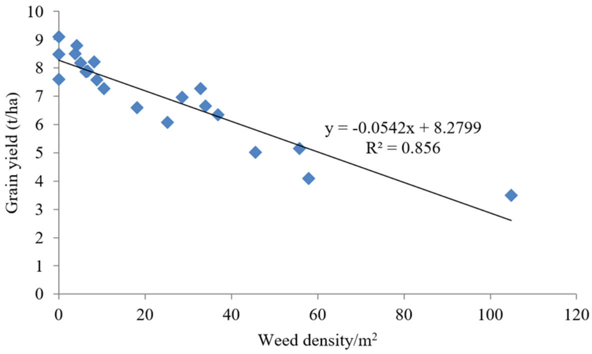

Figure 1. Linear regression line between weed density and grain yield among different crop establishment methods and weed management practices (2017)

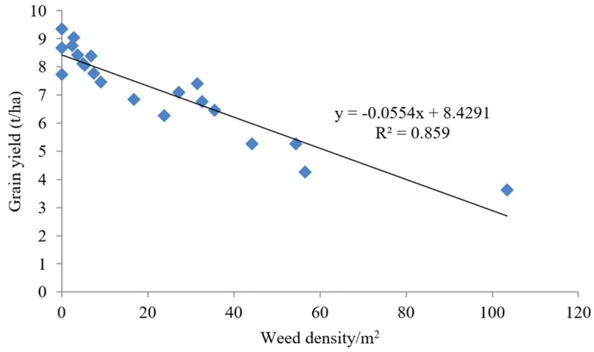

Figure 2. Linear regression line between weed density and grain yield among different crop establishment methods and weed management practices (2018)

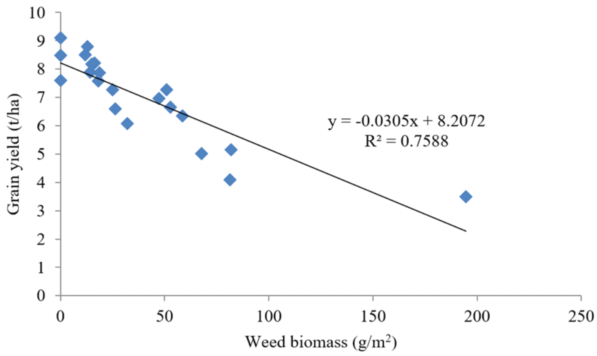

Figure 3. Linear regression line between weed biomass and grain yield among different crop establishment methods and weed management practices (2017)

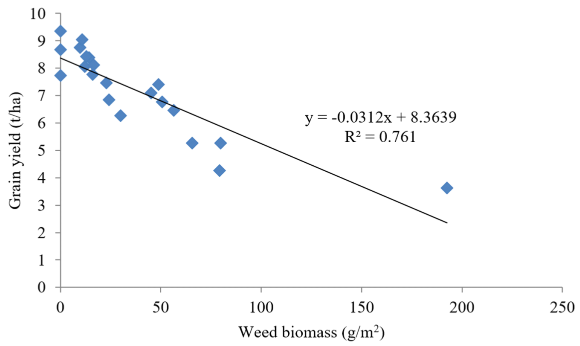

Figure 4. Linear regression line between weed biomass and grain yield among different crop establishment methods and weed management practices (2018)

Conclusion

SRI proved to be better method of crop establishment than transplanting and direct seeding whereas among the different herbicide treatments, penoxsulam was found superior in terms of grain yield and provided effective control of complex weed flora. Therefore, it was concluded that for enhancing the rice yield and for managing the weeds effectively, SRI with application of penoxsulam 22.5 g/ha was found effective to boost productivity of rice in Kashmir valley.

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