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Integrated weed management on growth and yield of transplanted *Kharif* rice and its residual effect on succeeding Lathyrus

Amalesh Ghosh, Mahua Banerjee, GC Malik, Duvvada Sarath Kumar and Monotosh Das Bairagya

Abstract
Rice (*Oryza sativa* L.) is a most important cereal crop grown in tropical and subtropical regions of the world and staple food for more than half of the world population. Generally, the yield reduction of rice due to weed growth may vary from 28-45% in transplanted rice. Hence, the field investigations were carried out at the agricultural farm of PSB (Institute of Agriculture) at Visva-Bharati, Sriniketan during wet seasons of 2014-15 and 2015-16 to study the integrated weed management in *kharif* rice (*Oryza sativa* L.) and its residual effect on succeeding Lathyrus (Lathyrus *sativus*). Experiments were tested in randomized block design replicated thrice. The experiment comprising of eleven treatments *viz*., T_1 - Mechanical weeding (25 DAT), T_2 - Bispyribac sodium 25g a.i ha^{-1} (25 DAT), T_3 - Cyhalofop butyl 70 g a.i ha^{-1} (25 DAT), T_4 - Pretilachlor 1.0 kg a.i ha^{-1} (3 DAT), T_5 - Pretilachlor 1.0 kg a.i ha^{-1} (3DAT) *fb* 1 Hand weeding (25 DAT), T_6 - Pretilachlor 1.0 kg a.i ha^{-1} (3DAT) *fb* 1 Mechanical weeding (25 DAT), T_7 - Metsulfuron methyl *fb* Chlorimuron ethyl 4 g a.i ha^{-1} (3DAT), T_8 - Metsulfuron methyl *fb* Chlorimuron ethyl 4 g a.i ha^{-1} (3 DAT) *fb* 1 Hand weeding (25 DAT), T_9 - Metsulfuron methyl *fb* Chlorimuron ethyl 4 g a.i ha^{-1} (3 DAT) *fb* 1 Mechanical weeding (25 DAT), T_{10} - Weed free check and T_{11}- Weedy check. The highest grain yield was recorded under two hand weedings during both years as a result of reduced weed dry weight and increased growth attributes. This was at par with application of Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3 DAT) *fb* 1 Hand weeding (25 DAT). The results indicated that herbicides applied in rice did not show their residual effects on succeeding Lathyrus. Even though the results of two hand weedings were better, it cannot be recommended at larger scale as it is costly, time consuming and laborious. Hence, pre emergence application of Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3 DAT) *fb* 1 Hand weeding (25 DAT) can be recommended for better weed control and productivity in transplanted *kharif* rice.

Keywords: Rice, herbicides, hand weeding, weed dry weight, weed control efficiency, succeeding Lathyrus

Introduction
Rice (*Oryza sativa*) is a major food grain crop of the world as well as India and more than half of the population subsists on it. Globally, the largest area under rice cultivation is in India (43.8 M ha) and the country produces 112.9 million t of rice with an average productivity of 2.78 t ha^{-1} (Agriculture Statistics at a Glance, 2018) [1]. India needs to produce 120 million tons by 2030 to feed its one and a half billion plus population by then. A real-time analysis of this scenario provides sufficient justification for strengthening, intensifying and introducing cutting edge science and technology for increasing rice productivity in India.

Weeds are often called plants out of place. They are unwanted, prolific, competitive, and often harmful to the environment and they occur in every rice field of the world. The average yield of rice in India is very low due to several constraints. Among them, weeds pose a major threat for increasing rice productivity. Uncontrolled weed growth caused 33-45% reduction in grain yield of rice (Manhas *et al*., 2012; Singh *et al*., 2007) [5, 11]. Weed management is one of the important aspect to increase the productivity per unit area. At present, no single practice i.e., either uses of herbicides or manual/mechanical weeding is convenient and effective in eliminating the weed management. So, there is a necessity that these herbicides are supplemented with Hand Weeding or Mechanical Weeding (HW)/ (MW) for broad spectrum weed control with respect to all kind of weeds in rice (Singh *et al*., 2004).

Lathyrus (*Lathyrus sativus* L.) is known as grasspea or chickling pea in English and the common Indian names besides *khesari* are teora, lakh and lakhodi.

It is a minor winter pulse usually considered as a poor man's pulse crop and is grown chiefly depending on the residual soil moisture in rice fields as a catch crop. The cultivation of this crop in India has been discouraged some years back for its neurotoxin (BOAA or ODAP) that causes a serious neuro-disease. Some varieties with lower toxic content have recently been developed and are now being grown in various states and locations. Lathyrus *sativus* have potential as multi-purpose crops in low to medium rainfall dryland farming systems. They are tolerant to a wide range of herbicides, tolerate some waterlogging, have no serious diseases, have high seed protein levels (25-30%). Not much works have been done to study the effect of IWM in rice and its residual effect on Lathyrus

Materials and Methods

Experimental site and soil status: The experiment was conducted at Agricultural farm, Sriniketan, Visva-Bharati, Birbhum, West Bengal during the year 2014-15 & 2015-16. The soil was sandy loam having pH 5.71, organic carbon 0.47%, available nitrogen, phosphorus and potassium are 138.53 kg ha^{-1}, 30.56 kg ha^{-1} and 145.41 kg ha^{-1} respectively.

Experimental design with treatment details: The experiment was conducted in Randomized Block Design with 11 treatments and replicated thrice. The treatments include T_1 - Mechanical weeding (25 DAT), T_2 - Bispyribac sodium 25g a.i ha^{-1} (25 DAT), T_3 - Cyhalofop butyl 70 g a.i ha^{-1} (25 DAT), T_4 - Pretilachlor 1.0 kg a.i (3DAT), T_5 - Pretilachlor 1.0 kg a.i ha^{-1} (3DAT) *fb* 1 Hand weeding (25 DAT), T_6 - Pretilachlor 1.0 kg a.i ha^{-11} (3DAT) *fb* 1 Mechanical weeding (25 DAT), T_7 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3DAT), T_8 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3DAT) *fb* 1 Hand weeding (25DAT), T_9 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3DAT) *fb* 1 Mechanical weeding (25 DAT), T_{10} - Weed free check and T_{11}- Weedy check. One third of recommended dose of Nitrogen @80 kg ha^{-1}through urea along with full amount of Phosphorus@ 40 kg ha-^{1} through Single Super Phosphate and full dose of Potassium @ 40 kg ha^{-1} through Muriate of Potash were applied as basal during final land preparation and remaining Nitrogen was top dressed in two equal splits, half at active tillering and another half at panicle initiation stage of the crop. Herbicides were applied with Knapsack sprayer as pre-emergence at 3 DAT for Pretilachlor1.0 kg a.i ha^{-1} and Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} and as post-emergence at 25 DAT for Bispyribac sodium 25g a.i ha-^{1} and Cyhalofop butyl 70 g a.i ha^{-1} using water @ 500L ha^{-1}. Excluding weed management practices, all the recommended improved packages of practices including plant protection measures were followed in the experiment to raise the crop.

Cultivar selection, biometric observations and calculations The long duration (145 days) and high yielding variety of rice MTU-7029 (Swarna) was used in the experiment. Twenty one days old seedlings of rice were transplanted in both the years respectively with two to three seedlings per hill with a spacing of 20 cm x 15 cm. The data on weed dry matter, Weed Index (%), WCE (%), and Plant height at 60 DAT and yield were recorded at harvest and leaf area index was calculated during 60 DAT. Leaf area index (LAI) was deliberated by dividing leaf area with ground area (Watson, 1947) [14].

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

Where
WCE = Weed control efficiency
WDC = Weed dry matter in control plot.
WDT = Weed dry matter in treated plot.

$$WI = \frac{Y_{WFC} - Y_T}{Y_{WFC}}$$

Where
WI = Weed index
Y_{WFC} = Average yield of the crop in weed free check
Y_T = Average yield of the crop in plot under treatment

Succeeding crop of Lathyrus: The succeeding crop variety of Lathyrus named Prateek (LS-157-14), is best suited for moisture stress conditions and requires fewer inputs, except quality seed, and can be successfully grown under paira (relay) cropping in rice fallow situation. Prateek have low p-N oxalyl- L-p-diaminopropionic acid (P-ODAP) content. The ODAP content of this variety is 0.07 to 0.10 per cent, which is safe for human consumption. Generally, optimum sowing time is 15 days before the harvest of rice crop. A seed rate of 60 kg ha^{-1} was adopted. In residual crop of Lathyrus, germination percent on 10 Days after sowing (DAS) and plant height on 30 DAS were measured.

Statistical analysis: The data recorded were analysed statistically in RED as per the method suggested by Gomez and Gomez (1984) [4]. The data on weed dry weight were subjected to square root transformation (vx+0.5) prior to statistical analysis to normalize their distribution. Wherever the treatment means were significant, critical differences were calculated at 5% probability level for comparisons of mean values. Non-significant differences among treatment means were denoted as NS.

Results and Discussion

Weed flora: The experimental field was infested dominantly with three categories of weeds. *Eclipta alba, Ludwigia parviflora, Marsilea quadrifolia, Alternanthera philoxeroids* among broadleaved weeds, *Cynodon dactylon, Echinochloa colona, Echinochloa crus-galli, Dactyloctenium aegyptium* among the grasses and *Cyperus iria, Cyperus difformis* and *Fimbristylis miliacea* among the sedges.

Weed dry weight and weed control efficiency: Weed control treatments significantly reduced dry weight of weeds during both the years of study (Table 1). Significantly lowest weed dry matter was noticed in weed free check plot (0.71 g m^{-2}, 0.71 g m^{-2}) which was followed by PE application of Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (2.38 g m^{-2}, 2.32 g m^{-2}) supplemented with HW on 25 DAT and highest weed dry matter was recorded in weed check plot (15.11 g m^{-2}, 15.78 g m^{-2}) during both the years. It indicates that if weeds were not controlled, their dry weight was continuously increased and crop growth was adversely affected. The reduced dry weight of weeds may be attributed to broad spectrum weed control by the application of pre-emergence herbicides *fb* one HW as observed in the plots in

which weed free check was given. These results are in conformity with findings of Singh *et al.* (2012) [9] who reported that dry weight of weeds were greatly reduced under weed free check in transplanted rice. During both the years, weed control efficiency (WCE) was recorded higher in weed free check (100%, 100%) and followed by PE application of Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} (3 DAT) + 1 hand weeding at 25 DAT (97.72%, 98.03%), Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding at 25 DAT (97.69%, 97.876%) and lower WCE was noticed in weedy check (Fig. 1). Similar findings of higher weed control efficiency with weed free check was also reported by Yadav *et al.* (2009) [15]. Weed index was noticed higher in weedy check (54.90%, 55.42%) followed by mechanical weeding at 25 DAT (26.04%, 27.27%) and lower in weed free check.

Table 1: Effect of integrated weed management practices on weed dry weight, weed control efficiency (WCE) and weed index at harvest in transplanted *kharif* rice

Treatments	2014-15			2015-16		
	Weed dry weight (g m^{-2})	WCE (%)	Weed Index (%)	Weed dry weight (g m^{-2})	WCE (%)	Weed Index (%)
T_1 - Mechanical weeding (25 DAT)	5.83 (33.46)	85.31	26.04	5.98 (35.23)	85.82	27.27
T_2 - Bispyribac sodium 25g a.i/ha (25 DAT).	4.22 (17.29)	92.41	13.40	4.05 (15.90)	93.60	15.22
T_3 - Cyhalofop butyl 70 g a.i/ha (25 DAT).	4.48 (19.61)	91.39	20.05	4.37 (18.56)	92.53	26.40
T_4 - Pretilachlor 1.0 kg a.i/ha (3DAT)	3.84 (14.26)	93.74	14.53	3.93 (14.97)	93.98	13.72
T_5 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding (25 DAT)	2.40 (5.27)	97.69	1.72	2.40 (5.29)	97.87	2.47
T_6 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	3.37 (10.83)	95.24	11.57	3.95 (15.08)	93.94	12.74
T_7 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT)	3.94 (15.05)	93.39	12.70	3.77 (13.74)	94.48	14.26
T_8 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Hand weeding (25DAT)	2.38 (5.19)	97.72	1.02	2.32 (4.90)	98.03	1.50
T_9 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	2.78 (7.26)	96.81	11.35	2.62 (6.39)	97.43	10.86
T_{10} - Weed free check	0.71 (0.00)	100.00	0.00	0.71 (0.00)	100.00	0.00
T_{11}- Weedy check.	15.11 (227.75)	0.00	54.90	15.78 (248.61)	0.00	55.42
S.Ed	0.11	-	-	0.12	-	-
C.D (P=0.05)	0.22	N.A	N.A	0.25	N.A	N.A

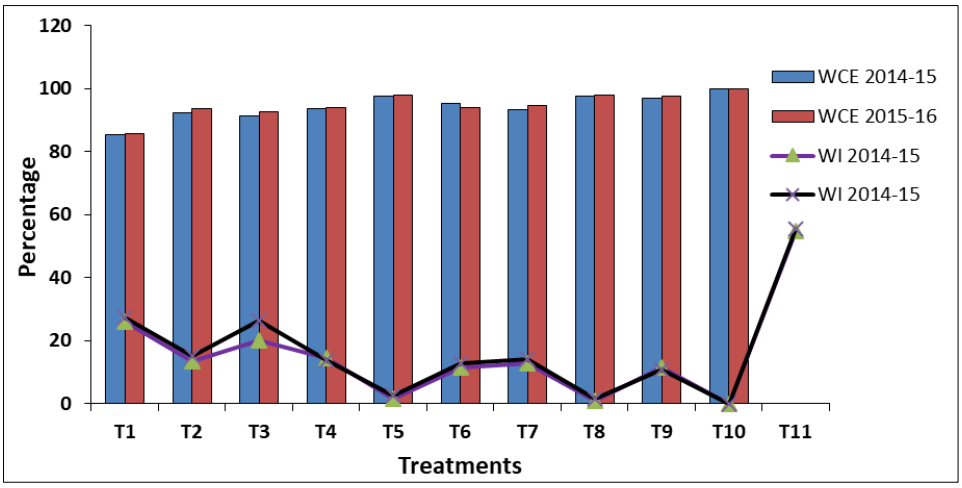

Fig 1: Effect of different treatments on WCE and WI during both years

Growth and yield of rice: Growth attributes and yield of transplanted rice were significantly influenced by weed control treatments during both the years (Table 2 and Fig.2 to 4). Significantly higher plant height was recorded in Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding at 25 DAT which was par with all the treatments except mechanical weeding at 25 DAT, application of Bispyribac sodium 25 g/ha at 25 DAT and lowest in weedy check plot during 2014-15. During 2015-16, maximum plant height was recorded in Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding at 25 DAT which was at par with all the treatments except mechanical weeding at 25 DAT, application of Bispyribac sodium 25 g/ha at 25 DAT, Cyhalofop butyl 70 g a.i/ha at 25 DAT and minimum in weedy check plot. In the year 2014-15, higher leaf area index was recorded in weed free check plot which was statistically at par with Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT), Pretilachlor 1.0 kg a.i/ha (3DAT) and lower leaf area was recorded in weedy check. Maximum leaf area during 2015-16 was recorded in weed free check plot which was on par with all the treatments except mechanical weeding at 25 DAT, Bispyribac sodium 25 g/ha at 25 DAT, Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 hand weeding (25 DAT) and weedy check plot. Increase in plant height and leaf area index might be due to better environment with increased uptake of both macro and micro nutrients by rice due to reduced crop weed competition. With respect to grain yield, during both the years, significantly higher grain yield was recorded in weed free check plot which was at par with Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Hand weeding (25DAT), Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 hand weeding (25 DAT) and minimum was noticed in weed check plot. Higher grain yield under these

treatments might be due to increased panicles/m^2 and grains/panicle. Superiority of weed free check might be ascribed to absence of weed competition due to complete removal of weeds from field and hence better crop growth. The results of weed free check is appreciably better in terms of weed control and rice grain yield, but as it is uneconomic, time consuming and laborious, it cannot be recommended at large scale. Similar findings were also obtained by Prasad *et al.*, 2001 [8], Kiran and Subrascanscan Veeraputhiran and Balasubramanian (2010) [13] and Nalini *et al.* (2012) [6]. Weeds in weedy check caused 54.90% and 55.41% reduction in grain yield during both years.

Table 2: Effect of integrated weed management practices on growth and grain yield in transplanted *kharif* rice

Treatments	2014-15			2015-16		
	Plant height (cm) at harvest	LAI at 80 DAT	Grain yield (Kg ha^{-1})	Plant height (cm) at harvest	LAI at 80 DAT	Grain yield (Kg ha^{-1})
T_1 - Mechanical weeding (25 DAT)	77.13	4.46	4577	78.70	4.39	4510
T_2 - Bispyribac sodium 25g a.i/ha (25 DAT).	75.37	4.49	5363	79.73	4.55	5253
T_3 - Cyhalofop butyl 70 g a.i/ha (25 DAT).	83.50	4.56	5283	80.80	4.63	5210
T_4 - Pretilachlor 1.0 kg a.i/ha (3DAT)	85.67	4.67	5293	86.53	4.61	5347
T_5 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding (25 DAT)	91.90	4.46	6097	92.33	4.49	6080
T_6 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	88.53	4.67	5477	86.83	4.60	5407
T_7 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT)	88.03	4.56	5407	87.23	4.56	5313
T_8 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Hand weeding (25DAT)	90.83	4.56	6130	91.83	4.59	6103
T_9 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	88.73	4.55	5490	90.18	4.58	5523
T_{10} - Weed free check	88.52	4.86	6193	90.37	4.86	6197
T_{11}- Weedy check.	72.87	4.33	2793	77.87	4.23	2763
S.Ed	5.24	0.09	309	4.91	0.10	327
C.D (P=0.05)	10.84	0.25	638	10.14	0.30	676

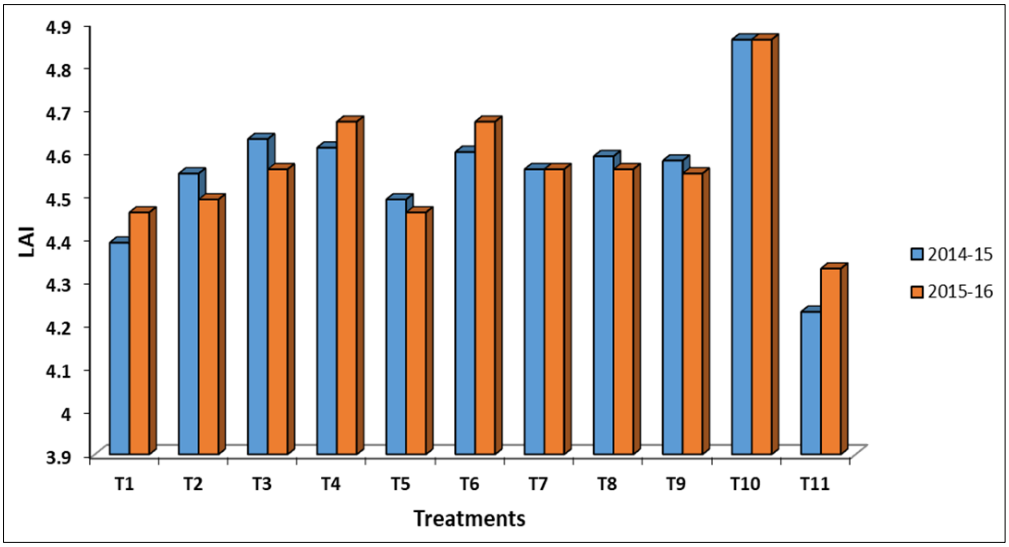

Fig 2: Effect of different treatments on LAI during both the years

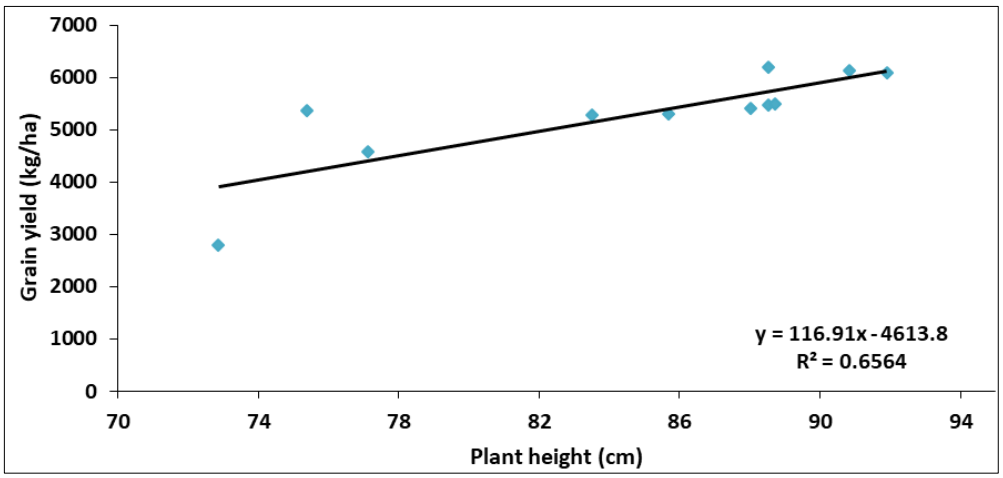

Fig 3: Coefficient of determination (R^2) between plant height and grain yield during 2014-15

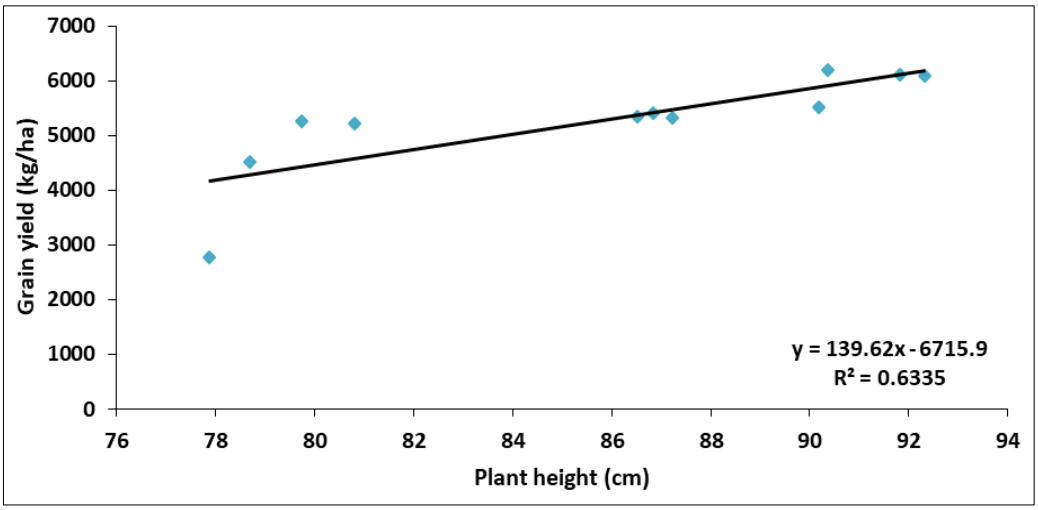

Fig 4: Coefficient of determination (R^2) between plant height and grain yield during 2015-16

Succeeding Lathyrus

No significant variation among the treatments was found with respect to germination percentage of Lathyrus on 10 DAS and significant difference was noticed with plant height on 30 DAS (Table 3). Among the different treatments, the higher germination was observed in weed free check which was followed by Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Hand weeding (25DAT), Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding (25 DAT) and lower germination in weed check plot during both the years. During both the years, higher plant height was recorded in weed free check plot which was at par with all the treatments except mechanical weeding at 25 DAT, application of Bispyribac sodium 25 g/ha at 25 DAT, Cyhalofop butyl 70 g a.i/ha at 25 DAT lower plant height in weed check plot.

Table 3: Residual effect of integrated weed management practices on succeeding Lathyrus

Treatments	2014-15		2015-16	
	Germination (%) at 10 DAS	Plant height (cm) at 30 DAS	Germination (%) at 10 DAS	Plant height (cm) at 30 DAS
T_1 - Mechanical weeding (25 DAT)	78.57	23.47	79.13	21.56
T_2 - Bispyribac sodium 25g a.i/ha (25 DAT).	80.33	24.17	80.05	24.05
T_3 - Cyhalofop butyl 70 g a.i/ha (25 DAT).	79.33	23.83	79.43	23.68
T_4 - Pretilachlor 1.0 kg a.i/ha (3DAT)	80.43	25.70	81.22	25.97
T_5 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Hand weeding (25 DAT)	86.60	27.43	84.60	27.10
T_6 - Pretilachlor 1.0 kg a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	85.47	25.92	82.37	26.60
T_7 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT)	83.43	26.03	80.57	26.71
T_8 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Hand weeding (25DAT)	87.63	27.73	85.47	27.37
T_9 - Metsulfuron methyl + Chlorimuron ethyl 4 g a.i/ha (3DAT) + 1 Mechanical weeding (25 DAT)	85.83	27.23	83.40	27.05
T_{10} - Weed free check	87.89	28.05	86.10	28.63
T_{11}- Weedy check.	74.68	18.61	72.67	19.50
S.Ed	4.28	1.29	4.10	1.44
C.D (P=0.05)	N.S	2.67	N.S	2.98

Conclusion

Application of methyl + Chlorimuron ethyl 4 g a.i ha^{-1} supplemented with HW at 25 DAT produced higher grain yield and this was on par with weed free check. Sequential application of herbicides *viz*., Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} or pretilachlor 1.0 kg a.i ha^{-1} at 3 DAT were also found promising and it can also be recommended for weed control in transplanted rice wherever the problem of paucity of labour for hand weeding prevails. Hence, application of PE application of Metsulfuron methyl + Chlorimuron ethyl 4 g a.i ha^{-1} supplemented with HW at 25 DAT can be recommended for better weed control, growth and yield of transplanted rice.

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