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Chemical Weed Management in SRI and Transplanted Rice under Temperate Condition

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ABSTRACT

Field experiment was conducted at Research Form of Faculty of Agriculture, SKUAST-Kashmir, Wadura, in a two factor randomized block design with three replications during *kharif* 2017 and 2018, to evaluate weed management in rice under SRI and normal Transplanting conditions. Application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai / ha as post emergence fallowed by application of bensulfuron methyl 0.6 % + pretilachlor 6 % GR (Erage) @ 10 kg/ha as pre emergence recorded significantly greater grain, straw and biological yield than all other weed management practices and weedy check. Grain yield increased by about 29% with application of Butachlor 1.5 kg *a.i.*ha^{-1} as pre emergence fb Oxadiargyl 100 g *a.i.*ha^{-1} as post emergence over butachlor application alone. Both the planting methods were counted statistically similar number of weeds/m^2 and recorded higher weed biomass and weed control efficiency at all the growth stages during both the years. The data reviled that significant increase in grain yield, number of panicles/m2 and grains / panicle in system of rice intensification (SRI) over normal transplanting method, however straw yield, biological yield and test weight did not differ significantly during both the years.

KEYWORDS

Chemical weed control, system of rice intensification (SRI), weed density, weed dry matter, weed control efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is the premier food crop of India and therefore, national food security system largely depends on the productivity of rice in different ecosystems (Singh *et al.*, 2017). Among the rice-growing countries, India stands first in area (43.79 m ha) and second in production (168.6 mt) next to China. However, the average productivity of rice in India is only 3.848 t/ha against the global average of 4.602 tonnes per hectare (Anonymous, 2019). In Jammu and Kashmir State, rice crop is cultivated over an area of 283.443 thousand hectares with a production of around 572.5 thousand tonnes and a productivity of 2.02 t/ha. However, in Kashmir valley the area under rice is 135.968 thousand hectares with a production of 358.2 thousand tonnes and productivity of 2.635 t/ha (Digest of statistics, 2016-17).

The existing system of paddy production, particularly green revolution technology is input intensive and favours cash rich farmers. Increasing prices of agricultural inputs prevent poor farmers from completely adopting modern production technologies (Stoop *et al.*, 2002). To improve resource use efficiency, the system of rice intensification was promoted as an alternative technology and resource management strategy for rice cultivation that may offer the opportunity to boost rice yields with less external inputs (Uphoff and Randriamiharisoa 2002). When rice fields are not flooded continuously and plants are widely spaced as recommended under SRI, weeds get a better chance to grow. Therefore, efficient weed management practices are required under SRI. The higher amount of labour for weeding is one of the most criticized aspects of SRI. So, efforts must be made to eliminate weeds and minimize their competition with rice plants by using less labour for effective weed control methods. Weed control helps to enhance the production environment, thereby allowing more of the inherent capacity of the plant to express itself in higher yields.

The Kashmir valley with temperate climate has a unique set of varieties suited to its agro-climatic situation. Despite this fact, the average yields (3.23 t/ha) are far below the potential yields (9 t/ha) owing to several constraints, the main among them being weed infestation and poor adoption of new technologies and shortage of water in the reproductive phase. Therefore, cost effective, consistent weed management and modify practice of rice cultivation for saving and efficient utilization of water in rice production system needs to be identify the system of rice intensification in comparison to normal transplanting method. Hence, an experiment entitled "Effect of chemical weed management in SRI and normal transplanting of rice under temperate conditions" was conducted to find out the most suitable transplanting method and weed management practices for rice cultivation in Kashmir valley.

MATERIALS AND METHODS

A field experiment was conducted at Research Form of faculty of Agriculture, SKUAST-Kashmir, Wadura (33°43'15" N, and of 75°5'39"E and altitude 1,596 m amsl). The site falls in the mid-altitude temperate zone characterized by hot summers and very cold winters with an average annual precipitation of 812 mm. The experiment was conducted during *kharif* 2017 and 2018 on silty clay loam soil, which was neutral in pH (6.78), low in nitrogen (215 kg/ha), and medium in available phosphorus (15.0 kg/ha) and potassium (205 kg/ ha). The rainfall received

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during the crop-growing season extending from May to October for 2012 and 2013 was 32 mm and 60 mm, respectively. The experiment comprised of two factors *viz*. 2 transplanting methods (Normal Transplanting and System of Rice Intensification) and 6 weed control methods (weedy check, Manual weeding at 3rd week, 6th week 9th week after transplanting; Application of Butachlor @ 1.5 kg *a.i.* /ha as pre emergence; Application of oxadiargyl @ 100 g *a.i.*/ha; Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR (Erase) @ 10 kg/ha as pre emergence and Application of Butachlore @ 1.5 kg *a.i.*/ha as pre emergence fb Oxadiargyl @ 100 g *a.i.*/ha as post emergence) were laid out in a two factor randomized block design with three replications. On the day of transplanting there was no standing water in the SRI field.

Transplanting was carried out during the 2nd week of June for both the years with 16 days old single seedling per hill square pattern of 25 cm × 25 cm in SRI and 30 days old 3 seedling per hill 20 x 15 cm distance in normal transplanting. Marked ropes at equal distances were used to achieve square planting. All the plots received uniform dose of 120 kg N / ha, 60 kg P_2O_5/ ha and 30 kg K_2O / ha. Whole P, K and half of N were applied as a basal dose before transplantating. The remaining half of N was applied in two equal splits at tillering and panicle initiation. However, FYM @ 10 t / ha was incorporated at the time of layout of the experiment.

The weeds falling in the quadrant 0.25 m^2 were uprooted from each plot periodically (30, 60 and 90 DAT), identified, counted and expressed as weed number / m^2. The weeds uprooted from the above 0.25 m^2 area from each plot at 30, 60 and 90 DAT for weed count were washed and after sun drying, they were oven-dried at 60-65 °C for 48 hours to a constant weight. The weight was expressed in grams and then converted into g/m^2. Both weed number and weed dry weight were subjected to square root transformation to normalize their distribution. Weed control efficiency for different weed control treatments was worked out as per the following formula:

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

Where,

WCE = weed control efficiency
WDC = weed dry weight in control plot
WDT = weed dry weight in treated plot

The data was statistically analyzed for critical difference as per the standard methods.

Weed Flora: It was observed that the experimental field was infested with grassy, broad leaved weeds as well as sedges. The prominent grassy weeds were *Echinochloa crusgalli*, *E. colona* and *Cynodon dactylon*, the broad leaved weeds were *Ammania baccifera*, , *Monochoria vaginalis Alisma plantago aquatic, Polygonum hydropiper, Sagitaria saggitifolia, Marselia quadrifolia, Leptochloa chinensis, Ischaemum rugosum,* and while the prominent sedges included *Cyperus iria*, *Cyperus defformis* and *Fimbristylis littoralis*.

RESULTS AND DISCUSSION

Paddy Yield

Results reviled that the system of rice intensification (SRI) was produced significantly higher grain yield than normal transplanting during both the year (Table 1**)**. In SRI system, specious and check row planting of younger seedling (16 days old) might be provided better and equal opportunity to every hill for profuse tillering, growth, photosynthesis, and grain filling resulted in greater grain yield over normal transplanting with narrow spacing and older seedling (32 days old). This result was also confirmed by Mandal et al., 2013. Straw yield and biological yield were recorded higher in SRI method, but both the methods were statistically similar during both the year of experimentation. In respect of weed management practices application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai / ha as post emergence fallowed by application of bensulfuron methyl 0.6 % + pretilachlor 6 % GR (Erage) @ 10 kg/ha as pre emergence recorded significantly greater grain, straw and biological yield than all other weed management practices and weedy

Table 1: Grain, straw and biological yield of rice as influenced by planting method and weed management practice

Treatments	Grain yield (t/ha)		Straw yield (t/ha)		Biological yield (t/ha)	
	2017	2018	2017	2018	2017	2018
	Establishment method					
Transplanting	5.86	5.96	7.57	7.71	13.45	13.67
SRI	6.19	6.24	8.26	8.32	14.45	14.56
SEm±	0.085	0.09	0.09	0.09	0.17	0.18
CD at ±5%	0.25	0.27	NS	NS	NS	NS
Weed Management						
Weedy Check	3.05	3.13	4.33	4.43	7.38	7.56
Weeding at 3rd week, 6th week 9th week after transplanting	5.74	5.82	7.70	7.78	13.43	13.60
Application of Butachlor @ 1.5 kg a.i. /ha	6.02	6.09	7.97	8.03	13.99	14.12
Application of oxadiargyl @ 100 g a.i./ha	6.06	6.13	7.99	8.09	14.06	14.22
Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 500 g/Kanal	7.50	7.57	9.64	9.72	17.14	17.29
Application of Butachlore @ 1.5 kg a.i./ha fb Oxadiargyl @ 100 g a.i./ha	7.77	7.87	9.94	10.02	17.70	17.88
SEm±	0.15	0.16	0.16	0.16	0.30	0.31
CD at ±5%	0.43	0.46	0.46	0.46	0.87	0.90

check. On the other hand, weedy check was produced significantly lower grain, straw and biological yield than all the weed management practices. It might be due to competition of weeds with rice plant for space, light, nutrients and other resources grain, straw and biological yield decrease. Mandal *et al.*, 2013 was also reported the same result. Mohan *et al.* 2010 also confirmed the same result.

Yield attributes

System of rice intensification (SRI) counted significantly more number of panicles / m^2 and grains / panicle over normal transplanting during both the years. It may be due to profuse tillering capacity of younger seedlings and better resource utilization in SRI system. The test weight was found statistically similar in both the transplanting methods during both the years (Table 2) . In respect of weed management practices application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai / ha as post emergence recorded significantly higher number of panicles / m^2 and number of grains / panicle than application of butachlore @ 1.5 kg ai/ha as pre emergence alone, manual weeding and weedy check, however, application of oxadiargyl @ 100 g ai / ha as post emergence alone and application of bensulfuron methyl 0.6 % + pretilachlor 6 % GR (Erose) @ 10 kg ai/ha as pre emergence were at par with it during both the years. Weedy check produces significantly lowest number of panicles /m^2 and grains / panicle than all the weed management practices during both the years. Weed management practices reduces the competition of crops for space, light, nutrient etc. and enhance the tillering capacity per unit area and healthier plants that improve the number of grains per panicle. The similar result was also found by Ganai *et al.*, 2018.

Table 2 : Panicles /m^2, grains / panicle and test weight of rice as influenced by planting method and weed management practice

Treatments	Panicles / m²		Grains / panicle		Test weight (g)	
	2017	2018	2017	2018	2017	2018
Establishment method						
Transplanting	376.7	383.4	99.4	101.9	24.37	24.63
SRI	391.1	397.8	105.4	107.9	24.88	25.14
SEm±	3.92	3.92	1.51	1.51	0.11	0.12
CD at ± 5%	11.5	11.5	4.4	4.4	NS	NS
Weed Management						
Weedy Check	302.0	308.7	75.8	78.3	23.91	24.17
Weeding at 3rd week, 6th week 9th week after transplanting	374.5	381.2	98.4	100.5	24.42	24.68
Application of Butachlor @ 1.5 kg a.i. /ha	389.7	396.4	103.5	106.0	24.64	24.91
Application of oxadiargyl @ 100 g a.i./ha	404.3	410.9	109.6	112.1	24.78	25.04
Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 500 g/Kanal	414.4	421.1	112.7	115.2	24.90	25.16
Application of Butachlor @ 1.5 kg a.i./ha fb Oxadiargyl @ 100 g a.i./ha	418.4	425.1	114.7	117.2	25.09	25.61
SEm±	6.8	6.78	2.62	2.62	0.20	0.20
CD at ± 5%	19.9	19.9	7.7	7.7	0.59	0.59

Test weight (1000 grain weight) recorded significantly greater with application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai / ha as post emergence than weedy check and manual weeding during both the years and application of butachlore @ 1.5 kg ai/ha as pre emergence alone during 2018, whereas rest of them statistically similar to each other. Weed management may improve the utilization of resources and reduced competition with crop which results higher net assimilation and healthier grains to contribute for higher test weight. Weedy check recorded significantly lower test weight than allne weed management practices except manual weeding during both the years.

Weed density

Both the planting methods were counted statistically similar number of weeds / m^2 at all the growth stages during both the years. Application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai/ha as post emergence reduces significantly weed population and counted lowest number of weeds / m^2 than all other weed management practices and weedy check at all the stages during both the years. Application of pre emergence fallowed by post emergence herbicide may be more efficient in controlling of weeds than single either pre or post application of herbicide or manual weeding. In weedy check plots counted significantly higher number of weeds /m^2 than all the weed management practices at all the stages during both the years (Table 3).

Weed dry weight

Planting methods did not show a significant difference in weeds dry matter accumulation (g / m^2) at all the growth stages during both the years. Application of butachlor @ 1.5 kg ai/ha as pre emergence fb oxadiargyl @ 100 g ai/ha as post emergence rerecorded significantly lowest weed dry matter accumulation (g / m^2) than all other weed management practices and weedy check at all the stages during both the years. Application of pre emergence fallowed by post emergence herbicide may be more efficient in reduction of weed biomass than single either pre or post application of herbicide or manual weeding. In weedy check plots was found significantly higher weed biomass (g /m^2) than all the weed management practices at all the stages during both the years (Table 4). The results are in close conformity with those of Kiran *et al.* (2010) and Ganai *et al.* (2014).

Table 3: Periodic weed density in rice as influenced by Transplanting methods and chemical weed management practices under temperate condition

Treatments	Weed density (No. / m^2)							
	30 DAT		60 DAT		90 DAT		At harvest	
	2017	2018	2017	2018	2017	2018	2017	2018
Establishment method								
Transplanting	3.52 (12.4)	3.45 (11.8)	5.43 (30.5)	5.33 (29.5)	4.61 (22.5)	4.49 (21.4)	4.20 (18.6)	4.10 (17.7)
SRI	3.81 (14.6)	3.75 (14.1)	5.67 (33.1)	5.59 (32.2)	5.00 (25.8)	4.89 (24.7)	4.42 (20.4)	4.32 (19.6)
SEm±	0.036	0.037	0.047	0.052	0.050	0.051	0.048	0.047
CD at ± 5%	NS	NS	NS	NS	NS	NS	NS	NS
Weed Management								
Weedy Check	5.54 (30.0)	5.45 (29.0)	8.16 (65.7)	8.07 (64.2)	7.42 (54.2)	7.33 (52.8)	6.91 (46.8)	6.80 (45.3)
Weeding at 3rd week, 6th week 9th week after transplanting	3.95 (14.8)	3.90 (14.3)	6.00 (35.2)	5.89 (33.8)	5.23 (26.5)	5.13 (25.5)	4.75 (21.7)	4.73 (21.5)
Application of Butachlor @ 1.5 kg a.i. /ha	3.62 (12.3)	3.47 (11.2)	5.78 (32.5)	5.69 (31.5)	5.00 (24.2)	4.90 (23.2)	4.52 (19.5)	4.35 (18.0)
Application of oxadiargyl @ 100 g a.i./ha	3.27 (9.8)	3.26 (9.7)	4.92 (23.3)	4.69 (23.8)	4.29 (17.7)	4.17 (16.7)	3.68 (12.7)	3.57 (11.8)
Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha	2.98 (8.0)	2.93 (7.7)	4.51 (19.5)	4.38 (18.3)	3.75 (13.3)	3.59 (12.2)	3.20 (9.3)	3.12 (8.8)
Application of Butachlore @1.5 kg a.i./ha fb Oxadiargyl @ 100 g a.i./ha	2.65 (6.2)	2.59 (5.8)	3.92 (14.5)	3.77 (13.3)	3.15 (9.0)	2.98 (8.0)	2.79 (6.8)	2.70 (6.3)
SEm±	0.63	0.063	0.082	0.091	0.086	0.088	0.084	0.082
CD at ± 5%	0.18	0.19	0.24	0.27	0.25	0.26	0.25	0.24

Figures in parenthesis are original values, data subjected to √x+1 transformation

Table 4: Periodic weed dry matter accumulation in rice as influenced by Transplanting methods and chemical weed management practices under temperate condition

Treatment	**Weed dry weight (g / m²)**							
	30 DAT		**60 DAT**		**90 DAT**		**At harvest**	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Establishment method								
Transplanting	3.19 (9.5)	3.12 (9.5)	5.75 (34.3)	5.58 (32.5)	6.36 (43.9)	6.18 (41.8)	6.70 (49.4)	6.67 (49.1)
SRI	3.44 (11.7)	3.36 (11.1)	6.07 (38.0)	5.98 (37.0)	6.91 (50.3)	6.74 (48.1)	7.31 (57.6)	7.18 (55.7)
SEm±	0.032	0.030	0.050	0.054	0.070	0.72	0.072	0.77
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Weed Management								
Weedy Check	4.97 (24.0)	4.94 (23.5)	8.74 (75.5)	8.64 (73.8)	10.31 (105.6)	10.19 (103.0)	11.48 (131.1)	11.32 (127.4)
Weeding at 3rd week, 6th week 9th week after transplanting	3.56 (11.9)	3.40 (10.6)	6.31 (39.1)	6.12 (36.7)	7.23 (51.6)	7.10 (49.7)	7.60 (57.0)	7.71 (58.9)
Application of Butachlor @ 1.5 kg a.i. /ha	3.27 (9.9)	3.14 (8.9)	6.10 (36.4)	5.95 (34.6)	6.92 (47.1)	6.77 (45.2)	7.21 (51.3)	7.11 (49.9)
Application of oxadiargyl @ 100 g a.i./ha	2.96 (7.3)	2.95 (7.7)	5.26 (26.8)	5.28 (27.1)	5.91 (34.5)	5.74 (32.5)	5.98 (35.1)	5.95 (34.8)
Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha	2.70 (6.4)	2.66 (6.1)	4.82 (22.4)	4.66 (20.9)	5.15 (26.0)	4.92 (23.7)	5.15 (25.8)	5.04 (24.7)
Application of Butachlore @1.5 kg a.i./ha fb Oxadiargyl @ 100 g a.i./ha	2.42 (4.9)	2.36 (4.7)	4.19 (16.7)	4.02 (15.3)	4.28 (17.6)	4.05 (15.6)	4.62 (20.63)	4.41 (18.6)
SEm±	0.056	0.052	0.087	0.094	0.12	0.13	0.12	0.13
CD at ± 5%	0.17	0.15	0.25	0.28	0.36	0.37	0.36	0.39

Figures in parenthesis are original values, data subjected to √x+1 transformation

Weed control efficiency

In both the method of rice transplanting were revealed that statistically similar weed control efficiency at all stages during both the year. Application of Butachlor 1.5 kg *a.i.*ha^{-1} as pre emergence fb Oxadiargyl 100 g *a.i.*ha^{-1} as post emergence observed that significantly higher weed control efficiency than all the weed management practices at all the stages during both the years (Table 5). The significantly lower weed control efficiency was recorded in manual weeding than all the chemical weed management practices at all the stages during both the year. Herbicides may be considered to be a viable alternative to hand weeding (Chauhan and Johnson, 2011; Anwar *et al.*, 2012).

Table 5: Periodic weed control efficiency in rice as influenced by Transplanting methods and chemical weed management practices under temperate condition

Treatment	Weed control efficiency (%)							
	30 DAT		60 DAT		90 DAT		At harvest	
	2017	2018	2017	2018	2017	2018	2017	2018
Establishment method								
Transplanting	56.72	57.53	53.73	55.25	57.68	58.64	61.12	60.61
SRI	53.62	55.42	50.78	50.90	53.58	54.50	57.44	57.43
SEm±	0.40	0.52	0.72	0.81	0.85	0.89	0.66	0.68
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Weed Management								
Weedy Check	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Weeding at 3 rd week, 6 th week 9 th week after transplanting	50.83	55.02	48.53	50.52	51.40	52.08	56.56	54.10
Application of Butachlor @ 1.5 kg a.i. /ha	59.31	62.15	51.84	53.16	55.37	56.16	60.87	60.86
Application of oxadiargyl @ 100 g a.i./ha	67.65	67.06	64.61	63.58	67.78	68.87	73.47	73.02
Application of Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha	73.56	74.09	70.53	71.88	75.72	77.29	80.50	80.75
Applic ation of Butachlore @ 1.5 kg a.i./ha fb Oxadiargyl @ 100 g a.i./ha	79.69	80.53	78.04	79.34	83.49	85.00	84.29	85.30
SEm±	0.69	0.90	1.25	1.39	1.47	1.54	1.15	1.19
CD at ± 5%	2.01	2.63	3.66	4.09	4.32	4.51	3.37	3.48

Regression Analysis

The relationship between weed density with grain yield, straw yield, panicles/m^2 and grains/panicle were analysed (Fig. 1 to Fig. 8) in terms of trend line and R^2 value and revealed that the weed density were inversely proportional with greater R^2 value of weed density V/S grain yield (0.944), straw yield (0.950), panicle/m^2 (0.993) and grains/panicle (0.992) that means if weed density increases then grain yield, straw yield, panicles/m^2 and grains/panicle were decreases significantly. The same trends were also observed with R^2 value in relationship of weed dry matter VS grain yield (0.942), straw yield (0.951), panicle/m^2 (0.991) and grains/panicle (0.986) that means if weed dry matter accumulation increases then grain yield, straw yield, panicles/m^2 and grains/panicle were decreases significantly. The same relationship also revealed by Ganai *et al.*, 2018.

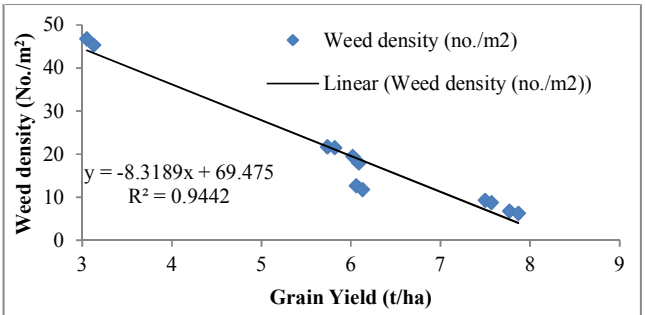

Fig. 1. Weed density (no./m^2) VS Grain yield (t/ha)

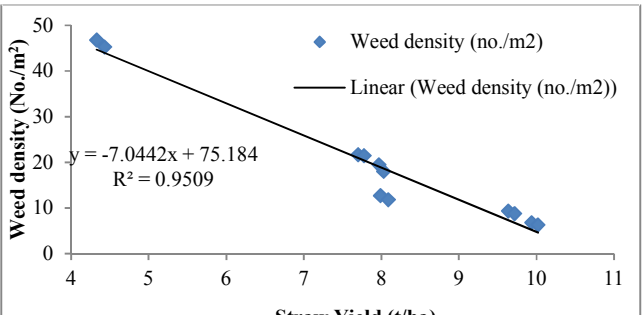

Fig. 2. Weed density (no./m^2) VS Straw Yield (t/ha)

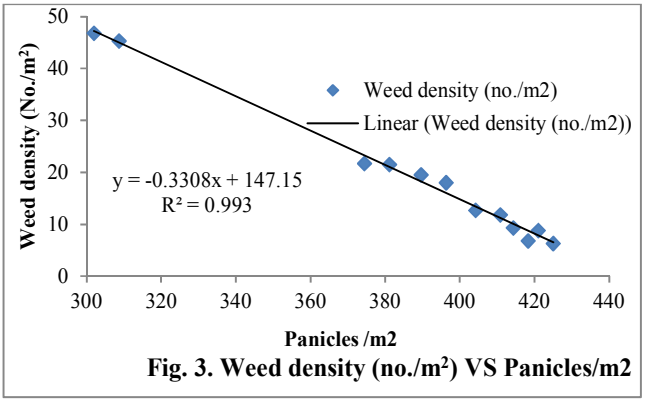

Fig. 3. Weed density (no./m²) VS Panicles/m2

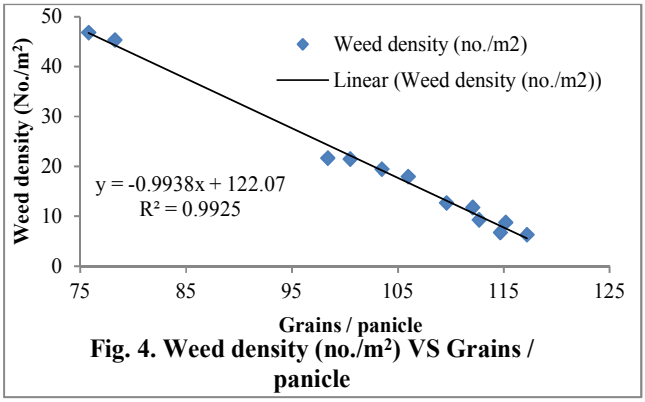

Fig. 4. Weed density (no./m²) VS Grains / panicle

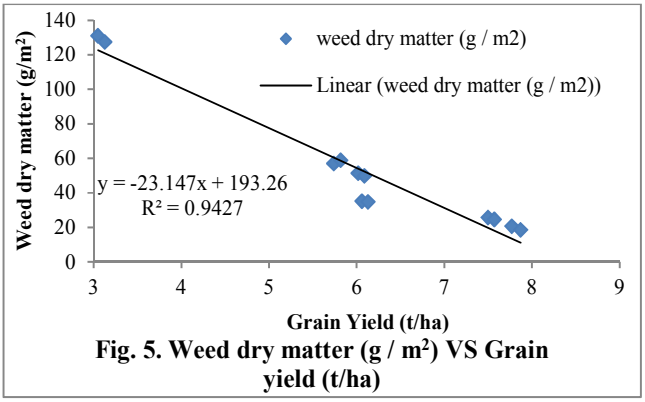

Fig. 5. Weed dry matter (g / m²) VS Grain yield (t/ha)

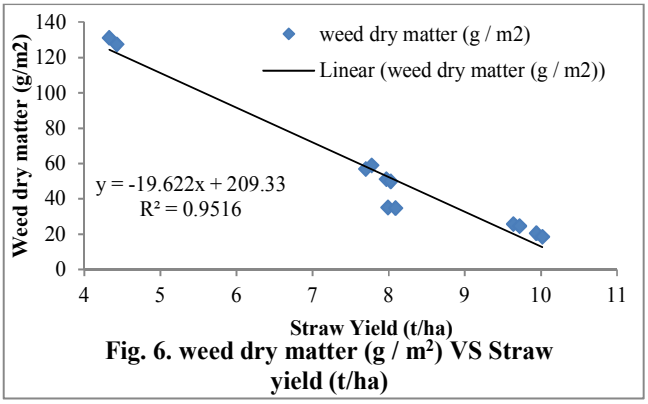

Fig. 6. weed dry matter (g / m²) VS Straw yield (t/ha)

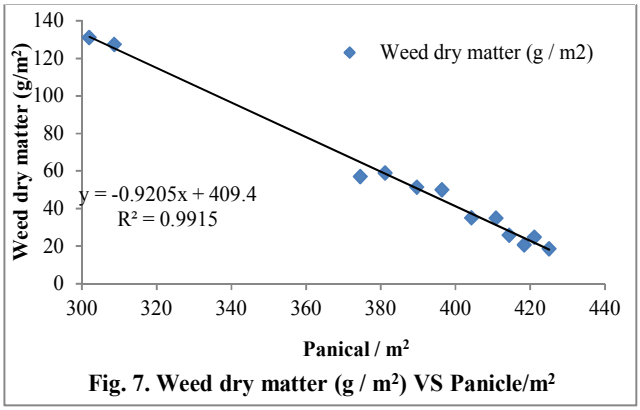

Fig. 7. Weed dry matter (g / m²) VS Panicle/m²

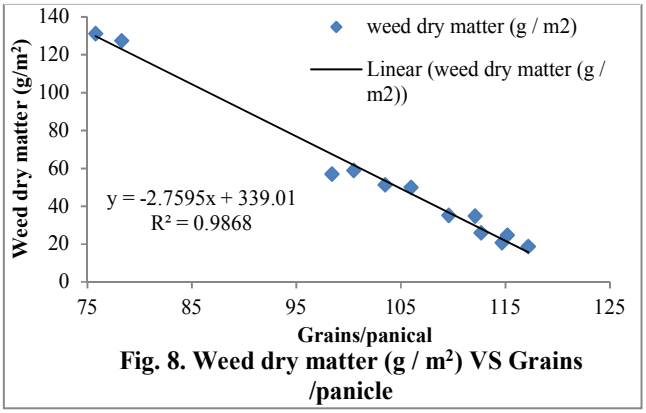

Fig. 8. Weed dry matter (g / m²) VS Grains /panicle

CONCLUSION

On the basis of above observations in it can be concluded that the system of rice intensification was found better rice cultivation practice over normal transplanting method to achieve higher grain production. In terms of weed management practice application of Butachlor 1.5 kg *a.i.*ha^{-1} as pre emergence fb Oxadiargyl 100 g *a.i.*ha^{-1} as post emergence and Bensulfuron methyl 0.6% + Pretilachlor 6% GR (Erage) @ 10 kg/ha were at par and superior than single herbicide application and manual weeding to control the weed infestation.

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