Indian Journal of Weed Science 41(1&2) : 55-61, 2009

Dual culture of rice and green manure crops : a low cost and eco-specific technology for weed management in semi-dry rice

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ABSTRACT

Field experiments were conducted to find out the effectiveness of dual cropping of green manure crops, its methods of incorporation and levels of nitrogen on weed management and to study the cost effectiveness of the system of dual cropping of green manure crop in semi-dry rice. Among the two green manure crops, cowpea (*Vigna unguiculata* (L.) Walp.) was more effective in suppressing weeds and recorded the minimum weed population and weed dry matter compared to horse gram (*Macrotyloma uniflorum* (Lam) Verdc). Incorporation of green manure crops with 2,4-D significantly reduced weed population and weed dry weight compared to other incorporation methods. Nitrogen application at different levels had no significant influence on weeds. Dual cropping of cowpea and its incorporation at 45 days after sowing using 2,4-D was able to meet 25% N requirement beside reducing the weeds in semi-dry rice with increased productivity and profitability.

Key words : Dual cropping, Green manure crops, Cono weeding, 2,4–D, Weed management

Rice production and productivity face a critical decline today due to increasing production cost and plateauing yield levels. Direct seeding is a way to cut down the cost of cultivation sizably. The dry sown (semi-dry) system of rice cultivation is a unique and extensively adopted in 20% rice growing area of our country. In Kerala, it constitutes more than 60% of the area under rice during *kharif* season. In this system, the early growth of rice, up to 30-40 days is in a dry soil environment and thereafter comes under submergence with the onset of south-west monsoon. The absence of stagnant water during the initial 4-6 weeks cause serious problems in dry sown low land rice with regard to weed management and application of organic manures affecting its productivity adversely. There is a greater possibility of intercropping green manure crops during the early stage of rice crop with less interference on rice growth (Mathew *et al*. 1991). In dry seeded system, this situation can effectively be capitalized by sowing green manure crops along with rice crop and allowing self incorporation due to flooding at the onset of monsoon. An undue delay in the onset of monsoon may cause problem in the incorporation of green manure crop in dry seeded system. Thus it is highly essential to identify alternative methods of incorporation for green manure crop without any adverse effect on the system. The present study is undertaken in this background to find out the effectiveness of dual cropping of green manure crops, its methods of incorporation and nitrogen levels on weed management, and to study the cost effectiveness of the system of dual cropping of green manure crop in direct seeded semi-dry rice.

MATERIALS AND METHODS

Field experiments were conducted at the Agricultural Research Station, Mannuthy, Thrissur in Kerala during the rainy (*kharif*) season of 2004-2005 and 2005-2006. Soil of the experimental site is sandy loam with a pH of 5.6, low in available nitrogen (236.9 kg/ha), high in available phosphorus (48.5 kg/ha) and available potassium (140 kg/ha). The experiments were laid out in completely randomized factorial block design with one control replicated thrice. Treatments consisted of two green manure crops, *viz.,* horse gram (*Macrotyloma uniflorum* (Lam) Verdc) and cowpea (*Vigna unguiculata* (L.) Walp) were sown along with rice crop, incorporated at 45 days after sowing (DAS) by one of the three methods of incorporation, *viz.,* using cono weeder, spraying 2,4-D (1.0 kg/ha), and allowing self decomposition due to flooding at the onset of monsoon. Two levels of nitrogen (100 and 75% of the recommended dose of 90 kg/ha) were super imposed over them. Direct sown rice grown alone, with 5 t/ha of FYM and recommended nutrient dose of 90-45-45 kg N, P_2O_5, K_2O/ha as per recommended package of practices of KAU, was taken as control. A medium duration rice variety '*Aiswarya*' was used for the study. Short duration synchronous flowering bush type vegetable cowpea, *Pusa Komal* and local variety of horse gram were the green manure crops. For concurrent growing of green manure crops, one row of cowpea/horse gram was sown in between two rows (20 cm) of rice in finely prepared soil by dibbling. Paddy seeds at 60 kg/ha and green manure crops at 20 kg/ha were used for sowing.

FYM at 5 t/ha was applied to control plots alone and incorporated by digging before sowing. Nitrogen fertilizer at the rate of 100 and 75% of the recommended dose were applied according to the treatment schedule ($^1/_3{}^{rd}$N Basal, $^1/_3{}^{rd}$ N at 45 DAS, $^1/_3{}^{rd}$ N at 60 DAS). Fertilizers P and K were applied uniformly to all the treatments. Irrigation was given uniformly to all the treatment as and when required. One hand weeding was given to all the treatments at 50 DAS. Observations on weed count and weed dry matter were collected before and after the incorporation of green manure crops per m^2 area by placing a quadrate of 50 x 50 cm randomly at four places within each plot and grain yield was recorded. Data were analysed statistically using ANOVA and the significance was tested by Fisher's least significant difference (P=0.05).

RESULTS AND DISCUSSION

Major weed flora in the experimental field was *Echinochloa colona*, *Panicum repens* and *Ischaemum rugosum* among grasses; *Ludwigia parviflora*, *Alternanthera sessilis, Cleome viscosa* and *Oldenlandia aspera*, among broad leaf weeds; *Cyperus rotundus*, and *Fimbristylis miliacea* among sedges.

Effect of dual cropping of green manure crops on weeds

The overwhelming influence of concurrent growing of green manure crops on weed suppression is evident from the data on weed population and dry matter production (Table 1 and 2). Concurrent growing of green manure crops significantly reduced the weed population and weed dry matter than sole cropping of rice in both the years. At 30 days after sowing (DAS), before green manure incorporation, the percentage declines of total weed count in cowpea-intercropped treatments were 52 and 68%, respectively during the first and second years compared to rice grown alone. The corresponding figures in horse gram intercropped treatment were 25 and 49%, respectively. The reduction in total weed dry matter production at 30 DAS due to concurrent growing of cowpea were 40 and 33% and that of horse gram were 25

Table 1. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on weed count (no./m^2) of dry sown rice at 30 DAS (before green manure incorporation)

Treatments	Grass weeds		Broad leaved weeds		Sedge weeds		Total weeds	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Rice+ green manure crops								
Horsegram	68.0	53.7	118.4	85.4	16.6	17.4	203.0	156.6
Cowpea	46.8	38.6	70.9	48.8	12.3	9.8	130.0	97.1
LSD (P=0.05)	12.4	7.8	17.1	11.1	2.3	2.4	21.0	14.2
Methods of incorporation								
Conoweeding	56.3	47.8	106.0	64.0	14.8	13.7	177.2	125.5
2,4 -D spray	60.3	44.2	87.8	69.2	14.5	13.8	162.7	127.1
Self decomposition	55.6	46.4	90.2	68.2	13.9	13.3	159.7	127.9
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Levels of N								
100% N	57.8	44.9	94.6	68.8	14.2	13.9	166.6	127.1
75% N	57.1	47.4	94.7	65.4	14.6	13.8	166.4	126.6
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	81.3*	111.3*	168.3*	169.3*	19.3*	21.7*	269.0*	302.3*

* *Rice alone vs. treatments significant;* DAS - Days after sowing

and 13%, respectively compared with control during the 1st and 2nd year (Table 2). Musthafa (1995) noticed that simultaneous raising of cowpea for *in situ* green manuring had reduced the weed growth and the weed biomass by 45%.

At 50 DAS i.e., after green manure incorporation, the reduction in total weed count due to concurrent growing of cowpea was 76 and 74% and that of horse gram was 61 and 63% during the 1st and 2nd year, respectively compared to rice grown alone (Table 3). The reduction in total dry matter production at 50 DAS due to cowpea green manuring was 68 and 37%, respectively compared with rice grown alone during the 1st and 2nd years and that of horse gram was 55 and 25%, respectively (Table 4).

The reduction in weed growth was evidently due to the successful smothering effect of cowpea. Similar results were reported by Musthafa (1995) and Resmy (2003). However, the higher weed population and weed dry matter in horse gram intercropped plots compared with cowpea might be due to the slow growth of horse gram, providing more conducive conditions for growth of weeds than cowpea. The system of concurrent growing of green manures resulted a labour saving of 40 man-days/ha for weeding alone thus reduced the cost of weed management substantially. The decrease in the population and dry matter production of weeds pointed out that green manure crops had grown only at the expense of weeds by using the growth resources which weeds would have otherwise utilized and may not have competed with rice for growth resources and might have resulted in increased yield of rice in dual cropping compared with pure crop of rice.

Effect of methods of incorporation of green manure crops on weeds

Methods of incorporation of green manure crops significantly influenced the weed count and weed dry matter production at 50 DAS (Table 3 and 4). Among the methods of incorporation, the treatments, wherein the green manure crops were allowed to be incorporated due to flooding, recorded the highest weed count and weed dry matter of all the three types of weeds, leading to higher total weed count and weed dry weight. Incorporation of concurrently grown green manure crop using conoweeder significantly reduced the count and dry matter production of grass weeds. Cono weeder used for uprooting and burying the green manure crops could also bury the weeds in between standing rows of rice. Grass weeds may be more in between the rows than within the rows. That may be the reason for reduced grass weed due to conoweeding. Due to conoweeding the total weed count and dry weight was reduced by 22% and 18%, respectively compared to self decomposition. Conjoint cropping of rice + dhaincha and incorporation of dhaincha on 37 DAS using cono

Table 2. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on dry weight of weeds (g/m²) of dry sown rice at 30 DAS (before green manure incorporation)

Treatments	Grass weeds		Broadleaved weeds		Sedge weeds		Total weeds	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Rice+ green manure crops								
Horsegram	6.62	5.08	6.29	7.21	3.39	3.55	16.30	15.85
Cowpea	5.75	4.28	5.35	5.73	1.81	2.32	12.92	12.34
LSD (P=0.05)	0.47	0.30	0.41	0.33	0.32	0.28	0.73	0.59
Methods of incorporation								
Conoweeding	6.05	4.77	5.66	6.39	2.66	2.95	14.38	14.13
2,4-D spray	6.32	4.57	5.83	6.52	2.62	2.97	14.77	14.08
Self decomposition	6.19	4.69	5.96	6.50	2.51	2.88	14.68	14.08
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Levels of N								
100% N	6.29	4.59	5.76	6.44	2.65	2.93	14.71	13.97
75% N	6.08	4.77	5.87	6.50	2.54	2.94	14.51	14.22
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	9.41*	6.66*	7.62*	7.69*	4.48*	3.89*	21.52*	18.24*

* Rice alone vs. treatments significant; DAS - Days after sowing

Table 3. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on weed count (No./m²) of dry sown rice at 50 DAS (after green manure incorporation)

Treatments	Grass weeds		Broadleaved weeds		Sedge weeds		Total weeds	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Rice+green manure crops								
Horsegram	30.1	43.8	96.6	63.4	19.9	14.2	146.6	121.4
Cowpea	19.8	36.7	57.1	39.6	11.2	8.6	88.2	84.9
LSD (P=0.05)	5.1	5.7	13.5	5.8	3.0	2.0	12.8	7.8
Methods of incorporation								
Conoweeding	15.6	33.3	87.7	51.3	13.3	12.0	116.6	96.7
2,4-D spray	32.1	43.2	40.7	41.2	9.8	9.4	82.5	93.8
Self decomposition	27.3	44.3	102.2	62.0	23.7	12.8	153.1	119.1
LSD (P=0.05)	6.3	7.0	16.5	7.1	3.7	2.5	15.6	9.5
Levels of N								
100% N	25.7	38.6	74.8	51.5	15.8	10.9	116.3	101.1
75% N	24.3	41.9	78.8	51.5	15.3	11.8	118.4	105.3
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	81.0*	118.7*	248.3*	185.0*	37.7*	22.7*	367.0*	326.3*

* Rice alone vs. treatments significant; DAS - Days after sowing

Table 4. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on dry weight of weeds (g/m²) of dry sown rice at 50 DAS (after green manure incorporation)

Treatments	Grass weeds		Broadleaved weeds		Sedges weeds		Total weeds	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Rice+ green manure crops								
Horsegram	6.35	7.17	10.73	6.92	5.76	3.43	22.84	17.53
Cowpea	4.75	6.28	7.19	5.88	4.18	2.83	16.13	15.00
LSD (P=0.05)	0.49	0.29	1.17	0.33	0.50	0.25	1.12	0.51
Methods of incorporation								
Conoweeding	4.78	6.39	8.19	6.71	4.96	3.10	17.94	16.21
2,4-D spray	6.21	6.80	5.73	6.10	3.57	3.08	15.52	15.99
Self decomposition	5.66	6.99	12.96	6.39	6.38	3.20	25.00	16.59
LSD (P=0.05)	0.60	0.36	1.43	0.41	0.61	NS	1.37	NS
Levels of N								
100% N	5.61	6.70	8.64	6.44	4.87	3.13	19.13	16.27
75% N	5.49	6.70	9.28	6.36	5.07	3.13	19.84	16.25
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	11.41*	9.54*	29.25*	9.66*	9.21*	4.29*	49.88*	23.50*

* Rice alone vs. treatments significant; DAS - Days after sowing

Table 5. Interaction effect of concurrently grown green manure crops and methods of incorporation on weed count (no./m^2) of dry sown rice at 50 day after oowing

Green manure crops	Methods of incorporation of green manure crops																	
	Grass weeds						Broad leaved weeds						Total weed count					
	1st year			2nd year			1st year			2nd year			1st year			2nd year		
	CW	2,4- D	SD	CW	2,4- D	SD	CW	2,4- D	SD	CW	2,4- D	SD	CW	2,4- D	SD	CW	2,4- D	SD
Horsegram	17.8	43.0	29.5	35.3	45.7	50.5	121.3	44.2	124.2	57.8	51.3	81.0	156.0	101.2	182.7	108.3	108.2	147.0
Cowpea	13.3	21.2	25.0	31.3	40.7	38.2	54.0	37.2	80.2	44.8	31.0	43.0	77.2	63.8	123.5	85.0	79.3	90.3
LSD (P=0.05)		6.7			7.1			11.8			9.8			16.1			12.6	

CW : Cono weeding; SD-Self decomposition

Table 6. Interaction effect of concurrently grown green manure crops and methods of incorporation on dry weight of weeds (g/m^2) of dry sown rice at 50 days after oowing

Green manure crops	Methods of incorporation of green manure crops																	
	Grass weeds						Broad leaved weeds						Sedges					
	1st year			2nd year			1st year			2nd year			1st year			2nd year		
	CW	2,4-D	SD	CW	2,4-D	SD	CW	2,4-D	SD	CW	2,4-D	SD	CW	2,4-D	SD	CW	2,4-D	SD
Horsegram	5.55	7.37	6.13	6.65	7.23	7.64	9.97	6.25	15.97	7.19	6.55	7.03	5.90	4.82	6.57	3.29	3.38	3.62
Cowpea	4.01	5.06	5.19	6.13	6.38	6.34	6.41	5.21	9.94	6.23	5.66	5.76	4.02	2.33	6.19	2.92	2.77	2.79
LSD (P=0.05)		0.77			0.44			2.08			0.58			0.88			0.45	

CW : Cono weeding; SD-Self decomposition

weeder proved better in terms of reducing total weed density over sole rice (Sankar *et al*. 2003). During both the years, population and dry weight of broad leaved weeds and sedges was significantly less in 2,4-D applied treatments. This has resulted in reduced total weed count (35%) and dry matter production (24%) due to application of 2,4-D. Application of 2,4-D has additional advantage of controlling broad leaved weeds and sedges in rice, as it is a selective herbicide against broad leaved weeds and sedges.

Compared to pure crop of rice, incorporation of green manure crops by self decomposition reduced the weed count and weed dry matter by 60 and 43%. Application of 2,4-D for incorporation of green manure crops resulted in a reduction of weed count by 75% and weed dry matter by 57%. Incorporation of green manure crops by conoweeding caused 69% reduction in weed count and 52% reduction in weed dry matter.

Effect of levels of N on weeds

Nitrogen application at 100 and 75% of the recommended dose (90 kg/ha) had no significant influence on the count and dry matter of weeds. Concurrent growing of green manure crops receiving both levels of nitrogen registered lower weed population and weed dry matter production compared with rice grown alone receiving 5 t/ha of FYM and 100% of the recommended nitrogen. With the recommended nitrogen dose, concurrent growing of green manure crops to meet the organic matter requirement of rice was the most effective in suppressing weeds as this recorded the minimum weed population and weed dry matter compared to the application of 5 t/ha of FYM. Reduction in weed growth in the early growth period evidently had been due to the successful smothering effect of green manure crops but application of 5 t/ha of FYM as basal dose to control plots might have benefited the weeds emerged in the early growth period.

Interaction effects of green manure crops and methods of incorporation of green manure crops on weed count and weed dry matter production at 50 DAS are given in (Table 5 and 6). Interaction effects of cowpea and incorporation of cowpea using 2,4–D recorded lesser weed count and weed dry matter in both year.

Yield and economics

Dual cropping of rice resulted in higher grain yield compared to pure crop of rice (Table 7). Nalini *et al*. (2008) reported higher rice yield with green manure intercropping due to effective suppression of weeds, restriction of nutrient drain by weeds and nutrient addition due to incorporation of dual cropped green manure crop. Methods of incorporation did not significantly vary in their influence on the yield of dry sown rice. Cost of

Table 6. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on yield and economics of dry sown rice (pooled data)

Treatments	Grain yield (Kg/ha)	Cost of treatments (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B: C ratio
Rice+ green manure crops					
Rice+Horsegram	3423	6020	28716	11991	1.72
Rice+Cowpea	3633	6220	37307	19132	2.05
LSD (P=0.05)	160	-	1980	1980	0.12
Methods of incorporation					
Conoweeding	3585	6267	33644	16048	1.91
2,4 -D spray	3513	5627	32730	15773	1.93
Self decomposition	3486	6467	32661	14865	1.83
LSD (P=0.05)	NS	-	NS	NS	NS
Levels of N					
100% N	3570	6244	33424	15851	1.91
75% N	34 86	5996	32599	15273	1.93
LSD (P=0.05)	NS	-	NS	NS	NS
Rice alone	3268*	12090*	27533*	4737*	1.83*

* *Rice alone vs. treatments significant*

cultivation for incorporation of green manure crops using cono weeding and 2,4-D was less compared to self decomposition. This is due to lesser infestation of weeds in these treatments. Gross return and net return did not reach the level of significance mainly because the grain and straw yield of rice was not significantly affected by the methods of incorporation. Rice yield in cowpea intercropped plots which received both 100 and 75% of recommended nitrogen fertilizer was on par and significantly higher compared to pure crop of rice which received 5 t/ha of FYM and full dose of nitrogen fertilizer. Thus there is a clear saving of 25% nitrogen fertilizer by growing cowpea along with rice.

Results of the study indicated that concurrent growing of cowpea could met 25% nitrogen fertilizer requirement besides guarantying a weed suppression (75%) with enhancement in yield to the tune of 365 kg/ha and reduction in labour requirement for weeding at 40 man-days/ha with increase in profitability to the tune of Rs.14562/ha. All the three methods tested were equally effective in incorporating the green manure crops. The selection of the methods depends on the situation, particularly the receipt of rainfall. If there is an undue delay in the onset of monsoon, green manure crops can be effectively incorporated by employing cono weeding or by the 2,4-D spray with the additional benefit of weed control. Dual cropping of cowpea and its incorporation using 2,4-D is a low cost weed management alternative for semi–dry rice.

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