Conservation practices for weed management in upland rice- based cropping system

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Abstract

A field experiment was carried out at Agronomy Farm, College of Agriculture, Vellanikkara from May 2019 to March 2021. The study was laid out in randomized block design, to develop conservation agriculture practices for upland rice-vegetable-green manure cropping system. It was found that different conservation agriculture strategies significantly impacted weed management compared to rice grown without any conservation agriculture practices. The total weed density and weed dry matter production were lower in direct seeded rice in flat bed+ brown manuring (11.47no/m^2), which was on par with direct seeded rice in flat bed+ green manuring (11.55no/m^2), and higher in direct-seeded rice alone in flat bed (21.83no/m^2) at 30DAS, and a similar trend was followed in 60 DAS and at harvest. Rice grown alone in raised bed recorded the lowest weed density and had a 28-39% reduction in weeds compared to rice grown alone in flat bed. A high grain yield of 3047.50 kg/ha and a B:C ratio of 2.59 was recorded in direct seededrice in flat bed+ green manuring. The lowest yield of 1540 kg/ha and lowest B:C ratio of 1.13was observed in direct seeded rice grown alone in a flat bed without any conservation agriculture practices.

Keywords: Brown manuring, Conservation agriculture, Flat bed, Green manuring, Raised bed, Upland rice.

Introduction

In Kerala, though the most important staple food crop is rice, the area and production of rice is decreasing at an alarming rate. Government of Kerala has taken several initiatives to promote paddy cultivation in the State, including upland rice cultivation. The water requirement of rice is high, nearly 1200 mm, and 30 % of the total water requirement is mainly for puddling and transplanting. Transplanting alone requires 240-250 man hours per hectare which increases the cost of production (Raj and Syriac, 2017). Hence upland rice cultivation is gaining popularity because of theless dependence on water and other resources. Upland rice is mainly grownas a rainfed crop, and weed infestations are the major constraintin upland rice cultivation. Conservation agriculture principles like minimumdisturbance to soil, permanent soil cover, and diversified crop rotation significantly influence productivity with less environmental impact. So better conservation practices are required for weed managementand improving upland rice productivity. In India and Kerala, there is dearth of information on resource-conserving techniques, such as bed planting of rice, brown manuring, green manuring, as well as crop diversification for productivity, profitability, soil health and weed management. Hence, the research was conducted to determine the suitability of conservation agricultural practices for upland rice - based cropping system and its influence on weed management.

Materials and Methods

The field experiment was conducted at Agronomy Farm, College of Agriculture, Vellanikkara, located

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at 10° 31′ N latitude and 76° 13′ E from May 2019 to March 2021. Experimental site soil was sandy loam with pH 4.7,EC 0.71d/m^{-1},OC (1.18 %), available N (174.4 kg ha^{-1}), available P_2O_5 (63.00 kg ha^{-1}) and available K_2O (201.00 kg ha^{-1}). Rice was raised during May as first crop, followed by okra in September as the second crop, and cowpea was raised in January as the third crop.The experiment was repeated for two years with the same layout duringboth the years. Rice crop was grown with six treatments and replicated in a randomised block design. Treatments consisted of T1- Direct seeded rice in flat bed + Brown manuring, T2- Direct seeded rice in flat bed + green manuring, T3- Direct seeded rice in raised bed + brown manuring,T4- Direct seeded rice in raised bed + green manuring,T5- Direct seeded rice in flat bed, T6- Direct seededrice in raised bed. Field was ploughed by tractor in the first year. Weeds and previous crop residues were removed and leveled. Rice seeds were planted in flat bed and raised bed. The plot size of flat bed was 5mx 4 m. Three raised beds of 5 m x1 m x 30 cm each weretaken in aplot area of 5 m x 4m. The same layout was used for raising the subsequent crops with minimum soil disturbance. Paddy seeds were dibbled @ 80 $kgha^{-1}$ at a spacing of 20×10 cm. The treatment T1 to T4 of rice was raised in two plots each to raise second crop okra and third crop cowpea in T1 to T8.The whole cropping system consisted of ten treatments. Cowpea seeds were also dibbled in alternate rows in treatments T1 to T4 for brown manuring and *in situ* green manuring. *In situ* green manuring was done by uprooting the cowpea plants at 25 DAS and placed between the paddy rows as mulch. For brown manuring, cowpea was incorporated after spraying of 2, 4- D @ 1.25 $kgha^{-1}$ at 25 DAS. Uniform hand weeding was done in all the plots at 30 DAS.

A quadrat of 1 m^2 was used, and different weed species present within the quadrat were collected. Weeds were categorized into grasses, broad-leaf weeds (BLW), and sedges and counted separately. Total number of weeds was obtained by adding grasses, broadleaf weeds, and sedges. Weeds collected wereoven dried at 80 °C to get constant weight for finding the weed dry matter production. Data pertaining to different observations were tabulated and subjected to statistical analysis by WASP 2.0, and the significance among the treatments was estimated at 5 per cent of probability. Two years data were pooled, and for weed density calculation, square root transformation was carried out.

Results and Discussion

Weed flora

Weed flora of the experimental site consisted of grasses, broadleaf weeds and sedges. Among grassy weeds, *Echinochloa colona, Setaria* spp.*, Digitaria sanguinalis, Eleusine indica, Panicum maximum,* and *Brachiaria* spp. were dominant. The broad leaf weeds identified were *Alternanthera bettzickiana, Ageratum conyzoides, Euphorbia hirta, Euphorbia geniculata, Mollugo disticha, Mitracarpus hirtus, Ludwigia perennis, Hemidesmus indicus, Phyllanthus niruri, Scoparia dulcis, Lindernia crustacea, Commelina benghalensis* and *Trianthema portulacastrum.* The only sedge identified in the field was *Cyperus iria.*

Weed density per m^2

The conservation treatments significantly affected weed density in rice sown during the years of study at 30, 60 DAS, and at harvest (Table-1).The results revealed that all conservation agriculture practices had a significant influence on managing weeds than the rice grown alone. In both flat bed and raised beds, growing cowpea for brown manuring and green manuring resulted in 58-73 percentage reduction inweeds compared to control i.e. direct seeding of rice grown alone in flat bed.It might be due to the smothering effect of cowpea grown with rice. Anitha et al. (2010), reported that the rice grown concurrently with green manure crops significantly reduced the weed dry matter and weed. The highest grasses, broad leaf weeds and sedges density after 30 days (12.57, 17.22, 4.54 no/m^2), 60

Table 1. Effect of treatments on total weed density (no./ m2) at 30,60 DAS and at harvest of rice (pooled data 2 years)

Treatments	Grasses			BLWs			Sedges		
	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest
T_1-Direct seeding rice in flat bed	7.57^{c}	8.45^{c}	5.07^{d}	8.50^{d}	7.39^{d}	5.18^{e}	1.27^{d}	1.52^{d}	1.00
+ Brown manuring	(57.50)	(71.50)	(25.67)	(72.33)	(54.67)	(26.83)	(1.67)	(1.83)	(1.00)
T_2-Direct seeding rice in flat bed	6.29^{d}	7.29^{d}	4.04^{f}	9.64^{cd}	9.68^{c}	6.31^{cd}	0.81^{e}	0.88^{e}	0.90
+ Green manuring	(39.67)	(53.33)	(16.33)	(93.00)	(93.67)	(39.83)	(0.67)	(0.33)	(0.83)
T_3-Direct seeding rice in raised bed	8.36^{c}	8.54^{c}	5.51^{e}	9.24^{cd}	8.35^{d}	5.43^{de}	1.68^{e}	2.12^{e}	0.98
+ Brown manuring	(70.00)	(73.00)	(30.33)	(85.33)	(69.83)	(29.50)	(2.83)	(4.00)	(1.00)
T_4- Direct seeding rice in raised bed	7.70^{c}	7.47^{d}	4.56^{e}	10.06^{c}	10.08^{c}	7.22^{bc}	1.38^{cd}	1.56^{d}	0.90
+ Green manuring	(59.33)	(55.83)	(20.83)	(101.17)	(101.67)	(52.17)	(2.00)	(2.00)	(0.83)
T_5- Direct seeding rice in flat bed	12.57^{a}	12.79^{a}	8.13^{a}	17.22^{a}	16.99^{a}	10.37^{a}	4.54^{a}	4.60^{a}	1.59
	(159.00)	(164.33)	(66.17)	(297.33)	(289.33)	(108.50)	(20.67)	(20.67)	(2.67)
T_6- Direct seeding rice in raised bed	10.25^{b}	10.85^{b}	7.02^{b}	14.29^{b}	14.44^{b}	7.98^{b}	3.67^{b}	3.72^{b}	1.38
	(105.17)	(117.67)	(49.33)	(204.83)	(209.17)	(63.83)	(13.67)	(13.33)	(2.00)
Sem	0.37	0.32	0.64	0.43	0.40	0.34	0.13	0.13	-
CD(0.05)	1.11	0.96	0.19	1.30	1.20	1.03	0.38	0.38	NS

*√x+0.5 transformed values, original values in parentheses.

days (12.79, 16.99, 4.60no/m^2), and harvest (8.13, 10.37, 1.59 no/m^2) was found in direct-seeded rice grown alone in flat bed without any conservation agriculture practices (Table-1). The lowest broad leaf weed count was recorded in brown manured plots during all stages of crop growth. The lowest broad leaf weeds count in brown manured plot compared to green manure plot may be due to application of 2-4-D, a selective herbicide recommended for broadleaf weeds. Iliger et al. (2017) reported that brown manuring could effectively control broadleaf weeds. Brown manuring of cowpea resulted in defoliation, and the fallen leaves which act as mulch and reduces the weed population by smothering the weeds in rice (Nagargade et al., 2018).

Land modification in planting i.e., direct seeding of rice in raised bed, resulted in a 28-36% reduction in total weed count compared to direct seeding rice in flat bed. Sepat et al. (2017), observed that in zero tilled raised beds, the population of weeds like *Echinochloa colona* and *Digera arvensis* was very less.

Total weed count and weed dry matter production

Direct seeded rice in raised bed + brown manuring resulted in 65-69% reduction in total weeds, and direct seeded rice in raised bed + green manuring recorded 57-67% reduction in total weeds compared to rice without conservation agriculture practices. Weed population was reduced in conservation agriculture by 50-60 per cent. Weed seed germination can be inhibited by the allelopathic effect of cereal residue (Jung et al., 2004). Among all the treatments, the total weed density and weed dry matter production were found to be the lowest in all conservation treatments and had a significant influence in weed suppression. The highest total weed density (21.83, 21.75, 13.30 no/m^2) and weed dry matter production (121.20, 129.83, 89.83 g/m^2) were recorded in non conservation treatment i.e. direct seeding rice grown alone in flat bed at 30 DAS, 60 DAS and at harvest respectively. Kayeke et al. (2007) reported that total weed count and weed dry weight decreased significantly in green manure treated plots in upland rice than in the control plots were rice was grown alone.

Weed density and dry matter production were less in direct seeded rice with brown manuring (Kumari and Kaur, 2016). Due to the dominant nature of green manure crop, intercropping with green manure in rice resulted in less availabilityof space, nutrients, water, and light to weeds in early growth stages and thereby reduced weed density and weed dry matter production (Barla et al., 2016). Similarly, here the intercropping of green manure cowpea and

Table 2. Effect of treatments on total weed density (no./ m^2), weed dry matter production(g/m^2), and weed control efficiency (WCE) of rice (pooled data 2 years)

Treatments	30DAS		60DAS		Harvest		WCE 30DAS	WCE 60DAS	WCE Harvest
	Total weed density	Weeddry matter production	Total weed density	Weeddry matter production	Total weed density	Weed dry matter production			
T_1-Direct seeding rice in flat bed + Brown manuring	11.47^{d} (131.50)	37.36^{d}	11.31^{d} (128.00)	7.35^{d}	42.67^{d} (53.50)	29.29^{d}	69.17	67.13	67.39
T_2-Direct seeding rice in flat bed + Green manuring	11.55^{d} (133.33)	39.87^{d}	12.13^{cd} (147.33)	42.74^{d}	7.58^{d} (57.00)	30.00^{d}	67.10	67.08	66.60
T_3-Direct seeding rice in raised bed + Brown manuring	12.58^{c} (158.17)	42.58^{cd}	12.12^{c} (146.83)	49.67^{c}	7.83^{cd} (60.83)	37.33^{c}	64.87	61.74	58.44
T_4- Direct seeding rice in raised bed + Green manuring	12.75^{c} (162.67)	49.06^{c}	12.63^{cd} (159.50)	55.33^{c}	8.62^{c} (73.83)	44.33^{c}	59.52	57.38	50.65
T_5- Direct seeding rice in flat bed	21.83^{a} (477.00)	121.20^{a}	21.75^{a} (474.33)	129.83^{a}	13.30^{a} (177.33)	89.83^{a}	0.00	0.00	0.00
T_6- Direct seeding rice in raised bed	17.99^{b} (323.67)	95.57^{b}	18.43^{b} (340.17)	99.08^{b}	10.75^{b} (115.17)	71.67^{b}	21.15	23.68	20.22
Sem	0.26	1.89	0.44	2.03	0.30	2.62	-	-	-
CD(0.05)	0.78	5.67	1.31	6.09	0.89	7.87	-	-	-

*√x+0.5 transformed values, original values in parentheses.

rice resulted in less availability of space and nutrients to weeds and reduced the total weed count and weed dry matter production in rice in conservation treatments than in nonconservation treatments.

Weed control efficiency

Among all the conservation treatments, direct seeded rice in flat bed + brown manuring showed maximum weed control efficiency of 67-69 % compared to all other treatments (Table-2). Maximum weed control efficiency might be due to weed suppression. Baghel et al. (2018) reported that higher weed control efficiency was recorded when conservation principles for rice based cropping system were followed.

Yield and yield attributes

All the conservation treatments recorded higher yield than non-conservation treatment. Higher grain yield (47.65 %) was recorded in rice grown in flat bed along with cowpea for green manuring than rice

Table 3. Effect of treatments on yield, yield attributes and economics of rice (pooled data 2 years)

Treatments	Panicles (no./m^2)	No. of grains per panicle	Percentage filled grain (%)	1000 grain weight (g)	Grain yield (kg/ ha)	Straw yield (kg/ ha)	Harvest index (%)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ ha)	Net returns (Rs./ ha)	B:C ratio
T_1-Direct seeding rice in flat bed + Brown manuring	241.50^{b}	150.38^{b}	86.15^{b}	30.30^{b}	2682.50^{b}	5825.00^{a}	0.31^{ab}	55997	130678	74681	2.34
T_2-Direct seeding rice in flat bed + Green manuring	264.83^{a}	163.70^{a}	87.82^{a}	31.62^{a}	3047.50^{a}	6078.33^{a}	0.33^{a}	55137	143066	87929	2.59
T_3-Direct seeding rice in raised bed + Brown manuring	225.33^{c}	127.77^{c}	80.67^{d}	28.59^{cb}	2233.33^{c}	4725.00^{c}	0.32^{ab}	56747	107550	50803	1.89
T_4- Direct seeding rice in raised bed + Green manuring	237.00^{b}	143.67^{b}	82.97^{c}	30.02^{b}	2647.50^{b}	5466.67^{b}	0.32^{ab}	55401	126149	70472	2.28
T_5- Direct seeding rice in flat bed	212.00^{d}	115.50^{d}	68.40^{f}	26.61^{d}	1540.00^{d}	4058.33^{e}	0.27^{c}	72427	82163	9736	1.13
T_6- Direct seeding rice in raised bed	210.33^{d}	104.27^{e}	77.27^{e}	27.54^{cd}	1996.67^{c}	4441.67^{d}	0.30^{b}	64027	98327	34299	1.53
Sem	1.88	3.38	0.47	0.39	87.19	90.70	0.01	-	-	-	-
CD(0.05)	5.65	10.15	1.42	1.17	261.57	272.09	0.03	-	-	-	-

grown alone in flat bed. Rice crop grown alone in raised bed recorded 23 % more grain yield and 9 % more straw yield than rice grown alone in flat bed (Table-3). As the pure crop of rice recorded lower height, number of tillers, leaf area, and dry matter compared to the cowpea intercropped rice resulted in poor development of photosynthetic surface which ultimately resulted in poor expression of yield and yield contributing characters like panicle/m^2, percentage filled grains, 1000 grain weight and finally low yield. Similar results were obtained by Anitha and Mathew (2010); Das et al. (2012); Gaire et al. (2013) where there was 11 per cent reduction in the yield of pure crop of rice compared to green manure intercropped plot. From this it is evident that competition for rice due to the growing of green manure crops was almost absent.

Economics

Direct seeded rice in flat bed + green manuring recorded the highest gross and net returns followed by direct seeded rice in flat bed + brown manuring due to higher yield and reduced cost of cultivation. The highest B:C ratio in direct seeding rice in flat bed+ green manuring was mainly due to the low cost of cultivation and high yield (Table-3). In upland rice, the major expenditure incurred is for weeding. By green manuring, cowpea spread as mulch, hindered weeds' growth and reduced the weed population. The results conform with Anitha and Mathew (2010), who reported that the system of concurrent growing of cowpea reduces the weed population and reduces the labour in rice crop by saving 40 man days per ha. So in upland rice,green manuring and brown manuring reduces the cost of cultivation and improves the B:C ratio. Similar results were reported by Kumar et al. (2011); Barla et al. (2016); Kumari (2016), who stated that the cowpea intercropped plots recorded high net returns and B:C ratio compared to sole cropping of rice.

Conservation agriculture practice followed in rice-okra-green manure cropping system significantly influences weed management of upland rice. Growing cowpea for green manuring and brown manuring under both systems of planting in flat bed and raised bed resulted in 58-73% reduction of weeds in upland situation. Growing cowpea as intercrop and its incorporation at 25 DAS either by cutting it and spreading as mulch (green manuring) or decomposing it using 2-4-D application (brown manuring) can be recommended as an effective weed management practice for upland rice based cropping system.

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