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Research Communication

Effect of methods of planting of rice (*Oryza sativa*) weed and nutrient management practices on growth and productivity of succeeding crops and system productivity of rice (*Oryza sativa*)-based cropping systems

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ABSTRACT

A field experiment was conducted at the Instructional farm, College of Agriculture, Vellayani, Kerala, India, during 2013–14, to study the effect of methods of planting, weed and nutrient management on rice (*Oryza sativa* L.) and effect on the succeeding cassava (*Manihot esculenta Crantz*.) intercropped with groundnut (*Arachis hypogaea* L.) and cowpea [*Vigna unguiculata* (L.) Walp.] in uplands. The experiment was laid out in split-plot design, comprising 3 main plot shaving methods of planting [broadcasting of sprouted seeds, dibbling (sprouted seeds with drum seeder along with weeding by power weeder) and dibbling (sprouted seeds with drum seeder along with stubble mulching)] and 5 subplots with methods of nutrient application [broadcasting (60, 30 and 30 kg N, P and K/ha), band placement (60, 30 and 30 kg N, P and K/ha), foliar spray of complex foliar fertilizer 19-19-19 @ 0.5%, foliar spray of diammonium phosphate (DAP) and sulphate of potash (SoP) each @ 2%, control] with 5 replications. For cassava intercropped with groundnut and cowpea recommended dose of fertilizer along with 0.5% foliar spray of 19-19-19 was applied at 30 and 14 days interval respectively. The results revealed that, the yield of succeeding crops as well as rice-equivalent yield of the cropping system (29.71 t/ha) was significantly increased by the method of planting of rice using drum seeder + stubble mulching @ 3 t/ha along with either broadcasting of 60, 30 and 30 kg N, P and K/ha or foliar spray of diammonium phosphate (DAP) and sulphate of potash (SoP) each @ 2% applied to rice. Residual effect of stubble mulching, basal application of nutrients along with foliar spray of DAP and SoP each @ 2% applied to rice enhanced the residual nutrients, yield and better profitability of rice-based sequential cropping system in uplands.

Key words: Methods of planting, Nutrient management, Rice-based cropping system, System productivity

Rice is one of the most important cereal crops and provides food security and livelihood for millions of people across the globe. It has been estimated that almost two-thirds of the upland rice area is in Asia. Among many factors, method of sowing, seed rate, integrated nutrient management etc, influence the crop yield under upland situations.

Cropping systems research has shown that short-duration (5–6 months) cassava varieties can be grown successfully in a rice- based cropping system. Since the development of cassava in initial stages is very slow, a short-duration crops such as groundnut can be incorporated. A legume like cowpea in rice-based cropping system either as a substitute or in a sequence enriches the soil owing to its capability to fix atmospheric nitrogen. It is expected that nearly 3 million ha area of rice fallows can be brought under cultivation, which can provide about 1.5–2 million tonnes (mt) of additional foodgrain production and help in meeting increasing demands of pulses and oilseeds (DAC, 2013). Therefore inclusion of pulses and oilseeds in the system is more beneficial than conventional cereal year after year. Foliar formulations are gaining importance in crop production owing to its quick response in plant growth.

With this background, the present study was undertaken to evaluate the residual impact of methods of planting along with weed and nutrient management on the productivity of rice based sequential cropping systemin an uplands.

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MATERIALS AND METHODS

The experiment was conducted at the Instructional farm, College of Agriculture, Vellayani, Kerala during August 2013 to August 2015. (8° 25' 46.94" N and 76° 59'1.12" E and at an altitude of 3 m above mean sea-level). A total rainfall of 1,518.1 mm and 2,236.5 mm was recorded during the cropping period of first and second year respectively. The soil of the experimental site was sandy clay. The sequential cropping system consisted of rice succeeded by cassava (intercropped with groundnut) and cowpea. The investigation was carried out in split-plot design with 5 replications. The 3 main plots with combinations of methods of planting and weeding [broadcasting of sprouted seeds, dibbling (sprouted seeds with drum seeder along with weeding by power weeder) and dibbling (sprouted seeds with drum seeder along with stubble mulching)] and 5 subplots included methods of fertilizer application [broadcasting (60-30-30 kg NPK/ha), band placement (60-30-30 kg NPK/ha at 10 days aftr planting (DAP), tillering and panicle-initiation stage), foliar spray of 19-19-19 @ 0.5% (at tillering, panicle initiation and flowering stage), foliar spray of diammonium phosphate and sulphate of potash each @ 2% (at tillering, panicle initiation and flowering stage), absolute control (without any fertilizer and organic manure)] for upland rice. Farmyard manure @ 5 t/ha was applied basal uniformly except absolute control at the time of land preparation. Urea, mussorie rockphosphate and muriate of potash were applied to the respective plots as per the treatments to supply N, P_2O_5 and K_2O. Weeding using power weeder was done at 20 and 40 days after sowing (DAS). Stubble mulching was done using paddy straw @ 3 t/ha.

Recommended dose of nutrients such as FYM @ 12.5 t/ha and NPK @ 110:120:120 kg/ha was applied uniformly to both cassava and groundnut (50-100-50 kg/ha – basal, 10-20-20 kg/ha – one month after planting (groundnut) and 50-0-50 kg/ha for the main crop after the harvesting of groundnut) (KAU, 2011). For cowpea, recommended dose of nutrients such as FYM @ 20 t/ha and NPK 20:30:10 kg/ha was applied uniformly (KAU, 2011). Along with the recommended nutrients, 0.5% foliar spray of 19-19-19 was applied to cassava + groundnut and cowpea at 30 and 14 days interval respectively. Varieties used in our study were 'Aiswarya' (rice), 'Vellayani Hraswa' (cassava), 'TMV 2' (groundnut) and 'Bhagyalakshmi' (cowpea).

Observations on growth parameters, such as plant height and number of leaves/plant for cassava, plant height and number of branches/plant for cowpea, were collected. For yield components, tuber yield for cassava, pod yield for groundnut and pod yield for cowpea were measured. System productivity in terms of rice-equivalent yield of the system was calculated using the standard formula.

$$\text{Rice equivalent yield} = \text{Rice grain yield} + \frac{\text{Tuber yield} \times \text{pod yield} \times \text{pod yield} \times \text{price of cassava} + \text{price of groundnut} + \text{price of } \textit{cowpea}}{\text{Price/kg of rice}}$$

The data were subjected to analysis of variance (ANOVA) as applied to split plot design (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Residual effect of treatments of rice on growth parameters of sequential crops (cassava intercropped groundnut and cowpea)

Among the methods of planting and weed control treatments in rice, the residual effect of dibbling of seeds + power weeding and broadcasting of seeds resulted in the highest cassava plant height of 198.5 cm and 133.7 cm in the first and second year respectively. The residual effect of dibbling of seeds + stubble mulching produced 207.9 leaves/plant in the first year and carry over effect of broadcasting of seeds produced 116.9 functional leaves/plant in the second year, which were the highest. Among the treatment combinations, during 2013–14, the highest plant height was noticed in dibbling of seeds + power weeding without any fertilizer application, while in the second year broadcasting of seeds along with broadcast application of 60-30-30 kg NPK/ha recorded the highest plant height which was at par with dibbling of seeds + stubble mulching along with band placement of 60-30-30 kg NPK/ha. In the first year, the residual effect of combination of dibbling of seeds + stubble mulching along with broadcast application of 60-30-30 kg NPK/ha was significantly superior to all the other combinations in producing maximum number of leaves/plant and in the second year, broadcasting of seeds + broadcast application of 60-30-30 kg NPK/ha resulted in the highest number of leaves/plant in cassava.

The residual effect of treatments of rice significantly influenced on the growth parameters such as plant height and branches/plant of cowpea in both the years (Tables 1 and 2). In the first and second year, the growth parameters were higher in the residual effect of stubble mulching applied to the preceding first crop rice. Holland (2004) also reported that mulched soil environment increased the soil biota and improved the nutrient cycling and organic matter. During the first year, the residual effect of band placement of 60-30-30 kg NPK/ha in rice recorded the highest growth parameters. In the second year, the maximum plant height was recorded by the residual effect of foliar application of 19-19-19 @ 0.5% in rice. The mechanical weeding in rice might have reduced the weed population in the first crop rice in which the nutrients were not depleted compared to the other methods of weed control. Therefore the residual as well as direct effect of nutrients applied to cowpea might have helped in enhancing the growth of cowpea. The re-

sidual effect of dibbling of seeds + power weeding as well as stubble mulching along with broadcasting and band placement of 60-30-30 kg NPK/ha in rice resulted in significantly higher plant height of cowpea in the first year. During 2014–15, the significantly highest plant height was observed in dibbling of seeds + power weeding along with

Table 1. Growth parameters of sequential crops (cassava and cowpea) influenced by the methods of planting, weed and nutrient management in rice

Treatment	Cassava				Cowpea			
	Plant height (cm)		No. of Leaves/plant		Plant height (cm)		No. of Branches/plant	
	2013–14	2014–15	2013–14	2014–15	2013–14	2014–15	2013–14	2014–15
Methods of planting and weed management (M)								
Broadcasting of seeds	169.5	133.7	190.6	116.9	56.9	63.0	5.0	4.6
Dibbling of seeds + power weeding	198.5	125.7	181.7	100.4	57.8	64.9	5.1	5.2
Dibbling of seeds + stubble mulching	176.2	126.8	207.9	107.54\	58.6	64.2	5.3	5.7
SEm±	0.663	0.767	1.316	0.397	0.359	0.257	0.064	0.081
CD (P=0.05)	2.161	2.499	4.292	1.295	1.170	0.839	0.206	0.265
Methods of fertilizer application (F)								
Broadcasting of 60-30-30 kg NPK/ha	181.1	126.2	202.8	121.4	58.1	62.6	4.9	5.3
Band placement of 60-30-30 kg NPK/ha	178.3	133.6	210.5	113.2	59.9	63.7	5.4	5.4
Foliar spray of 19-19-19 @ 0.5%	177.2	129.2	170.3	113.9	57.3	70.1	5.4	5.1
Foliar spray of DAP and SoP each @ 2%	178.5	127.2	214.2	103.0	56.6	62.6	5.3	5.0
Absolute control	191.9	127.4	169.1	90.00	57.1	61.2	4.98	5.01
SEm±	2.343	0.433	1.968	1.056	0.424	0.479	0.100	0.062
CD (P=0.05)	6.662	1.231	5.597	3.005	1.205	1.361	0.283	0.177
Interaction (M × F)								
Broadcasting of seeds + broadcasting of 60-30-30 kg NPK/ha	163.5	140.8	169.9	156.9	52.4	65.2	4.4	4.5
Broadcasting of seeds + band placement of 60-30-30 kg NPK/ha	164.6	128.6	190.9	102.8	59.9	55.2	5.4	4.7
Broadcasting of seeds + foliar spray of 19-19-19 @ 0.5%	184.4	136.3	195.5	125.2	59.5	68.8	5.4	4.7
Broadcasting of seeds + foliar spray of DAP and SoP each @ 2%	184.1	130.9	231.0	96.6	56.0	68.9	5.0	4.2
Broadcasting of seeds + absolute control	150.9	131.9	165.7	103.4	56.9	57.0	5.1	4.7
Dibbling of seeds + power weeding + broadcasting of 60-30-30 kg NPK/ha	201.3	130.8	166.1	113.9	60.9	65.5	5.0	5.4
Dibbling of seeds + power weeding + band placement of 60-30-30 kg NPK/ha	212.6	131.6	225.3	116.5	58.9	67.7	5.4	5.7
Dibbling of seeds + power weeding + foliar spray of 19-19-19 @ 0.5%	167.8	121.0	143.4	95.7	53.1	72.3	5.1	4.8
Dibbling of seeds + power weeding + foliar spray of DAP and SoP each @ 2%	185.6	117.2	224.5	96.5	57.9	59.1	5.2	5.2
Dibbling of seeds + power weeding + absolute control	225.3	127.8	149.2	79.4	58.2	59.9	5.1	5.1
Dibbling of seeds + stubble mulching + broadcasting of 60-30-30 kg NPK/ha	178.4	107.0	272.5	93.5	60.7	57.1	5.3	5.9
Dibbling of seeds + stubble mulching + band placement of 60-30-30 kg NPK/ha	157.9	140.6	215.3	120.2	60.9	68.2	5.4	5.9
Dibbling of seeds + stubble mulching + foliar spray of 19-19-19 @ 0.5%	179.4	130.3	172.81	120.8	59.1	69.4	5.6	5.7
Dibbling of seeds + stubble mulching + foliar spray of DAP and SoP each @ 2%	165.7	133.6	187.2	116.1	55.7	59.6	5.6	5.7
Dibbling of seeds + stubble mulching + absolute control	199.7	122.4	192.5	87.2	56.3	66.6	4.8	5.2
SEm±	4.057	0.750	3.408	1.830	0.734	0.829	0.173	0.108
CD (P=0.05)	11.539	2.131	9.694	5.204	2.088	2.357	0.490	0.307

DAP, Diammoniumphosphate; SoP, sulphate of potash

foliar application of 19-19-19 @ 0.5% (72.3 cm) which was significantly superior to all other combinations.The residual effects of dibbling of seeds + stubble mulching along with broadcast application of 60-30-30 kg NPK/ha and foliar spray of 19-19-19 @ 0.5% in the first crop rice resulted in higher number of branches/planting cowpea for the first and second year respectively.

Residual effect of treatments of rice on yield of sequential crops (cassava intercropped with groundnut and cowpea)

The residual effect of treatments applied to rice was not

Table 2. Yield of sequential crops (cassava + groundnut and cowpea) and rice-equivalent yield influenced by the methods of planting, weed and nutrient management in rice

Treatments	Cassava		Groundnut		Cowpea		Rice
	Tuber yield (t/ha)		Pod yield (kg/ha)		Pod yield (kg/ha)		equivalent
	2013–14	2014–15	2013–14	2014–15	2013–14	2014–15	yield (t/ha)
Methods of planting and weed management(M)							
Broadcasting of seeds	30.3	17.5	600.0	1,056.8	454.2	523.56	24.0
Dibbling of seeds + power weeding	29.1	16.4	552.2	1,028.7	660.4	744.2	24.7
Dibbling of seeds + stubble mulching	30.9	17.1	817.2	1,182.4	540.8	1,127.4	26.7
SEm±	0.103	0.292	17.119	4.348	95.952	15.287	0.525
CD (P=0.05)	0.237	NS	55.826	14.179	NS	49.852	2.337
Methods of fertilizer application (F)							
Broadcasting of 60-30-30 kg NPK/ha	31.9	18.6	789.1	958.8	618.4	761.5	25.9
Band placement of 60-30-30 kg NPK/ha	31.7	16.9	626.0	1,107.2	497.3	833.5	26.0
Foliar spray of 19-19-19 @ 0.5%	27.8	15.6	560.9	1,005.3	577.4	775.9	23.8
Foliar spray of DAP and SoP each @ 2%	29.9	17.8	597.4	1,370.7	532.3	793.1	25.8
Absolute control	29.2	16.1	708.89	1,004.74	533.4	827.9	24.3
SEm±	0.873	0.245	28.970	7.703	16.654	18.849	0.677
CD (P=0.05)	1.756	0.696	82.391	21.907	47.364	53.606	2.423
Interaction (M×F)							
Broadcasting of seeds +broadcasting of 60-30-30 kg NPK/ha	37.12	18.2	815.6	721.4	551.0	452.6	23.4
Broadcasting of seeds + band placement of 60-30-30 kg NPK/ha	31.4	18.9	451.6	1,118.5	576.4	596.8	26.3
Broadcasting of seeds + foliar spray of 19-19-19 @ 0.5%	26.5	17.9	434.4	981.8	341.9	621.9	23.5
Broadcasting of seeds + foliar spray of DAP and SoP each @ 2%	28.4	15.4	332.8	1,410.4	381.4	353.3	22.9
Broadcasting of seeds + absolute control	28.1	17.1	965.6	1,028.6	420.1	593.8	24.1
Dibbling of seeds + power weeding + broadcasting of 60-30-30 kg NPK/ha	28.1	17.4	521.9	786.5	645.8	800.3	24.5
Dibbling of seeds + power weeding + band placement of 60-30-30 kg NPK/ha	30.0	18.6	764.1	1018.2	444.4	868.1	26.4
Dibbling of seeds + power weeding+ foliar spray of 19-19-19 @ 0.5%	15.1 29.1	360.9	904.9	734.2	644.4	23.8	
Dibbling of seeds + power weeding+ foliar spray of DAP and SoP each @ 2%	30.3	16.4	779.7	1,268.2	750.9	721.9	25.9
Dibbling of seeds + power weeding + absolute control	27.8	14.5	334.4	1,165.4	726.5	686.3	22.7
Dibbling of seeds + stubble mulching + broadcasting of 60-30-30 kg NPK/ha	30.34	20.3	1029.7	1,368.5	658.3	1126.3	29.7
Dibbling of seeds + stubble mulching + band placement of 60-30-30 kg NPK/ha	33.7	15.7	662.5	1,184.9	471.3	1036.3	25.4
Dibbling of seeds + stubble mulching + foliar spray of 19-19-19 @ 0.5%	27.7	13.9	887.5	1,129.1	663.8	1061.3	24.0
Dibbling of seeds + stubble mulching + foliar spray of DAP and SoP each @ 2%	30.9	19.1	679.6	1,433.6	481.3	1209.3	28.1
Dibbling of seeds + stubble mulching + absolute control	31.6	16.7	826.6	819.0	429.3	1203.6	26.0
SEm±	1.513	0.424	50.178	13.343	28.845	32.647	1.173
CD (P=0.05)	3.042	1.205	142.705	37.945	82.036	92.848	3.484

DAP, Diammonium phosphate; SoP Sulphate of potash

For rice equivalent yield, the prices of different crops were: rice ₹18/kg, cassava ₹15/kg, groundnut ₹40/kg, cowpea ₹40/kg

observed on cassava tuber yield in the second year but in the initial year, the residual effect of dibbling of seeds + stubble mulching significantly resulted in 30.86 t/ha tuber and the increase in yield was 1.81 and 6.05% compared to residual effect of broadcasting of rice seeds and dibbling of seeds + power weeding. The stubble mulching and intercrop might helped in increasing the soil-moisture content as well as reduced the weeds and could have fixed some amount of nitrogen by groundnut at the time of incorporation as found by Robinson (1997). The residual effect of soil application of 60-30-30 kg NPK/ha as broadcasting resulted in higher tuber yields during both the years (31.9 and 18.7 t/ha respectively) and was statistically at par with residual effect of band placement of 60-30-30 kg NPK/ha (2013–14) and foliar spray of DAP and SoP each @ 2% (2014–15). The improvement in the number of functional leaves/plant might have resulted in better productivity. Moreover, the high residual soil nutrients of the previous rice along with the nutrients (soil and foliar) applied to cassava as well as the nutrients supplied from the incorporated groundnut have contributed to higher cassava yield. The residual effect of combination of dibbling of seeds + stubble mulching along with broadcast application of 60-30-30 kg NPK/ha to the first crop rice resulted in the highest cassava tuber yield of 36.7 t/ha (2013–14) and 20.3 t/ha (2014–15). These interactions were significantly superior to all the other combinations, except residual effect of broadcasting of seeds + broadcast application of 60-30-30 kg NPK/ha in the first year and dibbling of seeds + stubble mulching along with foliar spray of DAP and SoP each @ 2% in the second year, which were statistically similar.The residual nutrients and moisture conserved by stubble mulching also might added to the higher tuber yield of cassava.

The residual effect of stubble mulching using rice straw resulted in the highest pod yield of groundnut during both the years, which was significantly different from the carryover effect of the other 2 methods of weed control (Table 2). The residual effect of available soil-nutrient content after the rice crop might have enhanced the yield attributes of succeeding groundnut. Comparing the fertilizer-application methods, the residual effect of broadcast application of 60-30-30 kg NPK/ha resulted in the highest pod yield of 789.1 kg/ha in the first year which was on a par with absolute control. During 2014–15, the highest groundnut pod yield was resulted in the residual effect of DAP and SoP each @ 2% foliar spray with an increase of 23.08% compared to band placement of 60-30-30 kg NPK/ha. Similar findings were reported by Singh and Lakpale (2018) in soybean, who reported the maximum pods/plant, number of seeds/pod, seed index and higher grain yield with the application of recommended dose of fertilizer and spray of DAP @ 2% at pod-initiation stage. The residual effect of treatment combination, dibbling of seeds + stubble mulching along with broadcast application of 60-30-30 kgNPK/ha was found to record the highest pod yield which was significantly different from the other treatment combinations during the first year. In the second year, pod yield was higher in residual effect of dibbling of seeds + stubble mulching and broadcasting of seeds both along with DAP and SoP each @ 2% foliar spray (1,433.6 kg/ha and 1,410.4 kg/ha respectively) which was significantly superior to the other interactions. The similar results were observed by Singh and Singh (2014), where foliar application of DAP twice met out N and P requirement at the critical stages of the chickpea crop owing to ensured and prompt delivery of mineral nutrients to the site of photosynthesis, which leads to higher yield.

The residual effect of stubble mulching applied to the preceding first crop rice resulted in the highest pod yield of cowpea during the 2 years. Among the fertilizer application methods, during first year the maximum pod yield was noted by the residual effect of broadcasting of 60-30-30 kg NPK/ha in rice, being statistically at par with foliar spray of 19-19-19 @ 0.5%. Similar results were obtained in the second year also. Surgyan *et al.* (2018) reported that, application of N, P and K through foliar supplementation significantly influenced the grain weight/ear, grain yield and biological yield of pearlmillet. Comparing the treatment combinations, dibbling of seeds + power weeding along with foliar spray of DAP and SoP each @ 2% resulted in the highest pod yield during the first year, which was on at par with the other treatments, except dibbling of seeds + power weeding along with foliar spray of 19-19-19 @ 0.5% as well as the control. During the second year, the highest pod yield was obtained from the residual effect of dibbling of seeds + stubble mulching along with foliar spray of DAP and SOP each @ 2% in rice, being significantly superior to all other treatments, except dibbling of seeds + stubble mulching along with broadcasting of 60-30-30 kg NPK/ha in rice as well as the control, which were at par. The direct effect of applied nutrients and nitrogen fixation by cowpea and groundnut as well as the nutrient released by the decomposition of straw in rice might have contributed to higher yield in the best treatment. These results confirm the findings of with Clarkson and Scattergood (1982).

System productivity

The residual effect of dibbling of seeds + stubble mulching recorded the highest rice equivalent yield while taking the average of 2 years study and gave resulted in 9.54% and 7.33% more rice-equivalent yield than broadcasting of seeds and dibbling of seeds + power weeding respectively

Our results also support, who reported that residue incorporation in conventional tillage practised in rice–wheat cropping system for long-term period resulted in significantly higher system productivity than the other treatments the findings of Ranbir *et al* (2019). The residual effect of soil (broadcasting and band placement of 60-30-30 kg NPK/ha) as well as foliar application of fertilizer (foliar spray of DAP and SoP each @ 2%) resulted in higher rice-equivalent yield. Regarding the treatment combinations, the treatment combination of dibbling of seeds + stubble mulching along with broadcasting of 60-30-30 kg NPK/ha resulted in the highest rice-equivalent yield of 29.7 t/ha, which was superior to all the other combinations, except dibbling of seeds + stubble mulching along with foliar spray of water-soluble complex fertilizer DAP and SoP each @ 2% with an increase of 5.77%. Favorable individual effect of these treatments on yield of component crops in the system enhanced the rice-equivalent yield. The foliar fertilizers alone were not able to increase the system yield because it might not have made available the residual nutrients for a prolonged period as effective as that of soil-applied fertilizers. Fageria *et al*. (2009) also reported similar results.

It can be concluded that the residual effect of dibbling of rice seeds using drum seeder + stubble mulching @ 3 t/ha along with either soil application of 60-30-30 kg NPK/ha as broadcasting to rice or foliar spray of diammonium phosphate and sulphate of potash each @ 2% to rice would help in the sustainable production of the rice based cropping system in upland.

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