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Performance of Rice Grown after Cassava/Legume Intercrops at Badeggi in the Southern Guinea Savanna Ecological Zone of Nigeria

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Abstract

An experiment was conducted on the lowland experimental field of National Cereals Research Institute, Badeggi (9°45'N, 60°7'E, ALT 70.57[M]) in the southern Guinea savanna zone of Nigeria in 2011, 2012 and 2013 to determine the effects of cassava/legume inter-cropping patterns on grain yield of subsequent lowland rice. The result revealed that significant higher plant height, tiller/stool and grains/panicle were obtained from with rice grown after cassava/cowpea and cassava/*Aeschynomene* compared with rice grown after cassava/soybean and cassava/*Lablab*. Significantly higher rice panicles per metre, 1000 rice grain weight and rice grain yield were also observed in the same treatments. Cassava/cowpea and cassava/*Aeschynomene* are hence recommended to be planted before lowland rice.

Keywords: Performance; Rice; Growth; Cassava; Legume

Introduction

Rice is a cereal grain belonging to the grass family of *Poaceae* and to two species namely, *Oryza sativa* and *Oryza glaberrima*. It is a major staple food in both developing and developed world and its production has been essential for many countries. More than one third of the human population rely on rice for their sustenance, making it the most important of the world's food crops [1]. The potential land area for rice production in Nigeria is between 4.6-4.9 million ha. Out of this, only about 1.7 million ha or 35 percent of the available land area is presently cropped to rice [2]. This area includes five different rice environments or ecologies [3]. The upland ecology/rain fed lowland accounts for 55 to 60 percent of the cultivated rice land. An estimated 25 percent of Nigeria's rice area is under inland valley swamp rice production. The irrigated rice ecology accounts for about 18 percent of cultivated rice land and deep water or floating rice constitutes 5 to 12 percent of the national rice production area. Tidal (mangrove) swamp ecology contributes less than 2 percent to national rice production area [3].

FAO (2010; 2011; 2012) reported that world paddy production for the 2010 season was 700.7 million tonnes719.8 million tonnes and 728.7 million tonnes for 2012 respectively. *Oryza,* (2013) reported that Nigeria paddy production for 2012 was estimated at 4.2 million tonnes. World rice requirements are predicted to increase at a rate of 1.7% per year between now and 2025 (IRRI, 1993) [4].

Crop rotation has many benefits that can influence the success of crop production enterprises. Crop rotation is an essential practice in sustainable agriculture because of its many positive effects like increasing soil fertility and reducing crop competitiveness [5]. The positive effect of long-term rotation on crop yield has been recognized and exploited for centuries. During the last few decades, however, its benefits in terms of yield seem to have been ignored by farmers [6]. It is now evident that crop rotation increases yield and promotes agricultural sustainability [7].

During the off-season, rainfed rice lands are typically followed [8]. The straw and fallow weed vegetation are subjected to grazing by livestock. In a minor fraction of the area with conducive residual soil water-holding capacity, and/or a high groundwater table, upland crops, including legumes, are grown in the post-rice season. This practice is most common where the soil texture is loamy and easy to till. In well-drained rice lands, upland crops are grown prior to rice during the dry-to-wet season transition period. Very short duration crops are advantageous to permit maturity before the soil becomes waterlogged. Mungbean is a very common grain legume in the pre-rice niche.

Throughout a two years experiment, Filizadeh et al. [9] found that rice yields in rotation with soybean were higher compared with continuous rice. Rice yields from rotation plots were 17 and 21% higher in 2002 and 2003, respectively, compared with continuous rice plots. Anders et al. [10] reported higher yield of rice in rice grown after soybean than in rice wheat rotation. Grain yields of rice which had been preceded by a legume fallow were on average 0.2 mg ha^{-1} or about 30% greater than that preceded by a natural weedy fallow control, Becker and Johnson, [11] Lixiao et al. [12] stated that the grain yields of rice after fallow and upland crops rotation were compared in 2007. The rice yielded more after two seasons of upland crops than after two seasons of fallow. Among the three upland crops, maximum yield of rice was observed after two seasons of soybean. Toomsan et al. [13] recorded 50% higher rice yields in rice followed cover crop green mixtures than rice in bare fallow rotation. This study was therefore with the aim of determine the effects of cassava/legume inter-cropping patterns on grain yield of subsequent lowland rice.

Materials and Methods

The experiment was conducted at the lowland experimental field of National Cereals Research Institute, Badeggi (9°45'N, 60°7'E, ALT

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70.57 m) in the southern Guinea savannah zone of Nigeria with mean annual rainfall of 2066.3, 1163.6 and 899.7 mm distributed between April to October in 2011, 2012 and 2013 respectively with maximum and minimum temperature of 30-38°C and 14-26°C respectively. Raised beds for planting of cassava/legume intercrop were done manually. Beds were 2.5 m long, 0.5 m wide and 0.75 m high. Cassava was planted on the top sides of beds in two rows at inter and intra-row spacing of0.5 m (ten stands per bed) and legumes were planted by the sides of the beds at inter and intra-row spacing of 0. 5 m x 0. 25 m respectively except for soybean which was drilled immediately the beds were constructed. The cassava/legume intercropping was carried out between January and August using residual moisture. Velvet bean (*Mucuna puriens)*, cowpea (*Vigna unguiculata)*, soybean (*Glyxine max)*, hyacinth bean (*Lablab purpureus*) and Jointvetche (*Aeschynomene histrix)* legumes used as intercrops with cassava IIT 427 and there was sole cassava and natural fallow. The treatments were laid out in Randomized Complete Block Design and replicated three times. The plot size was 13.5 m x 5 m. The cassava/legume cropping lasted till August when cassava was harvested. Those plots previously cropped with cassava/legume intercrops were followed by rice.

Agronomic practices

Rice seedlings were raised in the nursery. The rice variety used was Faro 52. The nursery was done in the second week of July and the seedlings were ready for transplanting at three weeks after seeding. The beds made for cassava/legume intercrop were levelled manually and rice transplanting was done at a spacing of 20 x 20 cm at the rate of two seedlings per hill.

Urea (46%N), single superphosphate (18% $P_2O_{5)}$ and muriate of potash (60% K_2O) were applied to supply 80 kg/ha N, 40 kg/ha P_2O_5, 40 kg/ha K_2O/ha. The N was in split – applied in equal amounts at planting and panicle initiation. The fertilizers were applied by broadcasting method.

Hand weeding was done at 3 and 6 weeks after planting.

Data collected were

Soil sample, rice plant height, tiller/stool and panicle m^{-2}. Also taken were grains/panicle, weight of 1000 grain and grain yield. Rice height was done by measuring the rice plant from the ground level to the flag leaf using ruler at 3, 6, 9 and 12 weeks after transplanting. Tiller number was carried out by counting the number of rice plants grown after the initial two seedlings transplanted at 3, 6, 9 and 12 weeks after transplanting. Rice panicle number per meter by thrown one meter square quadrat inside rice plants in each plot and the panicles of rice that fell inside it were counted.

Grain number per panicle was determined by counting grains on the sample panicles from each plot. Weight of 1000 grains was taken after counting 1000 rice grains from each plot.

Rice grain from net plot of each plot was weighed using scale. The weight was measured in kilograms per plot which was converted to kilogram per hacter and later to tones per hacter

Results

Rice plant height (cm)

The result of soil nutrient status of experimental site is presented in Table 1 and it indicates that soil pH was slightly acidic in all the intercrops. Cassava/cowpea and cassava/*Aeschynomene* plots gave higher percentage organic carbon in all study periods and were at increased with the repetition of cassava/legume/intercrops. Nitrogen obtained in cassava/cowpea and cassava/*Aeschynomene* was 83.3%, 84.2% and 86.3% higher and those of *Mucuna,* soybean and *Lablab* were 72.7-78.5%, 71.4-75% and 38.9-52.9% when compared with natural fallow plots in 2011, 2012 and 2013 respectively. Organic carbon and available P were lower in plots where rice was grown after either sole cassava or natural fallow. Exchangeable bases were affected by cassava/legume intercrop in which 16.0-36.3%, 15.9-35.9 and 26.5-37.7% Ca, 39.6-55.7%, 40.5-56.0% and 31.8-51.8 Mg, 75.0-81.8, 66.6-75.0% and 30.0-50% K were found higher when comparing with natural fallow in 2011, 2012 and 2013 respectively.

The data on rice plant height revealed that it was significantly ($P<0.05$) affected by pre-rice cropping of cassava/legume intercrop (Table 2). The tallest rice plant was observed after cassava/*Mucuna* and cassava/*Aeschynomemne* at 3 WAT in 2011 cropping season. The height of rice grown after cassava/*Lablab*, sole cassava and natural fallow were similar at 3 WAT. At 6 WAT rice grown after cassava/*Mucuna* produced taller rice plant which was not significantly different from those obtained after cassava/cowpea and cassava/*Aeschynomemne* intercrops. Among all rice grown after cassava/legume intercrop, rice after cassava/*Lablab* produced the shortest rice plant height at 9 WAT. Rice grown after cassava/cowpea produced taller plant at 12 WAT. Generally, rice after natural fallow had the short plants and followed by sole cassava plots. In 2012 cropping season rice after cassava/*Aeschynomene* gave significant ($P<0.05$) taller rice plant height at 3 WAT while the one after natural fallow was the least (Table 2). Rice grown after cassava/*Mucuna*, cassava/cowpea and cassava/*Aeschynomene* gave similar but higher plant height at 6 and 9 WAT. However, at 12 WAT rice grown after cassava/*Mucuna* and cowpea produced taller but similar plant. The height of rice plants after natural fallow was shortest throughout the growing season (Table 2).

Rice tiller number per stool

Rice tiller number per stool was significantly affected by pre-rice

Treatments	Ph (H_2O)			Organic carbon %			Total N (g kg^{-1})			Avail P(mg kg^{-1})			Exch. Bases (cmol kg^{-1}) Ca			Mg			K			CEC(cmolkg^{-1})		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
Cassava/*Mucuna*	5.09	5.19	5.21	2.97	3.11	3.21	0.14	0.15	0.17	30.8	32.87	34.87	5.55	5.57	5.58	3.61	3.64	3.68	0.08	0.09	0.10	9.28	9.3	9.36
Cassava/cowpea	5.12	5.22	5.26	3.15	3.17	3.27	0.18	0.19	0.22	31.7	32.75	36.75	6.10	6.12	6.22	4.47	4.57	4.59	0.11	0.12	0.13	10.6	10.8	10.9
Cassava/soybean	5.23	5.33	5.36	3.13	3.16	3.26	0.13	0.16	0.17	30.7	31.76	35.76	5.30	5.33	5.35	3.41	3.51	3.57	0.09	0.11	0.13	8.80	11.1	9.05
Cassava/*Lablab*	5.10	5.30	5.35	2.94	2.94	2.24	0.11	0.14	0.13	29.8	30.86	32.86	4.6	4.63	4.64	3.28	3.38	3.39	0.09	0.11	0.13	7.97	8.12	8.16
Cassava/ *Aeschynomene*	5.61	5.62	5.69	3.29	3.30	3.33	0.18	0.19	0.21	31.7	33.78	34.78	6.10	6.21	6.23	4.47	4.57	4.58	0.11	0.12	0.14	10.6	10.9	10.9
Sole cassava	5.03	5.00	5.06	2.21	2.22	2.32	0.03	0.05	0.07	20.8	22.8	25.8	3.95	3.90	3.96	2.78	2.88	2.89	0.03	0.04	0.08	6.77	8.71	6.93
Natural fallow	5.0	5.0	5.02	2.0	2.1	2.20	0.03	0.04	0.08	28.7	29.7	30.0	3.88	3.89	3.91	1.98	2.01	2.21	0.02	0.03	0.07	5.88	5.93	6.19

Table 1: Influence of cassava/legume intercrop on soil chemical properties in 2011-2013 cropping seasons.

cropping of cassava/legume (Table 3). Generally, rice tiller number per stool was significantly higher in the order cassava/*Aeschynomene*, cassava/cowpea and cassava/soybean pre-cultivation of rice throughout the three years of study. Rice tiller number in cassava/*Mucuna*, in 2011 and 2012 were similar to that of cassava/*Aeschynomene* while that of soybean was at par with that in cassava/*Lablab* in 2013 only. The rice tiller number per stool also increased with continuous cultivation, except in the natural fallow treatment where it was declining.

Rice panicles per meter square

There was significant (P<0.05) effect of pre-rice cropping of cassava/legume on rice panicle per meter square (Table 4). Generally, rice panicle per meter square was higher under cassava/cowpea and cassava/*Aeschynomene* but was similar throughout the years of study. This was followed by cassava/soybean intercrop while it was least in cassava/*Lablab* in the three years. The natural fallow treatment had the least number of rice panicles which was followed by sole cassava throughout the years of study. It was observed that rice panicle increased with continuous cassava/legume rotation of cassava/legume intercrop with rice but decreased in rice after natural fallow in the years of study.

Rice grains per panicle

Rice grown after cassava/cowpea gave greater number of rice grain throughout the three years of study although it did not differ statistically with what was recorded in rice grown after cassava/*Mucuna* in 2011 and cassava/*Aeschynomene* in 2012 and 2013 (Table 5). This was followed closely by rice grown after cassava/soybean intercrop. Rice after cassava/soybean and cassava/*Aeschynomene* produced similar rice grain number per panicle in 2011. Rice following natural fallowing produced the least number of rice grains per panicle.

Weight of 1000 rice grain (g)

There was significant effect of pre-rice cropping of cassava/legume intercrop on the weight of 1000 rice grain (Table 6). In all the study periods, rice grown after cassava/cowpea and cassava/*Aeschynomene* gave the heaviest 1000 rice grain weight which was significantly greater than what was obtained in rice grown after the other treatments. This was followed by that in cassava/*Mucuna*. The rice following natural fallow had the least grain weight which was followed by sole cassava treatment.

Rice grain yield (kg/ha)

Rice grain yield was highest in the three years of study and in 2012 and 2013 in cassava/*Aeschynomene* respectively (Table 7). This was followed by rice grown after cassava/*Mucuna* intercrop in the three years of study. Rice grain yield in cassava/*Lablab* was least among the intercrops throughout the three years of study.

Discussions

Rice plant height was affected by cassava/legume intercropping. The taller rice plant observed in rice grown after cassava/legume intercrop could be due probably higher soil fertility status. The level of variation observed in rice plant height might be a function of differences in the preceeding cassava intercrop. This might be due to the fact that crops tend to establish and grow where soil nutrients tends to be improved. This result agrees with the findings of Morteza et al. [1] who observed variation in rice height, where rice was planted after different legumes.

Treatments	2011			2012					2013			
	Weeks after planting			Weeks after planting					Weeks after planting			
	3	6	9	12	3	6	9	12	3	6	9	12
Cassava Intercrop (CI)												
Cassava/*Mucuna*	16.6^{a}	34.9^{a}	57.5^{a}	75.5^{b}	20.1^{c}	44.0^{ab}	63.4^{as}	84.4^{ab}	21.7^{d}	53.6^{c}	70.3^{b}	93.9^{b}
Cassava/cowpea	15.8^{b}	34.3^{ab}	57.7^{a}	77.2^{a}	21.3^{b}	45.0^{a}	64.0^{a}	86.4^{a}	26.9^{b}	57.0^{b}	72.2^{a}	98.5^{a}
Cassava/soybean	15.6^{bc}	33.7^{b}	57.6^{a}	71.1^{cd}	19.4^{d}	43.3^{b}	61.7^{bc}	80.2^{c}	23.6^{c}	46.6^{d}	68.5^{c}	88.1^{c}
Cassava/lablab	15.2^{cd}	31.4^{c}	52.3^{b}	69.7^{d}	19.8^{d}	40.7^{c}	61.1^{c}	76.2^{d}	22.1^{d}	45.3^{d}	67.4^{c}	84.4^{d}
Cassava/*Aeschynomene*	16.5^{a}	34.1^{ab}	56.3^{a}	72.2^{c}	22.9^{a}	44.0^{ab}	64.0^{a}	83.6^{b}	27.5^{a}	58.7^{a}	71.4^{ab}	97.9^{a}
Sole cassava	15.1^{d}	29.7^{d}	50.9^{bc}	67.0^{e}	18.5^{e}	35.1^{d}	53.3^{d}	69.0^{e}	18.9^{e}	36.6^{e}	54.0^{d}	70.0^{e}
Natural fallow	14.8^{d}	22.2^{e}	47.5^{c}	58.7^{f}	15.7^{f}	24.8^{e}	49.5^{e}	59.7^{f}	15.2^{f}	24.3^{f}	48.7^{e}	59.8^{f}
Significant	*	*	*	*	*	*	*	*	*	*	*	*
SE±	0.1	0.3	1.3	0.5	0.2	0.4	0.6	0.6	0.1	0.5	0.5	0.6
CV%	3.4	3.3	8.5	2.6	3.3	3.7	3.6	2.7	3.0	4.0	2.9	2.4

Means followed by the same letter(s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 2: Effects of pre-rice cropping of cassava/legume intercrop on rice plant height at 3, 6, 9 and 12 WAT in 2011-2013 cropping seasons.

Treatments	2011	2012	2013
Cassava Intercrop (CI)			
Cassava/*Mucuna*	19.0^{a}	23.0^{b}	27.0^{d}
Cassava/cowpea	18.0^{b}	23.0^{b}	32.0^{b}
Cassava/soybean	16.0^{c}	22.0^{c}	28.0^{c}
Cassava/lablab	15.0^{d}	21.0^{d}	28.0^{c}
Cassava/*Aeschynomene*	20.0^{a}	26.0^{a}	33.0^{a}
Sole cassava	12.5^{e}	14.5^{e}	18.0^{e}
Natural fallow	9.3^{f}	9.0^{f}	7.0^{f}
Significant	*	*	*
SE ± CV%	0.2	0.3	0.2

Means followed by the same letter (s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 3: Effects of pre-rice cropping of cassava/legume intercrop on rice tillers/stool at harvest in 2011-2013 cropping seasons.

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Tiller number is an important yield component of rice. The variation in tiller number observed might be due to differences in legumes in the intercropping before rice.

The variation observed in rice grain per panicle might be due to the fact that legumes in intercropping system. The same was obtained by Morteza et al. [1] when rice was planted after different legumes. The higher grain number per panicle obtained in rice grown after cassava/ legume intercropping than in rice after fallow might be due to low fertility statusin the fallow system and this result is in consonance with the work of Yousefnia, Tabatabae and. Hashemi. The variation observed in 1000 rice grain weight might be probably that rice grains varies in grain filled capacity which might be the function of legumes in the rotation. This result is in consonance with the work of Morteza

Treatments	2011	2012	2013
Cassava Intercrop (CI)			
Cassava/*Mucuna*	273.0a	291.0^{a}	307.0^{b}
Cassava/cowpea	273.0a	297.0^{a}	326^{a}
Cassava/soybean	268.0b	276.0^{b}	298.0^{b}
Cassava/lablab	225.0c	250.0^{c}	298.0^{b}
Cassava/*Aeschynomene*	272.0a	298.1^{a}	327.0^{a}
Sole cassava	193.0d	180.0^{d}	188.0^{c}
Natural fallow	118.0e	116.0^{e}	144.0^{d}
Significant	*	*	*
SE±	1.1	4.5	4.5

Means followed by the same letter(s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 4: Effects of pre-rice cropping of cassava/legume intercrop on rice panicle (m^{-2}) at harvest in 2011-2013 cropping seasons.

Treatments	2011	2012	2013
Cassava Intercrop (CI)			
Cassava/*Mucuna*	126.0^{ab}	128.0^{bc}	129.0^{bc}
Cassava/cowpea	128.0^{a}	131.0^{ab}	133.0^{a}
Cassava/soybean	125.0^{b}	128.0^{bc}	130.0^{b}
Cassava/lablab	123.0^{c}	125.0^{c}	127.0^{c}
Cassava/*Aeschynomene*	125.0^{b}	133.0^{a}	134.0^{a}
Sole cassava	112.0^{d}	114.0^{d}	117.0^{d}
Natural fallow	96.0^{e}	94.0^{e}	93.0^{e}
Significant	*	*	*
SE±	0.6	1.2	0.8

Means followed by the same letter (s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 5: Effects of pre-rice cropping of cassava/legume intercrop on rice grains/ panicle at harvest in 2011-2013 cropping seasons.

Treatments	2011	2012	2013
Cassava Intercrop (CI)			
Cassava/*Mucuna*	27.7^{b}	29.0^{b}	31.0^{b}
Cassava/cowpea	30.1^{a}	31.0^{a}	33.5^{a}
Cassava/soybean	26.8^{cd}	27.0^{c}	30.2^{b}
Cassava/lablab	26.8^{cd}	27.0^{c}	30.1^{b}
Cassava/*Aeschynomene*	30.4^{a}	31.0^{a}	33.9^{a}
Sole cassava	26.5^{cd}	26.0^{d}	27.3^{c}
Natural fallow	25.5^{d}	25.0^{d}	23.6^{d}
Significant	*	*	*
SE±	0.3	0.3	0.4

Means followed by the same letter(s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 6: Effects of pre-rice cropping of cassava/legume intercrop on 1000 rice grain weight (g) at harvest in 2011-2013 cropping seasons.

Treatments	2011	2012	2013
Cassava Intercrop (CI)			
Cassava/*Mucuna*	2733.3^{b}	4565.6^{b}	4684.0^{b}
Cassava/cowpea	2933.3^{a}	4836.9^{a}	5039.6^{a}
Cassava/soybean	2200.0^{c}	3963.5^{c}	4329.5^{c}
Cassava/lablab	2066.7^{d}	3558.6^{d}	3821.7^{d}
Cassava/*Aeschynomene*	2800.0^{b}	4718.5^{a}	5000.0^{a}
Sole cassava	1466.7^{e}	2576.5^{e}	2670.0^{e}
Natural fallow	1096.7^{f}	1042.5^{f}	1005.0^{f}
Significant	*	*	*
SE±	66.7	49.2	77.1

Means followed by the same letter(s) within the same column/factor are not significantly different at 5% level of Probability (DMRT).

Table 7: Effects of pre-rice cropping of cassava/legume intercrop on rice grain yield (Kg/ha) at harvest in 2011, 2012 and 2013 cropping seasons.

et al. [1] who observed highest filled grain and highest 1000 rice grain weight in rice grown after potato.

The rice grain yield obtained from rice grown after cassava/legume intercropping varies significantly compared with rice after fallow (rice-rice) which ranged from 46.9-62.2%, 70.7-78.4 and 73.7-80.0% in 2011, 2012 and 2013 respectively. This result agrees with the work of Anders et al. [9] who reported higher rice yield in rice grown after soybean than in rice -wheat rotation. The result is in tandem with the findings of Becker and Johnson [1] that grain yields of rice which had been preceded by a legume fallow were on average about 30% greater than that preceded by a natural fallow. This also is in line with the findings of Morteza et al. [1] who obtained higher rice grain yield in rice after potato than in rice after rice. The lower rice grain yield obtained in natural fallow (rice-rice) might be due to declining factors of productivity; in agreement with the findings of Hobbs and Morris [14] The result was also in line with that of Regmi, Ladha, Pasuquin, Pathak, Hobbs and Shrestha [15]. The result was comparable to the work of Duxbury, Abrol, Gupta and Bronson and [16] and Imtiaz, Hassnain, Azeem Khan, Waqa, Abdul and Mujahid [17] who observed stagnating and even yield declines in long term experiments of rice – wheat rotation system in South Asia.

Conclusions and Recommendation

This study revealed that rice yield and yield components were affected by pre-rice cropping of cassava/legume intercrop. Rice after cassava/cassava/cowpea, cassava/*Mucuna* and cassava/*Aeschynomene* produced taller rice plant height, greater number of tiller/stool, panicle per meter square and grains per panicle. Maximum 1000 rice grain weight and rice yield was also found in rice after cassava/cassava/ cowpea, cassava/*Mucuna* and cassava/*Aeschynomene*. Therefore rice field should be not left fallowed. The rice field should be planted with cassava/cowpea and *Aeschynomene* to attain higher performance in subsequent rice cropping.

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