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Effect of Intercropping and Organic Manures on the Yield and Biological Efficiency of Cassava Intercropping System (*Manihot esculenta* Crantz.)

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Abstract: Field experiments were conducted to find out the effect of intercropping and organic manure's on the yield of cassava and the biological efficiency of the cassava intercropping system at Veterinary College and Research Institute Farm, Namakkal during 2001 and 2002. The popular hybrid of cassava H 226 was tried as test crop. Three intercropping systems viz., sole cassava, cassava+maize (var. African tall) and cassava+cowpea (var. CO 5) were assigned to main plots. Six organic manurial treatments viz., FYM (25 t ha^{-1}), Poultry manure (10 t ha^{-1}), composted poultry manure (10 t ha^{-1}), FYM (12.5 t ha^{-1})+poultry manure (5 t ha^{-1}), FYM (12.5 t ha^{-1})+composted poultry manure (5 t ha^{-1}) along with control (no organic manure) were assigned to sub plots. The study revealed that intercropping in cassava was beneficial in increasing the biological yield, tuber equivalent yield and land use efficiency. Cassava tuber equivalent yield, LER, ATER and AHER were higher in cassava+cowpea combinations. Among the manures, composted poultry manure either alone or with FYM had the highest biological yield, tuber equivalent yield and land use efficiency. The depletion of soil nutrients was lesser in sole cassava followed by cassava intercropped with cowpea.

Key words: Cassava, intercropping, poultry manure, biological efficiency

INTRODUCTION

Intercropping in cassava is a widely followed spractice in the humid and sub-humid tropics. In Latin America and Africa, cassava is most commonly associated with an early maturing grain crop such as maize or legumes. Cassava, a long season, wide spaced crop is slow in its initial growth and development and therefore, intercropping a short duration crop may increase the biological efficiency as a whole. Normally, green covers are planted with cassava for a variety of purposes such as cultural weed control, fertility and moisture conservation and forage production[1].

Among cassava growing countries, India ranks twelfth in area, but it is the seventh largest producer of cassava with a production capacity of 5.4 million tonnes from an area of 0.24 million hectares. However, India tops in productivity with 22.1 t ha^{-1} which is the highest for any country in the world[2].

Application of organic manures has various advantages like increasing soil physical properties, water holding capacity, organic carbon content apart from supplying good quality of nutrients. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In fresh poultry excreta uric acid or urate is the most abundant nitrogen compound (40-70 per cent of total N) while urea and ammonium are present in small amounts[3].

The nutritional value of unprocessed poultry manure deteriorates rapidly. Hence, the immediate processing of poultry manure to prevent its rapid decomposition and save its nutrient properties is, thus essential. Composting or the biological degradation of poultry manure produces a material with several advantages with respect to handling by reducing volume, mass of dry matter, odors, fly attraction and weed seed viability[4]. Composting poultry manure under anaerobic conditions helps for greater recovery of final product and negligible loss of nutrients particularly nitrogen[5].

Even though poultry manure contains more amount of nutrients than other manures, the research work on poultry manure is less when compared to farm yard manure, since poultry population is concentrated only in certain areas and hence the manure availability also. With this idea in view, the present study was formulated.

MATERIALS AND METHODS

Field experiments were conducted to find out the effect of intercropping and organic manures on the yield of cassava and the biological efficiency of the cassava intereropping system and Research

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Institute Farm, Namakkal during 2001 and 2002. The popular hybrid of cassava, H 226 was tried as test crop. Three intercropping systems viz., sole cassava, cassava+maize (var. African tall) and cassava+cowpea (var. CO 5) were assigned to main plots. Six organic manurial treatments viz., FYM (25 t ha-1), Poultry manure (10 t ha-1), composted poultry manure (10 t ha-1), FYM (12.5 t ha-1)+poultry manure (5 t ha-1), FYM (12.5 t ha-1)+composted poultry manure (5 t ha-1) along with control (no organic manure) were assigned to sub plots. The treatments were fitted in split plot design replicated thrice.

Two rows of intercrops were sown in between the rows of main crop as additive intercropping series.

Disease free setts of 20 cm length were prepared and planted at a spacing of 90 x 90 cm. Seeds of fodder maize and cowpea were dibbled in lines at a spacing of 30 x 20 cm accommodating two rows of intercrops between the rows of cassava. Manures were applied as per treatments and thoroughly incorporated at the time of forming beds and channels.

A fertilizer dose of 60:60:150 NPK Kg ha^{-1} was uniformly applied to all the plots. The entire dose of phosphorus, 50 per cent of recommended dose of nitrogen and 50 per cent of K were applied basally at the time of planting and the remaining 50 per cent of the recommended dose of nitrogen and potassium were top dressed in two equal splits at third and fifth month, respectively, as per the treatments. Fertilizers were applied only to the main crop. After initial and life irrigation on third day, subsequent irrigations were given to the experimental field at an interval of ten days. Three hand weeding on 30th, 60th and 90th day after planting and an earthing up at 120 DAP was given commonly for all the plots.

Composting of poultry manure was initiated using poultry manure and chopped sorghum straw. The bits of sorghum straw were mixed with poultry manure at the rate of 1:10 and packed in dug pits and closed with mud plaster. To maintain optimum moisture, water was sprinkled before it is being packed and left under anaerobic conditions for 75 days as suggested by Sims *et al*.[6] for composting poultry manure and poultry carcasses.

Biological yield of each treatment was determined by recording the total biomass produced and expressed in t ha-1. In order to compare the productivity of intercropping system, yield of cassava tuber and the fodder yield of intercrops were expressed as cassava tuber equivalent. Cassava tuber equivalent was arrived at by equating the green fodder (intercrops) cost to that of the cassava tuber as suggested by De *et al.,*[7].

Land equivalent ratio was calculated by adopting the formula given by Mead and Willey[8]. Even though sole crop of fodder maize and fodder cowpea was not included in the treatment schedule, they were raised separately and the yield was recorded for calculating LER.

The ATER was calculated by using the formula suggested by Hiebsch and McCollum[9].

$$ATER = \sum_{i=1}^{n} \{ (tiM / ti I) \times (YiI / YiM) \}$$

Where,

tiM = Duration of crop i in monocropping and
tiI = Total durationof the intercropping system
YiI = Yield of crop i in intercropping
YiM = Yield of crop i in sole cropping

The AHER was calculated using the formula suggested by Balasubramanian and Sekayange[10].

$$AHER = \sum_{i=1}^{n} \{YiI / (YiMn1)\}$$

Where,

n1 = Total number of possible harvests of crop i that could be obtained during the full intercrop period, if crop i was monocropped (n1 was taken as 4)
YiI = Yield of crop i in intercropping
YiM = Yield of crop i in sole cropping

The post harvest samples collected from each plot up to 30 cm depth were air dried under shade, powdered and sieved with a 2 mm sieve and analyzed for chemical properties using standard procedures

RESULTS AND DISCUSSIONS

Cassava Tuber yield: Intercropping systems and organic manures influenced the tuber yield of cassava. In cassava cultivation, the fresh tuber is the ultimate product that decides the benefit. Any practice that improves the yield would enhance returns and this is well known. In this study, various treatments imposed had their own influence on the tuber yield with varying magnitudes. Highest tuber yield was recorded by sole cassava followed by cassava intercropped with cowpea, which was comparable with sole cassava (Table 1). The lowest yield was associated with cassava intercropped with maize. In sole cassava, there was no competition for various resources except intra-species competition. This might have paved way for the increase in growth and yield parameters, which would have increased the yield. Many scientists[11-13] reported similar results of higher tuber yield by sole cassava.

Table 1: Effect of intercropping and organic manures on the yield (t ha^{-1}) of cassava and intercrops

	2001			2002		
Treatments	Cassava	Maize fodder	Cowpea fodder	Cassava	Maize fodder	Cowpea fodder
I_1	31.89	-	-	32.59	-	-
I_2	30.64	-	-	31.28	-	-
I_3	31.49	-	-	31.79	-	-
SEd	0.4	-	-	0.4	-	-
CD	0.88	-		0.9	-	-
M_1	21.83	2.05	0.99	22.03	8.86	6.17
M_2	31.63	2.59	1.26	32.35	10.13	7.91
M_3	32.16	2.62	1.25	32.48	10.24	8.12
M_4	34.67	3	1.42	35.44	12.56	8.32
M_5	33.62	2.66	1.33	34.1	11.21	8.15
M_6	34.15	2.81	1.31	34.92	12.41	8
Mean		2.63	1.26		10.9	7.78
SE_d	0.03	0.04	0.02	0.03	0.17	0.12
CD (P=0.05)	0.07	0.1	0.04	0.07	0.44	0.31

Even though cassava intercropped with cowpea recorded lesser yield than sole cassava, the yield reduction was not significant. There was a set back in the growth parameters due to cowpea intercropping. However, after the harvest of cowpea, the smothering effect was reduced slowly and an improvement in growth and yield parameters was obtained as evidenced in this present study and this might cumulatively have contributed for the increase in yield of cassava. Savithri and Alexander[14] reported that there was no significant difference in yield of cassava when intercropped with cowpea and this lend support to this present finding.

The reduction in tuber yield of cassava intercropped with fodder maize might be attributable to the higher competition by maize for resources in the early stages and the resultant effect on the growth and yield parameters up to harvest. Similar yield reduction by intercropping maize in cassava was reported by Ezumah *et al.*,[15] and Ikeorgu and Odurukwe[16]. Olasantan *et al.*,[17] concluded that the main factor limiting the yield in a cassava-maize intercropping system was the depression of the early cassava growth by vigorous maize component, which reduced the amount of assimilate allocated to cassava roots.

On comparing the data on yield due to the organic manures, it was clearly evident that all the treatments that received organic manures recorded higher tuber yield than no organic manure control suggesting the importance of organic manures. Higher tuber yield due to organic manures could be attributed to favourable changes in soil, which might have resulted in loose and friable soil condition and enabled better tuber formation. Moreover, positive influence of these treatments might be due to slow and steady availability of nutrients throughout the crop growth period from organic manures. Pillai *et al.*,[18] reported the beneficial effect of FYM at 12.5 t ha-1 in enhancing the yield of cassava tuber.

Adequate biomass production, better nutrient uptake and improvement in yield parameters might have resulted in higher tuber yield consequent to application of composted poultry manure either alone or in combination with FYM. Enrichment of soil N and P in available form by the addition of composted poultry manure might be responsible for good performance by CPM besides their higher NPK content compared to FYM. Jayanthi[19] reported similar result of higher yield of rice due to composted and recycled poultry manure. Increased castor seed yields due to the application of 10 t ha-1 of poultry manure was reported by Ugbaja[20] and increased egg plant yields up to 15 t ha-1 of poultry manure was reported by Opara and Asiegbu[21]. Ponsica *et al.*, [22] observed a higher efficiency of poultry manure than cattle manure in increasing the yield of maize.

Even though poultry manure had higher N than composted poultry manure, it did not record higher yield over composted poultry manure. The immediate mineralisation of N after application, at the stage, the plant had not even sprouted and the resultant loss of N by ammonia volatilization might be the reason for the relatively lesser yield recorded under poultry manure. Wolf *et al.*,[23] reported that 37 per cent of N in poultry manure was volatilized in 11 days after application, which might reduce the availability of N for plant uptake and this is concomitant to this result. Another ostensible reason might be the narrower C: N ratio of poultry manure. Low C: N ratio might have favoured aerobic fermentation in the field resulting in loss of Co2 and ammonia, thus reducing the nutrients especially N for plant uptake.

Intercrop yield: All the organic manures, especially CPM either alone or in combination with FYM recorded higher green fodder yield of both maize and cowpea (Table 1). Organic manure application, particularly CPM might have provided favourable soil conditions for the intercrops and also increased the availability of nutrients resulting in better growth and biomass accumulation, which in turn might have boosted the green fodder yield. Gangwar and Niranjan[24] earlier reported similar increase in dry matter production and green fodder yield of sorghum by application of FYM in conjunction with inorganic fertilizers.

Biological yield: The total dry matter yield of the intercropping system is denoted as biological yield and it was higher with cassava+maize intercropping, followed by cassava+cowpea than sole cassava (Table 2). The higher dry matter yield of maize evidenced in this study was the reason for the higher total dry matter yield in cassava+maize intercropping system. Olasantan *et al.*[25] reported that intercropping cassava with early maturing maize could maintain high mixture productivity and it is concomitant to this result.

Higher biological yield recorded by application of CPM either alone or with FYM might be due to the increased biomass recorded by the respective treatments in cassava and the fodder intercrops as evidenced in the present study.

Tuber equivalent yield: Cassava tuber equivalent yield was worked out mainly to evaluate the productivity of the intercropping systems. Since the intercrops tried were of different nature (maize, a cereal and cowpea, a legume), the values of intercrops were equated to the value of main crop and added to the main crop for easy comparison.

Cassava intercropped with cowpea registered the highest tuber equivalent yield than the other systems (Table 2). This might be due to the obvious reason of higher productivity of cassava in cassava+cowpea intercropping, comparable to the yield in sole crop and the cost of cowpea which was more than the cost of maize.

All the organic manurial treatments registered higher tuber equivalent yield than no manure control. The higher tuber equivalent yield registered by organic manures might be due to the higher yield of both cassava and the respective intercrops.

Land Equivalent Ratio (LER): Among the organic manures, irrespective of the intercrops, higher LER was recorded in CPM either alone or with FYM followed by PM either alone or with FYM (Table 2). This might be due to the higher yield recorded by both cassava and the intercrops under the manurial treatments.

Among the intercropping systems, cassava intercropped with cowpea registered higher LER than cassava intercropped with maize. The increased yield of base crop of cassava in cassava intercropped with cowpea, than cassava intercropped with maize might be the plausible reasons for such increase. The higher LER value was reported in cassava+cowpea combinations by many investigators. An LER of 1.48-1.56 by Mason *et al.*[26], 1.50-1.73 by Mba and Ezumah[27] and similarly higher LER values in cassava+maize intercropping; 1.36-1.84 by Ezumah[28] and 1.16 to 1.69 by Osiru and Hahn[29] are concomitant to this finding.

Area X Time Equivalency Ratio (ATER) (Table 2): Intercropping and organic manures influenced the ATER, which is a biologically logical approach for comparing productivities between two cropping systems or among several which resolves the interpretive inadequacy in LER by including duration of land occupancy in the intercrop monoculture comparisons[9]. Among the organic manures, CPM either alone or with FYM registered higher ATER, which might be because of the higher production of both cassava and the associated intercrops.

Among the intercropping systems, cassava+cowpea registered higher ATER than cassava-maize intercropping system due to the higher yield recorded by cassava in cassava+cowpea combinations. The ATER value of 1.05-1.06 recorded in this present investigation in cassava+cowpea combination is in accordance with the values arrived at; 1.13 by Mason *et al.*,[26], 1.04 by

Table 2: Effect of intercropping and organic manures on the biological yield and tuber equivalent yield (t ha^{-1}), LER, ATER and AHER of cassava intercropping systems.

	2001					2002				
Treatments	Biological Yield	Tuber Equivalent yield	LER	ATER	AHER	Biological Yield	Tuber Equivalent yield	LER	ATER	AHER
I_1	22.14	31.89	-	- -	21.48	32.59	-	-	-	
I_2	23.47	33.64	1.29	1.02	1.04	22.85	34.55	1.32	1.02	1.05
I_3	22.91	35.07	1.39	1.06	1.09	22.27	35.68	1.43	1.05	1.09
SEd	0.21	0.43	-	- -	0.22	0.42	-	-	-	
CD	0.48	0.95	-	- -	0.5	0.9	-	-	-	
M_1	17.9	23.68	1.28	1.02	1.04	16.13	23.95	1.29	1.02	1.05
M_2	23.08	33.74	1.32	1.04	1.06	22.29	34.68	1.37	1.03	1.06
M_3	22.83	34.24	1.33	1.04	1.07	22.47	34.86	1.38	1.04	1.07
M_4	25.42	37.13	1.38	1.05	1.08	25.16	38.08	1.43	1.05	1.09
M_5	23.51	35.84	1.33	1.04	1.06	23.4	36.58	1.4	1.05	1.08
M_6	24.3	36.57	1.37	1.05	1.07	23.75	37.49	1.41	1.05	1.08
SEd	0.31	0.03				0.31	0.04			
CD (P=0.05)	0.63	0.07				0.62	0.07			

Heibsch and McCollum[9] and 1.13 by Balasubramanian and Sekayange[10].

Area harvests equivalency ratio (AHER): The concept of AHER which combines the area and time factors in a practical sense for qualifying intercrop yield advantages particularly in multi-season associations, which has been shown to be a better and more practical measure of intercrop productivity by Balasubramanian and Sekayange[10] was also significantly influenced by the treatments. Application of CPM either alone or with FYM followed by PM+FYM recorded higher values of AHER attributable to the higher production in these treatments (Table 2).

Here, cassava+cowpea recorded higher AHER than cassava+maize, indicating the superiority of cowpea as a better intercrop in cassava than maize. An AHER of 1.14 in cassava+cowpea combination reported by Balasubramanian and Sekayange[10] agreed with the AHER value recorded in this study.

Post harvest soil nutrients: The reduction in soil available nutrients compared to initial status, particularly N and K in all the treatments might be due to the higher crop uptake than the quantity of nutrients applied (Table 3).

The higher available soil nutrients recorded in cassava intercropped with cowpea might be due to the leguminous nature and complementary effect of cowpea fodder. Especially after the harvest of cowpea, the N fixed by cowpea might have been taken up by cassava resulting in optimum uptake of soil nutrients especially N, without depleting the soil nutrients. Further, the organic acids produced by the residue of legumes during decomposition might have accelerated the liberation of nutrients especially available P in the soil. Swaify *et al.*,[30] reported the beneficial effect of legumes in cassava legume intercropping by nutritional contributions from their residues. Thamburaj[31] reported that the NPK content of the soil was improved due to raising of legumes in cassava.

The low available NPK recorded in cassava+maize combinations might be due to the competitive nature of maize for various nutrients. This is in conformity with the findings of Olasantan *et al.*[32] who reported that the soil fertility especially N was lower in cassava+maize intercropping than in cassava grown alone.

The available N, P and K in the post harvest soil were higher in treatments that received CPM either alone or with FYM followed by PM+FYM, PM and FYM. All the organic manurial treatments registered higher available N, P and K than no manuring. The higher NPK of the post

Table 3: Effect of intercropping and organic manures on the post harvest soil nutrient status NPK (kg ha^{-1}).

	2001			2002		
Treatments	Cassava	Maize fodder	Cowpea fodder	Cassava	Maize fodder	Cowpea fodder
Treatments	2001			2002		
	N	P	K	N	P	K
I_1	209.3	14.2	225.9	204.8	13.2	228
I_2	201	13	219.4	195.5	12.1	223.8
I_3	208.7	14.1	224.2	199.5	13.1	228.8
SEd	1.9	0.2	2.1	3.9	0.1	2.1
CD	4.3	0.3	4.6	NS	0.3	4.7
M_1	172.4	8.8	186.3	163.9	7.9	195.3
M_2	205.5	14	221.6	203.9	12.9	227.7
M_3	213	14.8	229.7	208	14	233.4
M_4	218.7	15.2	236.6	213.2	14.2	237.3
M_5	213.3	14.8	231.1	209.9	13.9	232.1
M_6	215.3	15.2	233.6	200.7	14	235.6
SE_d	2.8	0.2	3.0	6.8	0.2	3.1
CD (P=0.05)	5.6	0.4	6.1	13.5	0.4	6.2
Initial Soil Nutrient	225	16	248	216	18.5	256

harvest soil due to poultry manure might be due to its higher nutrients content. Savithri *et al.*,[33] reported a significant increase in the nutrient content of the soil after the harvest of sorghum due to the application of 6.25 t ha-1 of coir pith based poultry litter. Gupta *et al.,*[34] also concluded that the residual effect of organic manures after the harvest of wheat was in the order of poultry manure+FYM followed by PM, FYM and no organic manure which lend support to this present finding.

Conclusions: The study revealed that intercropping in Cassava was beneficial in increasing the biological yield, tuber equivalent yield, LER, ATER and AHER. Cassava intercropped with maize had the highest biological yield while Cassava tuber equivalent yield, LER, ATER and AHER were higher in cassava+cowpea combinations. Among the manures, composted poultry manure either alone or with FYM had the highest biological yield, tuber equivalent yield and land use efficiency. The depletion of soil nutrients was lesser in sole cassava followed by cassava intercropped with cowpea. Similarly, among the organic manures, composted poultry manure, either alone or with FYM had higher soil nutrients.

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