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Growth, Yield and Nutrient Content of Cassava and Mungbean Grown Under Intercropping

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Abstract

A field experiment was carried out to investigate growth, yield and yield components of cassava and mungbean and land use efficiency, economic returns, and the uptake of soil nutrients (NPK). The results showed that total top dry weights, leaf area indices (LAI), yield and yield components of cassava were not affected by intercropping patterns and did on total top dry weights and leaf area of mungbean. Whilst grain dry weights, and pods per plant of mungbean were affected by cropping patterns but not with grains per pod and 1000-grain weights. Land equivalent ratio and combined economic value were much greater for intercropping patterns than that of the sole crop both cassava and mungbean. Nutrient uptake per hectare of roots, stems, leaves of cassava were unaffected by intercropping patterns but did with that of mungbean due to the differences in plant populations. Total NPK uptake of cassava and mungbean grown together under intercropping patterns was similar to that of sole crop of cassava. However, the margin profit was much greater for intercropping plants than that of the sole crop since market prices were higher and the residues of plant materials of mungbean could be used to improve soil fertility apart from nodules of this legume crop being produced.

Introduction

Northeastern region of Thailand has been considered among the various regions of the country to be the largest producer of cassava (*Manihot esculenta* Crant). This crop has been recognised as one of the most important subsidiary cash crops apart from sugarcane. Cassava plantation usually takes place at the onset of the rainy season starting from May-June, and root yield could be harvested after being grown for 9-12 months. During the growth period, cassava normally takes at least 3-4 months to accumulate a large amount of leaves to cover ground area and then root development begins to fill up. Sole crop of cassava alone could possibly lead to the deterioration of soil fertility after several years of plantations. Therefore, to improve soil conditions and to achieve high yield of the crop it is of imperative value to investigate the growth and yield of cassava crop plants in relation to cropping patterns when grow together with legume crops such as peanut, mungbean, cowpea and soybean. These legume crops have been considered to be the suitable crops for use in intercropping patterns with cassava. They could possibly be used in improving soil fertility through its root nitrogen fixation and crop residues (Suksri, 1993). Laohasiriwong and Patanothai (1977) grown legume crops as intercropping plants with cassava and they found that the double-row intercropping pattern always produced higher yield than that of one-row intercropping pattern due to higher population per unit ground area hence, farmers attained better margins of income. Therefore, it is of significant value to carry out experiment on cropping patterns between cassava and mungbean as to specify appropriate pattern for further practices of growers of cassava particularly those growers in Northeast Thailand.

Materials and Methods

This experiment was conducted on Yasothon soil series (Oxic Paleustults) at the Experimental Farm, Khon Kaen University during 1997-1998 to investigate the effect of intercropping patterns on growth and yield of cassava and mungbean. Mean values of initial soil analysis data were 4.8 for pH, 0.04 per cent for total N, 0.72 per cent for organic matter content, 58.32 ppm for available P and 92.43 ppm for available K. Land area was ploughed twice followed by harrowing once. Two weeks before planting, dolomite was incorporated into all plots at the rate of 625kg ha^{-1}. Cassava and mungbean received a basal complete fertilizer 15-15-15 at rates of 188 and 156kg ha^{-1}, respectively. Weeding was carried out by hand - hoeing at 20 and 75 days after planting. An insecticide, Azodrin was sprayed onto the mungbean plants twice where appropriate throughout the growing season. The improved cassava variety "KU 50" and mungbean cultivar "Chainat 36" were used. The experiment was laid in a randomized complete block design with four replications and the treatments being used were as that of Table 1. The technique of growth analysis was used to measure the changes in growth of the aerial plant parts for both cassava and mungbean (Sestak, *et al.*, 1971). Cassava total top dry weights and leaf areas were measured from five plants of each replication at days 90, 180, 270 and 330 after planting. The final storage fresh root yield, storage roots per plant, and their dry weights were taken at random from ten plants of each replication and tissue analysis was carried out with the final harvest. With mungbean, eight plants from each replication were used for the determinations of dry weights and leaf areas and the plant samples were taken at days 15, 30, and 45 after sowing. The final grain

Table 1: The combinations of treatments being used for cassava and mungbean intercropping patterns with respect to their planting spaces and plant population/ha growing on Oxic Paleustults soil at Khon Kaen University.

Treatments	Row-spacing(cm)		Intra – row spacing(cm)		Population density(plants per ha^{-1})	
	Cassava	Mungbean	Cassava	Mungbean	Cassava	Mungbean
Cassava sole crop	100	-	100	-	10000	-
Mungbean sole crop	-	50	-	20	-	100000
100 x 100 cm. M1	100	50-50	100	25	10000	50000
100 x 100 cm. M2	100	30-40-30	100	25	10000	100000
200 x 50 cm. M3	200	50-50-50-50	50	25	10000	75000
200 x 50 cm. M4	200	40-40-40-40-40	50	25	10000	100000

M1 = 1 row of mungbean; M2 = 2 rows, M3 = 3 rows; and M4 = 4 rows of mungbean in between rows of cassava plants

yields and number of pods per plant were determined from 40 plants taken from each replication. Seed number per pod and 1,000 grain weights were determined from 100 pods, Leaf area measurement was carried out using leaf area meter (Model No. AAC-400, Hayashi Denko Co., Ltd. Japan). The fresh plant parts were dried in a forced air oven at 80°C for five days and then weighed out separately for dry weights of tops. Grains of mungbean were dried under the sun for 4 days and then weighed out for grain yield determinations.

Plant materials being used for plant nutrient analysis was collected presumably at physiological maturity of mungbean (60 days after planting) and cassava (330 days after planting) and they were oven dried at 60°C for five days. Nitrogen, phosphorous and potassium uptake were calculated by multiplying the quantity of dry matter of respective plant parts but excluding fallen leaves. Nutrient removal from soil was calculated but excluding stems and leaves of mungbean due to the fact that these plant materials could be used for the recycling of nutrients to the soil.

The obtained data were statistically analysed. Land use efficiency was calculated using land equivalent ratio (LER) as that of Mead and Willey (1980). That is:

$$\text{LER} = \Sigma^{n}_{i=1} (y^{I}_{i} / y^{M}_{i})$$

Where y^{I}_{i} = yield of crop derives from intercropping,
Y^{m}_{i} = yield of crop derives from sole cropping, and
n = total number of crop plants in the intercropping system.

Cassava and mungbean crops have differed in market value, hence the combined economic value (CEV) was used as the measurement of treatment productivity (Calavan and Weil, 1988). That is cassava fresh weight in kilos has to be multiplied by 2.2 cents (US currency) plus the grain yield in kilos of mungbean multiplied by 25 cents (36 Baht = 1 US dollar, the local values in Thai Baht were transformed to US dollars).

Results and Discussion

Cassava Total Top Dry Weights and Leaf Area Indices: With intercropping plants, total top dry weights (DW) of cassava were initially similar for all cropping patterns yet when the season progressed, total dry weights per hectare of cassava plants slightly increased with an increase in number of rows of mungbean and did with that of leaf area indices (LAI). The increases were found in most cases of both total dry weights and LAI. The results indicated that mungbean plants could presumably have contributed to the growth of the cassava plants by supplying some amount of nitrogen from nodules and crop residues. Total top dry weights and LAI of cassava sole cropping were similar to that of those intercropping treatments. The results indicated that sole cassava crop alone may not be of advantage since the amount of growth was not differed from the rest. LAI values reached maximum at day 180 and then declined with time to day 270 and then slightly increased to day 330. The decrease in LAI may be attributed to the advance in age of leaves and perhaps partly due to the inadequate amount of soil moisture content in dry season as suggested by Mason (1986). However, LAI values were, in most cases, greater than that reported by CIAT (1976) and Coc *et al.* (1979). They stated that maximum LAI for maximum root development should be at the values of 2-3. It has been suggested by Sornwat (1991) that LAI values for maximum root yield of cassava crop should be at the range of 4-6 as to attain 90 per cent light interception among crop canopies. LAI values of all treatments subsequently increased at final harvest at day 330. This may be attributed to the amount of rainfall, which was occurred during late growing season, hence the growth of tops (leaves) began to continue.

Yield and Yield Components: For tuber root yields and yield components of cassava, the results showed that storage root yield/ha, storage root/plant and dry weight/storage root were not influenced by intercropping patterns (Table 3). The results indicated that sole crop of cassava did not gain an advantage over those intercropping treatments. Furthermore, storage root/ha was lesser than that of the 100 x 100 cm. M1 intercropping treatment. This treatment grown with one row of mungbean gave the highest storage root yield/ha, dry weight/storage root, and harvest index (HI). However, there were no statistical differences found among the treatments. In terms of tuber root yield, and dry weight/storage root, one row of mungbean in betw

Table 2: Total top dry weights (DW. t/ha), leaf area indices (LAI) of cassava plants at days 90, 180, 270 and 330 after planting as influenced by cropping patterns and cassava plants grown as sole crop.

Treatments	Days after planting 90		180		270		330	
	DW	LAI	DW	LAI	DW	LAI	DW	LAI
100 x 100cm. M1	2.4	1.7	5.5	3.3	7.4	1.5	9.5	2.0
100 x 100cm. M2	2.3	1.7	5.6	3.5	7.5	1.5	9.6	1.9
200 x 50cm. M3	2.2	1.9	5.7	3.5	7.7	1.5	10.3	2.0
200 x 50cm. M4	2.3	1.7	6.1	3.8	8.1	1.6	11.6	2.2
Cassava sole crop	2.4	1.9	5.5	5.5	7.4	1.4	10.0	1.7
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	23.9	18.1	13.8	12.5	15.9	12.4	19.8	15.3

Table 3: Yield, yield components and harvest indices (HI) of cassava plants as influenced by Intercropping patterns and cassava sole crop.

Treatments	Storage root Dry weights (ton ha^{-1})	Storage roots per plants (number)	Dry weights per Storage roots (g)	HI
100 x 100 cm. M1	17.3	10.5	207.0	0.65
100 x 100 cm. M2	15.5	12.1	171.4	0.61
200 x 50 cm. M3	15.2	10.2	185.7	0.60
200 x 50 cm. M4	15.6	10.1	190.5	0.57
Cassava sole crop	16.3	11.1	183.7	0.64
$LSD_{0.05}$	NS	NS	NS	NS
CV (%)	20.3	10.1	13.8	9.80

rows of cassava could possibly be an ideal pattern for this intercropping system. Other treatments were somewhat inconsistently found in terms of storage dry weights, dry weights of the storage roots, and HI although there were no statistical differences found. Harvest indices were similar to those reported by Suksri and Wongwiwatchai (1988). These workers have grown cassava on the same type of soil at Khon Kaen University.

Mungbean Total Top Dry Weights and Leaf Areas Per Plant: For total top dry weights (DW) and leaf areas per plant (LA), the results showed that there were no statistical differences due to the effect of intercropping patterns found amongst the treated plants (Table 4). Total top dry weights and leaf areas increased with time to the final sampling period in all the treated plants. The results suggested that the mungbean plants were able to compete with cassava for light interception among the crop canopies i.e. there was no shading effect produced by cassava plant height affected growth of mungbean plants. At the final harvest for grains, mungbean plants were taller than that of the cassava plants (65 DAP). The results indicated that mungbean plants had its great ability to adapt themselves to such a high competitive environment as to compete for radiant energy from the sun hence, grain yield of individual plants was able to develop.

Mungbean Yield and Yield Components: Grain yield and number of pods per plant were significantly affected by intercropping patterns i.e. mungbean plants grown at four rows gave the highest grain yield than the rest but similar to that of the sole crop. Nevertheless, number of pods per plant was highest with that of 100 x 100cm M1 treatment and the rest became somewhat inconsistently found with an increase in number of rows in each treatment. There were no statistical differences due to treatment between sole crop and the 100 x 100cm. M1 treatment (Table 5). Grain dry weights/ha were highest with that of the sole crop but was not differed from the 200 x 50cm M4 treatment yet this treatment was significantly greater than the rest. The results indicated that sole crop of mungbean alone did not gain any advantage over the intercropping treatments. Number of grains per pod and 1000-grain weights were similar for all treatments. The results suggested that number of grains per pod and 1000-grain weights did not influence by intercropping patterns but perhaps the gene itself instead.

Land Use Efficiency and Economic Returns: Cassava plus mungbean intercropping treatments gave the result of land equivalent ratio (LER) from 1.66 to 1.97 for intercropping treatments compared with the value of 1.0 of sole crop of cassava (Table 6). These values equivalent to 66 to 97 per cent greater than that of the sole crop of cassava. The results indicated high output of land use efficiency. Therefore, cropping system could contribute more output to growers than sole crop. LER values for this work were relatively greater than those reported by Thongkhum (1994). With combined economic value (CEV), the results showed that the CEV was highest with 200 x 50 cm. M4 treatment (1,277 US Dollars ha^{-1}) followed by the 200x50 cm. M2 (1,256 US Dollars ha^{-1}), 200x50 cm. M3 (1,088

Table 4: Total top dry weights (DW, g/plant), and leaf areas (LA, cm^2/plant) of mungbean at days 15, 30 and 45 after planting as influenced by intercropping patterns with cassava grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	Days after planting 15		30		45	
	DW	LA	DW	LA	DW	LA
100 x 100cm. M1	0.88	129.5	6.2	310.2	20.8	808.6
100 x 100cm. M2	0.94	131.7	4.3	296.1	14.3	742.3
200 x 50cm. M3	0.92	129.5	4.5	314.3	15.4	743.1
200 x 50cm. M4	0.94	132.4	4.2	310.2	15.1	734.7
Mungbean sole crop	0.83	127.8	4.5	308.8	16.2	746.9
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS
CV (%)	15.0	6.8	18.8	11.3	30.1	12.1

Table 5: Yield and yield components of mungbean as influenced by intercropping patterns grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	Grain dry Weights (kg ha^{-1})	Pods per Plant (Number)	Grains per Pod (Number)	1000 grain weights (g)
100 x 100cm. M1	411.3	18.5	10.5	55.8
100 x 100cm. M2	640.0	13.5	09.7	58.5
200 x 50cm. M3	545.0	15.3	12.3	59.3
200 x 50cm. M4	712.7	14.4	11.5	59.3
Mungbean sole crop	737.3	15.3	11.0	58.8
$LSD_{0.05}$	90.2	3.6	NS	NS
CV (%)	22.6	12.2	5.7	8.2

US Dollars ha^{-1}) and the 100 x 100 cm. M1(1,1149 US Dollars). Whilst that of sole crop of cassava gave only 1,149 US Dollars ha^{-1} with the roughly margins of approximately 17, 15, 10 and 6 per cent for each treatment, respectively. The differences between cassava sole crop and intercropping treatments were large and statistical significance. The results vividly shown that intercropping system has its significant value in term of margin income for the growers of cassava. Apart from this, soil deterioration could be avoided largely with time. The additional income derives from cassava and legume intercropping systems has been reported by a number of workers e.g. Moreno and Hart, (1978); Ashokan *et al.* (1985), Sinthuprama, (1978).

Table 6: Land equivalent ratio (LER) and combined economic value (CEV) of cassava and mungbean crops as influenced by cropping patterns grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	LER	CEV (US Dollars ha^{-1})
100 x 100 cm. M1	1.66	1149.58
100 x 100 cm. M2	1.87	1256.92
200 x 50 cm. M3	1.70	1194.08
200 x 50 cm. M4	1.97	1277.42
Cassava sole crop	1.00	1088.44
$LSD_{0.05}$	0.631	51.16
CV (%)	14.0	13.8

Nutrient Uptake and Removal: ith nutrient uptake/ha of cassava plants, the results showed that, in most cases total nitrogen (N) uptake of stem was highest followed by tuber roots and eventually leaves and this trend was also found with phosphorous (P) uptake. That is P uptake was highest with stem followed by tuber roots and leaves. Whilst that of potassium (K) the uptake was highest with tuber roots followed by stem and leaves (Table 7). The results indicated that N has its significant effect on stem growth and did the P whilst K promotes tuber roots. The results confirmed the work reported by Suksri and Wongwiwatchai (1988). There were no significant differences among the treated cassava plants i.e. intercropping patterns had no effect on the uptake of NPK fertilizers. Furthermore, there were no differences between cassava sole crop and the intercropping plants. The results indicated that nutrient uptake was not affected by intercropping patterns.

For mungbean, the results showed that nitrogen (N) uptake/ha was highest with pods followed by leaves and least for stems whilst phosphorous (P) uptake/ha was somewhat similar for all parts of the mungbean plant. Nevertheless, potassium (K) uptake/ha, in most cases, was highest for stems followed by leaves and least with pods (Table 8). The results suggested that this legume grain crop required high K for more carbohydrates for grains as K has its important effect on electron e^- transport in the photosynthetic e^- transport chain as suggested by Suk (1998). There were some statistical differences among the

Table 7: Nitrogen (N), phosphorous (P) and potassium (K) uptake per hectare of tuber roots, stems and leaves of cassava as influenced by intercropping patterns grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf
100 x 100cm. M1	66.2	71.1	51.8	1.9	1.9	0.9	79.9	24.3	8.8
100 x 100cm. M2	59.3	73.8	52.5	1.7	2.0	0.8	71.5	25.2	7.2
200 x 50cm. M3	58.1	76.1	59.3	1.6	2.1	1.0	69.9	25.9	10.1
200 x 50cm. M4	59.6	88.3	58.7	1.7	2.4	1.0	71.8	30.1	9.7
Cassava sole crop	62.3	79.4	49.2	1.8	2.3	0.9	74.1	28.2	8.3
LSD $_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	20.3	22.3	22.2	20.3	21.8	24.2	20.3	21.8	23.8

Table 8: Nitrogen (N), phosphorous (P) and potassium (K) uptake per hectare of pods, stems, and leaves of mungbean plants as influenced by intercropping patterns grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	Pod	Stem	Leaf	Pod	Stem	Leaf	Pod	Stem	Leaf
100 x 100cm. M1	10.1	4.2	09.3	1.1	0.9	1.2	07.5	13.8	09.96
100 x 100cm. M2	15.7	6.5	13.4	1.8	1.4	1.7	11.7	21.1	14.20
200 x 50cm. M3	13.4	6.2	13.2	1.5	1.4	1.7	10.0	20.1	14.10
200 x 50cm. M4	17.5	7.3	16.9	2.0	1.6	2.1	13.0	23.8	17.30
Mungbean sole crop	18.1	7.7	17.1	2.0	1.7	2.2	13.5	25.2	18.20
LSD $_{0.05}$	04.32	02.37	04.17	0.61	0.51	1.53	03.21	07.71	04.41
CV (%)	22.6	13.5	15.9	22.5	13.5	15.8	22.60	13.50	15.80

treatments. This could be attributed to the differences in the number of plant populations. However, an increase in number of rows of mungbean gave no differences between the intercropping plants and mungbean sole crop particularly from 100 x 100cm M2 treatment upward.

With the total amount of soil nutrients taken up by both cassava and mungbean plants, the results showed that the amounts of nitrogen (N), phosphorous (P), and potassium (K) taken up by the plants in all intercropping plants and sole crop of cassava were similar. There were no statistical differences found (Table 9). The results indicated that cassava sole crop has no advantage over all intercropping patterns since the amounts of soil nutrients taken up by the intercropping plants both cassava and mungbean together were not greater than the sole crop of cassava. However, nutrient contents of stem plus leaves of mungbean were not included since these plant materials were used in recycling the nutrients to the soil. Therefore, it could be inferred that growing cassava sole crop gave less amount of income as previously discussed, hence whenever cassava crop is to be cultivated, it is necessary to apply the method of intercropping systems to all cultural practices of cassava. To sum up, it was evidently shown that cassava plus mungbean intercropping patterns increase land use efficiency and economic returns over cassava sole crop. The 200 x 50cm. M4 and 100 x 100cm. M2 were similarly shown in terms of yield and economic advantage. However, the . 100 x 100cm. M2 treatment could be considered to be the ultimate recommendation for practices to the growers whilst the 200 x 50cm. M4, in general, had much wider empty spaces between cassava rows and then this could favour the growth of weeds after the harvest of mungbean.

Table 9: Comparison between cassava sole crop and intercropping plants (whole plants of cassava plus mungbean) on nutrient (NPK) removal from soil as influenced by intercropping patterns grown on Oxic Paleustults soil at Khon Kaen University.

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
100 x 100cm. M1	194.7	5.9	120.3
100 x 100cm. M2	201.3	6.2	115.6
200 x 50cm. M3	206.8	6.3	115.9
200 x 50cm. M4	224.0	7.1	124.9
Cassava sole crop	190.8	4.9	111.6
LSD 0.05	NS	NS	NS
CV (%)	15.3	12.2	15.6

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