CROP ROTATION OF SWEET POTATO, CASSAVA, AND GABI WITH LEGUMES AS A CULTURAL MANAGEMENT SYSTEM

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ABSTRACT

Mungbean, bushbean, soybean and peanut planted in rotation with sweet potato did not significantly affect the vine length and fresh weight of the vegetative parts of the root crop but increased its marketable and total tuber yield. However, only the plants rotated with mungbean showed a significant increase in yield over the control.

Rotation planting of cassava with leguminous crops did not affect its yield and yield components as well as the agronomic characters studied.

Planting gabi in rotation with peanut significantly increased corm production compared with the mungbean and bushbean treatments. No pronounced effect of the other treatments on yield was noted. The weight of corms per plant and the corm yield per hectare of gabi showed similar response to the treatments while the number of runners per plant and plant height were not significantly affected by the treatments.

Cost and return analysis showed that among the legumes used as rotation crops, peanut yielded the highest combined net return regardless of the root crop used. This manifests that peanut-root crop rotation is the most profitable cropping pattern.

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KEY WORDS: Crop rotation. Root crops. Legumes. Cultural management. Cropping system.

INTRODUCTION

Exhaustive crops such as cereals and root crops must not be planted continuously for several seasons. Root crops like cassava, sweet potato and gabi are heavy users of soil nutrients particularly nitrogen, phosphorus and potassium. Their continuous cropping on the same piece of land decreases soil fertility and eventually results in low yield. Patterson and Speights (1964) noted that growing sweet potato on the same soil for 2 years reduced the percentage of roots by approximately 33% and 12% of the total yields for the second and third crops, respectively. For cassava, it was suggested that it should not be grown in the same field for three consecutive seasons unless the soil is properly managed.

Decrease in soil productivity caused by continuous planting may be corrected or slowed down by fertilizer application. However, due to the increasing cost of inorganic fertilizers especially N fertilizer, it has become imperative to explore cheaper means of augmenting soil fertility and productivity. One way of doing this is by adopting a cropping system, such as a rotation scheme among others, that will enable the crops to utilize the limited amount of fertilizers in a complementary manner.

The value of good crop rotation is usually measured by its effect on land productivity and/or its economic return. Studies have shown that the use of legumes in a crop rotation system increases the yield of the succeeding crops. The yield-increasing effects of crop rotation have been attributed to various factors including the improvement of soil fertility particularly when legumes are involved (Phillips and Norman, 1961 and Benninson and Evans, 1968 as cited by Lombin, 1981), the enhancement of balanced nutrient removal from the soil, and the improvement of physical properties such as aggregation, soil-water-holding capacity, and infiltration (Barber, 1959). Other known advantages of crop rotation include soil conservation, organic matter restoration, and insect pests and diseases control (Donahue, 1970). It has also been noted that the improvement of the soil brought about by planting legumes is primarily accomplished through the symbiotic. N_2-fixation of the crop (Sutherland et al., 1961).

In root crop-legume rotation scheme, the legumes may favorably affect the performance of the root crops planted in succession depending on the cultural practices employed, the legume used, and the prevailing environmental conditions in the area. In choosing the specific legume to be planted in rotation with root crops, adaptability must be considered along with the economic viability of the practice.

This study was conducted to evaluate and select promising legumes that could be used in crop rotation with sweet potato, cassava and gabi; to develop an effective cropping system utilizing selected promising legumes with sweet potato, cassava and gabi for optimum productivity per unit time; and to determine whether the legumes could supplement the needed inorganic fertilizer to maintain soil fertility.

MATERIALS AND METHODS

The experimental area was laid out in a randomized complete block design (RCBD) with three replications. Five different treatments (four with legumes and one without legume) were used in the rotation scheme.

Legumes were planted first under the required population densities: 300,000; 133,333; 200,000; and 200,000 plants/ha for mungbean (MG 50A), bushbean (Los Banos No. 2), soybean (TK 5), and peanut (Coronadal), respectively. Bushbean and mungbean were harvested at 2 months after planting while soybean and peanut at 3 months after planting. The plant residues were returned to the field and plowed under after harvest. Sweet potato (BNAS 51) was planted at a distance of 100 x 25 cm; cassava (Golden Yellow) at 100 x 75 cm, and gabi (Kalpao) at 50 x 50 cm. Each treatment plot measured 7 m x 5 m. Sweet potato was harvested 4 months after planting while cassava and gabi at 8 months after planting. Monoculture of the root crops was also done in separate plots for comparison.

The area was fertilized at the rate of 50 kg/ha each of P and K prior to the planting of both legumes and root crops. Other field management practices such as weeding, control of insect pests and diseases, irrigation, and cultivation were done whenever necessary.

RESULTS AND DISCUSSION

Sweet Potato

Sweet potato yield varied with the different croppings and different legumes planted in rotation (Tables 1 anu 2). Tuber yield was highest (15.96 tons/ha) during the first cropping and significantly decreased in the subsequent croppings except in the fifth cropping when the yield abruptly increased to a level comparable to that in the first cropping.

It was observed that the amount of rainfall directly influenced sweet potato tuber production. The total rainfall during the growing periods in the first (December 19, 1977 – April 29, 1978) and the fifth (March 4 – July 4, 1981) croppings was within the range of 800-860 mm (Table 3). In the second, third, and fourth croppings (October 19, 1978 – February 20, 1979; July 14 – November 30, 1979; and April 30 – October 8, 1980, respectively), the total amount of rainfall during the growing periods of sweet potato was within the 1200-1600 mm range. The amount of rainfall during the first and fifth croppings was within the range required for better growth of the crop. This favored tuber initiation and bulking and resulted in higher tuber yields than the other croppings. Pardales, Jr. (1981) reported that an annual rainfall of 250-1000 mm is best for this crop. The rainfall during the second to the fourth croppings was therefore too high for sweet potato to produce high tuber yield, hence yield reduction was observed after the first cropping. Ibekwe (1979) mentioned that high moisture levels over a period of several days, especially at 40 to 50 days after planting, coupled with good soil fertility, make sweet potato plants excessively vegetative at the expense of tuber formation.

However, no excessive vegetative growth was observed in this experi-

Table 1. Some agronomic characters and yield and yield components of sweet potato as influenced by different croppings.

Treatment (Cropping No.)	Vine Length (cm)	Fresh Wt. of Vegetative Parts/ Plant (kg)	No. of Tubers/Plant		Yield (t/ha)		Total Tuber Yield (t/ha)
			Marketable	Non-marketable	Marketable	Non-marketable	
First	350.86 c	0.37 b	1.07 ab	0.86	13.11 a	2.85 a	15.96 a
Second	296.62 c	0.46 b	0.60 c	0.84	7.06 bc	2.67 a	9.73 b
Third	447.56 b	1.25 a	0.28 d	0.50	2.71 c	1.43 b	4.15 b
Fourth	537.48 a	0.47 b	0.82 bc	0.69	3.73 c	1.20 b	4.93 b
Fifth	313.39 c	0.43 b	1.14 a	0.76	12.56 ab	1.73 ab	14.29 a
Mean	386.76	0.60	0.78	0.73	7.83	1.98	9.81
C. V. (%)	15.82	37.15	28.51	41.16	57.08	1.98	9.81

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

Table 2. Some agronomic characters and yield and yield components of sweet potato as affected by rotated legumes.

Treatment (Legume)	Vine Length (cm)	Fresh Wt. of Vegetative Parts/Plant (kg)	No. of Tubers/Plant		Yield (t/ha)		Total Tuber Yield (t/ha)
			Marketable	Non-market-	Marketable	Non-market-	
W/o legume	373.61	0.53	0.70 bc	0.65	6.25 c	2.02	8.27 b
Mungbean	378.34	0.60	0.81 abc	0.68 b	9.03 a	2.02	11.05 a
Bushbean	382.56	0.65	0.85 ab	0.80 ab	8.48 ab	1.96	10.44 ab
Soybean	421.26	0.62	0.67 c	0.59 b	6.98 bc	1.90	8.88 ab
Peanut	378.01	0.59	0.87 a	0.95 a	8.43 ab	1.99	10.42 ab
Mean	386.76	0.60	0.78	0.73	7.83	1.98	9.81
C. V. (%)	16.13	32.03	18.86	33.02	24.05	40.06	21.42

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

Table 3. Monthly rainfall (mm) in ViSCA throughout the duration of the study (August, 1977 – December, 1981).*

Month	1977	1978	1979	1980	1981
January	176.9	339.9	151.1	356.9	431.8
February	446.9	139.3	57.9	266.6	87.6
March	125.7	158.3	42.7	57.7	41.9
April	46.7	130.3	190.1	149.4	70.1
May	121.8	146.6	138.8	24.9	88.2
June	203.9	142.0	304.1	357.9	363.0
July	337.5	214.7	237.7	271.2	293.8
August	477.2	424.2	81.6	457.9	123.7
September	219.7	462.0	209.4	298.4	382.7
October	76.6	278.4	384.2	191.7	273.8
November	224.2	181.5	269.6	506.9	297.0
December	65.6	472.7	258.9	230.9	266.3

*Data were taken from the PAG-ASA Station, ViSCA, Baybay, Leyte.

ment. It is speculated that during periods of heavy rain, some soil nutrients might have been lost due to excessive moisture. Moreover, heavy rains did not occur during the early growth stages of sweet potato in most of the croppings conducted. Although nutrient losses from the soil occurred during periods of heavy rain, its negative effect on the crop could have been minimized since sweet potato already had well-developed root system and was capable of utilizing some of the available soil nutrients. Moreover, the fertility of the soil might have been just enough to produce the observed tuber yield of sweet potato.

Highest total tuber yield (11.05 tons/ha) was obtained from mungbean-sweet potato rotation. This significantly differed from the control but was statistically comparable to the yields of treatments using the other legumes (Table 2).

Sweet potato rotated with mungbean, bushbean and peanut produced average marketable yields of 9.03, 8.48, and 8.43 tons/ha, respectively, which were significantly higher than the yield of the control (6.25 t/ha). Soybean planted as a rotation crop failed to enhance the marketable root yield of sweet potato. Apparently, sweet potato production was influenced by the rotated legumes.

The average sweet potato yield per cropping increased by 81.69% when rotated with mungbean, followed by bushbean (70.62%) and peanut (69.62%) rotations compared to continuous monoculture (Table 4). Lowest percent yield increase of 25.75% was observed in the control wherein sweet potato was planted and the field was

Table 4. Percentage yield change of root crops per cropping when planted in rotation with different legumes (based on the average yield per cropping of the continuous monoculture crops).

Treatment	Yield per Cropping (tons/ha)	% Increase (+) or Decrease (–)
Legume-sweet potato rotation		
W/o legume	6.25	25.75
Mungbean	9.03	81.69
Bushbean	8.48	70.62
Soybean	6.98	40.44
Peanut	8.43	69.62
Monoculture (continuous)	4.97	–
Legume-cassava rotation		
W/o legume	24.41	35.61
Mungbean	20.53	14.06
Bushbean	22.84	26.89
Soybean	22.58	25.44
Peanut	24.92	38.44
Monoculture (continuous)	18.00	–
Legume-gabi rotation		
W/o legume	7.73	– 0.38
Mungbean	6.29	– 18.94
Bushbean	6.01	– 22.55
Soybean	7.15	– 7.86
Peanut	8.72	12.37
Monoculture (continuous)	7.76	–

left idle after harvest for a period of one legume cropping.

Although mungbean-sweet potato rotation produced the highest yield, it did not give the highest net return (Table 5). The highest net income per cropping was obtained from peanut-sweet potato rotation. Peanut produced higher yield and also commanded a good market price. Mungbean and bushbean used in crop rotation are also promising.

Cassava

The tuber yields varied in the different croppings (Table 6). A decreasing trend in total tuber yield similar

Table 5. Combined cost and return analysis per hectare per cropping of root crops and legumes under a rotation scheme and of monoculture root crops.

Treatment	Total Gross Income/ Cropping (₱)	Total Expenses/ Cropping (₱)	Total Net Income/ Cropping (₱)
Legume-sweet potato rotation			
W/o legume	3125.00	2458.00	667.00
Mungbean	7945.74	4952.00	2993.74
Bushbean	7402.22	5007.00	2395.22
Soybean	7843.10	5374.00	2469.10
Peanut	9521.96	5462.00	4059.96
Legume-cassava rotation			
W/o legume	8543.50	2995.00	5548.50
Mungbean	13940.64	5487.78	8452.86
Bushbean	14115.51	5007.00	8572.68
Soybean	16155.08	5374.00	10244.08
Peanut	16379.40	5462.00	10380.40
Legume-gabi rotation			
W/o legume	5797.50	3128.00	2669.50
Mungbean	7471.28	4952.00	1853.28
Bushbean	8563.06	5007.00	2886.06
Soybean	8980.70	5374.00	2936.70
Peanut	12461.48	5462.00	6329.48
Monuculture (root crop)			
Sweet potato	2485.00	1958.00	527.00
Cassava	6300.00	2495.00	3805.00
Gabi	5820.00	2628.00	3192.00

to that obtained in sweet potato was observed. This indicates that continuous legume-cassava rotation croppings would reduce soil productivity despite the incorporation of legume residues and the addition of inorganic fertilizers during each planting. Unlike sweet potato, cassava yield was not adversely affected by excess rainfall during the growing period of the crop in this experiment. Highest rainfall of 2157.3 mm was observed during the

Table 6. Some agronomic characters, yield and yield components of cassava as influenced by different croppings.

Treatment (Cropping no.)	Plant Height (cm)	Fresh Wt. of Stalks/ Plant (kg)	No. of Tubers/Plant		Yield (t/ha)		Total Tuber Yield (t/ha)
			Market-able	Non-market-able	Market-able	Non-market-able	
First	327.62 a	2.42 a	7.83 a	5.58 a	27.77 a	4.21 a	31.98 a
Second	259.07 b	1.82 ab	6.10 b	3.00 b	25.44 a	2.88 b	28.32 a
Third	192.91 c	0.85 b	5.02 c	4.69 ab	15.95 b	4.00 a	19.96 b
Mean	259.86	1.69	6.32	4.42	23.05	3.70	26.75
C. V. (%)	13.04	36.29	7.51	25.98	20.45	24.93	16.10

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

first cropping (December 29, 1977 – October 29, 1978) when highest tuber yield was obtained. A rainfall of 1859.3 mm was observed during the last cropping (August 23, 1980 – April 30, 1981) when tuber yield was lowest. According to Baker et al. (1981), a rainfall exceeding 1000 mm with a distribution which would allow growth for at least 9 to 10 months is desirable for cassava.

Total tuber yield of cassava was directly related to the number and weight of marketable tubers, plant height and fresh weight of stalks per plant. Highest values were obtained in the first cropping and values declined during the subsequent croppings (Table 6).

Planting legumes in rotation with cassava did not increase the yield and yield components of cassava (Table 7). Cassava production was not infuenced by the nitrogen fixed by the legumes and the decomposed organic matter of the leguminous crops which were plowed under.

Although the treatments with and without rotated legumes did not differ in yield, the tuber yields of these treatments were 14-38% higher than that of continuous monoculture cropping (Tables 4 and 7) Peanut planted in rotation with cassava showed a 38.44% increase in yield over cassava monoculture. This combination also gave the highest combined net return (Table 5). However, the other legumes used also proved to be promising in terms of combined monetary benefits compared to cassava monoculture. Due to the higher seed yield and higher market price of peanut, higher combined net returns from peanut and cassava were obtained in one year of rotation planting. However, it only slightly differed from the soybean-cassava combination.

Gabi

Gabi yield significantly decreased after the first cropping (Table 8). Results suggest that the inherent fertility of the soil was just enough to give high corm yield in the first cropping. Subsequent reduction in soil fertility might have occurred due to continuous legume-root crop plantings, and this caused a significant decrease in gabi corm yield in the succeeding croppings. Furthermore, the amount of nutrients and organic matter that the legumes contributed to the soil including the fertilizer applied every cropping must have been inadequate to increase or even sustain the yield of gabi. No significant differences in corm yield were noted from the second to the fourth croppings.

Corm yield of gabi did not significantly increase regardless of legumes rotated with it or whether it was rotated with legumes or not (Table 9). However, the highest corm yield was obtained when gabi was planted after peanut. Peanut produced higher seed yield compared to soybean and mungbean. This is a major advantage of using peanut in a rotation scheme if higher return is desired.

The yield of gabi whether grown after legumes or with no rotated legumes (control) was statistically the same because the decomposed organic

Table 7. Some agronomic characters, yield and yield components of cassava as affected by rotated legumes.

Treatment (Legume)	Plant Height (cm)	Fresh Wt. of Stalks/ Plant (kg)	No. of Tubers/Plant		Yield (t/ha)		Total Tuber Yield (t/ha)
			Market-able	Non-market-able	Market-able	Non-market-able	
W/o legume	264.00	1.72	6.70	4.40	24.21	3.57	27.98
Mungbean	267.13	1.74	5.77	4.39	20.53	3.69	24.22
Bushbean	251.69	1.68	6.43	4.56	22.84	3.94	26.77
Soybean	246.10	1.49	6.21	4.44	22.58	3.57	26.15
Peanut	270.40	1.84	6.47	4.31	24.92	3.72	28.64
Mean	259.86	1.69	6.32	4.42	23.05	3.70	26.75
C. V. (%)	7.47	28.86	12.15	17.91	14.76	15.97	12.70

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

Table 8. Some agronomic characters, yield and yield components of gabi as influenced by different croppings.

Treatment (Cropping No.)	Plant Height (cm)	No. of Runners/ Plant	Fresh Wt. of Stalks/ Plant (kg)	Wt. of Corm/ Plant (kg)	Corm Yield (t/ha)
First	120.55 a	4.85 a	0.44 a	0.30 a	12.04 a
Second	99.90 ab	2.46 b	0.28 b	0.15 b	5.92 b
Third	89.38 b	2.04 b	0.21 b	0.13 b	5.09 b
Fourth	91.04 b	1.90 b	0.28 b	0.14 b	5.65 b
Mean	100.22	2.81	0.30	0.18	7.18
C. V. (%)	15.16	42.98	30.82	35.41	33.22

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

Table 9. Some agronomic characters, yield and yield components of gabi as affected by rotated legumes.

Treatment (Legume)	Plant Height (cm)	No. of Runners/ Plant	Fresh Wt. of Stalks/ Plant (kg)	Wt. of Corm/ Plant (kg)	Corm Yield (t/ha)
W/o legume	101.40	2.89	0.30 b	0.20 ab	7.73 ab
Mungbean	93.97	2.45	0.21 b	0.16 b	6.29 b
Bushbean	93.62	2.70	0.22 b	0.15 b	6.01 b
Soybean	100.72	2.79	0.31 ab	0.18 ab	7.15 ab
Peanut	111.37	3.22	0.48 a	0.22 a	8.72 a
Mean	100.22	2.81	0.30	0.18	7.18
C. V. (%)	16.83	27.65	48.42	30.64	30.29

Treatment means within a column followed by a common letter are not significantly different from each other at 5% level, DMRT.

matter and the nitrogen fixed by the legumes might have been utilized during the early vegetative growth of the root crop. Moreover, corm production was not benefited by the rotation planting of legumes due to the long growth duration of gabi.

The vegetative material of gabi when planted after peanut was significantly heavier than when it was planted without legumes in rotation. However, their corm yields did not differ significantly, indicating that the effect of the legumes was more on the vegetative growth rather than on corm production. The number of runners per plant and plant height did not vary among treatments.

A 12.37% increase in the average yield per cropping of gabi was obtained when it was planted in rotation with peanut as compared to that of continuous monoculture (Table 4). All the other treatments showed reduction in yield. Although the yield of gabi rotated with peanut was not significantly different from the control, this treatment gave the highest economic returns (Table 5). It also produced the highest total net income in one year compared to the other combinations. Therefore, peanut-gabi upland rotation appears to be most profitable based on the combined benefits from growing the two crops on the same piece of land.

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