ROOT CROPS-LEGUMES ROTATION AT VARYING FERTILIZER LEVELS

Alfredo B. Escasinas, Rodolfo G. Escalada and Mario E. Baliad

Instructor and Professor, Department of Agronomy and Soil Science, and Research Assistant, Philippine Root Crop Research and Training Center (PRCRTC), Visayas State College of Agriculture, Baybay, Leyte, Philippines.

Funded by the Philippine Council for Agriculture and Resources Research and Development (PCARRD) and the International Development Research Centre (IDRC), Canada.

ABSTRACT

Sweet potato yield was not significantly affected by fertilizer application even at the rate of 90-60-60 kg NPK/ha. Similar result was noted in cassava root yield. Fertilizer application in gabi at the rate of 0-60-60 kg NPK/ha resulted in 4.98 t of corms per hectare. This did not significantly differ from corm yield obtained at 30-60-60 and 90-60-60 kg NPK/ha.

Planting root crops in rotation with legumes even without applying inorganic fertilizers may be employed and reasonable yields can still be obtained. It appears that all the legume crops used were promising and can be used in rotation with the root crops to increase land productivity. However; mungbean, bushbean, and soybean produced the highest gross and net income when planted in rotation with gabi, cassava, and sweet potato, respectively, and contributed greatly to the total income.

Ann. Trop. Res. 8: 87-95.

KEY WORDS: Crop rotation. Fertilizer levels. Inorganic fertilizer. Legumes. Root crops. Organic matter.

INTRODUCTION

Intensive and continuous land cultivation tends to exhaust soil nutrients rapidly such that good soil management is required to sustain optimum crop yields. Patterson and Speights (1964) mentioned that exhaustive crops such as cereals and root crops must not be grown continuously in the same area for several seasons. For example; cassava, sweet potato and gabi heavily use soil nutrients especially N, P, and K.

Decrease in soil fertility due to continuous cropping may be slowed down or corrected by applying fertilizers which may either be inorganic or organic. The inorganic form is more commonly used. However, due to its prohibitive cost and frequent non-availability, alternative sources should be explored.

Cropping systems, specifically crop rotation, enable the crops to utilize complementarily the limited amount of fertilizers. The use of legumes in a crop rotation scheme may increase yield of succeeding crops due to amendment of soil N, restoration of organic matter, minimized build-up of insect pests, and reduced incidence of diseases (Donahue, 1970). Improvement of soil due to planting of legumes in a crop rotation system is mainly through the symbiotic nitrogen fixation of the crop (Sutherland et al., 1961).

The legume plant materials incorporated into the soil plus the amount of N fixed by the plant contribute only a small amount of nutrients to the soil. Hence, the inherent fertility of the soil should be augmented with inorganic fertilizers. This study attempted to determine the amount of inorganic fertilizer needed by root crops to supplement the nutrients provided by the legume rotation crops; and to evaluate and select promising legumes for rotation with sweet potato, cassava, and gabi for optimum land productivity per unit time.

MATERIALS AND METHODS

An experimental area of 1,836 m^2 was alternately plowed and harrowed at 1-week interval. The split plot arranged in randomized complete block design (RCBD) with three replications was used. Legumes (mungbean, bushbean and soybean) were assigned as the main plots and the five fertilizer levels (0-0-0, 0-30-30, 0-60-60, 30-60-60, and 90-60-60) as the subplots. Each subplot measured 35 m^2 (7 m x 5 m). Before planting, the root crops (sweet potato, cassava, and gabi) were applied with specific fertilizer treatments while the legumes were fertilized at the rate of 50 kg each of P and K per hectare.

The rotation scheme started with root crops as the first crop. The planting dates of legumes and root crops and the intensity of cropping per year were varied, particularly for short-term crops such as sweet potato. Under this scheme, two croppings of sweet potato and one cropping of the legume crop were made in a year.

Each root crop was planted using the following spacings: sweet potato (BNAS-51) - 100 x 25 cm; cassava (Golden Yellow) - 100 x 75 cm; and gabi (Kalpao) - 50 x 50 cm. Weeding, control of insect pests and diseases, irrigation, and cultivation were done whenever necessary.

After harvesting each root crop, the legumes were planted using the recommended plant populations of 300,000, 133,333, and 200,000 plants per hectare for mungbean (MG 50-A), bushbean (Los Baños #2), and soybean (TK-5), respectively. The plant residues were returned to the field after each harvest.

RESULTS AND DISCUSSION

Sweet Potato

No significant differences in vine length, herbage weight, number and weight of marketable roots, and total root yield of sweet potato were observed regardless of the legume species used as rotation crop. Total root yield ranged from 6.21 to 7.29 t/ha in sweet potato-legume rotation. No interaction effects were noted between legumes and fertilizer levels. Similarly, the total yields of sweet potato were not significantly affected by the different fertilizer levels although the length and weight of vines, and the number of roots per plant were affected (Table 1). Even without application of inorganic fertilizer, sweet potato still produced reasonable yields when rotated with legumes.

Highest gross and net income were obtained from sweet potato rotated with soybean (Table 2). Generally, higher net income was obtained from the crop rotation system without application of fertilizer compared to those that received inorganic fertilizer. This could be attributed to the added cost of the commercial fertilizer and other labor inputs which increased the total cost of production.

Cassava

Most of the parameters studied on cassava including total root yield did not vary with the legumes used in rotation (Table 3). Similarly, interaction between legumes and fertilizer levels was not significant. On the average, the total root yields of cassava ranged from 24.06 to 26.70 t/ha when rotated with legumes.

Application of P and K without nitrogen both at 30 and 60 kg/ha did not increase the yield of cassava. However, plants applied with 30 and 60 kg/ha of nitrogen in addition to P and K yielded higher than those that received P and K only. The yield of the control plants was statistically similar to that of fertilized plants suggesting that on the basis of total yield, application of inorganic fertilizer could be dispensed with. Cassava might have utilized considerable amounts of the nutrients released from the decomposing organic matter including the nitrogen fixed by the legumes.

In a related experiment where root crops were planted ahead of legumes, rotation planting with leguminous crops did not affect the yield of cassava (Escasinas and Escalada, 1984). It is probable that due to the inherent fertility of the soil, and cassava being a deep-rooted crop capable of extracting nutrients beyond the soil surface, the fertilizer applied to the soil surface was not fully utilized by the crop thus, the non-significant plant response.

Cost and return analysis revealed that cassava rotated with bushbean produced higher gross income and consequently higher net return (Table 4). Even without application of inorganic fertilizer, rotation planting of cassava with legumes seems profitable.

Table 1. Agronomic characters and yield of sweet potato as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Length of Vines (cm)	Wt. of Vines/Plant (kg)	No. of Roots/Plant		Yield (t/ha)		Total Root Yield (t/ha)
			Marketable	Non-Marketable	Marketable	Non-Marketable	
Legume							
Mungbean	385.62	0.46	1.25	1.21b	5.14	1.06b	6.21
Bushbean	402.26	0.49	1.18	1.51a	4.71	1.36a	6.07
Soybean	399.35	0.51	1.30	1.31ab	5.98	1.31a	7.29
Fertilizer Level (kg NPK/ha)							
00-00-00	373.02b	0.42b	1.39a	1.50a	5.31	1.32a	6.63
00-30-30	395.55ab	0.49ab	1.04c	1.06b	4.67	0.79b	5.46
00-60-60	368.95b	0.47ab	1.25ab	1.11b	5.78	1.33a	7.11
30-60-60	407.94ab	0.53a	1.11bc	1.50a	4.47	1.33a	6.07
90-60-60	433.25a	0.51a	1.42a	1.55a	5.89	1.49a	7.34

[1] Average of three croppings. In a column, treatment means followed by a common letter are not significantly different at 5% level, DMRT.

Table 2. Summary of the combined cost and return analysis of sweet potato production as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Gross Income (₱/ha)	Total Expenses (₱/ha)	Total Net Income (₱/ha)
Legume			
Mungbean	10712.10	5070.40	5641.70
Bushbean	9102.16	5053.40	4048.76
Soybean	12307.55	5420.40	6887.15
Fertilizer Level (kg NPK/ha)			
00-00-00	10722.94	4611.00	6111.94
00-30-30	10402.94	4891.00	5511.94
00-60-60	10959.60	5171.00	5788.60
30-60-60	10439.60	5548.00	4891.60
90-60-60	11011.27	5686.00	5325.27

[1] Average of three croppings.

Gabi

The yield of gabi did not considerably vary with the legume crop used in rotation with it (Table 5). Likewise, no significant interaction effect on the yield of gabi was observed between legumes and fertilizer levels used. However, the agronomic characters and yield except the number of suckers per plant were significantly affected by the different fertilizer treatments.

Corm yield increased with application of fertilizer at higher rates. An average corm yield of 5.63 t/ha was obtained with application of 90-60-60 kg NPK/ha and this was comparable to yields obtained from application of 0-60-60 and 30-60-60 kg NPK/ha. This result shows that gabi could still produce comparable yields at these fertilizer levels provided that legume rotation is practised.

Cost and return analysis revealed lowest income when gabi-soybean rotation was employed (Table 6). However, highest net return was obtained when mungbean was used in the rotation scheme. Higher net return was obtained from gabi without fertilizer application com-

Table 3. Agronomic characters and yield of cassava as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Plant Height (cm)	Wt. of Stalk/ Plant (kg)	No. of Roots/Plant		Yield (t/ha)		Total Root Yield (t/ha)
			Marketable	Non-Marketable	Marketable	Non-Marketable	
Legume							
Mungbean	203.40	1.25	4.41	3.07b	20.12	3.95	24.06
Bushbean	225.60	1.49	4.44	3.53a	21.80	4.90	26.70
Soybean	214.55	1.33	4.27	3.33ab	20.19	4.28	24.47
Fertilizer Level (kg NPK/ha)							
00-00-00	212.95	1.34abc	4.33	3.05b	20.76ab	3.92b	24.67ab
00-30-30	210.33	1.15c	4.03	2.89b	18.32b	3.94b	22.26b
00-60-60	208.13	1.27bc	4.17	3.01b	18.78ab	4.05ab	22.83b
30-60-60	216.71	1.44ab	4.71	3.71a	22.94a	4.93ab	27.87a
90-60-60	224.47	1.59a	4.63	3.90a	22.71ab	5.05a	27.76a

[1]Average of three croppings. In a column, treatment means followed by a common letter are not significantly different at 5% level, DMRT.

Table 4. Summary of the combined cost and return analysis of cassava as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Gross Income (₱/ha)	Total Expenses (₱/ha)	Total Net Income (₱/ha)
Legume			
Mungbean	12276.16	5607.50	6668.66
Bushbean	14259.76	5590.50	8669.26
Soybean	11389.23	5851.80	5537.43
Fertilizer Level (kg NPK/ha)			
00-00-00	12722.59	5148.00	7574.59
00-30-30	11870.92	5548.00	6322.92
00-60-60	12029.59	5708.00	6321.59
30-60-60	13485.59	5965.50	7520.09
90-60-60	13099.89	6046.83	7053.06

[1] Average of three croppings.

pared to those applied with fertilizers. Although fertilizer application significantly increased the yield of gabi (Table 5), the practice did not prove to be profitable. This was attributed to the high cost of inorganic fertilizers and other inputs used. Hence, the use of fertilizers for upland gabi production appears not advisable.

Considering the fertility status of the soil (44 kg available N/ha, 41.8 kg Olsen's P/ha and 741.8 kg extractable K/ha), rotation planting with leguminous crops may be a good substitute to inorganic N as observed in this experiment. Aside from improving the soil condition of the field, the legumes can provide additional income.

Regardless of whether rotation planting of legumes and root crops gave a significant effect on the latter or not, legumes contributed greatly to the total income. It appears that all the legume crops used were promising and can be used in rotation with the root crops.

Table 5. Agronomic characters and yield of gabi as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Plant Height (cm)	No. of Suckers/Plant	Wt. of Stalk/Plant (kg)	Wt. of Corm/Plant (kg)	Corm Yield (t/ha)
Legume					
Mungbean	51.62	3.72	0.08a	0.12	4.84
Bushbean	46.12	3.45	0.05b	0.12	4.74
Soybean	52.46	3.40	0.08a	0.14	5.46
Fertilizer Level (kg NPK/ha)					
00-00-00	49.76ab	3.27	0.07ab	0.12ab	4.74b
00-30-30	46.81b	3.18	0.06b	0.11b	4.59b
00-60-60	48.78ab	3.64	0.07ab	0.13ab	4.98ab
30-60-60	50.85ab	3.51	0.07ab	0.13ab	5.14a
90-60-60	54.14a	4.02	0.08a	0.14a	5.63a

[1] Average of two croppings. In a column, treatment means followed by a common letter are not significantly different at 5% level, DMRT.

Table 6. Summary of the combined cost and return analysis of gabi as affected by rotation with legumes and fertilizer levels.[1]

Treatment	Gross Income (₱/ha)	Total Expenses (₱/ha)	Total Net Income (₱/ha)
Legume			
Mungbean	11682.58	5668.50	6014.08
Bushbean	9920.40	5785.50	4134.90
Soybean	8662.20	6090.50	2571.70
Fertilizer Level (kg NPK/ha)			
00-00-00	9884.40	5281.00	4603.40
00-30-30	9766.90	5561.00	4205.90
00-60-60	10059.40	5841.00	4218.40
30-60-60	10184.40	6098.50	4085.90
90-60-60	10546.90	6459.33	4087.57

[1] Average of two croppings.

LITERATURE CITED

DONAHUE, R.L. 1970. Our Soils and Their Management. The Interstate Printers and Publ. Inc., Danville, Illinois. 409 pp.

ESCASINAS, A.B. and ESCALADA, R.G. 1984. Crop rotation of sweet potato, cassava, and gabi with legumes as a cultural management system. Ann. Trop. Res. 6:63-76.

PATTERSON, D.R. and SPEIGHTS, D.E. 1964. Influence of crop rotation, fertilizer and variety on yields of cracking sweet potato roots. Proc. Amer. Soc. Hort. Sci. 84:431-435.

SUTHERLAND, W.N., SHRODER, W.D. and PESEK, J.T. 1961. Efficiency of legume residue nitrogen and inorganic N in corn production. Agron. J. 53:339-342.