INTERCROPPING SWEET POTATO WITH LEGUMES AS A CULTURAL MANAGEMENT SYSTEM

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ABSTRACT

The use of legume intercrops reduced the overall growth of sweet potato. The yield of sweet potato declined by as much as 17.78% while that of the legumes by 14.94% due to competition for nutrients and light between the main crop and the intercrops. However, inoculation of the legume intercrops with *Rhizobium* minimized the competition for nitrogen and allowed the sweet potato to develop enough herbage. Sweet potato intercropped with inoculated legumes produced root yield which was 6.5% higher than that intercropped with uninoculated legumes.

Significant differences were observed on the effects of legume intercrops and their interaction with inoculation on sweet potato productivity. Bushbean was a better intercrop than either mungbean or soybean because this legume matures earlier than the other two. Bushbean and mungbean increased sweet potato yield upon inoculation but inoculated soybean seemed to depress the yield of the root crop.

In general, inoculation of the legume intercrops and intercropping were more beneficial and profitable. Intercropping was 4 and 3.5 times more profitable than monoculture when the legumes were inoculated and uninoculated, respectively.

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KEY WORDS: Cropping system. Root crop-legume intercropping. Monoculture. Inoculation. N-fixation.

INTRODUCTION

The average Philippine farm is characterized by small landholdings, limited power and general abundance of labor which make it seemingly suited for crop diversification (PCARR, 1976). However, many Filipino farmers still practise the monoculture system. Crop diversification, particularly intercropping in root crop farms, was stressed by Villamayor (1982) to be advantageous because the spacing of root crops is generally wide leaving ample space for the growing of other crops, and the root crops have relatively longer growth duration such that the intercrops provide an income for farmers while waiting for the main crop to mature. It is however, inevitable that the planting of more than one crop on the same piece of land at the same time would result in a certain degree of competition for growth factors like light, nutrients and moisture which oftentimes result in yield reduction of either or both crops (Dalal, 1974).

Moody (1981) stated that whenever nutrient competition occurs, nitrogen is the first element that becomes limiting. It is also the growth factor that is deficient in most of our soils. Hence, a major problem exists between achieving a successful crop intensification and preventing the ultimate depletion of nitrogen and other essential nutrients in the soil.

The utilization of legumes in many cropping systems like intercropping had been found to partly solve the problem due to the legumes' ability to fix nitrogen (Alexander, 1977; Tisdale and Nelson, 1975; and NAS, 1979b). However, their potential as intercrops for root crops needs to be tested. This study, therefore, aimed to evaluate and select a good legume intercrop for sweet potato and to determine the role of inoculation with *Rhizobium* on the productivity of both crops.

MATERIALS AND METHODS

Land Preparation. An area of about 1,365 m^2, previously a rice paddy and converted to upland conditions, was alternately plowed and harrowed twice. The same area was used for the succeeding croppings where all treatments were maintained at their respective plot assignments. There was a total of 10 consecutive croppings which started in August 1977 and ended in November 1981. The fallow period between croppings was 3-4 weeks. Prior to the first cropping, the soil in the experimental area had the following properties: soil pH, 5.6; organic matter, 1.2%; Olsen's P, 27.5 ppm; and extractable K, 210 ppm.

Field Layout and Experimental Design. The area was laid out in a split plot arranged in randomized complete block design with three replications. Each subplot had an area of 48 m^2. Rhizobial inoculation and non-inoculation of the legume intercrops were designated as the main plots while the legume species used as intercrop [mungbean (*Vigna radiata* – Mg 50-10A), bushbean (*V. sinensis* x *V. sesquipedalis* – LB Bush sitao No. 2), and soybean (*Glycine max* – TK-5)] were designated as the subplots.

A monoculture check of the legume intercrops under both inoculated and uninoculated treatments, and of sweet potato were provided for comparison. Inoculation was done by coating the legume seeds with *Rhizobium* sp. peat inoculants before planting.

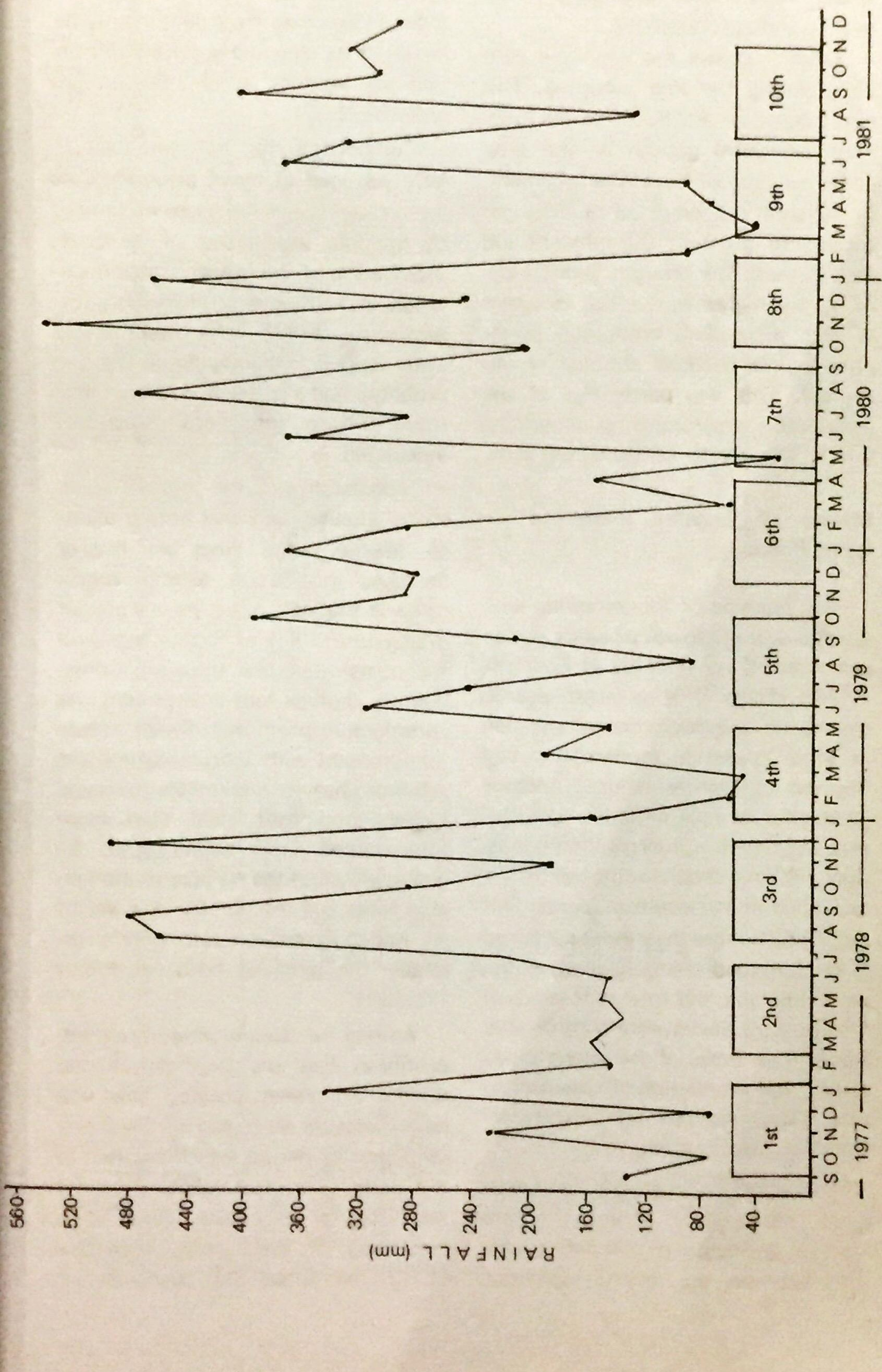

Figure 1. Rainfall distribution throughout the experimental period superimposed with cropping durations of sweet potato.

which caused the consistently low sweet potato productivity.

Table 1 shows the very low root yield during the first cropping. This result could be attributed to the luxuriant vegetative growth of the crop at the expense of its root enlargement. In the sixth cropping, 30 kg N/ha was applied to augment the inherent soil fertility and this brought about a significantly higher root yield. However in the succeeding croppings, sweet potato yield declined although N was applied. This was partly due to the unfavorable environmental conditions during the growth period of the crop.

Effects of Legume Intercrops on Sweet Potato

The practice of intercropping limited the overall growth of sweet potato and reduced its yield by as much as 17.78% (Table 1). Vine length was 35 cm shorter in intercropped plants than in those grown in monoculture and this led to slightly reduced herbage yield. Storage root initiation was likewise depressed in intercropped plants. About 90 marketable roots per 24 m^2 developed in monoculture plants. This was 17.52% more than those produced in intercropped plants. Consequently, the marketable and total root yields of monoculture plants were considerably higher than those of the intercropped plants. The production of non-marketable roots was not significantly affected by intercropping.

The reduction in growth and subsequent productivity of sweet potato may be attributed to competition for light between the legume intercrops and the root crop. Sweet potato is not a good competitor for light mainly because of its creeping growth habit unlike the legumes which have upright growth habit.

Competition for nutrients particularly nitrogen in sweet potato-legume intercropping seemed to be minimized by rhizobial inoculation of the latter. Inoculation of legumes enhances nodulation and subsequent N-fixation (Ritaga et al., 1980). Thus, sweet potato intercropped with inoculated legumes probably had a better N nutrition than those whose intercrops were not inoculated.

Inoculation of the legume intercrops allowed the sweet potato plants to develop longer vines and heavier herbage. Inoculation effects largely came in the form of earlier and greater availability/supply of N, thus easing up the competition for nitrogen. Consequently, storage root enlargement was considerably promoted. Sweet potato intercropped with inoculated legumes produced heavier marketable roots and higher total root yield than those intercropped with uninoculated legumes although the number of marketable roots and the number and weight of non-marketable roots were practically the same in both treatments (Table 1).

Among the legume intercrops used, bushbean had the least detrimental effects on sweet potato. This was partly because bushbean has the shortest maturity period which resulted in the earlier and fast recovery of the associated sweet potato plants upon harvesting of the former. Alcantara (1973) mentioned that bushbean has

Planting. Sweet potato (BNAS-51) which served as the main crop was planted at 100 cm between rows and 25 cm between hills with one cutting per hill. The legumes were drilled in double rows in between the rows of sweet potato at a distance of 25 cm away from the row of sweet potato and 50 cm away from each other. Sweet potato and legumes were planted on the same date. Mungbean and soybean were thinned to 15 plants per linear meter and bushbean to 10 plants per linear meter.

In the monoculture plot, sweet potato was also spaced at 100 cm between rows and 25 cm between hills. Legumes were sown at a distance of 50 cm between rows and were thinned to the desired number as in the intercropped plots.

Cultural Management. Fertilizers were applied in band along the rows of sweet potato and legumes at 50 kg each of P_2O_5 and K_2O per cropping. There was no nitrogen applied during the first five croppings but 30 kg N/ha was applied starting on the sixth cropping to augment the remaining available nitrogen in the soil. In the monoculture scheme, sweet potato received 50 kg/ha each of P_2O_5 and K_2O, while legumes received 30 kg/ha each of P_2O_5 and K_2O per cropping. Both crops also received 30 kg N/ha starting on the sixth cropping. Pesticides were periodically sprayed to protect the plants against insects and diseases. Handweeding was done twice in all the treatments. Drainage canals were constructed around the experimental plots to drain excess water especially during heavy rains.

Harvesting. Four months after planting, sweet potato plants from the four middle rows of each treatment were harvested. Harvested roots were sorted as marketable and non-marketable. Roots which were at least 2.5 cm in diameter and 6.25 cm in length were considered marketable. All roots below this measurement were considered non-marketable. Sweet potato debris were chopped and plowed under. Legume plants from the six inner rows of each treatment were harvested. Green pods of bushbean and seeds of soybean and mungbean were gathered. All plants were cut after harvesting and the plant refuse was incorporated in their respective plots.

An economic analysis was made for each intercropping scheme and for the sweet potato and legumes grown in monoculture.

RESULTS AND DISCUSSION

Generally low root yields of sweet potato were obtained in this experiment. This was largely due to poor soil conditions and untimely plantings of the root crop with reference to rainfall (Fig. 1). The experimental area was originally a rice paddy which was converted to an upland area only upon the implementation of this experiment. Moreover, the clayey soil texture caused drainage problems at the height of the rainy season and water stress during dry months. These problems seemed to have been minimized at the later plantings. However, the continuous plantings in the same area might have decreased soil fertility

Table 1. Growth and yield parameters of sweet potato as affected by number of croppings, inoculation of intercropped legumes and legume intercrops.

Treatment	Growth Parameters		Yield Parameters				Total Root Yield (t/ha)
	Vine Length (m)	Herbage Yield (kg/plot)	Number of Roots/Plot: Market–able	Number of Roots/Plot: Non-Market–able	Root Yield (tons/ha): Market–able	Root Yield (tons/ha): Non-Market–able	
No. of Croppings							
1	4.21 b	70.31 a	62.50 c	31.83 d	2.26 d	0.51 g	2.77 d
2	2.71 f	34.05 e	172.67 a	99.33 b	5.78 c	1.00 ef	6.78 c
3	3.33 def	28.74 e	53.61 c	40.11 d	5.62 c	1.47 cd	7.09 c
4	2.12 g	31.23 e	55.78 c	48.55 cd	5.99 c	1.86 c	7.85 c
5	4.05 bc	49.63 cd	53.00 c	35.66 d	6.04 c	1.35 de	7.39 c
6	2.86 ef	60.97 b	117.22 b	134.66 a	10.89 a	3.52 a	14.41 a
7	5.05 a	52.23 c	105.28 b	74.28 bc	8.77 b	2.38 b	11.14 b
8	4.09 bc	33.20 e	52.78 c	46.61 cd	2.13 d	0.69 f	2.82 d
9	3.48 cde	61.86 b	41.78 d	21.28 e	5.69 c	1.09 def	6.78 c
10	3.55 bcd	43.66 d	56.44 c	50.94 cd	2.84 d	0.69 f	3.53 d
Mean	3.56	45.79	77.09	58.31	5.59	1.43	7.03

Table 1. Continued . . . .

Treatment	Growth Parameters		Yield Parameters				Total Root Yield (t/ha)
	Vine Length (m)	Herbage Yield (kg/plot)	Number of Roots/Plot		Root Yield (tons/ha)		
			Market-able	Non-Market-able	Market-able	Non-Market-able	
Inoculation							
With	3.71 a	47.63 a	77.53	57.07	5.82 a	1.43	7.25 a
Without	3.41 b	43.96 b	76.65	59.54	5.37 b	1.44	6.81 b
Legume Intecrops							
Mungbean	3.56	46.57 a	75.70 b	60.15	5.45 b	1.40	6.85 b
Bushbean	3.48	47.12 a	80.36 a	58.35	5.94 a	1.53	7.47 a
Soybean	3.59	43.74 b	75.25 b	56.48	5.41 b	1.44	6.85 b
C.V. (a) %	23.49	18.80	21.32	60.41	46.13	37.28	39.89
C.V. (b) %	10.05	20.60	18.88	35.60	18.87	28.05	19.07
C.V. (c) %	11.39	15.37	13.23	14.56	16.26	41.35	11.41
Monoculture							
Sweet potato (Averaged over 10 croppings)	3.91	47.97	90.60	56.90	6.93	1.62	8.55

Means within a column followed by a common letter are not significantly different at 5% level, DMRT.

a fairly high N-fixing potential.

The N-fixation capacity of the legume intercrops used was in the descending order of soybean, bushbean, and mungbean (Alcantara, 1973; NAS, 1979a). Soybean is also known to remove considerable amounts of N for its seeds. As reported by Kang (1975), the N fixed by soybean is not enough for its needs. It requires an addition of about 30 kg N/ha when the crop is inoculated and 60 kg N/ha without inoculation. Mungbean might not be a high N feeder like soybean but its limited N-fixing potential could still result in a similar net negative balance in soil N as that of soybean.

Table 1 shows the comparative effects of the three legumes used as intercrops on sweet potato. All the three legume species influenced vine growth to a similar magnitude. However, the herbage produced by the soybean-intercropped plants was considerably lighter than those produced using the other two legumes. This indicates that the increase in vine length of sweet potato intercropped with soybean could be a response to light competition at the expense of vigor. Thus, a significant reduction in storage root initiation of sweet potato resulted. Sweet potato intercropped with soybean produced about 75 marketable storage roots per 24 m^2 plot. This is similar to that obtained from intercropping with mungbean but about five roots less than that produced with bushbean as intercrop. These results could be attributed to the varying degrees of competition among the crop combinations, wherein the sweet potato-bushbean mixed crop experienced the least degree.

Inoculation seemed to reduce the dependence of the legumes on the inherent soil N. This practice was also observed by Ritaga et al. (1980) and Kang (1975) to have increased the nodulation and height of legumes. The increased N fixation due to inoculation minimized the competition for the inherent soil nitrogen and enabled the root crop to increase utilization of the element. This consequently increased the initiated storage roots of sweet potato.

The above sequence of events seem to be true for sweet potato intercropped with bushbean and mungbean. This occurred primarily because these legumes did not considerably increase herbage yield upon inoculation. On the other hand, soybean grew more vigorously when inoculated and became more competitive for light than sweet potato. Thus, soybean reduced the yield of sweet potato instead of increasing its productivity upon inoculation.

Legume Productivity as a Function of the Cropping System

The yields of the legumes were considerably reduced when used as intercrops of sweet potato (Table 2). The legume intercrops produced an average of 14.94% less yield than the monoculture. Soybean was the least affected by sweet potato with a yield reduction of about 11.05% followed by bushbean (13.82%) and mungbean (19.97%).

Although the legumes in this study possessed a certain advantage in light

Table 2. Legume yields (kg/ha) as affected by inoculation and cropping systems.

Inoculation/Legume		Yield (kg/ha) As Monocrop	As Intercrop	% Yield Reduction upon Intercropping
Inoculated with *Rhizobium*	Mungbean	611.60	516.80	15.50
	Bushbean	4249.20	3644.20	14.24
	Soybean	698.90	633.90	9.30
Mean				13.01
Without Inoculation	Mungbean	569.90	460.30	24.44
	Bushbean	3818.10	3306.30	13.40
	Soybean	669.70	584.00	12.80
Mean				16.88
		% Advantage of Inoculated over Uninoculated Legume		
	Mungbean	7.32	20.02	
	Bushbean	11.29	10.22	
	Soybean	4.36	8.54	
Mean		7.66	12.93	

utilization over sweet potato due to their upright growth habit, other growth factors like nutrients and moisture could also be limiting. Thus, their culture in association with another crop (sweet potato) resulted in some degree of competition which could account for the observed yield reductions.

The productivity of the legumes was considerably increased by inoculation. *Rhizobium* inoculation increased the yield of the legumes by 7.66% when grown as a monocrop and 12.93% when used as intercrops of sweet potato (Table 2).

Among the legumes used, mungbean had the highest response to inoculation when grown as an intercrop of sweet potato (Table 2). The yield of the inoculated plants increased by 20.02% over that of the uninoculated plants. However, the yield of uninoculated mungbean when grown as a monocrop, only increased by 7.32%. Bushbean had practically similar response to inoculation under both systems of planting. The yield of inoculated soybean increased by 4.36% when grown as a monocrop and by 8.54% under the intercropping system.

The Economics of Intercropping

Despite the yield reduction of both sweet potato and legumes with intercropping, the practice was still more profitable than sweet potato monoculture. On the average, the return per peso investment in the intercropping system was 4.26 and 2.12 in the monoculture system (Table 3).

Inoculation of the legume intercrops with *Rhizobium* was likewise a better practice. Average net return from the inoculated treatment was ₱4,547.50 per ha per cropping. This was 3.06 times more profitable than ₱1,120.30 per ha per cropping obtained in sweet potato monoculture and 16.9% more profitable than without inoculation. Inoculation of the three legumes raised the profitability of their respective intercropping schemes.

Among the different crop combinations, sweet potato-bushbean produced the highest net income. Regardless of inoculation treatment, this crop combination had an average return per peso investment of 6.29 which was considerably greater than that of sweet potato – soybean (3.30), sweet potato – mungbean (3.20) and monoculture sweet potato (2.12). The highest overall profit was obtained in the sweet potato-inoculated bushbean intercropping scheme, i.e. ₱7,468.70 per ha over 4 months cropping period or 5.67 times more income than practising monoculture. However, it should be noted that the return per peso investment does not take into account the time spent in the practice of the system. In the case of mungbean and bushbean, two croppings are possible in 4 months if planted as sole crops, hence, the return on investment (ROI) will be higher than that obtained in the crop combination based on a 4-month duration.

There are two major factors contributing to the relative advantage of bushbean over the other two legumes. First, bushbean is least detrimental to sweet potato growth due to its early maturity and its fairly high N-fixing capacity and second, this legume is a high yielder by virtue of its product – the green pods sold as fresh vegetable. Although the price per kilogram of bushbean is cheaper, the quantity of produce is more than enough to compensate for the low market price. Moreover, this legume is quite in demand in the local market. The only problem is that bushbean pods as fresh vegetable are more perishable than the dried grains of soybean and mungbean.

Table 3. Economic analyses per hectare of sweet potato-legume intercropping schemes and monocultures of sweet potato and legumes (averaged over 10 croppings).

Crop Combinations	Gross Income (P/ha)		Total Gross Income (P/ha)	Production Cost (P/ha)	Net Income (P/ha)	Return per Peso Investment
	Sweet Potato	Legumes				
Sweet potato-inoculated mungbean	2835.00	3100.80	5935.80	2809.70	3126.10	3.40
Sweet potato-uninoculated mungbean	2610.00	2761.80	5371.80	2759.70	2612.10	3.01
Sweet potato-inoculated bushbean	3235.00	7288.40	10523.40	3054.70	7468.70	6.74
Sweet potato-uninoculated bushbean	2695.00	6612.60	9307.60	3004.70	6302.90	5.85

Table 3. Continued . . .

Crop Combinations	Gross Income (₱/ha)		Total Gross Income (₱/ha)	Production Cost (₱/ha)	Net Income (₱/ha)	Return per Peso Investment
	Sweet Potato	Legumes				
Sweet potato-inoculated soybean	2665.00	3169.50	5834.50	2786.70	3047.80	3.34
Sweet potato-uninoculated soybean	2750.00	2920.00	5670.00	2736.70	2933.30	3.26
Monoculture sweet potato	3465.00	–	3465.00	2344.70	1120.30	2.12
Monoculture legumes						
Inoculated mungbean		3669.60	3669.60	1810.00	1859.60	2.61
Uninoculated mungbean		3419.40	3419.40	1750.00	1669.40	2.45
Inoculated bushbean		8498.40	8498.40	1950.00	6548.40	6.69
Uninoculated bushbean		7636.20	7636.20	1852.00	5784.20	6.03
Inoculated soybean		3494.50	3494.50	1855.00	1639.50	2.39
Uninoculated soybean		3348.50	3348.50	1788.00	1560.50	2.35

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