RESIDUAL NITROGEN FROM LEGUMES AND ITS EFFECT ON THE SUCCEEDING CROP OF SWEET POTATO

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ABSTRACT

Three legumes (mungbean, bushbean, and soybean) and sweet potato (control) were planted during the first cropping. After harvesting each crop, the residues except those of sweet potato were plowed under and incorporated into the soil. The final planting of sweet potato was done subsequently after the legume residues had been decomposed. Results showed that there was a significant increase in the weight and length of vines of the three legumes. Weight and number of marketable tubers, weight of non-marketable tubers, and total tuber yield greatly increased in plots previously planted to bushbeans and soybeans while the said parameters had no effect on mungbeans. Tuber yield and other agronomic characters were positively influenced by the different fertilizer levels. Fertilizer level of 0-30-60 kg/ha increased considerably the tuber yield of sweet potato planted after bushbeans or soybeans. Cost and returns analysis revealed that, regardless of the level of fertilizer applied, higher net profits were obtained from plots previously planted to bushbeans and soybeans. The best result was noted in the continuous sweet potato cropping treated with 60-60-60 kg/ha on both croppings. Considering net returns per unit time, however, alternate cropping of sweet potato with bushbeans or soybeans gave greater output in addition to the improved physical conditions of the soil.

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INTRODUCTION

Increased production of sweet potato can be attained even with relatively less inputs as manifested by its wide adaptability. However, when continuously grown, it can cause depletion of soil fertility and may lead to the rapid breakdown of organic matter, thus leaving the soil bare making it vulnerable to erosion (Martin *et al.*, 1976). Moreover, the continuous cropping of sweet potato may encourage the build up of weeds, insect pests, and diseases (Pearson, 1967). Hence, planting of alternate crops before or after sweet potato has always been recommended.

Leguminous crops are usually utilized as alternate crops to precede sweet potato since they can fix atmospheric N, thus improving the soil N content (Hughes and Henson, 1964). They may also enhance the friability of the soil. Ultimately, these conditions are supposed to augment the yield of the subsequent crop.

This study investigated the effect of residual nitrogen from legumes on the succeeding crop of sweet potato, the optimum levels of P and K that would give the highest yield for sweet potato, and the desirability of using legumes as alternate crops to precede sweet potato.

MATERIALS AND METHODS

A split-plot arranged in a randomized complete block design with three replications was laid out at the experimental area of the Department of Agronomy and Soils, Visayas State College of Agriculture, Baybay, Leyte. The different legume treatments served as main plot and the fertilizer levels as sub-plots. The treatments were as follows:

Legume treatments (main plot):

L_0 = sweet potato-sweet potato
L_1 = mungbean-sweet potato
L_2 = bushbean-sweet potato
L_3 = soybean-sweet potato

Fertilizer levels (sub-plots) in kg/ha N, P_2O_5, and K_2O:

0-0-0	0-60-30
0-30-0	0-30-60
0-0-30	60-60-60
0-30-30	

Mungbeans (MG_{50}-($_{10}$G) and soybeans (TK_5) were seeded at a distance of 60 cm x 20 cm, while bushbeans (#2) at 60 cm x 25 cm, each at the rate of three plants per hill. After harvest, the legume residues were plowed under. Three weeks later, the area was planted to sweet potato (BNAS-51) at a distance of 100 cm x 25 cm with one cutting per hill.

The legumes uniformly received fertilizer at the rate of 10-50-50 kg/ha. One-half of the total amount of N, and the total amounts of P and K fertilizers were applied at planting time; the other half of N was applied one month later. Cultural practices such as weeding, spraying of pesticides, and irrigation and drainage were done.

During the first cropping, bushbeans were harvested as green pods two months after planting, while

mungbeans and soybeans were harvested as dry beans one-half month later. Sample plants were uprooted at the flowering stage and the extent of nodulation determined and compared through ocular observation. The sweet potato crop was harvested four months after planting. The plants were sampled for vine length and fresh weight, and number and weight of marketable and non-marketable tubers. Harvest index was also calculated from the ratio between the total tuber yield and the sum of total tuber yield and fresh weight of vines.

RESULTS AND DISCUSSION

Legumes.

Extent of Nodulation. — Soybean produced more and bigger nodules with pink-red interior than the other two legumes. Although the number of nodules in bushbean and mungbean plants was more or less similar, the former produced slightly bigger nodules than the latter. This reflects the efficiency of the legume in providing the soil with nitrogen in symbiosis with the nitrogen-fixing bacteria.

Herbage Yield (t/ha). — The total herbage yield of legumes revealed that bushbeans produced more vegetative parts than mungbean (Table 1). Soybeans developed the least herbage due to excessive leaf abscission at maturity.

Yield of Legumes (t/ha). — Yield of each legume was obtained to determine the feasibility of growing alternate crops other than continuous cropping of sweet potato. The results indicate that mungbeans, bushbeans, and soybeans yielded 0.62, 1.78, and 0.55 t/ha, respectively (Table 1). The higher yield obtained from bushbeans was attributed to the long, fresh green pods harvested.

Table 1. Pod and herbage yield of the three legumes.

Legumes	Yield (t/ha)	Herbage Weight (t/ha)
Mungbeans	**0.62**	**30.53**
Bushbeans	**1.78**	**34.98**
Soybeans	**0.55**	**18.02**

Sweet Potato (First Cropping).

Sweet potato was planted and applied with fertilizer at different levels during the first cropping to compare the alternate cropping of sweet potato with legumes and the continuous cropping of sweet potato.

The different fertilizer treatments significantly affected the length of vines and the number and weight of marketable tubers (Table 2). These differences were attributed to the enhanced growth as well as increased carbohydrate production and translocation to the tubers. The effects of fertilizer on the other parameters were not significant.

Sweet Potato (Second Cropping).

Length of Vines (cm). — Vine length significantly increased in

plots preceded with the three legumes (Table 3). This indicated that the nitrogen derived from the legume residues contributed to the enhanced growth of the succeeding sweet potato crop.

Fertilizer application also affected the length of vines. As the amount of fertilizer was increased, the vine length also increased. Plants with 0-30-60, 0-60-30, and 60-60-60 fertilizer levels had significantly longer vines than those which did not receive fertilizer.

Weight of Vines (kg/plot). — Plots previously planted to bushbeans and soybeans had markedly heavier fresh vine weight than plots preceded with mungbeans and without legumes (Table 3). The differences were due to the following: Compared to the other legumes, bushbeans provided the greatest bulk of organic materials to the soil as indicated by the highest herbage produced. On the other hand, soybean was observed to have more effective nodulation than the two legumes. These confirmed the results obtained by Martin (1976) that increased organic matter content and good nodulation improved the physical condition and friability of the soil and maintained or increased the residual N in the soil.

Vine weight tended to increase in proportion with the fertilizer level with the 60-60-60 treatment having a significantly increased vine weight. This was probably due to the sufficient supply of N brought about by the legumes and the fertilizers applied.

Marketable Tubers. — Plots preceded with bushbeans and soybeans had significantly more marketable tubers than the control (Table 3). Bushbeans had probably added enough organic matter to the soil as shown by the higher amount of plant refuse produced, while soybeans might have improved the soil N contents as indicated by its effective nodulation. The least number of marketable tubers was noted in plots previously planted to mung-

Table 2. Yield and yield components of sweet potato (first cropping) at different fertilizer levels.

Fertilizer Levels	Vines		Marketable Tubes/plot		Non-marketable Tubers/plot			Total Tuber Yield
	Length/ Plant (cm)	Weight/ Plot (kg)	Number	Weight (kg)	Number	Weight (kg)	Index	
0-0-0	311.40	14.41	33.67	5.77	22.67	0.65	0.308	7.13
0-30-0	311.80	15.35	24.67	5.17	21.33	0.73	0.273	6.56
0-0-30	347.07	16.68	33.67	6.88	24.33	0.78	0.310	8.31
0-30-30	379.40	16.12	36.67	7.12	24.00	1.06	0.346	9.09
0-60-30	377.13	16.48	38.33	7.51	25.67	0.82	0.336	9.25
0-30-60	367.20	17.28	42.00	8.70	35.33	1.10	0.362	10.90
60-60-60	392.07	20.20	48.33	10.27	28.67	0.89	0.355	12.50
Mean	351.73	16.65	36.62	7.34	26.00	0.90	0.328	9.10
CV (%)	7.29	12.35	7.92	17.45	34.51	32.22	22.57	25.79
LSD .05	45.63	ns	7.92	2.28	ns	ns	ns	ns
LSD .01	63.97	ns	11.10	3.19	ns	ns	ns	ns

Table 3. Growth parameters and yield and yield components of sweet potato at different legumes and fertilizer treatments.

Treatments	Vines		Marketable Tubers/Plot		Non-Marketable Tubers/Plot		Total Tuber Yield (t/ha)	Harvest Index
	Length/ plant (cm)	Plot No. (kg)	Wt (kg)	No.	Wt. (kg)	Yield/ha)		
Legumes								
without legumes	440.66a	20.15a	23.38a	4.48a	21.86a	0.84ab	3.33a	0.209a
mungbeans	577.59b	27.97ab	22.86a	5.01a	18.14a	0.82a	3.64a	0.174a
bushbeans	614.26b	29.02b	28.48b	6.65b	19.10a	1.04bc	4.81b	0.210a
soybeans	598.61b	32.24b	30.10b	7.48b	19.43a	1.09c	5.35b	0.201a
Mean	557.78	27.34	26.20	5.91	19.63	0.94	4.28	0.201
Fertilizer Levels								
0-0-0	447.30a	25.73a	19.17a	4.40a	16.42a	0.65a	3.15a	0.166a
0-30-0	504.30b	26.34a	22.00ab	4.81ab	19.00ab	8.82ab	3.52ab	0.177ab
0-0-30	561.50cd	26.78a	25.17ab	5.17b	17.24a	0.78ab	3.72ab	0.186ab
0-30-30	540.98bc	26.12a	14.33b	5.49b	18.75ab	0.89b	3.99b	0.195bc
0-60-30	618.07e	26.81a	29.50c	6.70c	22.50c	0.93b	4.77c	0.223cd
0-30-60	594.62de	28.30a	29.42c	7.12c	19.50abc	1.17c	5.18cd	0.229d
60-60-60	637.68e	31.32b	33.83d	7.66c	24.00c	1.38c	5.65d	0.227d
Mean	557.78	27.34	26.20	5.91	19.63	0.94	4.28	0.201
CVa(%)	22.35	39.32	10.18	27.66	19.63	13.29	23.56	34.54
CVb(%)	10.77	11.48	15.22	21.50	26.31	25.05	18.14	16.32

[1] *Means followed by the same letters are not significantly different at 5% level according to Duncan's Multiple Range Test.*

beans. This legume was reported to have a depressing effect on tuber production particularly at low N levels. It apparently secreted certain toxins, yet to be identified, which depressed the growth of the succeeding crop (Sanchez, 1976).

Fertilizer levels 0-30-60, 0-60-30, and 60-60-60 significantly caused the production of more marketable tubers than the control. The number of marketable tubers increased considerably at higher P and K levels especially with adequate supply of N. This was attributed to the high amounts required by sweet potato on these nutrients as mentioned by Kipps (1970).

Weight of marketable tubers obtained from plots previously planted to bushbeans and soybeans was significantly heavier than those from the control. However, the yields obtained from plots preceded with mungbeans were not significantly different from the control. The results followed that of the number of marketable tubers.

Tuber yields increased in proportion with fertilizer levels. Higher yields were obtained from fertilizer levels 0-60-30, 0-30-60, and 60-60-60 than from the control.

Non-marketable Tubers. — Although the legume treatments did not show significant results (Table 3), the average number of non-marketable tubers in plots not previously planted to legume (L_0) was more than those in plots preceded with legumes. These results implied that the three legumes had increased production of marketable tubers of sweet

potato. This could be an advantage since tuber production of sweet potato is determined primarily by greater number and weight of marketable tubers produced.

Fertilizer application positively influenced the number of non-marketable tubers. Fertilizer levels 0-60-30 and 60-60-60 significantly caused the formation of more non-marketable tubers. This was because they hastened tuber formation instead of tuber enlargement (Edmond, 1971).

Heavier weights of non-marketable tubers were obtained in plots preceded with bushbeans and soybeans. However, only those obtained from plots previously planted to soybeans were significantly different from the control. Lighter and smaller non-marketable tubers developed in the control.

The fertilizer levels also affected the weight of non-marketable tubers. Heavier weights of non-marketable tubers were obtained from 0-30-60 and 60-60-60 fertilizer levels.

Total Tuber Yield (t/ha). Plots preceded with bushbeans and soybeans, had significantly higher total tuber yield and had more and heavier marketable tubers than the control. There were no significant effects observed in plots preceded with mungbeans.

The different amounts of fertilizers applied positively influenced the total tuber yield. Significantly higher yields were noted in fertilizer levels 0-60-30, 0-30-60, and 60-60-60 than in the control. This revealed that sweet potato demanded higher amounts of P and K and an adequate supply of N.

Harvest Index. — Harvest indices were not significantly influenced by the legumes. However, plots not preceded with legumes gave higher harvest indices than plots preceded with legumes.

As fertilizer level increased, a corresponding increase of harvest index was noted. Plots supplied with fertilizer levels 0-60-30, 0-30-60, and 60-60-60 kg/ha had significantly higher harvest indices than those in plots which did not receive fertilizer. The treatments mentioned significantly influenced the production of bigger and heavier tubers than the control.

Cost and Returns Analysis.

The cost and returns incurred in the alternate cropping practice was determined so that the profitability of the practice can be ascertained.

The results showed that regardless of the fertilizer levels used, the cropping sequence involving bushbeans or soybeans followed by sweet potato gave higher net returns than the continuous sweet potato cropping and alternate cropping of sweet potato with mungbean (Table 4). Fertilizer application of 60-60-60 kg/ha in the continuous cropping of sweet potato gave the highest net profit. This was attributed to the higher tuber yields noted in the first cropping. Although tuber yields in plots previously planted to any legume were greater than in plots not previously planted to legumes during the second

Table 4. Cost and returns analysis of legumes and sweet potato under the first cropping and sweet potato under the second cropping at different legume and fertilizer treatments.

Treatments	Yield (t/ha)		Expenses (₱)			Gross Income (₱)			Net Income (₱)
	a	b	a	b	Total	a	b	Total	
A. Monoculture									
Sweet potato-sweet potato									
0-0-0	7.31	2.66	1355.30	1355.30	2710.60	5482.50	1995.00	7477.30	4766.90
0-30-0	6.56	2.50	1562.30	1562.30	3124.60	4920.00	1875.00	6795.00	3670.40
0-0-30	8.31	3.61	1405.50	1405.50	2811.00	6232.50	2707.50	8940.00	6129.00
0-30-30	9.09	3.10	1612.50	1612.50	3225.00	6817.50	2325.50	9143.00	5917.00
0-60-30	9.25	3.30	1819.50	1819.50	3639.00	6937.50	2475.00	9412.50	5773.50
0-30-60	10.90	3.85	1662.70	1662.70	3325.40	8175.00	2887.50	11062.50	7737.10
60-60-60	12.50	4.31	2340.70	2340.70	4681.40	9375.00	3232.50	12607.50	7926.10
Mean					3359.50			9348.28	5988.55
B. Combination Scheme									
1. Mungbean*-sweet potato									
0-0-0	0.62	2.60	1608.10	1355.30	2963.40	4932.20	1950.00	6882.20	3918.80
0-30-0	0.62	2.83	1608.10	1562.30	3170.40	4932.20	2122.50	7054.70	3884.30
0-0-30	0.62	3.12	1608.10	1405.50	3013.60	4932.20	2340.00	7272.20	4258.60
0-30-30	0.62	3.15	1608.10	1612.50	3220.60	4932.20	2362.50	7294.70	4074.10
0-60-30	0.62	4.41	1608.10	1819.50	3427.60	4932.20	3307.50	8239.70	4812.10
0-30-60	0.62	4.69	1608.10	1662.70	3270.80	4932.20	3517.50	8449.70	5178.90
60-60-60	0.62	4.74	1608.10	2340.70	3948.80	4932.20	3555.00	8487.20	4538.40
Mean					3287.80			7668.50	4380.20
2. Bushbean*-sweet potato									
0-0-0	1.78	3.55	1958.10	1355.30	3581.40	6226.50	2662.50	8889.00	5575.60
0-30-0	1.78	3.94	1958.10	1562.30	3420.40	6226.50	2955.00	9181.50	5661.10
0-0-30	1.78	3.89	1958.10	1405.50	3363.60	6226.50	2917.50	9144.00	5780.40
0-30-30	1.78	4.38	1958.10	1612.50	3570.60	6226.50	3285.00	9511.50	5940.90
0-60-30	1.78	5.38	1958.10	1819.50	3777.60	6226.50	4035.00	10261.50	6483.90
0-30-60	1.78	5.77	1958.10	1662.70	3620.80	6226.50	4327.50	10554.00	6933.20
60-60-60	1.78	6.76	1958.10	2340.70	4298.80	6226.50	5070.00	11296.50	6997.70
Mean					3637.90			9834.00	6196.11
3. Soybean * - sweet potato									
0-0-0	0.55	3.84	1708.10	1355.30	3063.40	5531.45	2880.00	8411.45	5848.05
0-30-0	0.55	4.80	1708.10	1562.30	3270.40	5531.45	3600.00	9131.45	5861.05
0-0-30	0.55	4.25	1708.10	1405.50	3113.60	5531.45	3187.50	8718.95	5605.35
0-30-30	0.55	5.84	1708.10	1612.50	3320.60	5531.45	4005.00	9536.45	6215.85
0-60-30	0.55	6.02	1708.10	1819.50	3527.60	5531.45	4515.00	10045.45	6918.85
0-30-60	0.55	6.42	1708.10	1662.70	3370.80	5531.45	4815.00	10346.45	6975.65
60-60-60	0.55	6.79	1708.10	2340.70	4048.80	5531.45	5092.50	10623.95	6575.15
Mean					3887.80			9545.02	6157.13

Legend: a = First Cropping (sweet potato for monoculture and legumes for combination scheme)
b = Second Cropping (Sweet potato for both)
* = Legumes were applied with 10-50-50

Price/kg:
Sweet Potato = ₱0.75
Mungbean = ₱8.00
Bushbean = ₱3.50
Soybean = ₱10.00

Conversion Rate:
$1.00 = ₱7.50

cropping, the higher yield did not compensate for the difference in tuber yields obtained during the first cropping. This could be traced to the environmental conditions during the second cropping which encouraged vine growth instead of tuber formation and development. This implied that planting should be properly timed and that the monthly rainfall distribution of the locality should be made use of.

It was evident that the crops grown had different growth duration. The combined cropping of sweet potato with legumes, specifically bushbeans and soybeans, took eight months to grow, while the continuous sweet potato cropping took 10 months. Considering net returns per unit time, therefore, alternate cropping of sweet potato with bushbeans or soybeans gave greater output and had the advantage of improving the physical conditions of the soil.

LITERATURE CITED

EDMOND, J.B. 1971. *Sweet potatoes: production, processing, marketing*. Westport, Connecticut. The Avi Publishing Co. Inc. pp. 110-116.

HUGHES, H.D., and HENSON, H.R. 1964. *Crop production: principles and practices*. New York: MacMillan Co. pp. 225-235.

KIPPS, M.S. 1970. *Principles of field crop production*. Bombay, New Delhi. Tata McGraw-Hill Publishing Co. Ltd. pp. 108-116.

MARTIN, J.A., LEONARD, W.H., and STAMP, D.L. 1976. *Principles of field crop production*. New York: MacMillan Publishing Co. Inc. pp. 166-169.

SANCHEZ, P.A. 1976. *Properties and management of soils in the tropics*. New York: John Wiley and Sons, Inc. pp. 74-87.

TISDALE, S.L., and NELSON, W.L. 1975. *Soil fertility and fertilizers*. New York. MacMillan Publishing Co. Inc. pp. 442-560.