Legume and Nonlegume Crop Residues as Sources of N in Oxisols and Ultisols[1, 2]

Raúl Pérez-Escolar, T. W. Scott, and M. A. Lugo-López[3]

ABSTRACT

Further attempts were made to explore the N supplied by legume and nonlegume crop residues through crop rotation experiments on a sandy Oxisol and a clayey Ultisol. In the initial crop, soybean yields were only fair, (1,680 to 1,792 kg/ha). Mungbeans, (1,125 to 2 044 kg/ha), winged beans, (1,456 to 2,800 kg/ha), and corn yields were good, (4,480 to 6,123 kg/ha). In the second crop (corn at both sites), grain yields were striking as a result of fertilizer N, regardless of the previous crop. On the Ultisol, corn tended to yield more following the legumes than following corn, but differences were not statistically significant. About 80% of the maximum corn yield was attained when corn followed the legumes and no fertilizer N was applied, especially in the Ultisol.

INTRODUCTION

Preliminary studies to explore the N supplied by crop residues through crop rotation experiments on Oxisols and Ultisols under conditions in Puerto Rico have been recently reported (7). Substantially higher yields of corn were obtained in a sandy Oxisol and a clayey Ultisol from the first crop of corn following soybeans or corn than following fallow. Although the yield of the second corn crop following soybeans was slightly higher than that of the first, the second corn crop after initial corn and fallow were substantially higher. The effect of fertilizer N at all sites was striking, regardless of the previous crop in the rotation. There was no apparent relationship between the amount of N returned to the soil and yields of subsequent corn crops. It was noted that the three continuous corn crops on a clayey Ultisol, which were harvested over a period of less than 14 mo, produced about 18,000 kg/ha of grain with the application of 110 kg/ha of N/crop. It was postulated that this would not be possible unless a substantial amount of N was available from sources other than the fertilizer N, such as mineralization of soil organic matter or root residues.

This initial work led to further studies with other edible legumes, which after harvesting, would have more green matter in the stover.

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[3] Soil Scientist, Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus, Río Piedras, P.R., Professor and Soil Scientist, Cornell University, Ithaca, N.Y., and Professor and Soil Scientist (Ret.), Agricultural Experiment Station, University of Puerto Rico, now Consultant, Cornell University, respectively.

MATERIALS AND METHODS

Crop rotation experiments were conducted at two different locations: Manatí on an Oxisol (Bayamón series), Typic Haplorthox, with high sand content, oxidic, isohyperthermic; and Corozal on an Ultisol (Humatas series), Typic Tropohumults, clayey, kaolinitic, isohyperthermic (4). The Bayamón soil occurs at an elevation of 50 to 130 m, fully exposed to the sun, while the Humatas occurs at elevations of 220 to 580 m with northern exposure. Soil samples were taken at both sites at 0-25 and 25-50 cm depths previous to the establishment of the treatment differentials, and were analyzed for pH, organic matter content, cation exchange capacity, and exchangeable Ca, Mg, K, and Al using standard methods (2). Native vegetation included broad-leaf weeds and grasses.

The rotation experiments followed a split-plot design with six replications. The main plots were four rotations: Soybeans (*Glycine max*) and corn (Zea mays L.); winged beans (*Psophocarpus tetragonolobus*) and corn; mungbeans (*Phaseolus aureus*) and corn; and corn in monoculture. The subplots included two treatments for the corn crop following the initial crop; 0 and 67 kg/ha of fertilizer N applied as urea, all when the plants were 1 mo old. Plots were 4.57 × 9.15 m in size.

For the first crop in the rotation, corn hybrid Pioneer X-306-B, soybean variety Jupiter, winged bean selection 16 (obtained from the Mayagüez Institute of Tropical Agriculture), and an unidentified variety of mungbeans introduced from Trinidad were planted in the corresponding plots on April 1, 1976 and May 17, 1976 at Manatí and Corozal, respectively. The legumes and the corn were planted at 61 cm between rows, and 23 cm between plants. Weeds were removed by hand from all plots as necessary. Excellent crop protection from insects and diseases was achieved through the preventive biweekly use of Sevin and Dithane[4] at rates of 1.25 and 1.5 lb/acre, respectively. The plots at both sites were irrigated as necessary using a sprinkler system. The legume crops and the corn received the following application of fertilizer broadcast at planting: 112 kg/ha of P_2O_5 as triple superphosphate, 112 kg/ha of K_2O as sulphate, and 56 kg/ha of Mg as sulphate. The initial corn crop received 110 kg/ha of N, but no N was applied to the soybeans, winged beans, and mungbeans.

At Manatí, mungbeans were harvested as dry pods 90 days after planting; the stover was plowed under with a rotavator. Winged beans, because of the indeterminate nature of the crop, were harvested periodically from about mid-August to the first week of October 1976. Soybeans

[4] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

and corn were harvested during the first week of October at 180 days of age. The legume and corn stover were plowed under on November 5, 1976.

At Corozal, mungbeans were harvested at 60 days at the green-pod stage. The border rows were left unharvested to estimate dry-grain yields. The inner rows were planted again without receiving any additional fertilizer. The objective was to obtain a second crop of mungbeans, in view of the relatively quick growth observed in the first crop, while the other legumes and the corn were still immature or not ready for final harvesting. Winged beans were harvested periodically, as in Manatí, from Mid-September to the end of October. Corn and soybeans were harvested at the end of October. In addition, the amount of legume stover was determined and analyzed for N by the Kjeldahl technique (2). The second crop corn at both sites, was planted on February 22, 1977, at Manatí, and on April 13, 1977, at Corozal. Rows were 75 cm apart. Half of each plot received fertilizer N at the rate of 67 kg/ha 1 mo after planting. The corn

TABLE 1.—*Selected chemical properties of the two soils used in the crop residue experiments*

Soil	Depth	Organic matter	Acidity	Cation exchange capacity	Exchangeable cations			
					Ca	Mg	K	Al
	Cm	*%*	*pH*			*Meq*		
Bayamón sandy	0–25	1.6	5.2	2.5	1.3	0.8	0.1	0.3
Oxisol	25–50	.7	4.8	2.3	1.2	.7	0	.4
Humatas clayey	0–25	3.7	5.1	7.9	6.4	.8	.7	0
Ultisol	25–50	1.2	4.6	12.4	3.0	.8	.2	8.4

crops received broadcast fertilizer applications as follows: 224 kg/ha of P_2O_5 as triple superphosphate; 168 of K_2O as sulphate; and 90 of Mg as sulphate.

RESULTS AND DISCUSSION

Table 1 gives selected chemical properties of the two soils. The pH of the surface layer at the two sites was slightly over 5.0, decreasing with depth to 4.6 and 4.8 at the Corozal Ultisol and the Manatí Oxisol sites, respectively. Organic matter content of the clayey Ultisol was 3.7; in the sandy Oxisol it was less than half that value. CEC was nearly 8 meq in the Ultisol. Ca saturation was over 80% in the Ultisol and 52% in the Oxisol. Al was low in the Oxisol and negligible in the surface layer of the Ultisol, but increased to almost 70% saturation in the 25 to 50 cm layer of the latter. This should not pose any problem except for highly sensitive crops such as sorghum (8).

Table 2 gives grain and stover yields of the initial crop of legumes and corn at both sites. The soybean yields were only fair when compared with yields of other experiments at the same sites and at other locations. Yields of about 3,170 kg/ha have been previously obtained in the Bayamón sandy Oxisol and in liming experiments at other sites (6). Yields of winged beans and mungbeans compare favorably with those obtained at locations outside Puerto Rico (1, 5). Corn yields are good especially at the Oxisol site, a reverse situation as compared to previous work at the same locations (3).

The grain yields of the corn crop following the initial corn, soybeans, winged beans, and mungbeans are given in table 3 for the two sites. At

TABLE 2.—*Initial grain and stover yields of legumes and corn crops*

Crop	Yields in Oxisol		Yields in Ultisol	
	Grain	Stover	Grain	Stover
		Kg/ha		
Corn (Pioneer X-306B)	6,123	7,258	4,480	2,969
Soybeans (Jupiter)	1,680	2,050	1,792	2,173
Winged beans (W.B. 16)	1,456	2,733	2,800[2]	2,240
Mungbeans	1,125[1]	2,710	2,044[1] or 2,800[2]	2,576

[1] Dry-grain weight.
[2] Green-pod weight.

TABLE 3.—*The effect of plowed-in legume and corn stover and roots on yield of field corn, Pioneer X-306B*

Rotation	Fertilizer N applied	Yield on indicated soil	
		Ultisol	Oxisol
		Kg/ha	
Corn, corn	0	2,337	4,716
Corn, corn	67	3,938**[1]	5,191**
Mungbeans, corn	0	3,022	5,382
Mungbeans, corn	67	3,705**	6,157**
Soybeans, corn	0	3,295	4,327
Soybeans, corn	67	4,296**	5,352**
Winged beans, corn	0	3,096	4,658
Winged beans, corn	67	3,747**	5,765**

[1] Highly significant differences against no N.

the Corozal site, (Humatas clay) corn with or without fertilizer N (as whole treatments) tended to yield more following soybeans, mungbeans and winged beans than when following the initial corn crop. The differences, however were not significant, even though the initial corn crop received 110 kg/ha of fertilizer, while the legume crops did not receive fertilizer N. This was not the case at the Manatí site, (Bayamón sandy loam), except for corn following mungbeans, with or without fertilizer N, in which case corn yields tended to be more than corn following the other legumes or corn, although differences again were not significant.

The effect of fertilizer N applied to the corn crops succeeding the initial crops was again striking at both sites. In four out of six cases the increased yield attributable to applied fertilizer N surpassed 1,000 kg/ha; in one case at Corozal the increase reached 1,600 kg/ha (corn following corn, both crops with 67 kg/ha of applied N).

At both sites, about 80% of the maximum corn grain yields obtained when fertilizer N was applied could be obtained when corn followed the legumes and no N was applied, especially on the clayey Ultisol. At Manatí, as much as 90% of the maximum yields in the second crop were obtained with no N following corn. However, it must be remembered that the original corn crop and the second corn crop received 110 and 67 kg/ha of fertilizer N, respectively.

Table 4 shows the amount of stover plowed under and its N content. As in the previous experiment, there was no apparent statistical relationship between the amount of N returned to the soil from these residues and mean yields of the subsequent corn crop.

TABLE 4.—*Dry matter plowed under, its N content, and yield of field corn X-306B (kg/ha) on plots where no mineral N was applied*

Treatment	Oxisol			Ultisol		
	Stover	N	Corn yield	Stover	N	Corn yield
	Kg/ha	*Kg/ha*		*Kg/ha*	*Kg/ha*	*Kg/ha*
Corn	7,258	60	4,716	2,969	14	2,336
Soybeans	2,050	12	4,327	2,173	20	3,022
Winged beans	2,733	30	4,658	2,240	28	3,295
Mungbeans	2,710	33	5,384	2,576	24	3,096

Total corn yields of 6,817 and 10,840 kg/ha were obtained at Corozal and Manatí, respectively, for the two subsequent corn crops. At Corozal 17,899 kg/ha of grain (both legume + subsequent corn) were obtained without fertilizer N; at Manatí, 18,628 kg/ha. With fertilizer N, the respective yields increased to 20,239 and 21,535 kg/ha. These are sizeable amounts of grain for a period of less than a year. This would not be possible unless a substantial amount of N became available from sources other than the fertilizer, as also observed in a previous experiment (7). The mineralization of soil organic matter and root residues may play a significant role in supplying this N. This problem needs further study.

RESUMEN

Se realizaron experimentos adicionales de rotación de cosechas para constatar las posibilidades del uso de residuos de cosechas—leguminosas y noleguminosas—como fuentes de N en dos localidades: un Oxisol arenoso y un Ultisol arcilloso. Los experimentos se diseñaron como parcelas subdivididas. Los tratamientos principales eran las cuatro rotaciones: 1) maíz, maíz; 2) sojas, maíz; 3) habichuelas mung, maíz; y 4) habichuelas aladas, maíz. Los subtratamientos consistieron de dos niveles de N: 0 y 67 kg/ha aplicados un mes después de la siembra. En las cosechas iniciales se obtuvieron rendimientos medianamente elevados de sojas, bastante elevados de habichuelas mung y habichuelas aladas (a base de rendimientos

informados de áreas productoras de estos cultivos nuevos para Puerto Rico) y buenos rendimientos de maíz. En la cosecha siguiente de maíz, el aumento en los rendimientos que pueda atribuirse a la aplicación de 67 kg/ha de N fue tan drástico como en experimentos anteriores, independientemente de la cosecha anterior. En el Ultisol, se obtuvieron rendimientos de maíz substancialmente más elevados después de la cosecha inicial de las tres leguminosas que cuando se sembró maíz por dos veces consecutivas en el mismo terreno. La situación en el Oxisol fue diferente, a excepción de la rotación habichuelas mung-maíz. Se logró como 80% de los rendimientos máximos de maíz sin necesidad de aplicar N como abono cuando las siembras previas en la rotación fueron leguminosas. En este caso, hay la ventaja adicional de que se pueden sembrar y cosechar leguminosas comestibles. En Manatí se lograron producciones de grano utilizable de la magnitud de 18,628 kg/ha, incluyendo la leguminosa y el maíz en sólo dos cosechas en alrededor de un año; en Corozal, 17,899 kg/ha. Con el uso de N, estas producciones ascendieron a 21,535 y 20,239 kg/ha, respectivamente. Esto no sería posible si no hubiese disponible una cantidad substancial de N de otras fuentes, aparte del abono, y la que quizás pueda atribuirse a la mineralización de la materia orgánica del suelo y de los residuos de cosechas anteriores.

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