Utilization of N from Crop Residues in Oxisols and Ultisols[1,2]

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ABSTRACT

An attempt was made to evaluate the N supplied by crop residues through crop rotation experiments on Oxisols and Ultisols. Field experiments were conducted on three typical soils following a split-plot design. Main plots were three rotations: soybeans, corn, corn; fallow, corn, corn; and continuous corn. Subplots included two treatments: 0 and 110 kg/ha of fertilizer N. Fair yields of soybeans were obtained while corn yields were good, especially on the Humatas soil (Ultisol), 6240 kg/ha. Substantially higher yields were obtained in the Bayamón (Oxisol) and Humatas soils from the first corn crop following soybeans or corn than when following fallow. Although the second corn crop yield following soybeans was slightly higher than the first, the second corn crop after initial corn and fallow were substantially higher. The effect of applied N at all sites was striking, regardless of the previous crop. There was no apparent relationship between the amount of N returned to the soil and yields of subsequent corn crops.

INTRODUCTION

With the greatly increased cost of N fertilizer and its relative unavailability to most farmers in less developed countries, more attention is being given to alternate sources of N in food crop production. A reexamination of the amount of N which can be supplied from mineralization of crop residues is essential, especially in acid soils of the tropics where information is limited.

Of particular importance is the role of edible legumes in a rotation to supply food and provide N to a subsequent crop. The N-supplying power of many tropical legumes, and more so of non-legumes, has not been well assessed. Knowledge of the factors that modify this N supplying power under tropical environments is almost negligible. Studies along this line may shed some light on these areas which might have a practical significance.

Evidence from other areas indicates that the degree of maturity of the legumes and non-legumes plowed under influences in large measure

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their N-supplying power. This is a reflection of the C:N ratio. The less mature the material, the easier it is for the N mineralizing microorganisms to decompose it and render available greater quantity of N to the succeeding crop.

This paper reports an attempt to evaluate the N supplied by crop residues through crop rotation experiments conducted on Oxisols and Ultisols.

MATERIALS AND METHODS

Crop rotation experiments were conducted on three different soils, the chemical characteristics of which are shown in table 1. They are: sandy Oxisol (Bayamón), clayey Ultisol (Humatas), and clayey Oxisol (Catalina). The Bayamón soil is a typic Haplorthox, clayey with a high sand content, oxidic, isohyperthermic. The Catalina is a Tropeptic Haplorthox, clayey, oxidic, isohyperthermic. Humatas is one of the typic Tropohumults, clayey kaolinitic, isohyperthermic.[4] The Bayamón soils have an undulating topography at an elevation of 50 to 130 m and are fully exposed to the sun. The Catalina and Humatas soils occur in hilly areas with northern exposures at elevations of 220 to 580 m. At all sites the pH is around 5.2. Native vegetation consists of broad leaf weeds and grasses typical of the humid tropics.

TABLE 1.—*Selected chemical properties of soils used in the crop-residues experiments*

Soil	Depth	Organic matter	pH	C.E.C. cations	Exchangeable cations Ca	Mg	K	Al
	cm	*%*			*Meq/100 g*			
Bayamón	0–25	1.6	5.2	2.5	1.3	0.8	0.1	0.3
sandy loam	25–50	.7	4.8	2.3	1.2	.7	0	.4
Humatas clay	0–25	3.7	5.1	7.9	6.4	.8	.7	0
	25–50	1.2	4.6	12.4	3.0	.8	.2	8.4
Catalina clay	0–25	3.9	5.2	8.7	7.1	1.0	.6	0
	25–50	1.2	5.2	4.8	4.0	.6	0	0

The rotation experiments followed split-plot designs with six replications, where the main plots were three rotations: soybeans, corn, corn; fallow, corn, corn; and corn, corn, corn. The subplots included two treatments for the two corn crops following the initial crop: 0 and 110 kg/ha of N applied as urea, one fourth at planting time and the rest, when plants were 1 month old.

[4] Soil Survey Investigations Report No. 12, Soil Conservation Service, USDA, in cooperation with Puerto Rico Agricultural Experiment Station, 1967.

For the first crop in the rotation, corn hybrid Pioneer X-306B and soybean variety Jupiter were planted in the corresponding plots on the same day. Grasses and weeds were allowed to grow on the fallow plots. Weeds were removed by hand from the corn and soybean plots as necessary. Crop protection practices to prevent insect and disease incidence were followed as recommended under local conditions.[5] The plots in the sandy Oxisol and in the clayey Ultisol were irrigated as necessary using a sprinkler system. The soybean and corn experimental plots received a complete fertilizer at planting, except that no N was applied to the soybeans.

After harvesting the first corn and soybean crops, the corn roots, soybean stover, and weed fallow were plowed under about 2 weeks before planting the next crop (X-306B corn). The second and third crops[6] in the rotation (corn), also received a complete fertilizer, except that half of each plot received no N while the other half received N at

TABLE 2.—*The effect of plowed-under soybean stover, fallow, and corn ratoons on yield of field corn X-306B (kg/ha)*

Treatments	Bayamón sandy loam		Humatas clay		Catalina clay
	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1
			Kg/ha		
Fallow, 0 N	2377	4073	1814	3162	4461
Fallow + N	3940**[1]	5577**	3867**	6765**	5734**
Soybean, 0 N	3972	4325	2770	3005	4782
Soybean + N	5745**	5595**	4495**	6488**	6729**
Corn, 0 N	2879	3816	2137	2773	4870
Corn + N	5284**	5413**	5088*	6369**	5976**

[1]** Highly significant over no nitrogen.

the rate of 110 kg/ha. Data on grain yields were taken at the three locations. In addition, the amount of soybean stover and weed fallow were determined in the sandy Oxisol and analyzed for n.

RESULTS AND DISCUSSIONS

The initial soybean and corn grain yields are given in the following tabulation:

Soil type	*Soybean yield kg/ha*	*Corn yield kg/ha*
Bayamón sandy loam	1743	4950
Humatas clay	1620	6240
Catalina clay	1061	4473

[5] "Control de plagas de importancia en la finca y el hogar en Puerto Rico", Est. Exp. Agr. Univ. P.R. Publicación 89, 90 y 91, 1974.

[6] The third crop was not grown on the clayey Oxisol because the land rental contract with the owner-operator could not be renewed after harvesting the second crop in the rotation.

TABLE 3.—*Dry matter plowed under, its nitrogen content, and yield data of field corn X-306B*

Treatment	Dry matter	Nitrogen	Mean corn yield of two crops
		Kg/ha	
	Bayamón sandy loam		
Fallow	5270	78	2478
	6430	90	3196
	6240	98	3959
	8330	140	3596
	8450	142	2375
	9580	144	3740
Soybean stover	790	7	4047
	1025	7	4616
	1090	8	4691
	1340	9	3838
	1490	10	3800
	1671	12	4077
	Humatas clay		
Fallow	2370	26	2480
	3280	28	2386
	4770	51	2854
	4495	55	2942
	5535	68	2264
	6640	70	1999
Soybean stover	4560	11	2835
	5730	12	3461
	3060	35	2920
	3200	42	2075
	4440	55	2967
	5070	101	3068
	Catalina clay[1]		
Fallow	780	9	6342
	880	10	2394
	1020	18	4391
	1730	19	4255
	2550	33	5738
	4100	82	3468
Soybean stover	3000	22	4562
	3000	23	4600
	3500	30	4500
	5510	46	5618
	5400	49	5752
	5300	62	3659

[1] Yield of one corn crop.

The soybean yields were only fair when compared with yields of previous experiments at the same sites. Yields approximating 3170 kg/ha have been previously obtained in the Bayamón soil and in liming experiments at other sites. The corn yields were good, expecially at the Humatas site.

Grain yields of the corn crops following the initial corn crop, soybean crop, and fallow are given in table 2 for the three sites. In the first crop on both the Bayamón and the Humatas soils, corn with and without fertilizer N (as whole treatments) following soybeans yielded substantially more than corn following fallow. Mean differences were significant. This was not the case at the Catalina clay site.

The effect of applied fertilizer N on succeeding corn crops was striking at all sites for the succeeding corn crops regardless of the previous crop. In the Humatas soil, the yield was doubled in five instances out of six, as in the Bayamón soil. The increased yield due to applied N was also evident at the Catalina site.

Table 3 gives data on the amount of soybean stover and weed fallow plowed under and their N content. The N content is presented in increasing amounts as calculated from its percent and the amount of dry matter plowed under. There was no apparent statistical relationship between the amount of N returned to the soil from these residues and average yields of the subsequent corn crops. When a legume, such as soybeans, is harvested, the stover has a low N content and a relatively high C:N ratio. Consequently, the mineralization of the residues and release of available N to the succeeding crop is likely to be low.

The three continuous corn crops on Humatas soil, which were harvested over a period of less than 14 months, produced about 18,000 kg/ha of grain with the application of 110 kg/ha of N/crop. This would not be possible unless a substantial amount of N was available from sources other than the applied N, such as through mineralization of soil organic matter or root residues.

This initial work should lead to further studies with other edible legumes in the rotation, which, after harvesting, would have more green matter in the stover with a lower C:N ratio. Mineralization studies should help to clarify the situation.

RESUMEN

Para explorar las posibilidades de usar los residuos de cosechas como fuentes de N en oxisoles y ultisoles, se hicieron experimentos de rotación de cosechas en tres localidades: un oxisol arenoso, un ultisol arcilloso y un oxisol arcilloso. Se usó un diseño de parcelas subdivididas. Los tratamientos principales fueron las tres rotaciones: 1) habichuelas soyas, maíz, maíz; 2) barbecho, maíz, maíz; y 3) maíz, maíz, maíz. Los subtratamientos consistían de dos niveles de N aplicados al maíz después de la cosecha inicial: 0 y 110 kg/ha. En la cosecha inicial se obtuvieron rendimientos medianamente altos de soyas y buenos rendimientos de maíz, especialmente en el suelo Humatas, en el

que se obtuvieron 6240 kg/ha. Se obtuvieron rendimientos substancialmente más altos de maíz en los suelos Bayamón y Humatas en la rotación en que el maíz seguía a las soyas o al maíz que en las que éste seguía al barbecho, aunque la segunda cosecha de maíz que seguía a maíz y a barbecho fue substancialmente más alta. El efecto del N aplicado como abono fue dramático en todos los sitios, independientemente de la cosecha inicial. No parece que hubo relación entre la cantidad de N que se incorporó al suelo en los residuos y las cosechas subsiguientes de maíz.