Contributions to Improve Fallow System in Yucatan State Mexico

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Abstract—*More than 25 percent of earth warming can be attributes to deforestation practices such as crop rotations performed in southeast part of Mexico. In the Yucatan peninsula 20 percent of staple foods such as maize and beans are produced under slash and burn system. It has been practiced for many centuries by native Mayans however population pressure and food scarcity made short fallow periods. Thus soil fertility decline and farmers used to changed to new fertile areas slashing and burning about 250 thousand per year. Natural degradation is a problem in this region therefore a project to contribute to fallow system was developed to try to assure grain production in the same deforested land for more years than the farmers do.*

A field study was conducted in the field station "Uxmal" belonging to the National Institute on Forestry, Agriculture and Animal Husbandry Research on a Luvisol rodic *soil in the state of Yucatan. From 1996 to 2003 two legumes, spontaneous weeds, and continuous cropping using fertilizer treatments were established. It was concluded that is possible to return to same area in short periods using at least two years, also produce maize continuously in this soils for more than three years. Variations on yields are due to rainfall than soil fertility conditions.*

Introduction

Farmers in the Yucatan Peninsula have been used crop rotation systems for many hundred of years. More than 25 percent of earth warming can be attributed to this type of agriculture. 17 millions of ha-1 are lost by deforestation actions in the world. Latin America contributes with 40 percent of total area and Mexico is ranked fourth with 700 thousand ha-1 (Bandy, et. al., 1994). Yucatan state rendered 20 percent to basic crops under slash and burn system (SAGARPA 2001).

Therefore this paper can be regard as a contribution to improve the knowledge about fallow systems in Yucatan state and the possibility to stay in the same area growing maize.

Methodology

The study was conducted at the field station "Uxmal" (latitude 20° 25' N, longitude 89° 46' W) belonging at the National Institute on Forestry, Agriculture and Animal Husbandry Research (INIFAP) located in the Yucatan State in the southeast of Mexico. The soil of the study area was a *Luvisol rodic* (FAO system), and experimental area is 50 m above sea level. Annual rainfall average is 900 mm and mean temperature is about 26 ° C. Rainy season starts in June and lasts until the end of October a period of about five months.

The treatments were replicated four times in the study that had a randomized block, split plot design using plots of 12 X 26 m. Treatments using *Mucuna pruriens*, *Leucaena leucocephala*, spontaneous weeds and continuous cropping were assigned to the main plots (table 1).

Sub plots were sown with maize and fertilized with treatments 20-50-0, 40-100-0 of nitrogen, phosphorus and potassium respectively also a control plot without fertilizer was included.

In 1996 experimental area was slash and burned in order to start the experiment for two and four years treatments regarding both as zero year. *Mucuna pruriens* was sown at 1m between rows and plants and *Leucaena*

Table 1. Treatments description of improved fallow and growing seasons.

Treatments	Years							
	1996	1997	1998	1999	2000	2001	2002	2003
Leucaena 2 years fallow	CC	CC	MC	F	F	CC	CC	CC
Leucaena 4 years fallow	MC	F	F	F	F	CC	CC	CC
Mucuna 2 years	CC	CC	MC	F	F	CC	CC	CC
Mucuna 4 years	MC	F	F	F	F	CC	CC	CC
Spontaneous weeds. 2 years	CC	CC	MC	F	F	CC	CC	CC
Spontaneous weeds. 4 years	MC	F	F	F	F	CC	CC	CC
Continuous cropping(maize)	C C	CC	CC	CC	CC	CC	CC	CC

C C = continuous cropping, M C= Maize cropping and legume sowing, F = Fallow

leucocephala at 1m between plants and 2 m between rows. Sowing distance of maize was 1m between rows and 50 cm between plants leaving two by hole.

Soil samples were taken at a depth of 30 cm before and after burn the experimental area. Analysis for pH, OM, P, K, Ca Mg, Fe, Zn, Cu and Mn were done following the usual methods. Soil moisture disturbed samples were collected weakly all over the years making determinations by the gravimetric method. Annual rainfall was also registered from a meteorological station located at field station from sowing to harvest maize. From 2001 to 2003 spontaneous weeds were measured taking the population density. Legumes biomass was also registered after fallow period in 2000 year using a squared frame of 0.5 X0.5m (10 samples per plot) and no analysis of variance was performed for these data. Maize yield was evaluated all the years. In 2002 year a hurricane affected the yield of maize and the original condition of the experiment. Therefore analysis of variance was not performed for some data. Analysis of variance was performed for population density of spontaneous weeds, legumes contribution to yield of maize and grain yield of maize under fertilizer treatments. Mean separation was made using L.S.D test.

Results and Discussion

Results of chemical characterization are shown in table 2. According to data without burn organic matter and phosphorus are at medium level and very high for potassium and calcium pH is slightly alkaline. With burn organic matter is high as well as phosphorus, potassium, calcium and the pH.

It thus appears that low CEC can regard as limiting factor to yield of maize. Similar results of organic matter content increase, agreed these data (Perez, 1975; Navarrete, 1977; Sanchez y Salinas, 1981; Uribe, 1982; Nair. 1984).

Table 2. Soil analysis content before and after burn experimental area. INIFAP.2003.

Soil parameter	Soil management	
	Before burn	After burn
Organic mater (%)	2.96	3.37
Phosphorus ppm	24.28	26.25
Potassium ppm	306.78	348.93
Magnesium ppm	465.36	461.43
Calcium ppm	2446.07	2492.86
pH	7.09	7.39
CEC meq/100 gr	17.55	17.26

Soil moisture content data with *Mucuna pruriens* were slightly higher than those registered with *Leucaena leucocephala* mainly in dry season due to organic matter contribution which keeps the soil moisture content (Campos and others 1983; Ramirez and others 2001) (table 3).

No significant differences were found for plant population of spontaneous weeds (table 4). *Mucuna pruriens* had a slightly depressive effect on spontaneous weed population compared to *Leucaena leucocephala* in 2001 year. In 2002 year spontaneous weed were damage by hurricane. The recover started in 2003 year without a clear tendency among treatments, may be due to previous damage above cited.

Even though no significant differences were found with the use of legumes a tendency to improve the yield of maize was observed with *Leucaena leucocephala* in both 2001 and 2203 years (table 5). Quantity of biomass contribution and a fast decomposition to organic matter can be regard as important factors that show the tendency observed.

Mucuna pruriens contribution of biomass was better than the other treatments in both 2 and 4 fallow years due to a mulch of leaves left in the soil without decomposition (table 6). Similar results are reported by Ramirez and others (2001) in Quintana-Roo state in the same type of soil (*Luvisol rodic*). On the other hand *Leucaena*

Table 3. Soil moisture content in improved fallow system for two seasons. INIFAP 2003.

Treatments	Dry season S.M %	Wet season S.M %	Annual average
Leucaena leucocephala 2 years	22.88	31.33	27.10
Leucaena leucocephala 4 años	22.32	30.83	26.57
Mucuna pruriens 2 years	23.81	32.05	27.93
Mucuna pruriens 4 years	24.67	31.97	28.32
Spontaneous weeds 2 years	23.03	31.73	27.38
Spontaneous weeds 4 years	23.68	31.45	27.56
Continuous cropping(maiz)	21.83	31.37	26.60
Average	23.17	31.53	

S.M% = Soil Moisture %

Table 4. Plant population density of spontaneous weeds. INIFAP 2003.

	Years/thousands/plants/ha			
Treatments	01	02	03	Average
Leucaena leucocephala 2 years	2101	666	1373	1380
Leucaena leucocephala 4 años	2191	860	2100	1717
Mucuna pruriens 2 years	2083	730	1820	1544
Mucuna pruriens 4 years	2014	630	2056	1567
Spontaneous weeds 2 years	2103	711	1353	1389
Spontaneous weeds 4 years	2032	593	930	1185
Continuous cropping (maiz)	1914	743	1306	1321

Table 5. Treatments contribution to grain yield of maize after fallow. INIFAP 2003.

	Years /t/ha		
Treatments	2001	2002	2003
Leucaena leucocephala 2 years	1.98	0.26	2.36
Leucaena leucocephala 4 años	1.97	0.14	2.08
Mucuna pruriens 2 years	1.83	0.33	1.52
Mucuna pruriens 4 years	1.91	0.17	1.67
Spontaneous weeds 2 years	1.85	0.22	1.80
Spontaneous weeds 4 years	1.95	0.18	2.15
Continuous cropping (maize)	1.84	0.14	2.06

Table 6. Biomass quantity yielded by treatments after fallow. INIFAP 2003.

Treatments	Biomass (g/0.25 m^2)
Leucaena leucocephala 2 years	142.1
Leucaena leucocephala 4 años	126.7
Mucuna pruriens 2 years	253.1
Mucuna pruriens 4 years	205.4
Spontaneous weeds 2 years	180.6
Spontaneous weeds 4 years	163.4
Continuous cropping (maiz)	194.2

leucocephala seems to reduce biomass in both treatments, but the size of leaves and a fast decomposition is given lees biomass compared to other treatments.

Fertilizer treatments applied to maize are shown in table 7. No significant differences were found in 1996, 1997 and 2001 years for grain yield, however in 1998 to 2003 years significant differences shows that the best treatment was 40-100-0 of nitrogen, phosphorus and potassium respectively. For rain fed conditions distribution of rainfall is more important than quantity due to critical stages such as blooming and grain filling. In figure 1, rainfall is about 500 to 800 mm as an average in eighth years data. More than 800 mm occurred only in two years (1999 and 2001) except hurricane year. Yield variations among years depend on the quantity and proper distribution of the rainfall.

Conclusions

Organic matter content, phosphorus, potassium, calcium, and the pH increases with burn compared to no burn.

Mucuna pruriens had a slightly depress effect on spontaneous weeds compared to *Leucaena leucocephala*.

Table 7. Grain yield of maize under fertilizer treatments. INIFAP 2003.

	Years/ t/ha								
Fertilizer treatments	**1996***	**1997***	**1998**	**1999**	**2000**	**2001***	**2002**	**2003**	**Average**
0-0-0	0.83	2.47	2.17b	2.08b	1.75b	1.89	0.11	1.22c	1.80
20-50-0	0.94	2.72	2.47b	2.89a	2.05a	1.75	0.17	2.32b	2.16
40-100-0	1.26	3.28	2.91a	2.84a	2.30a	1.87	0.15	2.63a	2.44
L.S.D	-	-	0..330	0.304	0.266	-	-	0.231	

Any two means having a common letter are not significantly different at 5 % of level of significance. LSD Test
* No significant

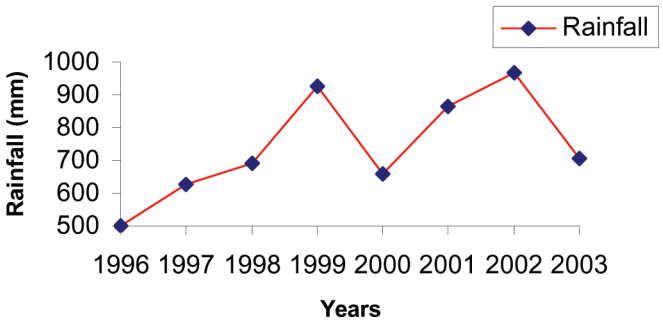

Figure 1. Annual rainfall from sowing to harvest grain maize. INIFAP (2003).

There are no clear contribution to yield of maize from legumes, but *Leucaena leucocephala* shows a tendency.

Mucuna pruriens biomass contribution was better than *Leucaena leucocephala* and spontaneous weeds.

Fertilizer response started at third year of continuous cropping with maize achieving high yield of grain with the treatment 40-100-0 of nitrogen, phosphorus, and potassium respectively.

Is possible to return to same area in short periods using at least two years also produce maize continuously in this soils for more than three years.

Conservation of natural resources can be enhanced using legumes to extend periods of crop and preserving forestry and flora for another purposes

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