Intsormil

TRIP REPORT

SOME ECOLOGICAL ASPECTS OF FARMING SYSTEMS IN SOUTHERN HONDURAS

by

C. R. Carroll, Consultant
Baylor University

April, 1983

CONTRACT NO.: AID/DSAN/XII-G-0149

☆ International
Sorghum/Millet

☆ Collaborative Research
Support Program
(CRSP)

A Research Development Program of the Agency for International Development, Participating Land-Grant Universities, Host County Research Agencies and Private Donors.

Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln

REPORT TO INTSORMIL:
SOME ECOLOGICAL ASPECTS OF FARMING SYSTEMS IN SOUTHERN HONDURAS

April 29, 1983

Dr. C. R. Carroll
Assistant Director
Inst. of Environmental Studies
Baylor University
Waco, Texas 76798

CROP MIXES AND PRACTICES

In most shifting agricultural practices, intercropping is common. Successful mixes usually depend on cereal and legume combinations. In these situations, the combined yields are frequently greater than would be expected by simply summing the independent yields of the legume and the cereal. It is generally accepted that the nitrogen fixing properties of the legume-Rhizobium association provides excess nitrogen that is available to the associated cereal plant. The contribution from the cereal to the

yields of the legume is less obvious. The practice in southern Honduras of intercropping to structurally similar cereals, corn and sorghum, is therefore unusual. The similar morphologies of the two plants and their generally similar nutrient requirements suggest that competitive interactions would be strong. Given the assumed low nutrient status of the soils, as discussed below, [illegible] cereal polyculture would seem maladaptive to the region. The generality of this cereal polyculture and the observation that yields may be low but not unusually so, suggests that other unknown mitigating factors may be important. Such factors may include species differences in root architecture and, as discussed later, the role of mycorrhizae may be significant.

Legumes become an important part of the polyculture only at higher elevations, for example, at San Antonio. Local farmers suggest that the legumes require cooler temperatures, however, there is an important interaction between cool temperatures and soil conditions. In Figure 1, I have attempted to illustrate the relationship between elevation and net photosynthesis. "A" and "B" illustrate declining temperatures as a function of increasing elevation. Photosynthetic rates are inhibited by high mid-day temperatures that frequently occur at low elevations and also by cool and cloudy conditions that occur at higher elevations, typically above 1800 meters. This is illustrated in figure "C". Respiration rates have an exponential relation to temperature. Frequently, respiration rates in plants double with every 10 degree centigrade rise in temperature. San Antonio has an elevation of about 550 meters and would lose approximately 5.5 degrees centigrade compared to sea level temperatures due to the dry adiabatic lapse rate. This decline in temperature alone would reduce

plant respiration rates at San Antonio by a factor of about 1.5. This is illustrated in figure "D". Net photosynthesis, the difference between gross photosynthesis and respiration, is illustrated in figure "E", and indicates a sharp rise in net photosynthesis with increasing elevation. At higher elevations, of course, net photosynthesis would begin to decline. This differential response by photosynthesis and respiration to temperature has provided part of the explanation for the widely observed phenomena of high plant diversity and productivity at mid-elevational localities throughout the wet tropics. However, with legumes there is an important interaction between soil conditions and lower temperatures at higher elevations. In order to maintain the symbiotic nitrogen-fixing bacteria in their root nodules, legumes must supply the bacteria with carbohydrates. Therefore, legumes can get by on low levels of soil nitrogen, but require relatively high levels of phosphorus. Indeed, phosphorus has frequently been cited as the most limiting factor for legume productivity in the tropics. In Table 1, if these values can be considered representative of this region of Honduras, and phosphorus levels are extremely low. Phosphorus deficiencies exacerbate the effects of high temperatures on productivity. Under conditions of phosphorus deficiency the behavior of the plants' stomata becomes erratic and water use deficiency declines strikingly. The presence of such low levels of available phosphorus in this region has very likely played an important role in restricting legume production to higher elevations. Seen in this light, the Indore compost operation that we saw at San Antonio is particularly significant. The manure-plant residue compost is an excellent combination for producing suitable available phosphorus for these soils. Note that these soils have very high levels of calcium and occasionally, high levels of zinc.

Under these conditions, if phosphorus is applied in a highly soluble form as, for example, in super phosphate fertilizers, the phosphorus has a tendency to form rather insoluble complexes with the calcium and zinc, and therefore becomes unavailable to the plants, thus lowering the availability of these other mineral nutrients. This does not seem to be a problem when phosphorus is slowly released with the high chelating properties of organic manure. Thus, fertilizing legumes with small amounts of compost could increase legume productivity significantly in the lower elevations. If this is combined with a cereal polyculture, then the surplus nitrogen produced by the legumes could, of course, enhance cereal yields as well.

The practice of leaving unburned plant residues on the fields and planting directly through the mulch also has some advantages for improved productivity. Several studies, primarily in Africa, have demonstrated that cereal yields can be improved through mulching practices as much as they can be improved through the addition of synthethic fertilizers. In tropical regions mulches provide numerous advantages. These include: maintaining higher soil moisture levels; reducing photo-oxidation processes that result in compact soil oxides; slow nutrient release; and protection from various kinds of erosion. Indeed, the only fields that showed any degree of erosion were fields that had exposed soils. Presumably, increasing practices of burning fields would result in increasing erosion and declining soil fertility. Given the low levels of nitrogen and phosphorus coupled with the high levels of calcium, magnesium, iron and manganese, the practice of burning vegetation residues before planting should lead to some long-term serious problems. The fallow length in this region is probably too short to allow for an adequate accumulation of nutrients in the fallow vegetation. The burning process, while

making some nutrients more immediately available to the subsequent crop, can produce long-term fertility declines. Some likely possibilities include the following: the loss of some nitrogen through volatilization; and the increase in the insoluble fraction of phosphorus due to an increase in alkalinity, especially in the presence of large amounts of calcium and iron.

The practice of selectively removing legume trees from the fallow vegetation, of course, further degrades the value of the fallow period for increasing soil nitrogen levels. It was striking that several of the most highly valued trees that occur in the fallow cycle were legumes. Several farmers remarked that these trees have largely disappeared from their region as a consequence of intense cutting for firewood. Since many of these trees exhibit the property of sprouting from cut stumps or coppicing, there would seem to be considerable potential for managing these fallow tree species much as they are managed in coppice forests of western Europe. The practice, developed in parts of Africa, of alley planting would seem appropriate for this region. In this system, crops are planted between rows of legume trees. In this way, the trees provide both a windbreak and a source of nitrogen for the interplanted crops. This system is also a reasonable compromise when long fallow periods are no longer possible.

While the important role of nitrogen fixation has been emphasized in many polyculture studies, we should not neglect the importance of symbiotic relationships that enhance phosphorus and water availability. Especially in tropical regions, many trees and crops have a symbiotic relationship with root fungi known as mycorrhizae. The various kinds and plant relationships that these fungi have is too complicated to go into in this report, however some generalities may be made. Although the precise mechanism is

still largely unknown, the presence of these fungi greatly enhances the availability of phosphorus. Also, the hyphal filaments of the the fungi radiate extensively throughout the soil and greatly enhance the uptake of water to the host plant. Thus studies of polycultures of trees and crops that maximize the abundance of nitrogen-fixing and mycorrhizal species could make a major contribution to the long-term sustainability of these agricultural systems.

Fig. 1

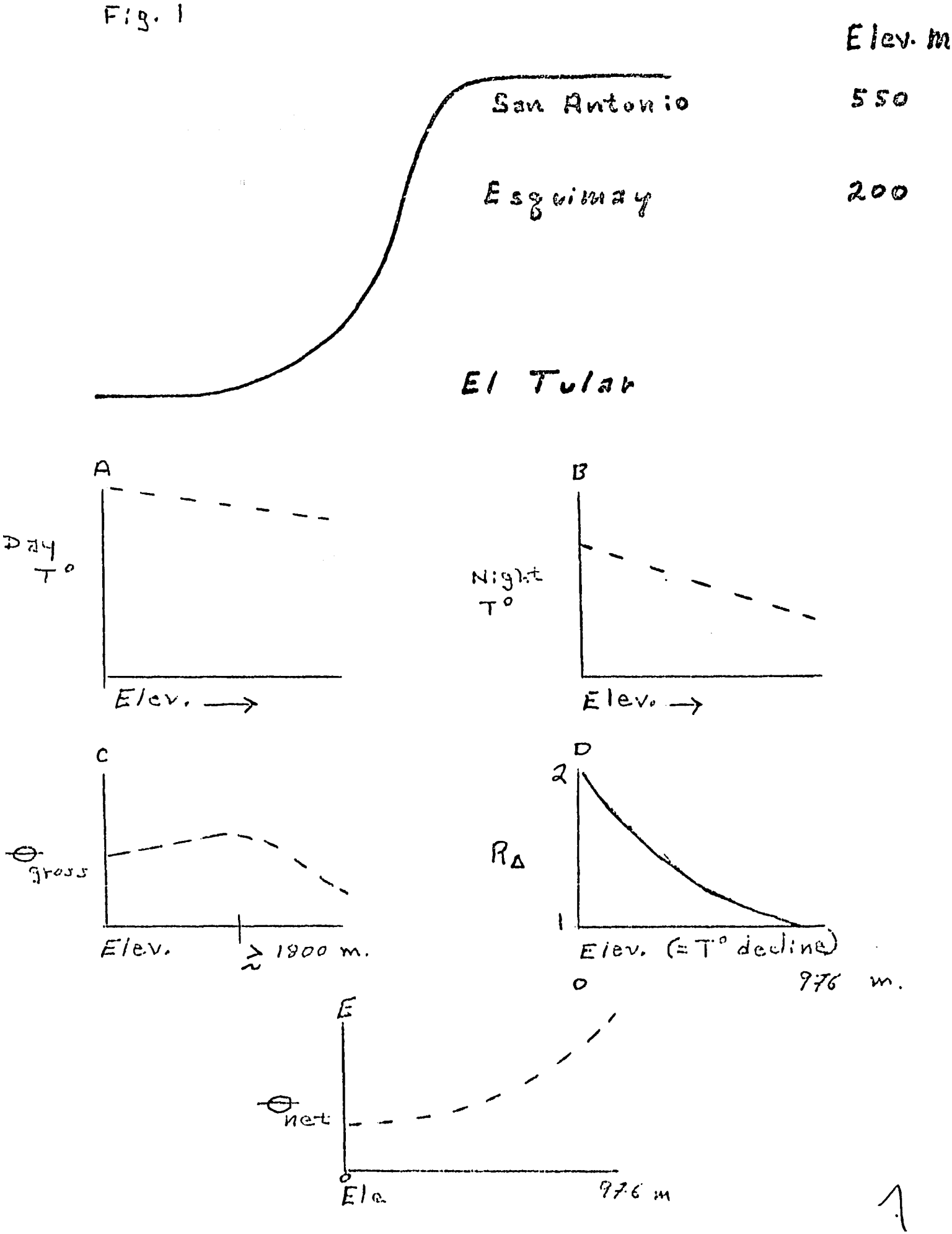
Elev. m
San Antonio
550
Esquimay
200
El Tular
A
Day T°
Elev. →
B
Night T°
Elev. →
C
Θ gross
Elev.
≳ 1800 m.
D
2
R_Δ
1
Elev. (= T° decline)
976 m.
E
Θ net
0
Ele
976 m

TABLE 1. SOIL QUALITY (ppm element - available form)

Sample	pH Acidity	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Zinc	Iron	Manganese
"Tierra buena"	6.4 Mildly Acid	Low	05 Very Low	388 Very High	>4000 Very High	>500 High	1.38 High	>20.0 High	10.0 High
"Tierra Regular"	7.1 Mildly Alkaline	Low	02 Very Low	452 Very High	>4000 Very High	>500 High	***	Insufficient *** Sample	
"Tierra arenosa"	5.4 Strongly Acid	Low	03 Very Low	380 Very High	2160 Very High	440 High	0.82 High	>20.0 High	10.0 High
"Tierra faldo"	6.9 Mildly Acid	Low	00 Very Low	160 Medium	>4000 Very High	>500 High	0.20 Low	16.0 High	10.0 High
"Tierra arcellos barria-losa"	6.6 Mildly Acid	Low	01 Very Low	160 Medium	— >4000 Very High	>500 High	0.58 High	>20.0 High	10.0 High
"Tierra mala"	6.4 Mildly Acid	Low	00 Very Low	224 High	>4000 Very High	>500 High	0.10 Low	10.0 High	10.0 High