Efficiency of Energy Production in Maize-Bean and Other Mixed Cropping Systems[1/]

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The unique potentials of the tropics include an extended growing season in many areas, limited only by lack of moisture from providing year-around crop production possibilities. With availability of family labor, generally small farm size in the case of subsistence farmers, and under-used land in the current farming systems, the logical measure of crop yields may not be kilograms per hectare, nor the indicated move toward improved technology a complete changeover to "modern" monoculture. The farm family must usually live from the production on this small area, and their entire economic and nutritional well-being revolves around its potential and productivity. In this situation, more appropriate measures of productivity include production per day, total protein production, or distribution of production through the year. Traditional economic indicators of success such as net return per hectare, or return based on investment, are certainly less important than sustaining production through as long a period as possible and minimizing risk. Finally, the social

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1/ Paper presented in Annual Meetings, American Society of Agronomy, Las Vegas, Nevada, November 14, 1973.

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Francis & Heichel 1973

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viability of the intercropping system must be compared to "modern" technological monoculture systems, as farm families continue to leave the land throughout the tropics in a continuous and problematic migration to urban centers.

Complete data which allow a critical comparison of these mixed cropping systems with monoculture are limited, and this is a serious restriction to our discussion of the relative physical potentials of these two alternatives. However, data from South and Central America, Africa and Asia do give indications about several maize-bean systems, as well as others which involve sorghum, cowpea, sweet potato, cassava, and other tropical grain legumes. Although total agronomic productivity or even protein production may be reduced in some mixed cropping systems, the economic return from the system may easily offset the loss in production due to the yield of a high value pulse crop component. The examples which are presented will thus be evaluated in physical, economic and social/nutritional terms.

Physical/Production Potentials and Comparisons

Critical data over several seasons which would allow a rigorous comparison of monoculture versus mixed crops is lacking in the literature. Available reports do indicate that there are some combinations of crops which yield more than single species. Data from the Puebla project in México for 1971 and 1972 (Slide 3) show a reduced yield of maize, an increased yield of beans, and a total increase in yield per hectare when the two crops were grown in an appropriate combination with respect to populations and nitrogen rates. Needless to say, the bean component adds greatly to the economic and nutritive value of the mixed crop alternative.

Similar data were collected this past year in the highlands of Guatemala in Chimaltenango (Slide 4). These are selected treatment combinations, as not all mixtures of the two crops gave superior total yields. The maize yields in mixed crolping schemes in this Guatemala report are not reduced by presence of beans, since the second crop is planted about 4 months after the first and they only overlap.

A study at Makerere University in Uganda (Slide 5) over 2 seasons showed that a combination of 2/3 maize and 1/3 beans produced more than either crop alone. It is even more intriguing to note that maize in this mixture produced more than maize grown alone, an unlikely possibility in the long run if adequate fertility is supplied. The same researchers, however, reported similar results for the mixture of sorghum and beans (Slide 6), where sorghum in a mixed system out-produced the sorghum in a pure stand.

Maize was grown with three legumes in Morogoro, Tanzania (Slide 7), where the grain yields were reduced by competition in all but the case of pigeon pea - this is a long season crop which grows very slowly at the outset, and thus offered less competition to maize, and was able to produce a reasonable grain yield in 8 months. A striking example of reduced production occurred in our CIAT trials in the cassava program. Beans interplanted with cassava, only competing during the first 4 months of a 10-month growth cycle of this starchy root crop, effectively reduced yields from 40 Tons (cassava alone) to 20 Tons/ha (cassava and beans).

It is apparent from these data and others in the literature that there are combinations of crops which will produce yields in excess of what was produced with monoculture. One must chose carefully his crop combination, fertility and population level, and relative times of planting. This does not imply that a better variety of beans or more responsive hybrid of maize, might not produce even more than these present yields, and thus show superiority over the mixed crop system. On the other hand, it is critical to keep in mind that specific varieties of each crop, well-adapted to the competitive situation in a mixed system, have only been selected by the farmer - there has been little or no interest by the breeder until recently in this activity.

Protein Production and Efficiency

When the growth cycle of these crops is included, a calculation is possible of production of grain dry matter, as well as protein production, per day the crop is in the field. This measure is particularly critical in the tropics where there is a potential for crop production through the entire year. Even where rainfall limits this potential, there is a challenge to use the available moisture and growing days in the most efficient manner possible. In Slide 12, data from Western Nigeria show this relationship in two mixed cropping systems. It is particularly impressive to compare the relative production of protein/ha/day, where the mixtures with a reasonably successful legume component show a particular advantage. In Uganda, the results show a distinct advantage of the Maize-Bean mixture over either monoculture (Slide 13). The same advantage is found in the sorghum-bean mixtures, with a 50% better protein production in both intercrop population levels. In contrasting results, the Morogoro (Tanzania) data indicate that the superiority of maize yields over the intercrop system carried this monoculture to a greater protein production per day than any of the mixtures tested. A mixture with pigeon peas was highly productive per day, and in terms of protein but the long growing season reduced its efficiency per day. This factor must be considered - if certain crops such as pigeon pea or sorghum can resist drought when other crops would not, their performance must be compared only against feasible alternatives, and not against other crops under irrigation or grown during the wet season. Although some conflicting results are found, there is a tendency toward greater protein production and more efficient production, when the legume is a successful component of the mixed cropping system.

Economic Considerations / Net Return to Farmer

An important consideration to any farmer, large or small, is the net return which he receives from his harvested crop. Beans are almost always higher priced in commerce than maize, this price sometimes reaching the unbelievable ratio of 10:1. This unique situation occurred last year in Colombia, when farmers rejected a new early high yielding hybrid for the highlands which was one month to 40 days earlier than their local variety. They readily rejected 1 to 2 tons additional maize yield to assure a bean yield of 500 kg, since the new maize would not support the heavy bean plants, and special cargamanto beans were selling for $1 per kilo.

In a unique intercropping study in Zaria, Northern Nigeria, Andrews (Slide 8) studied the replacement of a traditional long season sorghum crop with a sorghum intercropped with two short season crops in succession. As shown, the yield and net return from the mixed crops were almost double the traditional sorghum crop, when it was grown in the normal manner for the zone. Intercropping with millet in the following year, 1970, produced equally spectacular results.

In Grenada, West Indies, a comparison of monocultures of maize and pigeon peas were made with two intercrop systems (Slide 9). The traditional system has 3 seeds of maize and 3 of pigeon pea in the same hole, with no thinning. This was compared to a system which placed 3 seeds of each crop in alternate holes, later thinning to one plant. At the lower less competitive population, the economic advantage of more pigeon peas is seen on the slide. Finally, the economically best treatments in the fertilizer trial or mixed crops in the Puebla Project, Mexico (Slide 10) are shown for two successive years. Again, bean yields were remarkably higher in the mixed cropping system, and net return each year was 2.7 and 2.3 times the return for maize in 1971 and 1972, respectively. Again, these are not random treatments, but the best combinations in their respective trials. These economic relationships are highly dependent on market prices, and especially in the price differential between grain legumes and maize. The security of an income based on more than one crop is also important to the small farmer. Where a severe drop in price for a single crop could destroy him financially, this risk spread over two or more crops affords a degree of freedom which a marginal operator needs so badly.

Social Viability and Nutritional Importance

The obvious benefits of a mixed system to the farm families' nutrition need not be detailed. If a range in planting dates is feasible, in addition to the range in crop species already suggested, the subsistence family is assured of a much better complement and variety of food than if single crops of a single species were harvested, and mostly sold, once or twice during the year. Saving is difficult, if possible at all, and the only real assurance is the stored crop product or the crops which can be harvested continuously through as much of the year as possible. Major social advantages - which closely relate to other factors already described - are listed on Slide 11, where a monocultural system is compared to multiple or high-diversity systems (see Dickinson, 1972. Professional Geographer). Much of the stability of the diverse system stems from its nutritional advantage, mix of crop species, relative resistance to crop pests and diseases, low capital investment, and low dependence on fossil fuels and other presently or potentially scarce inputs. Stability of production, diet, and income through the year are encouraged, and more farmers are involved directly in the immediate working and economic decisions - since this system is usually most feasible with a small farm family and its available supply of labor. As a social institution, the economically viable subsistence farm provides employment and a reasonable standard of living for rural families, and prevents in part the disastrous heavy migration to urban slums which has plagued Latin America and other areas of the tropics for decades.

<u>Summary</u>

This presentation has outlined the physical, nutritional, economic and social advantages of mixed cropping systems for the subsistence farmer in the tropics. Some systems, and some operations of systems are susceptible to mechanization or use of animal power - this opens the possibility of an even wider exploitation of these potentials. The need for as complete a nutritional package, produced on the farm, is critical to a farmer whose economic potential does not permit the purchase of any processed or prepared products, or his physical distance from point of supply is an over-riding constraint. Finally, the social stability in tropical countries which will result from this emphasis on the welfare and nutrition - the way of life of the rural family, will help the development process proceed in the most efficient and rapid manner possible.

Slide 1

EFFICIENCY OF ENERGY PRODUCTION IN MAIZE - BEAN AND OTHER MIXED CROPPING SYSTEMS

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Slide 2

CRITICAL EVALUATION OF CROPPING SYSTEMS

1. Physical Factors – Production / Hectare
3. ~~2.~~ Economic Factors – Net Return
4. ~~3.~~ Social Viability / Nutritional Importance
2. ~~4.~~ Protein Production ~~per Day~~ and Efficiency

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Slide 3

~~PUEBLA PROJECT – MEXICO~~

MAIZE AND BEANS: PUEBLA PROJECT, MEXICO
(Yields in kg/ha)

		Maize	Beans	Total
1971	Maize alone	4219 ~~2891~~	0 ~~1845~~	4219 ~~4736~~
	Beans alone	0	1300	1300
	Maize + Beans	2891	1845	4736
1972	Maize alone	4634	0	4634
	Beans alone	0	1222	1222
	Maize + Beans	4056	2446	6502

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Slide 4

MAIZE AND BEANS. CHIMALTENANGO, GUATEMALA
(Yields in kg/ha)

	Maize	Beans	Total
Maize Alone	3799	—	3799
Beans Alone	—	650	650
Maize + Beans	4233	444	4677

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Slide 5

MAIZE AND BEANS: KAMPALA, UGANDA
(Yields in kg/ha)

	Maize	Beans	Total
Maize Alone	4.000	—	4.000
2/3 M : 1/3 B	4.500	500	5.000
1/3 M : 2/3 B	3.000	1.000	4.000
Beans Alone	—	1.600	1.600

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Slide 6

SORGHUM AND BEANS: KAMPALA, UGANDA
(Yields in kg/ha)

	Sorghum	Beans	Total
Sorghum Alone	4.000	-	4.000
2/3 S : 1/3 B	4.400	300	4.700
1/3 S : 2/3 B	2.500	600	3.100
Beans Alone	-	700	700

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Slide 7

Maize and Legumes. Morogoro, Tanzania
(Yields in kg/ha)

	Maize	Legume	Total
Maize Alone	3255	—	3255
Maize + Beans	2070	60	2130
Maize + Pigeon Pea	2350	930	3280
Maize + Cowpea	1635	60	1695

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Slide 8

Sorghum and Relay Crops: Zaria, Nigeria
(Yields in kg/ha; Net Return in Shillings)

	Sorghum	Intercrops	Total Yield	Return
1) Sorghum Alone (192 days)	2050	—	2050	1305
2) Sorghum (192 days) with	1053			
Maize (94 days) and		2757		
Cowpea (77 days)		133	3943	2222
3) Sorghum (192 days) with	1161			
Millet (94 days) and		2495		
Cowpea (77 days)		187	3643	2585

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Slide 9

MAIZE AND PIGEON PEAS: GRENADA, WEST INDIES
(Yields in kg/ha; Net Returns in E.C.$)

	Maize	Pigeon Pea	Total	Return
Maize Alone	3690	—	3690	270
Pigeon Pea Alone	—	2340	2340	435
Traditional Mix	3190	1420	4610	625
Alternate Hills	2430	1940	4370	845

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Slide 10

MAIZE AND BEANS: PUEBLA PROJECT, MEXICO
(Yields in kg/ha; Net Income in Pesos)

	Maize	Beans	Total	Income
~~1970: Mixed Crop~~	~~1642~~	~~2073~~	~~3775~~	~~5749~~
1971: Maize Alone	4219	—	4219	2201
Beans Alone	—	1300	1300	2343
Mixed Crop	2891	1845	4736	5955
1972: Maize Alone	4634	—	4634	3053
Beans Alone	—	1222	1222	2426
Mixed Crop	4056	2446	6502	6963

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Slide 11

MONOCULTURE VS MULTICROPPING SYSTEMS FOR TROPICS

	Monoculture	Multicropping
1) NET PRODUCTION	High (fossil fuels)	Moderate (sustainable)
2) DIET CONTRIBUTION	Low	High
3) SPECIES DIVERSITY	Low	High
4) SPACE UTILIZATION	Poor	Excellent
5) INHERENT STABILITY	Low	High
6) NUTRIENT CYCLES	Open	Closed
7) ECONOMIC STABILITY	Boom or Bust	High
8) SOCIAL VIABILITY	Volatile	Stable

[Ref. Dickinson, J.C. 1972. Professional Geographer, Vol. 24(3)]

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Slide 12

MAIZE AND LEGUMES: IBADAN, NIGERIA

	Total Yield (kg/ha)	Yield (kg/ha/day)	Protein (kg/ha/day)
Maize Alone	2180	19.0	1.9
Maize + Cowpea	2830	24.5	3.4
Cowpea Alone	1220	10.6	2.7
Maize Alone	2180	19.0	1.9
Maize + Mung	2560	22.3	2.7
Mung Alone	1080	9.4	2.3

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Slide 13

MAIZE AND BEANS: KAMPALA, UGANDA

	Total Yield (kg/ha)	Yield (kg/ha/day)	Protein (kg/ha/day)
Maize Alone	4.000	33.4	3.3
2/3 M : 1/3 B	5.000	41.7	4.8
1/3 M : 2/3 B	4.000	33.4	4.6
Beans Alone	1.600	13.3	3.3

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