Effect of Low-Input Techniques on Tropical Corn Production on Small-Scale Farms

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INTRODUCTION

Small-scale farms, although declining in numbers, still remain very important components of the U.S. economy. Small-scale farms are defined on the basis of family farms with acreage ranging from 1 to 40 a or the family being dependent on the farm for a major portion of its income; the family has established commodity mixes and limited resources such as land, capital, and labor; the family members provide most or all the labor and management input; or the farm has gross annual income equal to or less than $10,000 (McGowan, 1987 a,b,; Ward, 1989). According to H. W. Kerr (1991), "for over 100 yr the small farm sector has richly contributed to the varied landscape and economic stability of the U.S." The decline in numbers among small-scale farmers has been largely due to poor profitability of many traditional enterprises in which they engage. To remain profitable, the small-scale farmer will of necessity have to adopt alternative production methods which are less costly, produce non-traditional "specialty crops" which carry a high market value, or develop value added products from their enterprise. For example, in field corn *(Zea mays* L.), alternative production technologies such as ridge planting have resulted in up to 50% reduced input of fertilizers and pesticides (McDermott, 1990).

This study evaluated intercropping and reduced inputs of herbicides and fertilizers as alternative low-input techniques for producing tropical corn on small-scale farms in north Florida. Intercropping is a form of mixed cropping whereby two or more crops are grown simultaneously on the same unit land area during all or part of the life cycle of the respective crops (Mullen, 1995). Intercropping systems have been traditionally practiced by small farmers in many developing countries and have become an area for research focus in the U.S. (Calavan and Weil, 1988). The Farming Systems Research and Extension (FSR/E) approach (Hildebrand and Poey, 1995: Byerlee et al., 1982) was used in carrying out the study. In the FSRE methodology, development techniques for adoption by small-scale farms requires the participation of the farmers themselves in all steps of the project, such as planning, implementation, evaluation, and dissemination of results.

Florida bas an extended warm crop growing season (March to mid-November) which is conducive for production of many tropical crops. Hiebsch, et al. (1995) stated that long warm seasons which cannot adequately support two sole crops may be more productive when fully utilized by intercrops. Intercropping involving a cereal and a legume may lead to increased total productivity per unit land area when the yield of the cereal is added to that of the legume intercrop. There is also the added benefit of environmental and economic sustainability obtainable from this practice (Fortin and Edwards, 1995; Calavan and Weil, 1988).

The objective of this research was to determine the optimal yields of non-irrigated tropical corn grown with reduced input of fertilizer and herbicides or grown with cowpea *(Vigna unguiculata* [L.] Walp.) as an intercrop on small-scale farms in north Florida.

MATERIALS AND METHODS

On-farm demonstration research was carried out in Gulf and Jackson counties in north Florida. This was supported by on-station research at the Florida A&M University farm at Quincy, in Gadsden County. The on-farm research was conducted with the participation of small-scale farmers in each of the counties. The soil type in Gulf and Jackson counties was very sandy, while the soil at the Gadsden county location had a high clay content. The research study was conducted in 1992, 1993, and 1994. The Gadsden county component was in 1993 and 1994. At the county level, extension personnel were instrumental in selecting the farmers and monitoring the study throughout its duration.

Pioneer Brand hybrid 3192 tropical corn was planted in the plots in May to June of each year. A plant density of approximately 18,000 to 22,000 plants/a was desired.

A randomized complete block design with two replications and six treatments was used to evaluate the techniques. Plot size was 130 A x 40 ft. The six treatments were as follows: 1) cornonly - no fertilizer or herbicide applied, 2) corn intercropped with cowpea - no

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fertilizer or herbicide; 3) corn + atrazine at 2 lb a.i./a, 70 lb/a of a 5-10-15 mixed fertilizer and 40 lb/a of ammonium nitrate (NH_4NO_3); 4) corn intercropped with cowpea and 2O lb/a of NH_4NO_3 plus 35 lb/a of a 5-10-15 mixed fertilizer, 5) corn + 35 lb/a of a 5-10-15 mixed fertilizer and 40 lb/a of NH_4NO_3; 6) corn intercopped with cowpea plus 20 lb/a of NH_4NO_3 35 lb/a of a 5-10-15 mixed fertilizer.

Harvesting of the corn was done whenever the grains were field-dried to approximately 13 % moisture content. The cowpea crop was harvested when the pods were mature green, approximately 8 wk after planting. In the third yr, 1994, the cowpea was not harvesteddue to labor shortage.

For the sole crop corn, sample data were collected from a 65 sq ft area for determination of dry matter yield and other parameters. However, for the intercrop corn, the sample area was doubled since the cowpea occupied a 36-in-wide section in those rows. Cowpea was sample harvested over the same area as the corn. Field data collected on corn yield and other parameters were as follows. Plant height was calculated as the distance from soil level to the base of the last true leaves at the top of the plant. Ear height was determined by measuring the distance from the base of the plant to the point of stalk attachment of the first mature ear (cob) on the plant. Plant population was determined by counting the number of plants in the harvested area of each treatment. Row and grain number per ear were determined by manual counting of 10 cobs from each treatment. Ear weight was calculated as the total weight of the harvested cobs from the individual treatments, while grain yield was calculated as the total weight of the shelled grain of 20 ears from each treatment. All parameters were extrapolated to determine their values on a per-a basis.

RESULTS AND DISCUSSION

Analysis of variance showed significant yr and location effects for grain yield and other parameters ($P \leq 0.05$). Therefore, the data were further analyzed on the basis of individual yr. Tables 1 through 3 show the yield parameters for tropical *corn* produced in Jackson County. In 1992, the 687 lb/a grain yield of sole crop **corn** without herbicide or fertilizer was not significantly ($P \leq 0.05$) different from the grain yield of the corn intercropped with cowpea (Table 1), However, when the pod yield of the cowpea is added, the total yield from the intercropped treatments would be increased up to 1,267 lb/a. For that particular yr, higher grain yield (>1,780 lb/a) was obtained from the sole crop corn to which the 70 lb/a of 5-10-15 mixed fertilizer plus 45 kg/ha of NH_4NO_3 was applied (treatment 5). The yield pattern for the second yr (1993) in this county was similar to that of the first yr (Table 2). In that yr highest corn grain yield (1,242 lb/a) was obtained from the sole plot corn to which herbicide and fertilizers (treatment 3) were applied. However, in the third yr of the study, both the sole crop corn and the corn intercropped with cowpea and which received no fertilizer or herbicide application gave grain yields which were not significantly diffferent ($P < 0.05$) from the other treatments (Table 3). The yields realized in sole corn treatment may have been due to the increased plant density (over 32,793 plants/a) or a change in location within the same county. This change came about because the first farmer participant was unable to cooperate the third yr of the project. Although not measured, it seemed as if the natural fertility of this soil was greater than that of the previous location.

Tables 4 through 6 shows the responses for the Gulf County study. Here again in 1992 (Table 4), sole crop corn which received the high level of 5-10-15 and NH_4NO_3 (70 lb/a and 40 lb/a, respectively, treatment 3) gave the highest grain yield (6,007 lb/a). Yields from the plots to which no fertilizers or herbicide was applied (treatments 1 and 2), were not significantly different ($P \leq 0.05$) from the plots having the cowpea intercrop (1,121 lb/a to 2,424 lb/a). In 1993 (Table 5), the sole crop corn which received no fertilizers or herbicide application (treatment 1) gave the highest grain yield of over 3,560 lb/a. Over the two yr, the yield difference realized from the corn component in the intercrop treatments would be partially compensated for by the total yield/a (corn grain yield and cowpea pod yield).

Table 6 shows the response for Gulf County in 1994. Highest corn grain yields were obtained from the sole crop corn to which fertilizer and herbicides were applied (1,538 lb/a and 1,357 lb/a, treatments 3 and 5). These yields were significant when compared to yields from the intercropped plots or those not treated with herbicide or fertilizers.

Tables 7 and 8 shows the response from the on-station study carried out on the university's farm. In both yr., the sole crop corn which received no herbicides or fertilizers yielded as much as those plots which received these chemicals. The high clay content of the soil at this location and hence a high level of inherent natural fertility (determined by soil test) may partially account for this. Also, at this location, the corn was planted on an area previously planted with winter legume cover crops. Although cowpea was planted in the intercrop plots, it was not harvested in either yr because of labor problems. The corn grain yields obtained from the intercropped treatments was similar in trend to those

at the county level although numerically greater.

Total productivity (TP) is equal to the yield of the main crop (in this study, tropical corn) plus the yield of the intercrop (Fortin and Edwards, 1995). It is expected that TP will result in increased yields per unit land area which would be greater than those in the monoculture crop. This outcome was realized at Jackson County in the 1992 study (Table 1) where TP= 1,266 lb/a (treatment 2) vs 687 lb/a (treatment 1), and in 1993 Table 2) when TP= 1,166 lb/a (treatment 6) vs 767 lb/a (treatment 5).

At the Gulf County location in 1992, TP resulted in increased yields but these were not greater than those of the comparable intercrop (Table 4.). However, in the 1993 study, TP was greater when the sole crop with pesticide and fertilizer (treatment 3) was compared (not statistically) to the intercrop receiving the same application (treatment 4).

CONCLUSION

Under rainfed cropping systems in north Florida, low input technique of intercropping tropical corn with cowpea may lead to increased yield outcome for small-scale farmers. Potentially, the intercrop may ensure some returns for the farmer, thus guarding against risk of total loss, if the corn crop fails to return marketable yields. However, when grown in this manner, there may be competition between crop species for light and nutrients which may result in overall low yields among the crop species. The latter will be exacerbated under poor soil fertility conditions. The yields which were obtained in Jackson and Gulf counties seemed to point in this direction. On the other hand, adequate soil fertility conditions may lead to increased yields as evidenced from the Gadsden County studies. Reducing the amount of fertilizer applied for tropical corn on sandy and largely infertile soils may also result in low uneconomic grain yields. Except the Gulf County in 1993, treatments 1 and 2, and Gadsden County in 1994, treatment 3 corn grain yields were at or slightly below state average (2,670 lb/a). Additional studies on row spacing (between and intra) as well as timing methods of applying fertilizer needs to be carried out to further examine these techniques.

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Table 1. Mean yield components of tropical corn grown at Jackson County, Florida, 1992

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Ear ht	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	687b	0.12a	352b	17431a	5.9b	1520b	9.0a	24.0a	52.8c	22152a	10.5a
Corn-cowpea intercrop (no chemical treatment)	543b (1266)	0.09a	447ab	8534b	6.7ab	941b	12.0a	25.6a	61.4abc	9079b	11.0a
Sole crop corn (Pesticide and fertilizer)	2185a	0.10a	506a	15252a	7.1a	3039a	13.0a	39.8a	63.8ab	19610a	11.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	869b (1236)	0.07a	535a	7082 b	7.5a	1412b	14.0a	25.6a	63.0abc	9442 b	11.0a
Sole crop corn (Fertilizer)	1809a	0.15a	539a	15979a	7.5a	3184a	13.0a	26.0a	67.3a	19247a	11.0a
Corn-cowpea intercrop (Fertilizer)	561b (928)	0.04a	534a	7445b	7.5a	1048a	12.0a	24.0a	56.3bc	7626b	11.0a
R^2	0.81	0.001	0.84	0.35	0.32	0.82	0.55	20.1	30.7	0.39	0.45

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 2. Mean yield components of tropical corn grown at Jackson County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	203c	0.03cd	215b	9805b	4.3c	724c	12.0a	56.3d	14526a	3.0c
Corn-cowpea intercrop (no chemical treatment)	192c (373)	0.06bcd	384a	4358c	5.9b	615c	13.0a	59.1cd	4721b	6.5b
Sole crop corn (Pesticide and fertilizer)	1242a	0.01d	474a	13799ab	7.1a	3329a	13.0a	75.6a	15252a	11.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	306c (1 121)	0.14ab	482a	4721c	7.5a	1416c	13.0a	67.3b	4721b	10.0a
Sole crop corn (Fertilizer)	767b	0.17a	436a	14526a	6.7ab	2352b	12.0a	66.9b	15615a	9.0a
Corn-cowpea intercrop (Fertilizer)	352c (1 166)	0.12abc	464a	4721c	7.5a	1121c	12.0a	63.8bc	5084b	9.5a
R^2	0.82	0.002	**0.88**	0.37	0.38	0.86	0.50	36.6	0.38	0.93

Means within columns followed by **the** same letter are not significantly different at the 0.05 probability **level** according to Duncan's New Multiple Range Test,
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 3. Mean yield components of tropical corn grown at Jackson County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	904ab	0.12a	333a	26873ab	5.1b	2533b	12.0a	29.9a	59.8a	33047a	10.5b
Corn-cowpea intercrop (no chemical treatment)	904ab	0.15a	329a	24876ab	5.5b	3257ab	I3.0a	32.3a	63.8a	26692ab	11.0ab
Sole crop corn (Pesticide and fertilizer)	1356ab	0.09a	361a	31958a	5.9ab	5066ab	13.0a	31.1a	67.3a	34862a	12.0ab
Corn-cowpea intercrop (Pesticide and fertilizer)	678ab	0.03a	419a	20155ab	5.9ab	3257ab	12.0a	31.1a	63.8a	18702b	12.5ab
Sole crop corn (Fertilizer)	1538a	0.08a	437a	33410a	6.3a	5789a	13.0a	35.8a	70.9a	37041a	13.0a
Corn-cowpea intercrop (Fertilizer)	633b	0.07a	413a	16342b	6.3a	2352b	13.0a	29.9a	63.8a	163421,	12.0ab
R^2	0.59	0.001	0.65	0.29	0.30	0.63	0.18	15.8	16.9	0.33	0.63

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 4. Mean yield components of tropical corn grown at Gulf County, Florida, 1992

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	2424bc	0.09a	402b	24694a	5.9ab	4849b	12.0ab	24.0b	56.3ab	25057a	13.0a
Corn-cowpea intercrop (no chemical treatment)	1121c (1845)	0.09a	341b	9079c	5.5b	1701b	12.0b	20.5b	49.2b	11802c	13.0a
Sole crop corn (Pesticide and fertilizer)	6007a	0.15a	612a	23605a	8.3a	11217a	14.0a	32.3a	70.9a	25057a	13.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	2351bc (3164)	0.04a	507a	12529c	7.9a	4252b	13.0ab	25.2ab	61.0ab	12166c	14.0a
Sole crop corn (Fertilizer)	3437b	0.11a	454ab	18158b	7.1ab	4668b	13.0ab	25.2ab	56.3ab	21789c	13.0a
Corn-cowpea intercrop (Fertilizer)	2352bc (2720)	0.13a	475ab	10713c	7.1ab	3980b	12.0ab	25.2ab	57.5ab	11984c	13.0a
R^2	0.80	.001	0.71	0.39	0.28	0.78	0.61	28.3	26.0	0.40	0.45

Means within columns followed by the same letter arc not significantly different at the 0.05 probability **level** according to Duncan's New Multiple Range Test,
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 5. Mean yield components of tropical corn grown at Gulf County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	3618ab	0.15a	206a	11621cb	4.3a	619bc	11.0ab	53.9a	14526a	9.5a
Corn-cowpea intercrop (no chemical treatment)	181b (362)	0.07a	184a	6900c	4.3a	351c	11.0a	50.4a	7989b	8.5a
Sole crop corn (Pesticide and fertilizer)	1016a	0.11a	394a	13800ab	6.3a	1899a	13.0a	55.1a	16705a	11.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	471ab (1285)	0.13a	339a	6537c	5.5a	816abc	12.0a	63.0a	7263b	12.0a
Sole crop corn (Fertilizer)	702ab	0.13a	314a	17068a	5.5a	1566ab	13.0a	63.0a	18887a	10.0a
Corn-cowpea intercrop (Fertilizer)	362ab (1177)	0.11a	317a	7445c	5.5a	758abc	12.0a	56.3a	7445b	9.0a
R^2	0.59	0.001	0.55	0.36	0.19	0.67	0.49	15.0	0.36	0.35

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 6. Mean yield components of tropical corn grown at Gulf County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Ear ht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	680bc	0.07a	222ab	22878ab	4.7c	19721a	12.0a	35.8ab	68.5bc	22878a	12.5a
Corn-cowpea intercrop (no chemical treatment)	159c	0.15a	124b	7989b	4.3c	271a	12.0a	24.0b	58.7c	159784a	12.5a
Sole crop corn (Pesticide and fertilizer)	1538a	0.11a	456a	33773a	7.1a	4342a	14.0a	72.1a	96.1a	33773a	12.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	588c	0.09a	327ab	14345ab	7.5a	1538a	13.0a	37.4ab	72.1bc	14345a	12.0a
Sole crop corn (Fertilizer)	1357ab	0.09a	368ab	27236ab	6.7b	37091a	13.0a	39.8ab	76.8b	27236a	12.5a
Corn-cowpea intercrop (Fertilizer)	498c	0.04a	278ab	12529ab	5.9b	1130a	12.0a	38.6ab	75.6b	12529a	11.0a
R^2	0.76	0.0006	0.70	0.28	0.37	0.45	0.33	25.6	35.0	0.25	0.35

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 7. Mean yield components of tropical corn grown at Gulf County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	2034a	0.11a	400a	12347a	6.3b	3347a	13.0bc	75.6ab	17068a	12.0a
Corn-cowpea intercrop (no chemical treatment)	814a	0.11a	393a	6537b	7.1ab	1356a	12.0bc	70.9b	6356b	12.5a
Sole crop corn (Pesticide and fertilizer)	1943a	0.15a	511a	11984a	8.7a	3167a	12.0bc	90.2a	12710a	12.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	995a	0.11a	471a	6214b	7.9ab	1650a	14.0a	80.3ab	6537b	12.0a
Sole crop corn (Fertilizer)	1624a	0.18a	340a	12347a	5.9a	2826a	12.0a	78.0ab	14889a	12.0a
Corn-cowpea intercrop (Fertilizer)	860a	0.66a	404a	4903b	7.1ab	1107a	13.0ab	73.2ab	6537b	13.0a
R^2	0.59	0.0006	0.52	0.33	0.30	0.61	0.82	23.6	0.37	0.41

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 8. Mean yield components of tropical corn grown at Gulf County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (**no** chemical treatment)	2533ab	0.07a	558a	30868ab	7.9a	7237a	14.0a	38.6a	79.1a	50841a	13.0a
Corn-cowpea intercrop (no chemical treatment)	1131b	0.09a	379a	13800c	7.1a	3889a	12.0a	35.8a	75.6a	20518b	12.5a
Sole crop corn (Pesticide and fertilizer)	2895a	0.09a	564a	33047a	8.7a	11579a	13.0a	42.1a	100.8a	45757a	12.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	1312ab	0.04a	579a	20518abc	9.1a	5789a	13.0a	34.7a	80.3a	21971b	13.0a
Sole crop corn (Fertilizer)	2442ab	0.09a	479a	31314ab	8.3a	1086a	12.0a	43.3a	89.0a	4540a	13.0a
Corn-cowpea intercrop (Fertilizer)	1583ab	0.11a	583a	8832bc	9.1a	6513a	13.0a	48.0a	92.5a	22334b	13.0a
R^2	0.59	0.0004	0.52	0.32	0.22	0.41	0.40	14.8	18.5	0.38	0.40

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test,