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Multiple Cropping and Pest Control Intensity -- Preliminary Economic Results

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Abstract

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Introduction

Over the past several years farming operations have become fewer and larger. As indicated by Stanton and Tweeten, this phenomenon in general has been associated with increasing returns to size of operations[1]. Martin has suggested that even when there are no longer economies of size, there remains an incentive to expand as long as there are no diseconomies since more units of output are better than less at the same net profit per unit. Commonly, such expansion behavior has been associated with larger blocks of land per farming operation (Stanton and Tweeten).

In some areas of the U.S. a long growing season offers another means of expansion -- more intensive utilization of land and equipment through multiple cropping. In the southeastern Coastal Plain double and triple cropping is increasing.

The drive for more efficient utilization of resources lead producers to explore combinations of agronomic and horticultural crops under irrigation. An added incentive for these developments was the potential reduction of risk through enterprise diversification and reduced variability of soil moisture through irrigation.

Such changes in farming patterns necessitated changes in direction of research. To date, several publications have emerged to satisfy these new demands (Dowler, et. al., Gallaher, Johnson, et. al, Kays, et. al., Nelson, et. al., Standifer and Ismail, Sumner, et. al., and Wilkinson, et. al.).

The prior research goal primarily had been to maximize yield through chemical, biological, and cultural means.[2] However, this approach became obviously infeasible for farming patterns involving, say, one agronomic and two horticultural crops from the same land in a single year. In many cases trade-offs are apparent in such crop yields due to temporal considerations and input and biological interactions.

A multiple cropping research project, now in its sixth year at the Coastal Plain Experiment Station in Tifton, Georgia, employs an integrated pest management approach utilizing net returns as the criterion for effectiveness and future direction of research. Three cropping systems involving 4 pest control intensities (PCIs) are under investigation by a team of researchers spanning several disciplines. Cropping systems were designed to stymie accumulations of pests such as nematodes, insects, and weeds.

Purpose

The purpose of this paper is to present results from 5 years of data for 1 of the 3 systems being researched. The 2 systems not selected for display involve 2-year cycles; thus results are available for only 2 cycles. The system selected for presentation is a 1-year cycle yielding results for 5 cycles.

PCIs (pest control intensities) are compared via net returns to land, management, overhead, and risk. The aim is to ascertain within the system presented the effect of PCI on net returns. This aim is tempered with an evaluation of risk.

Research Design

The experimental area, under center-pivot irrigation, is on Tifton loamy sand, typical of the middle Coastal Plain, with an east slope of less than 4 percent. The cropping system analyzed in this paper encompasses: turnip greens for processing, planted on February 20; field corn, planted on April 15; and southern peas for processing, planted on August 15.

All PCIs involve 6 replications in a randomized block design. PCI 1 is a standard check. The soil is sterilized each year, cultivated and hand weeded when needed before weeds are 1 inch high. Thus, herbicides and nematicides are unnecessary. Insecticides are employed in accordance with PCI 2. A foliage fungicide is applied for prevention.

PCI 2 encompasses a broad sprectrum soil fumigant, hand weeding before weeds are 1 inch high if needed, a nematicide (except 1978 and 1979), and a foliage fungicide for prevention. Herbicides and insecticides are applied rountinely with the aim of virtually complete control.

PCI 3 does not involve a soil fumigant or hand weeding. However, herbicides are employed as in PCI 2. Insecticides are applied on the basis of scouting reports. If harmful insects are spotted, the appropriate insecticide is used. A nematicide and foliage fungicide are also used.

PCI 4 involves less than virtual control of weeds. Only 1 herbicide is used to reduce weed competition. Insecticides are applied on the basis of scouting reports. However, chemicals are less toxic than those used on other levels. A soil fumigant, hand weeding, and a nematicide are not used. A foliage fungicide though is used for prevention.

Factors which are controlled for all PCIs include: soil moisture, soil fertility, soil pH, tillage method, cultivars, and planting and harvesting dates. Application of most nutrients and herbicides for all PCIs is through the center-pivot irrigation system.

Results

Selected results of 5 years of experimentation are presented (Tables 1 and 2). Table 1 shows multiple crop yields for turnip greens, field corn, and southern peas by PCI. Table 2 depicts returns from the multiple cropping system as well as costs of pest control inputs. With just 5 years of data from only 4 PCIs, results are preliminary. Thus, interpretation, which represents a consensus of the interdisciplinary research committee, is tentative.

Any improvements in yield over time, as may be observed (Table 1), are largely the result of the learning experience associated with a never-before-tried multiple cropping system under center-pivot irrigation. This is partially the case for southern peas where yield slipped significantly across all PCIs from 1975 to 1976. This was attributed to premature harvesting. Yields were much improved over the next 3 years partially for the reason indicated and partially because of favorable fall weather conditions. Low yields for turnip greens in 1975, PCI 2, and 1976, PCIs 2 and 3, were hypothesized to be

Table 1. Multiple Crop Yields[a] for Turnip Greens, Field Corn, and Southern Peas by Pest Control Intensity and Year

Year	Greens tons/acre				Corn bushels/acre				Peas cwt/acre			
	PCI											
	1	2	3	4	1	2	3	4	1	2	3	4
1975	8.3	4.3	5.1	5.1	177.6	204.8	189.5	175.9	14.72	12.37	12.13	10.00
1976	9.5	1.7	4.6	8.9	235.5	231.1	189.8	211.8	7.29	7.00	4.88	3.48
1977	7.5	4.5	2.1	2.0	199.8	200.1	186.5	173.9	14.69	15.33	10.65	9.15
1978	10.2	8.6	6.4	5.4	216.0	198.0	194.0	183.0	16.93	18.74	10.16	12.67
1979	10.3	10.6	9.0	9.0	186.0	184.0	166.0	171.0	20.34	18.21	21.19	17.14

a Average of 6 replications.

Table 2. Multiple Crop Returns and Costs of Pest Control Inputs by Pest Control Intensity and Year

Year & Management Level	Returns[a]		Costs[a]				
	Gross returns	Net returns	Soil fumigant	Hand weed	Herb-icide	Insect-icide[b]	Nemat-icide
	dollars/acre						
1975							
1	923.74	-514.17	700.00	180.00	0.00	18.63	0.00
2	767.00	-318.39	350.00	60.00	35.21	32.58	127.20
3	769.22	181.48	0.00	0.00	24.48	23.25	84.80
4	713.80	238.52	0.00	0.00	16.13	9.99	0.00
1976							
1	995.09	-350.85	700.00	90.00	0.00	16.78	0.00
2	631.45	-496.07	350.00	90.00	35.38	16.78	127.20
3	651.26	-21.52	0.00	0.00	26.77	16.78	127.20
4	870.21	345.06	0.00	0.00	22.95	3.70	0.00
1977							
1	931.74	-413.85	700.00	97.20	0.00	10.76	0.00
2	805.82	-243.71	350.00	91.20	24.65	16.13	42.40
3	608.61	-14.54	0.00	0.00	22.98	10.76	84.80
4	559.04	39.83	0.00	0.00	12.75	8.11	0.00
1978							
1	1115.32	-286.91	700.00	93.90	0.00	37.38	0.00
2	1031.31	-67.76	350.00	123.60	24.88	38.06	0.00
3	819.90	91.79	0.00	0.00	24.38	37.38	127.20
4	776.87	207.32	0.00	0.00	18.45	19.45	0.00
1979							
1	1105.01	-198.82	700.00	40.50	0.00	30.64	0.00
2	1086.28	164.49	350.00	55.80	20.44	36.01	0.00
3	1017.77	444.93	0.00	0.00	18.17	31.54	85.28
4	974.11	516.81	0.00	0.00	12.95	24.40	0.00

a 1979 dollars.

b Does not include the cost of application.

caused by a herbicide-nematicide interaction. Low yields for 1977 were attributed to poor stands. As expected, yields of all 3 crops in general tend to decline across PCIs from 1 to 4. Thus, if yield were the criterion for research effectiveness, PCI 1 would be preferred to PCI 2, and PCI 2 to PCI 3, etc.

However, when net return is used as the criterion, a different pattern is exhibited (Table 2). Indeed, the order is reversed. For all years PCI 4 is most profitable.

Table 2 also shows the cost of pest control inputs by PCI. A charge for scouting reports, though not shown in Table 2, is $10.00 per acre for PCIs 3 and 4. The expense of soil fumigation and hand weeding takes its toll on profitability for PCIs 1 and 2. The higher cost of intensive herbicide usage is generally observable for PCIs 2 and 3. Costly nematicide treatments are also depicted for the same PCIs, except for PCI 2, 1978 and 1979. The change was an effort to lend evidence regarding suspicion of detrimental effects from the nematicide on yield.

Insecticide costs (Table 2) would have been higher under different assumptions. The assumption regarding southern peas for the cost and returns analysis was that the processor gained control of the crop at first bloom. Thus, all management activities and associated costs from that point onward became the responsibility of the processor. The change in responsibility is reflected in the producer price of peas. As can be seen (Table 2), PCI 4, which entails the least input for insect control and yields higher net returns in any given year, was also least costly.

It is perhaps somewhat myopic to impose net returns as the sole criterion for gaging the results of this paper. Risk of course is an important factor as it may vary with PCI. Thus, results should be tempered in this fashion.

Hall has employed the use of the second moment of random variables from normal distributions to capture the element of uncertainty. A similar procedure is followed here. Within the limits of this study it is expected that greater PCI is associated with lower variability in gross returns (1979 dollars) as more care should result in more consistent results.

Variance estimates (S^2_{1-4}) are as follow: PCI 1, 12639.06; PCI 2, 35923.34; PCI 3, 29866.95 and; PCI 4, 29205.72. It appears that except for PCI 1 (standard check) the reverse of the expectation occurs -- less variability is associated with less intensive pest control.[3] A test of the null hypothesis may be stated as

$$H_o : \sigma_i^2 = \sigma_i^2 \qquad i \neq i, \binom{4}{2}$$

given that N = 30 observations for PCI_i and that

$$\frac{S_i^2(N-1)N}{S_i^2(N-1)N} > F_{(29,29,0.05)} = 1.85 \qquad i \neq i$$

in order to reject the null hypothesis. The null hypothesis was rejected for $S_1^2 = S^2_{2-4}$. However, all other possible combinations were not rejected. The conclusion is that PCI 1 is less risky than the other PCIs and that risk associated with the other PCIs is not significantly different.

Conclusions

Results from 5 years of experimentation seem to suggest that less intensive pest control is more desirable for this multiple cropping system. This conclusion is consistent with the underlying theme of integrated pest management which concerns not only private but also social costs associated with the use of chemical controls (Feder and Regev, Hall, Miranowski, and Norgaard). The results of the analysis of risk herein are not inconsistent with the evidence presented by Hall and Miranowski except in an extreme case which corresponded to the highest pest control intensity which consistently yielded negative net returns.

Since the results of this study are preliminary, it is probably inappropriate to draw conclusions at this time. The real value of this research thus far could well be the illustration of the importance of economics in such an interdisciplinary endeavor. The results of simple budgeting have been quite revealing to many of the cooperating researchers and have been important in providing direction for future research involving integrated pest management of multiple cropping systems in the southern Coastal Plain.

As the result of cooperative efforts thus far, future projects will likely involve a much greater number of PCIs to facilitate estimation of reliable production functions in order to provide a more definitive study of economic thresholds for the application of pest control measures for various multiple cropping systems.

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Footnotes

1 Returns to size refers to expansion of the operation and does not involve a proportional expansion of all farm resources.

2 No implication is intended regarding the appropriateness of such a goal.

3 Less intensive pest control is associated with more reliance on scouting reports (PCIs 3 and 4).