Economic Comparisons of Alternative and Conventional Production Technologies for Eggplant in Southern Georgia

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Abstract: *Environmental concerns about pesticide usage in traditional production systems are prompting vegetable producers to consider alternative systems. Research results from a multi-year study on eggplant in southern Georgia compare two alternative production technologies to the conventional rye cover crop technology. Alternative technologies utilize beneficial insect principles as substitutes for conventional pesticide controls. Using field data, eggplant production budgets are developed to generate net return estimates under each system. Yield and profitability results strongly favor the traditional rye cover system. Cost reductions achieved by using alternative technologies are not sufficient to offset the reduced yields and returns generated from these technologies. Cash input requirements for alternative systems suggest potential for limited resource producers.*

Key Words and Phrases: *Alternative systems, Budgets, Eggplant, Expected value, Limited resource, Stochastic dominance.*

Vegetable production in Georgia approached 225,000 acres in 1992 representing a 13 percent increase from the 1990 acreage level and a 30 percent increase over 1987 (Georgia Cooperative Extension Service, Feb. 1993). The 1993 farm gate value of vegetable production was estimated to exceed $334 million (Stephens and Dunn), more than a 200 percent increase over the 1985 farm gate value (Georgia Agricultural Statistics Service), when adjusted for inflation to 1993 real dollars (U.S. Department of Agriculture, 1988-1995).

Expansion of Georgia cotton acreage in 1994 reversed some of the statewide vegetable expansion. But selected vegetable enterprises remain far ahead of their 1987 acreage, suggesting longer-term potentials for success. One such enterprise is eggplant. Georgia eggplant acreage had expanded rapidly since 1987, exceeding 2,000 acres in 1992. In 1994, eggplant ranked 20th in acreage among all vegetable crops and was 94 percent ahead of its 1987 acreage level (Georgia Cooperative Extension Service, July, 1993). Eggplant is especially prominent in southern Georgia where more than 98 percent of the total state acreage is grown (Georgia Cooperative Extension Service, July, 1993).

Along with this vegetable acreage increase has come a trend for increased chemical and fertilizer expenses in Georgia agricultural production (Georgia Agricultural Statistics Service). To achieve these gains, vegetable producers are now utilizing intensive production systems with chemical and fertilizer inputs averaging 15 percent of their total variable production costs (Georgia Cooperative Extension Service, July, 1993). While field crops utilize systems that meet or exceed the 15 percent level, the average dollar magnitude of fertilizer and chemical expenditures on vegetable acreage is more than twice that on field crops ($258 to $123). These high-cost input systems can be financially infeasible for limited resource producers who comprise some 67 percent to 75 percent of Georgia's farm operations (Brown), but contribute only 7 percent of the total state agricultural sales (U.S. Department of Commerce).

Applications of these increased quantities of chemicals and fertilizers, especially in the sandy soils of southern Georgia, also present environmental concerns for the ecology of the region and quality concerns for both rural and urban water supplies. Clarke and McConnell reported in 1986 that about one million people in the rural areas of southern Georgia received their water supply from domestic wells and another 1.6 million state residents obtained water from other groundwater sources. Potential contamination of these water sources has prompted small-plot research into alternative production systems that utilize less toxic pesticide inputs and more desirable application schedules while remaining economically viable for both traditional and limited-resource producers. The research reported in this study was conducted to evaluate the economic viability of alternative eggplant production systems in southern Georgia. Multi-year data were gathered from field trials conducted on four research farms of the Coastal Plain Experiment Station in Tifton, Georgia. Stochastic dominance and expected value analyses were used to develop risk efficient rankings of the production systems. This eggplant research represents one portion of a more comprehensive project which also examines bell pepper and tomato enterprises in similar systems.

System Field Trials

The field trials in this research were conducted over the 1992 and 1993 eggplant production seasons at the Horticulture Hill, Little River, Black

Shank, and Hodnett Farms of the Coastal Plain Experiment Station. Trials consisted of strip beds of crimson clover, *Trifolium incarnatum* L. 'Dixie'; subterranean clover, *Trifolium subterraneum* L. 'Mt. Barker'; and rye, *Secale cereale* L. 'Wrens Abruzzi,' with each system having four replications at each farm. Trial procedures were based on previous system research efforts conducted in vegetable production (Bugg et al.; Phatak et al.).

The rye system is typical of conventional eggplant production systems being utilized in the region. Rye is drilled as a cover crop in October of the previous year, deep-turn plowed as green manure in the spring, and eggplants are transplanted into the bare ground beds. Pest control (disease, insect, nematode and weed) is achieved primarily by applications of chemicals prior to transplanting and continuing throughout the production season. Weed control through mechanical cultivation is also practiced.

The clover systems selected for these research trials are alternative systems that have shown promise in earlier production systems research (Bugg et al.). These alternative systems utilize beneficial insect principles to reduce chemical applications during the production season. Clovers are drilled at the same time as the rye cover crop. In the spring, the central third of each clover bed is killed with a spray application of contact herbicide, glyphosate, produced by Monsanto Corporation. The area is subsoiled and tilled for transplanting. Insect pest control during the growing season is maintained by beneficial predator insects that have been sustained in the clover strips alongside each vegetable row. Nematode control in these eggplant systems has formerly been attained by fall applications of soil-incorporated nematicides. Non-chemical nematode control was initiated in the 1993 season by planting velvet bean as a fall green manure prior to clover seedings. Weed control is achieved by a combination of mulch and contact grass herbicides. The clovers begin to naturally die back in early summer and thus provide a mulch that inhibits weed growth. An optional, late-season shielded application of contact herbicide may be necessary on the clover strips if grassy weed infestations become serious.

Each replication was treated as a separate plot for economic analysis. Variations in the farm soils required different irrigation treatments and some minimal variation in inputs during the growing seasons. After basic production budgets were developed for each system, input variations were incorporated according to location and system. Yield data were obtained by harvest for each replication in each growing season (four harvests in 1993 and three in 1992). Combining this data, annual net return calculations for each replication in the research plan were generated.

Conceptual Model

The theoretical basis for this research centers on the stochastic economic state variable we call "annual net return per acre." Specifically, annual net return per acre is defined as the difference between gross returns per acre and total production system costs per acre. Total production system cost includes preharvest variable costs, harvesting and marketing costs, fixed costs, and charges for overhead and management. Mathematically, the annual net return per acre, Π_{AB}, for a field plot designation A, and a production system B is formulated as:

$$\prod_{AB} = \sum_{t=1}^{T} (Y_t)(P_t) - \sum_{j=1}^{J} (X_j)(r_j)(1+i) - [(\sum_{k=1}^{K} r_k)(\sum_{t=1}^{T} Y_t)] - \sum_{d=1}^{D} (X_d)(r_d) - L$$

where A = field and farm designation, B = production system, t = harvest time period, Y_t = eggplant yield in period t, P_t = eggplant market price in time period t, X_j = quantity of input or operation j, r_j = price per unit of input or operation j, i = biannual interest rate, r_k = cost per unit of harvest and marketing activity k, X_d = number of implement d's used in the system, r_d = annual fixed cost per implement d, and L = annual charges for overhead and management.

Prices and Input Costs. Eggplant market prices were developed from Atlanta Wholesale Market weekly quotations over the June-July marketing period (Georgia Cooperative Extension Service, Nov. 1993). Actual weekly harvest dates were recorded for each location and the corresponding market price for that week was paired with the actual yield. Produce harvested on each field plot was graded into marketable, cull and rot classifications. The marketable yield was adjusted to a per acre basis and recorded for each respective location and system. Harvest times were determined according to the market readiness of the fruit. No harvest timing adjustments were made in anticipation of market price changes. Likewise, no minimum expected yield was established as a harvest guide whereby yield estimates below the minimum would result in all harvesting activities being discontinued. Gross return figures were calculated for each location by taking the product of yield and per unit price.

Charges for machinery and labor requirements in eggplant production were developed from University of Georgia Cooperative Extension Service enterprise budgets (Georgia Cooperative Extension Service, July, 1993). Input quantities and prices were recorded by production system and field test plot for each year of the research project. When input prices were not directly available because of use of materials on station inventory, local supplier prices were surveyed to determine the prevailing price. Average per acre costs for selected inputs for each system, along with the total preharvest variable input costs associated with each system, are presented in Table 1.

Risk Efficiency Criteria. Risk is a concept wherein producers know all possible outcomes and the probabilities that each outcome will occur. Although often improperly interchanged, risk differs fundamentally from uncertainty. In uncertainty, producers know that they are subject to various outcomes, but do not know the probabilities of given outcomes occurring. Risk efficient sets are composed of all outcomes that would be most desirable at some period of the time frame. Each set is determined on the basis of producer risk aversion. When producer aversion is not known with certainty, the efficient set is based on approximations of the probability distributions (Chyen et al.). These distributions are approximated through an assumed preference relation and various approximations of decision probability distributions (Wetzstein et al.). The efficiency criteria adopted by the researcher specifies the preference and probability distribution restrictions under which the analysis is made. For this paper, distributions of profit and yield are compared for each of the three production systems.

Two efficiency criteria widely used in risk studies are expected value analysis (EV) and stochastic dominance (SD). The more basic condition, expressed in all risk efficiency criteria and necessary for one distribution to dominate another, is EV. This analysis involves taking the first moments of the decision density functions. Stochastic dominance analysis compares the areas below probability distributions of the respective production systems. A system, A, is said to express first degree stochastic dominance (FSD) over another system if its cumulative probability function remains below the cumulative probability function of an alternative system at all points. Second degree stochastic dominance (SSD) over another system is expressed if the area below system A's cumulative distribution is less than or equal to the area below the dominated distribution. SSD allows the formation of risk efficient sets composed of all systems whose probability functions comprise a portion of the efficient frontier.

Results

Production budgets were estimated for crimson clover, subterranean clover and conventional rye eggplant production systems by averaging

Table 1.
Average Per Acre Costs of Selected Inputs and Preharvest Variable Input Costs by Production System

Input/System	Fertilizers	Herbicides	Insecticides & Fungicides	Nematicides	Total Selected System Costs	Average Total Preharvest Input Costs
	---dollars per acre---					
Crimson Clover	117.47	43.35	0.00	29.88	190.70	689.45
Subterranean Clover	116.85	43.35	0.00	29.88	190.88	698.44
Conventional Rye	140.52	12.50	69.76	59.75	282.53	743.72

input quantities and costs over the 1992 and 1993 production seasons at all locations. Comparisons by system for selected inputs are presented in Table 1 along with full system estimates of total average preharvest input costs.

Eggplant summary statistics for yield and profit were aggregated for the 1992 and 1993 production seasons and are presented in Tables 2 and 3. Results in each table are presented, by production system, for each of the four locations in the small plot test. Aggregate results over all locations are also provided.

Profit and yield, while not perfectly correlated, are closely related. For example, consider an increase in yield. Such an increase would be expected to increase total variable harvest costs which are tied to the volume of product handled. Gross returns would also be increased, assuming each producer has no effect on the general market price for eggplant, as yield increases without a decrease in price per unit. The proportional relationship between these changes would then determine the amount and direction of change in producer profits.

Results for profit and yield measures were highly variable. This variance can be partially attributed to the small plot scale of the tests which required extrapolation of data to reach a "per acre" basis. An additional factor was the south Georgia weather during the 1993 growing season. Compared to the prior twenty-year averages, temperatures from April 25 through June 29, 1993, were some two degrees cooler than normal, but almost 2.5 degrees warmer than in 1992 (Coastal Plain Experiment Station). Precipitation during this period in 1993 was 3.45 inches or almost 5 inches below the twenty-year average annual rainfall (8.37 inches) for the period. Despite the use of irrigation, this period of weather stress reduced 1993 eggplant yields and likely contributed to the unusually large variances in the yield data results.

Input Costs. Examination of the distribution of expenditures on selected inputs and the total average preharvest input costs associated with each system can identify potential areas for producer savings. From Table 1, clover systems are shown to have lower fertilizer costs than conventional rye systems and substantially less input expenditures on insecticides, fungicides and nematicides. Further savings may be possible with less chemical applications if the velvet bean method of nematode control proves effective in continued tests. Total herbicide costs increase with the clover systems due to the pre-transplant strip-killing of clover to prepare the seedbed. But an approximate $90 per acre total savings is indicated for these selected inputs when a clover production system is adopted.

Table 2.
Yield Summary Statistics for Four Research Locations, 1992 and 1993 Production Seasons

System/Location	Sample Size	Mean	Variance	Minimum	Maximum
		---------------	cartons per acre	---------------	
All Locations:					
Crimson Clover	32	193.43	18,412.99	0.00	617.64
Subter. Clover	32	91.28	9,535.18	0.00	398.32
Conv. Rye	32	514.94	63,945.44	55.80	1,067.24
Horticulture Hill:					
Crimson Clover	8	221.60	15,620.96	95.36	398.80
Subter. Clover	8	165.71	23,323.73	0.00	398.32
Conv. Rye	8	598.13	12,097.71	438.08	797.64
Little River:					
Crimson Clover	8	213.46	44,997.25	0.00	617.64
Subter. Clover	8	79.15	6,292.81	0.00	222.88
Conv. Rye	8	801.61	36,639.56	448.44	1,067.24
Hodnett:					
Crimson Clover	8	158.03	10,952.61	49.36	360.04
Subter. Clover	8	34.91	618.59	7.08	85.32
Conv. Rye	8	300.29	34,479.53	55.80	636.04
Carpenter:					
Crimson Clover	8	180.63	6,987.40	85.32	298.40
Subter. Clover	8	85.34	1,821.58	22.20	156.56
Conv. Rye	8	359.72	17,947.90	161.16	531.88

Total preharvest input costs for each system are also presented in Table 1. The conventional rye system was found to have approximately $50 per acre greater expenditures on preharvest inputs, including labor. Clover systems are essentially equal in cost with the difference representing the cost differential between crimson and subterranean clover seeding costs.

Table 3.
Net Returns Summary Statistics for Four Research Locations, 1992 and 1993 Production Seasons

System/Location	Sample Size	Mean	Variance	Minimum	Maximum
		---------------dollars per acre---------------			
All Locations:					
Crimson Clover	32	346.85	846,786.51	-907.99	2,938.95
Subter. Clover	32	-398.52	405,432.20	-934.46	1,689.98
Conv. Rye	32	2,461.26	4,154,659.21	-853.78	7,161.34
Horticulture Hill:					
Crimson Clover	8	655.01	785,330.62	-216.24	2,018.04
Subter. Clover	8	61.93	1,022,548.36	-926.20	1,689.98
Conv. Rye	8	3,379.67	984,133.37	1,979.28	5,320.18
Little River:					
Crimson Clover	8	455.67	1,912,316.96	-907.99	2,938.95
Subter. Clover	8	-421.11	281,562.32	-934.46	541.61
Conv. Rye	8	4,891.98	2,051,720.87	2,401.99	7,161.34
Hodnett:					
Crimson Clover	8	49.24	548,342.29	-691.44	1,564.08
Subter. Clover	8	-764.94	19,346.62	-919.46	-498.92
Conv. Rye	8	731.91	808,511.58	-853.78	2,253.23
Carpenter:					
Crimson Clover	8	227.47	264,493.59	-453.19	969.85
Subter. Clover	8	-469.94	69,875.89	-833.84	19.50
Conv. Rye	8	841.51	422,151.03	-59.77	2,150.74

The preharvest input costs are averages over all locations for each system and indicate the potential for input expenditure savings that clover systems offer. This savings is especially important to limited resource farmers whose operations generate between $2,500 and $40,000 of annual gross sales. A recent survey of limited resource and commercial farming operations in two south Georgia counties indicated that the limited resource operations were over-utilizing fertilizer, labor and machinery inputs in their present enterprises (Nelson, Brown and Toomer). Clover production systems utilize these inputs in different proportions from conventional production systems. Adoption of clover production systems by limited-resource producers could shift their operations toward more efficient input utilization while reducing their dependence on chemical applications during the growing season.

Yields. Eggplant production yields, aggregated over all locations for the 1992 and 1993 marketing seasons, ranged from a low of zero marketable cartons per acre to a high of 1,067.24 cartons. Standard eggplant marketing cartons are 1 1/9 bushel in size with a net weight of 33 pounds (Georgia Cooperative Extension Service, Nov. 1993). The conventional rye system produced the highest average yield (514.94 cartons per acre) when aggregating over all locations. This yield level appears reasonable given the 1992 state average yield of 494 cartons per acre for irrigated bare-ground acreage (Georgia Cooperative Extension Service, Feb. 1993). Conventional rye systems also produced the highest average yields at each of the four locations. Crimson clover systems had the second highest yields with an average of 193.43 cartons per acre over all locations. Subterranean clover yields were a distant third, generally half or less of the crimson clover yields and ranging from 10 percent to 27 percent of the conventional rye yield. Average yields for the alternative systems over all locations, as a percentage of the conventional rye yield, were 17.7 percent for subterranean clover and 37.6 percent for crimson clover.

Location appeared to influence eggplant yield with the most likely factor being soil type and the associated productivity rating. According to U.S. Department of Agriculture Soil Conservation Service soil surveys of Tift County, both the Little River and Horticulture Hill farms contain loamy sand soils that possess good productivity ratings. Carpenter Farm is predominantly Carnegie sandy loam, but does not have the production capacity of the loamy sand soils. Hodnett Farm is predominately a Lakeland deep sand soil with less than 1 percent organic matter. The productivity rating is fair. As would be expected, eggplant yields at Hodnett Farm trailed all other locations for each system.

Another factor that influenced yields was heavy weed infestations in the tilled row. Placement of the clover strips alongside the vegetable row provides ready transfer of beneficial insects when needed. But the strips also limit the use of mechanical cultivation to suppress weeds within the vegetable row. It was observed that both alternative systems had heavier weed infestations within the vegetable row than the conventional production system. Fertility drain by these weeds, along with the additional nutrient demands of the clovers, may have exhausted available nutrient supplies. This is especially suspected in 1993 when severe drought in southern Georgia required frequent, heavy irrigation to maintain crop growth. As water translocated through the plants, nutrients would also be transported which could have led to deficiencies.

Net Returns. Calculations of net returns per acre were generated for each system replication plot at each location (Table 3). Research technician logs of production inputs and operations at each farm were combined with market prices and input cost estimates to produce net return figures. Average net return levels, by system and location, ranged from -$765 on Hodnett subterranean clover to $4,892 for Little River conventional rye. Considering by locations, subterranean clover was profitable at only the Horticulture Hill Farm. Crimson clover showed an average profit over each location with a maximum net return of $655 per acre and a minimum of $49. Examining each of the thirty-two observations separately, each system was found to have at least one plot with negative net returns.

Net returns for these research results were calculated using marketable harvested produce yields. For some replications, these yields were extremely low and resulted in a large percentage loss of preharvest input investment while also incurring the harvesting and marketing costs on the low yield. Actual field operations would be expected to establish a minimum harvest yield level below which no harvesting and marketing activities would occur. When the minimum yield level was not reached, producers would lose only their preharvest investment and would not incur any harvesting or marketing costs. In this research, actual harvest yields were used to more fully illustrate the range of net return possibilities.

Expected Value Analysis. Analysis of the yield and net returns summary statistics in Tables 2 and 3 according to expected value criteria shows that the conventional rye system dominates the subterranean and crimson clover systems. This dominance exists when systems are compared over all locations and remains in place when the analysis is extended to an individual location basis. Crimson clover dominates subterranean clover in a similar manner for both yield and net returns.

Stochastic Dominance Analysis. Given the clear dominance shown by mean-variance measures, further analysis of the systems would not usually be necessary to compare production systems. But inclusion of statistical verification permits the graphical representation of yields and profits presented in Figures 1 and 2, thus introducing risk estimates.

Risk aversion of producers is introduced to the analysis by considering stochastic dominance criteria. When cumulative probability functions are

Figure 1.
Marketable Eggplant Yields

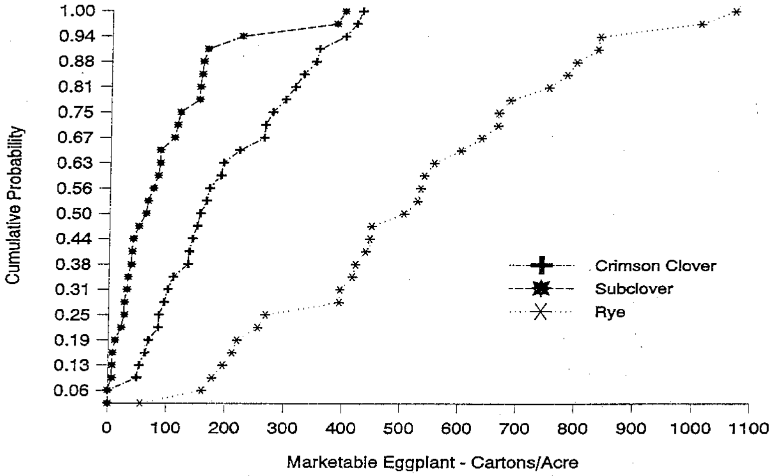
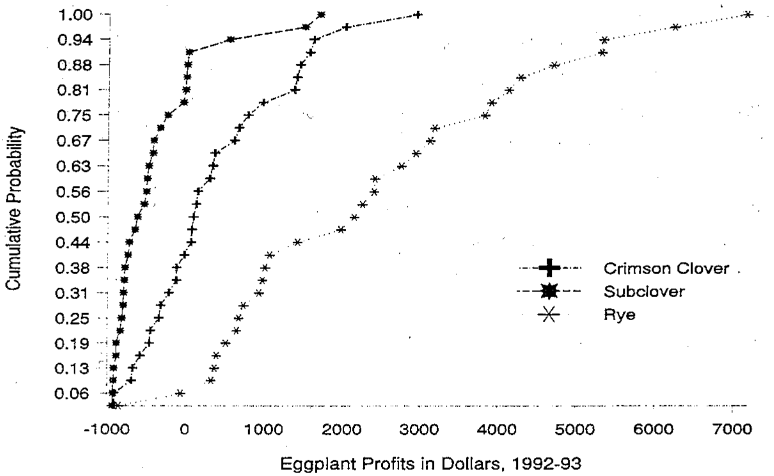


Figure 2.
Eggplant Net Returns



generated for each production system in terms of yield (Figure 1) and net returns (Figure 2), the alternative production systems are shown to not enter the risk efficient set of systems when considered over all locations. The conventional rye system is thus found to have first degree stochastic dominance for both yield and net returns. This indicates that the clover systems, as designed in this research, are not preferable alternatives to the conventional rye system currently being used in eggplant production.

Conclusions

Economic comparisons of eggplant production systems using expected value and stochastic dominance analysis indicate that the conventional rye system remains superior to alternative clover systems on the basis of both yield and net returns. Difference in yield between rye and clover systems continues to be the driving factor toward this result. Possible reasons for the yield differentials include extremes in weather conditions, degrees of vegetable row weed infestation, and differences in nutrient requirements between the conventional and alternative systems. Adoption of either alternative system would currently be expected to lower per acre yields. But sufficient reductions in input costs to more than offset the revenue loss from a yield reduction may be possible.

Differences in preharvest variable input costs are noted between systems with the clover systems being approximately 6 percent to 7 percent less. Potential savings are identified in the clover systems for selected production input items, especially insecticides and fungicides. And the potential savings on input expenditures are expected to have additional value to limited resource farmers, given their current efficiency level in utilizing the inputs and the size of input expenditures per acre required for vegetable production.

Potential environmental benefits are expected with the input adjustments in clover systems. Adoption of either alternative system would mean a shift from more traditional harsh pesticides to products that are more environmentally friendly. The timing of pesticide applications would also change as more applications are made prior to transplanting the vegetable plants. This new schedule should appeal to consumers with concerns about pesticide residues and may also reduce the threat to water supplies since pesticides would be applied prior to the irrigation season for the crop.

Alternative eggplant production systems utilizing clovers are not economically comparable at this time with the conventional rye system. Yield differentials between the systems are too large to be overcome by input expenditure savings. But identifiable benefits from input expense reductions and more desirable environmental practices justify continued research on this topic.

Notes

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