workshop sobre metodologias de avaliação socioeconômica da pesquisa agropecuária

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MODELLING THE USE AND ADOPTION OF TECHNOLOGIES BY UPLAND RICE AND SOYBEANS FARMERS IN CENTRAL-WEST BRAZIL

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1. Introduction

The composition of Brazilian agricultural supply has been widely discussed (Homem de Melo, 1983). In addition, since 1974 the Brazilian government has invested a considerable amount of resources in agricultural research. At present, there are certain amounts of knowledge and technologies available however, these appear to be adopted by farmers with a considerable lag. Furthermore, this lag is not the same for all products, for all farmers and for regions and communities.

It seems that several conjunctural factors and structural transformations in the Brazilian economy together with different policies can be related to the agricultural supply composition and technological gap.

Technology availability for different crops has been pointed out as a determinant factor of the disparity in the regional composition of agriculture in Brazil (Homem de Melo, 1983).

Agricultural supply dynamics has led to changes in land allocation for different crops. The growth of the area with soybeans in the Center-West region since the late 1970's is one the most important events of this process of change (Teixeira, 1987).

The Center-West region in those years had a large contribution to Brazilian agricultural supply. Of the total area with rice, soybeans, corn, beans and wheat in Brazil, 17,5% are in Center-West region. For rice the share is 31.9% and for soybeans is 28.4%. The regional yields (kg/ha) are higher than the Brazilian average yields for soybeans, corn, cassava, cotton and sugar cane. For wheat and rice the center-west yields are lower since the average for Brazil includes irrigated areas.

Upland rice, because of its effect on soil quality* has a long tradition in the region and farmers who recently migrated there tend to cultivate it. Since 1970/71 the area with rice has considerably increased. In Mato Grosso do Sul, this occurred during 1970/79 then started to decline. In Mato Grosso the decline started in 1979/80 and in the Goias in 1980/81. In 1985/86 in all 3 states the area with upland rice increased again.

Data on new land opened in the states of Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás and Distrito Federal indicate that rice is a vehicle for opening up new land. In 1972, 193 thousand hectares of new land were opened in those states, and the increase afterwards was such that in 1977; 643 thousand hectares were opened. Since then, apart from 1980, there has bean a decline in the rate new openings (Banco do Brasil/DEPES/ANDIV). At the same time, the area planted with upland rice in Mato Grosso and Mato Grosso do Sul has declined, it has declined with a lag in Goiás.

With soybeans, a product recently introduced in the region, the area cropped has increased almost every year.

The purpose of this study is, to use data collected by EMBRAPA units to explain the technological adoption process. In this paper, we use one data set from CNPAF, for upland rice and soybeans. We plan to examine additional data sets in the future.

The analysis of the technological adoption process for those two products is a challenge since they are different from each other both because of their markets relations and structure of production.

Rice is consumed mainly by lower income and has a very small world market. Upland rice is planted in 85% of total area with rice in Brazil (Census 1980). Soybeans a recently introduced/ product has a strong linkage with the industrial sector and with the world market.

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* It has been historically cultivated as a way of correcting soil before turning the land to pasture.

2. Methodology

The major purpose of this paper is to explore reduced form determinants of the adoption of certain technologies and cultural practices for upland rice and soybeans. See Feder, Just and Zilberman, 1985, for a general survey of the adoption literature. In the data used here, we know farmers' practices only at the time of the survey; no retrospective information is available. This means we are unable to model the complete diffusion process. Instead we examine reduced form determinants of the adoption and extent of adoption of a set of practices.

We view the adoption of technology as an economic decision based on discounted expected marginal benefits and costs. The empirical specification used in this paper is consistent with a variety of models of farmer or farm household optimization: maximizing expected profits, excepted utility of profits or expected utility of consumption and leisure subject to production function and time constraints (see Roe and Graham-Tomasi, 1986). For convenience in exposition, let us take the first alternative. Discounted expected profits, V(·), will be composed of two parts: the difference in discounted expected value of production of all crops and livestock with and without adoption of the particular technology, minus the difference in costs. We can think of this as the difference of two profit functions, each of which being a function of the base year constraints and information of farmers. The constraint and information sets include four components; two at the farm and two at the community levels. At the farm level we view as constraints, firstly, human capital factors associated with the farm decision making process and, secondly, factors associated with the quantity and quality of land owned. We view other quasi-fixed factors, such as machinery, as adjustable over the time horizon of the farmer, and therefore do not include them as exogenous or pre-determined covariates. At the community level, the information set includes expected input and output prices; the level of farm services, especially extension and input services; and agro-climate factors related to yield levels and instability comprise the groups of factors that we consider.

Two types of human capital are plausibly related to technology adoption, education and experience. All else equal, both should be positively related to information available to the farmer. Experience may provide both general farming knowledge as well as specific knowledge about his or her particular farm, while education may enable the farmer to better process the information provided by different sources, and may increase both the allocative and technical efficiency of the farmer (Jamison and Lau, 1982). We assume all farming decisions are made by the household head and use his (or her) years of education as our measure of education, his age as a measure of general farming experience, and the number of years he has lived in the region as a measure of more region-specific experience. We would prefer to use the amount of time the farmer has been farming in the area; unfortunately this information is not available. Similarly, it would be useful to distinguish different types of education (such as technical and non-technical schools).

Regarding land, we use the area owned rather than the area cultivated as our quantity variable. We do this because much land is rented, even in the short run, and is an input which farmer have choice over. One could argue that in the long run land sales are possible; we take a more medium run perspective here, while recognizing that larger farms may result from better managerial ability. The survey provides us with two types of variables relating to farm level land quality; the topography of the land (before any leveling or terracing is undertaken) and the degree of soil erosion. It might have been useful to have more precise data (see for instance Sidhu, 1983, or Bhalla, 1988, for examples of input demand and yield analyses which indicate the usefulness of good land quality data.

Previous studies of farm technology adoption have used similar specifications, farmer education is almost always included, although experience measures other than age are seldom available; sometimes land quality data are also included. It is unusual, however, to find studies that use community level variables other than prices. We would argue, however, that the availability of input provision, marketing and extension services probably influence the adoption process, as do agro-climate variables such as rainfall distribution. (Birkhauser, Evenson and Feder, 1989, survey the extension impact literature). We take two approaches to modeling community influences.

We first include municipio-level dummy variables to capture these effects in an arbitrarily general way; we call this the fixed effect estimates. Secondly, we include variables designed to measure the community factors direcly[1/]. Among the community factors, we include municipio-level mean and standard deviations of rice and soy yields. These are derived from seven years of data on municipio-level rice and soy area and production. The source is independent of the sample, so there are no artificial correlations arising from data construction. These variables are designed to proxy for agro-climatic influences which affect both the level and variation in yields. A second set of variables attempts to measure the level of services available to farmers. We do not use information at the farm level, say whether he or she has regular visits from an extension agent, because such a variable would be endogenous in our model. In particular extension visits may arise because both the agent and the farmer want them. Agents may go to better farm managers, on better land (or land closer to their offices), so as to maximize their impact. Provided there is useful information to extend there is likely to be more demand for it by better farmers on better endowed land. Thus inclusion of a farm level variable on extension contact is likely to give an upward biased coefficient on extension, as well as biasing downwards the education, experience and land quality coefficients. The availability of extension and other services at the community level may be more plausibly taken as exogenous to farmers under certain assumptions and so should ameliorate the problem of simultaneity bias. (Since there are too few sample observations in each municipio to use that as a meaningful level of aggregation we define community factors at the microregion). Based on the sample, we construct the percentage of farmers who have contact with EMBRAPA, with EMATER and who are associated with a cooperative. Ideally we would like this community information to come from sources independent of the sample. We are working on collecting such data, and include, at this time, the availability of centralized storage capacity at the municipio level.

1/ We cannot hope to capture all factors which influence farmer decisions; what we hope to do is identify among these factors, those which have a large influence on technology adaption.

As for prices we only have input prices at the state level, and as there are only three states covered in the survey there would not be enough data points to measure their effect; thus they are omitted.

Having defined our variables we can outline the statistical model. Let

$$V_{i\Lambda} = X_i\beta_\Lambda + \varepsilon_{i\Lambda} \qquad (1)$$

be the discounted expected profits function using the adapted technology for the ith farm, X_i is a vector of characteristics defined above and ε_i is a random error. Let

$$V_{in} = X_i\beta_n + \varepsilon_{in} \qquad (2)$$

be discounted expected profits without the new practice. If $V_i = V_{i\Lambda} - V_{in}$, then if $V_i > 0$ the technology or culturaal practice is adopted and not if $V_i < 0$. Note that we consider each practice separately. We do not observe V_i and ε_i but we do observe both X_i and whether the practice is adopted or not. If we let $D_i = 1$ it the practice is adopted, that is if $V_i > 0$, then we have a standard model of qualitative choice. For this paper we assume ε_i to be distributed as a normal random variable with mean zero and unit variance, which is a probit model, and is estimated by maximum likelihood.

There are some dependent variables, notably fertilizer use per hectare, which are continuous variables and which are estimated by the method of least squares. (Since almost all farmers use some fertilizer, data censoring at zero is not a problem). This linear specificiation can be derived from a quadratic profit function (we abstract in this case from the possibility that coefficients may vary based on the technology used, see Pitt and Sumodiningrat, 1988).

3. Description of data

The data set comes from a study conducted at CNPAF (Teixeira, 1987, Barbosa e Teixeira, 1987).

Its main purpose was explain, at the farm level, the reasons for soybeans expansion (sometimes at the expense of food crops such as rice in Center-West region) and to characterize the form of production. The sample regions were selected based on total acreage and production data for the two crops from 1973 to 1984. The municipios were selected based on the increase over time of soybeans area and the decrease over time of rice areas. The number of farmers sampled was 200: 100 in Goias, and 50 in both Mato Grosso and Mato Grosso do Sul (Teixeira, 1987). Additional data were collected on some variables which characterize the regional agricultural sector such as: storage facilities, credit, extension, health and education services, price of products and prices of inputs.

In order to describe the data set was used table analysis According to farm size variable, table 3.1 shows that for the Center-West region, the sample compriser of large farms (49,6% of the farms sampled have more than 500 ha). This happens especially in state of Mato Grosso, where farms larger than 1.000 ha represent 39,2% of the state sample. In Mato Grosso do Sul the larger frequencies are for farms in the 501 - 1.000 ha, and 10.-250 ha brackets. In the state of Goias, farms 251 - 500 ha size, are the most frequent.

Since the distribution of farms by sizes is not the same for all three states, tables 3.1.A, 3.1.B and 3.1.C have the composition of soybeans and rice production by farm size for each state. However, it is possible to infer that for all three states the area farmed is larger than area owned, the average area with soybeans is larger than average area with rice and soybeans yields are higher than rice yields. This happens in all farm sizes. It can be noted that in state of Goias in all farm sizes there are permanent crops, and in the states of Mato Grosso and Mato Grosso do Sul this happens only on larger farms.

The ratio average area with cultivated pasture to average area with native fields is greater than one for all farm sizes in Goias, and only for farms larger than 1.000 ha in states of Mato Grosso and Mato Grosso do Sul. Also, rice yields have a different pattern in these states. In Goias yields decrease as the size of farms increases up to 1.000 ha; in Mato Grosso and Mato Grosso do

Sul rice yields increase as size of the farms increases up to 500 ha. Soybeans yields have a more homogeneous pattern. They tend to increase with farm sizes in all three sector.

Most of the farmers in the sample came from other geographical regions; 60% to have no more than 10 years in the region. Usually they are young and the average family size is 4 to 5 persons.

The level of education decreases with the farmers' age (Table 3.2.A). The more educated farmers have smaller families and larger farms. However, less educated farmers are having better results in terms of rice yields and rice share of area planted is higher for those farmers. For soybeans, yields increase with level of education.

Farmers care more for soil analysis when it is for soybeans; however, for cover fertilizing rice received more attention (Table 3.3). Inocculation for soybeans seeds is used by 50% of the farmers. For rice, erosion control, use of certified seeds, treated seed, use of fertilizer and incorporated residuals are more frequent when farmers are better educated (tables 3.3.B and 3.3.C). However, for credit use this does not happen.

For soybeans the relationship between adoption of technologies and level of farmers' education was not as clear as for rice. But it was possible to note that better educated farmers care more about the use of cover fertilizer, do more plowing and more terracing. Non-mechanized weed control is more frequent for less educated farmers.

4. Technology and Cultural Practices: Regression Results

Not all of the technology information collected in the survey is used in the regression analysis. Some practices are adopted by almost everyone and others by very few farmers; for these, there is no variation to explain. Some practices, such as use of herbicides for soy farmers, are very hard to explain with the covariates we use; others are sufficiently close to those we do report that they provide no additional information. We focus on nine practices, five for upland rice and four for soybeans. They are whether the farmer does soil analysis (for both rice and soy fields); whether the farmer uses certified rice seed or inoculated soy seed; whether he uses cover fertilizer (for rice) and total fertilizer usage per hectare (for rice and soybeans); whether action is taken against rice blast (brusone); whether soy fields are planted in (preferred) holes (or whether rows are used). Each dependent variable is estimated in isolation; these regressions cannot, therefore, take account of complementarities in technological practices. With the assistance of CNPAF and CPAC agronomists we worked with a scheme which assigns a score to packages of practices. With the results was created an overall technology adoption index for each farmer: the higher the index, the closer the farmer is to "optimal" (or recommended) practices. We include this index as the tenth dependent variable, treating it as a continuous dependent variable. It should be clear that relying on this index alone is unlikely to be a good empirical strategy; we therefore consider it in conjunction with the regressions explaining the adoption of individual practices.

The regression results are presented in Tables 4.1,4.2. They are discussed by group of covariates. We look, firstly, at the effect of farmer human capital on the dependent variables, secondly, at the effect of community service variables, thirdly, at the farm-level land quantity and quality variables and finally at community-level agro-climatic variables.

(a) Education and Experience Effects

Education of the farm operator has a positive, significant at the 5% level, effect in five of the ten regressions.

The overall index of soy cultivation practices rises half of a point (out of 100) for each year of education. Using soil analysis for both rice and soy cultivators is positively related to education as is the quantity of fertilizer used on soybeans and the use (or not) of cover fertilizer for upland rice. These effects are robust to the inclusion of either region dummy variables or region-specific variables. It is possible that there exist interaction effects of education with the degree of regional EMBRAPA, EMATER or coop service, or with agro-climatic factors; however because of the small sample size these are difficult to detect.

Age of operator, which should proxy for general experience. does not explain any of the adaption patterns. Time spent in the current region of residence is, however, strongly positively related for rice farmers to the use of methods to control blast, and negatively related for soybeans farmers to the probability of using preferred planting techniques. This suggests that learning about the particular conditions of the center-west region, and how to cope with them, does occur, for these largely immigrant (usually from the south) farmers.

(b) Regional Service Availability

In many of the regressors the microregion dummy variables are jointly and individually significant at the 5% level. It is thus interesting to include region-level variables which may be pausibly related to cultural practice adoption. The level of EMBRAPA regional contact is positively related to a variety of upland rice practices: use of certified seed, use of cover fertilizer, the quantity of fertilizers used per hectare, and the use of measures to control blast. For soy farmers regional EMBRAPA contacts serve to convince farmers to use unconventional (and preferred) planting methods. The effects of EMATER are more mixed; farmers in regions more intensively served by EMATER tend to use soil analysis on rice farms, use certified seeds and inoculated soy seeds, use less fertilizer per hectare on soy farms and score higher on the soy technology practice index.

Farmers in regions with stronger levels of coop association are less likely to adapt preferred upland rice cultivation practices such as having soil analyzed, using certified seeds and they use less fertilizer; they are also more likely to use conventional planting methods for soybeans. The existence of modern storage facilities does not have a significant impact on any of these practices.

The net positive impacts of EMBRAPA and EMATER service availability is quite interesting and potentially important. In unreported probits explaining the probability of a farmer having EMBRAPA or EMATER contacts it was found that being better educated and younger made it more likely to have such contacts. EMATER contacts are also more likely in areas with lower soy yields. more variability in yields. Farmers with larger owned holdings are more likely to be associated with cooperatives, as are farmers in less well endowed areas, as measured by mean yields, with lower yield variation.

(c) Land Quantity and Quality

Total area owned has no effect on the technology variables save on the use of certified rice seed. Topography does seem to be related to the use of preferred practices for soybean farmers. Farmers owning less level land are more likely to use soil analysis, plant with preferred methods, use more fertilizer per hectare and score higher on the soy technology adoption index. For upland rice farmers topography has less impact, except for a positive effect on the use of cover fertilizer on farms with steeper slopes. The presence of soil erosion is associated with lower probabilities of using cover fertilizer and less total fertilizer use, but with a larger likelihood of using control methods for blast. On soy farms we are more likely to find farmers using conventional planting methods on farms with eroded land.

(d) Regional Agro-Climatic Conditions

Agro-climatic conditions are proxied at the municipio level by mean soy and rice yields, and the standard deviation of those yields over a seven year period (1979/80-1985/86). Basic patterns differ for upland rice and for soybeans. For upland rice, it is in less productive municipios that soil analysis and certified seeds tend to be used. The variability of yields has no significant effects on rice cultural practice. For soybeans it is in better endowed areas that inoculated seeds and preferred planting methods are used. Agro-climatic variability also induces use of inoculated seeds, a higher technology index score and less fertilizer per hectare. The use of less fertilizer is consistent with the greater probability of using inoculated seeds, with nitrogen fixing capabilities.

(e) Crop Area Shares and Yields

The adoption of preferred practices or technologies is not an end of itself. Rather there is an ultimate goal of unit cost reduction or total factor productivity increase. In this section we use our reduced form specification to explain both the share of cropped area to upland rice, soybeans and maize; and rice and soybeans yields. Not all farmers grow all three crops, alghough most grow soybeans. In principle we should model this fact using a Tobit or generalized Tobit procedure. Here we ignore those considerations and use OLS as our estimating procedure The results are reported in Table 4.3.

For upland rice very little is explained by any of our covariates. The only significant variables are whether the farmer's state of origin is Rio Grande do Sul or Parana, which is associated with less upland rice sown. Given that upland rice is not important in these states this finding is not surprising. With more years in the central west region there is a tendency to increase the share of rice, but the coefficient is not significant at conventional levels. Originating in Rio Grande do Sul or Parana is positively related to the share of soybeans and negatively to the maize share. There is some indication that more experience may lead to less soybeans grown, and there is a pronounced negative effect of education on the share of maize grown. For maize there are also some strong effects of the region of current residence, suggesting a role for agro-climatic factors. This is corroborated in part by the positive effects of mean rice yields on the maize share as well as its negative effect on the soybean share. Also areas more served by EMATER or a coop are more likely to be maize growing areas.

When we look at the rice and soybean yield regressions we see that there is no explanatory power whatever. This is rather disturbing especially for soybeans given the new technologies and practices being advanced. It may be that these cultural practices have no effect on yields, or that other input use is adjusted when these practices are adapted resulting in no net yield gain. A third possibility is that the production and/or area data were poorly reported. Our empirical work can shed no light on this important question.

5. Summary

We would argue, on the basis of these results, that it is possible to identify some of the determinants of the adoption of new technologies and cultural practices, at least within the simple static model outlined in section 2. It would be preferable, however, to explain both the extent and process of technological adoption by farmers; this would be possible only with longitudinal data in which each farmer is tracked over several seasons. In any case, for both longitudinal and cross section surveys, the results reported above suggest that it may be prudent to adopt a rather broader strategy to technological survey data collection than is commonly found. In particular, in addition to technological use data, it would be advantageous to collect information on the human capital and socio-economic characteristics of farmers, on indicators of land quality and on community level factors. These should include both those related to underlying agro-climatic potentials and those related to the availability of relevant farm services. We think that widening the scope of these surveys will have high marginal returns in terms of helping program evaluators and policy makers understand the processes underlying technological adoption.

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Table 3.1 - Classification of farms sampled by total area in states of Goias, Mato Grosso do Sul and Mato Grosso.

Size Frequency Percentage Perc. line Perc. row	States: Goiãs	M. G. do Sul	Mato Grosso	Total
< 10	2 1.00 100.00 2.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 1.00
10 - 250	26 13.00 52.00 26.00	17 8.50 34.00 34.69	7 3.50 14.00 13.73	50 25.00
251 - 500	27 13.50 55.10 27.00	11 5.50 22.45 22.45	11 5.50 22.45 21.57	49 24.50
501 - 1.000	25 12.50 48.08 25.00	14 7.00 26.92 28.57	13 6.50 25.00 25.49	52 26.00
> 1.000	20 10.00 42.55 20.00	7 3.50 14.89 14.29	20 10.00 42.55 39.22	47 23.50
Total	100 50.00	49 24.50	51 25.50	200 100.00

Table 3.1.A - Total area composition, rice and soybeans yields, shares and production by farms size sampled in state of Goias.

		Size (ha)			
		10 - 250	251 - 500	501 - 1.000	> 1.000
1) Areas (ha)					
a) Total	n	26	27	25	20
	average	146.2	357.1	673.8	1901.2
b) Owned	n	26	27	25	20
	average	90.2	252.5	372.3	1293.0
c) Rice	n	?6	27	25	20
	average	12.5	34.5	55.2	147.9
d) Soybeans	n	26	27	25	20
	average	85.5	181.6	231.7	505.9
e) Permanent crops	n	26	27	25	20
	average	0.2	0.1	2.9	72.8
f) Cultivated pasture	n	26	27	25	20
	average	30.9	36.1	68.8	333.3
g) Native fields	n	26	27	25	20
	average	4.5	19.8	58.9	288.6
h) Forests	n	26	27	25	20
	average	4.0	20.1	26.7	181.5
i) Improdutivies	n	26	27	25	20
	average	1.8	4.1	5.	28.0
2) Yields (kg/ha)					
a) Rice	n	15	20	21	16
	average	1751.9	1450.4	1077.9	1337.7
b) Soybeans	n	20	25	22	17
	average	1874.9	2035.9	1887.8	2047.8
3) Share					
a) Rice	n	26	27	25	20
	average	0.09	0.1	0.08	0.08
b) Soybeans	n	26	27	25	20
	average	0.55	0.5	0.35	0.28
4) Production					
a) Rice	n	15	20	21	16
	average	39813.3	57557.6	58764.0	245137.5
b) Soybeans	n	20	25	22	17
	average	204550.9	404075.4	496102.3	1299000.0

Table 3.1.B - Total area composition, rice and soybeans yields, shares and production by farms size sampled in state of Mato G. do Sul.

		Size (ha)			
		10 - 250	251 - 500	501 - 1.000	> 1.000
1) Areas (ha)					
a) total	n	17	11	14	7
	average	142.5	338.4	672.1	3218.7
b) Owned	n	17	11	14	7
	average	81.0	151.1	554.2	2779.9
c) Rice	n	16	11	14	7
	average	7.1	30.4	43.1	58.6
d) Soybeans	n	16	11	14	7
	average	88.7	200.9	264.1	644.3
e) Permanent crops	n	17	11	14	7
	average	0.0	0.0	0.1	4.7
f) Cultivated pasture	n	17	11	14	7
	average	4.7	9.5	41.6	1225.4
g) Native fields	n	17	11	14	7
	average	20.3	34.8	119.2	570.9
h) Forests	n	17	11	14	7
	average	13.0	0.0	43.6	359.0
i) Improdutivies	n	17	11	14	7
	average	1.3	0.0	8.6	0.0
2) Yields (kg/ha)					
a) Rice	n	8	5	6	4
	average	1300.0	1493.6	1218.7	1185.0
b) Soybeans	n	15	11	11	5
	average	1670.6	1823.0	2195.8	1970.5
3) Share					
a) Rice	n	16	11	14	7
	average	0.06	0.1	0.06	0.02
b) Soybeans	n	16	11	14	7
	average	0.66	0.58	0.41	0.21
4) Production					
a) Rice	n	8	5	6	4
	average	16975.0	108180.0	173760.0	104700.0
b) Soybeans	n	15	11	11	5
	average	151380.0	354000.0	729272.7	1754400.0

Table 3.1.C - Total area composition, rice and soybeans yields, shares and production by farms size sampled in state of Mato Grosso.

		Size (ha)			
		10 - 251	251 - 500	501 - 1.000	> 1.000
1) Areas (ha)					
a) Total	n	7	11	13	20
	average	107.9	317.7	725.1	2469.1
b) Owned	n	7	11	13	20
	average	57.1	215.6	426.4	1997.9
c) Rice	n	7	11	12	20
	average	12.9	10.4	43.5	106.2
d) Soybeans	n	7	11	12	20
	average	57.9	247.3	375.1	590.7
e) Permanent crops	n	7	11	13	20
	average	0.0	9.1	0.0	10.0
f) Cultivated pasture	n	7	11	13	20
	average	0.0	10.4	60.8	605.3
g) Native fields	n	7	11	13	20
	average	65.1	46.7	82.7	338.7
h) Forests	n	7	11	13	20
	average	0.0	21.6	30.5	350.0
i) Improdutivies	n	7	11	13	20
	average	0.0	0.0	0.4	58.2
2) Yields (kg/ha)					
a) Rice	n	4	5	8	14
	average	1400.0	1416.0	963.4	1179.0
b) Soybeans	n	5	9	11	18
	average	2013.0	2255.0	1847.0	2312.2
3) Share					
a) Rice	n	7	11	12	20
	average	0.18	0.03	0.05	0.05
b) Soybeans	n	7	11	12	20
	average	0.86	0.69	0.52	0.3
4) Production					
a) Rice	n	4	5	8	14
	average	31500.0	34680.0	68250.0	179914.3
b) Soybeans	n	5	9	11	18
	average	198180.0	691333.4	701272.7	1536733.4

Table 3.2 - Discription of the producers and the farms, %, average and STD

Variables Farmers age	Number	%
30 years	200	24
30 - 40 years	200	32,5
41 - 50 years	200	30,0
50 years	200	13,5
Experience in the region		
5 years	191	38
5 - 10 years	191	22
10 years	191	40

	Number	average	STD
Family size	194	4,7	1,7
Area owned	200	614,3	1009,9
Total area	200	851,2	1137,0

Table 3.2.A - Description of the producers and the farms by level of farms formal education

		Education		
		Less than 4 years	4 to 8 years	More than 8 years
1) Producers age				
a) < 30 years	n	105	53	34
	%	14.3	33.9	41.2
b) 40 - 40 years	%	24.8	39.6	47.0
c) 51 - 50 years	%	40.9	16.9	8.8
d) > 50 years	%	20.0	9.4	0.3
2) Experience in the region				
a) < 5 years	n	98	52	33
	%	37.7	38.5	36.4
b) 5 - 10 years	%	18.4	26.9	27.3
c) > 10 years	%	43.9	34.6	36.4
3) Family size	n	104	50	33
	average	5.14	4.34	3.9
	STD	1.59	1.67	1.46
4) N. of adults	n	101	42	23
	average	2.13	2.21	2.3
	STD	0.99	1.22	0.63
5) N. of children	n	101	43	23
	average	3.08	2.65	2.17
	STD	1.37	1.51	0.89
6) Area owned	n	105	53	34
	average	494.27	681.36	844.9
	STD	768.05	1186.93	1326.92
7) Total area	n	105	53	34
	average	637.82	1020.17	1215.4
	STD	811.46	1273.61	1606.66
8) Price yields	n	65	35	23
	average	1395.57	1364.29	1048.0
	STD	798.24	807.52	651.32
9) Soybeans yields	n	86	44	30
	average	1919.56	2125.46	1965.4
	STD		1021.29	467.4

10) Rice share	n	103	52	34
	average	0.12	0.06	0.09
	STD	0.50	0.12	0.14
11) Soybeans share	n	103	52	34
	average	0.56	0.46	0.38
	STD	0.94	0.39	0.29

Table 3.3 - Frequency of adotion of technologies for rice and for soybeans

n1 = observations
n2 = adopted

1) Soil analysis		
a) Rice	n1	189
	n2	88
b) Soybeans	n1	189
	n2	138
2) Use fertilizer when plante		
a) Rice	n1	188
	n2	171
b) Soybeans	n1	189
	n2	178
3) Use of residuals		
a) Rice	n1	143
	n2	119
4) Broad costing application		
a) Rice	n1	209
	n2	7
5) Plant in line		
a) Rice	n1	206
	n2	198
6) Conventional planting		
b) Soybeans	n1	360
	n2	263
7) Use of cover fertilizer		
a) Rice	n1	188
	n2	32
b) Soybeans	n1	189
	n2	17
8) Use of inoculant		
b) Soybeans	n1	360
	n2	112
9) Do brusone control		
a) Rice	n1	205
	n2	21
10) Had brusone attack and its control		
a) Rice	n1	62
	n2	16

Table 3.3.A - Frequency of variables that can be related to technologies adoption

1) Look TV	n1	187
	n2	151
2) Contact with EMBRAPA	n1	187
	n2	42
3) Use of credit	n1	189
	n2	104
4) Listen radio	n1	187
	n2	91
5) Belong to cooperative	n1	187
	n2	89
6) Contact with EMATER	n1	187
	n2	127

Table 3.3.B - Topography and technologies for rice by years of farm education of the producers

Variables		Education		
		Less than 4 years	4 to 8 years	More than 8 years
1) Topography	n	105	53	34
a) < 3 graus	%	70.5	65.4	52.9
b) 3 - 8 graus	%	25.8	30.8	44.1
c) > 8 graus	%	2.8	3.8	2.9
2) Erosion control	n	105	53	34
	%	5.7	3.8	17.6
3) Soil analysis	n	105	53	34
	%	35.2	54.7	70.6
4) Greenbook	n	105	53	34
	%	15.2	18.9	17.6
5) Terracing	n	105	53	34
	%	5.7	16.9	2.9
6) Plowing	n	105	53	34
	%	93.3	98.1	88.2
7) Deep plowing	n	99	51	31
a) < 20 cm	%	37.4	31.4	35.5
b) 20 - 30 cm	%	54.5	54.9	61.3
c) > 30 cm	%	8.1	13.7	3.2
8) Harrowing	n	13	3	5
	%	0.0	0.0	0.0
9) Fertilizer at planting time	n	104	53	34
	%	88.5	92.4	97.1
10) Amount of fertilizer	n	104	53	34
	average	178.9	195.1	198.09
11) Cover fertilizer	n	104	53	34
	%	13.5	22.6	17.6
12) Amount of total fertilizer (9 + 11)	n	104	53	34
	%	190.0	212.9	204.85
13) Residuals incorporated	n	90	40	27
	%	78.7	97.5	92.6
14) Certified seeds	n	104	53	34
	%	40.4	47.2	50.0
15) Traeted seeds	n	104	53	34
	%	75.0	79.2	82.3
16) Use of credit	n	105	53	34
	%	60.0	54.7	50.0

17) % of area with brusone	n	105	53	34
	average	15.54	18.1	13.1
18) % of area with insect	n	105	53	34
	%	3.1	5.0	4.1

Table 3.3.C - Topography and technologies for soybeans by years form education of the producers.

Variables		Education: Less than 4 years	4 to 8 years	More than 8 years
1) Topography	n	105	53	34
< 3 graus	%	56.1	58.5	64.7
> 3 graus	%	40.9	42.5	35.3
2) Erosion control	n	105	53	34
	%	7.6	3.8	8.8
3) Greenbook	n	105	53	34
	%	35.2	28.3	41.2
4) Terracing	n	105	53	34
	%	16.2	18.9	26.5
5) Plowing	n	105	53	34
	%	87.6	94.3	91.2
6) Deep plowing	n	85	45	26
a) < 20 cm	%	31.7	26.7	46.1
b) 20 - 30 cm	%	60.0	53.3	42.3
c) > 30 cm	%	8.2	20.0	11.5
7) Fertilizer at planting time	n	105	53	34
	%	91.4	98.1	94.1
8) Amout of fertilizer	n	105	53	34
	average	253.9	270.7	289.7
9) Cover fertilizer	n	105	53	34
	%	6.7	7.5	14.7
10) Total amount of fertilizer (7 + 9)	n	105	53	34
	average	256.0	279.2	309.7
11) Soil analysis	n	105	53	34
	%	69.5	67.9	91.2
12) Manual weeds control	n	105	53	34
	%	26.7	20.7	20.6
13) Use of herbicides	n	105	53	34
	%	45.7	50.9	47.0
14) % of area with disease	n	105	53	34
	average	2.6	3.5	2.6
15) % of area with insect	n	105	53	34
	average	23.7	22.8	23.2

TABLE 4.1

Soy Technology and Cultivation Practice Adaption Regressions

	Technology Adaption Index		Soil Analysis		Use Unoculated Seeds[a]		Plant w/ Preferred Methods[a]		Total Fertilizer/Ha	
Total Area Owned Ha/1000	-.819 [0.98]	-.886 [0.84]	-.141 [1.28]	-.119 [1.10]	-.065 [0.89]	-.060 [0.90]	.024 [0.35]	.048 [0.88]	-8.762 [1.23]	-9.213 [1.31]
Age of Operator yrs/100	10.839 [1.31]	9.667 [1.18]	1.248 [1.07]	1.392 [1.16]	1.185 [1.76]	1.001 [1.46]	-.815 [1.09]	-.989 [1.30]	-73.443 [1.04]	-65.465 [0.93]
Education of Operator (years)	.553 [2.53]	.588 [2.72]	.060 [1.95]	.714 [2.24]	.001 [0.07]	.012 [0.65]	-.010 [0.50]	-.018 [0.92]	4.501 [2.46]	4.069 [2.28]
Regional Experience of Operator, years/100	-2.478 [0.30]	-1.164 [0.15]	-.612 [0.55]	-.369 [0.34]	-.224 [0.30]	-.058 [0.08]	2.873 [3.52]	2.532 [3.03]	1.054 [0.02]	-14.800 [0.22]
Land Inclined > 3°	2.584 [1.51]	2.814 [1.66]	.499 [2.11]	.366 [1.53]	-.034 [0.24]	-.046 [0.31]	.317 [1.98]	.303 [1.89]	28.782 [2.03]	25.347 [1.79]
Erosion Present	.980 [0.28]	.780 [0.22]	.824 [1.30]	.701 [1.24]	.336 [1.13]	.295 [1.01]	-1.231 [2.88]	-1.067 [2.56]	19.595 [0.70]	26.150 [0.85]
Micro-region:[b]										
Rodonopolis (MT)	3.819 [1.30]		-.079 [0.20]		.882 [3.46]		.066 [0.24]		-30.069 [1.24]	
Alto Taquari (MS)	5.020 [1.44]		.319 [0.65]		.740 [2.54]		.126 [0.41]		-34.597 [1.20]	
Planalto Goiano (GO)	3.772 [0.98]		.830 [1.20]		.442 [1.42]		.586 [1.82]		5.690 [0.17]	
Serra do Caiapo (GO)	2.570 [0.71]		-.356 [0.77]		.619 [1.99]		-.342 [0.97]		-26.230 [0.87]	
Meia-Ponte (GO)	4.694 [1.11]		-.894 [1.77]		.895 [2.35]		.396 [0.97]		-33.812 [1.00]	
Vertente Goiana do Paranaiba (GO)	6.414 [2.01]		-.372 [0.88]		.731 [2.58]		-.814 [2.46]		-54.309 [2.07]	
% Farmers with EMBRAPA Contact		-5.168 [0.45]		1.119 [0.76]		-.768 [0.94]		2.655 [2.95]		105.673 [1.31]
% Farmers with EMATER Contact		14.787 [2.49]		-.321 [0.40]		2.024 [4.09]		-.633 [1.11]		-108.194 [2.29]
% Farmers with Coop Association		-.742 [0.13]		-.031 [0.04]		-.455 [0.96]		-.927 [1.79]		-17.826 [0.38]
Municipio:										
Mean Soy Yields (1979/80-1985/6)		1.639 [0.33]		.853 [1.59]		1.087 [3.32]		.814 [2.14]		-27.520 [0.87]
Standard Deviation of Soy Yields (1979/80-1985/6)		16.581 [1.81]		1.037 [0.81]		2.814 [3.59]		-.205 [0.25]		-124.035 [1.66]
Modern Storage Capacity, tons/1000		-11.284 [0.30]		-.847 [0.60]		-1.422 [1.38]		1.540 [1.40]		-7.554 [0.08]
Constant	64.093 [13.44]	49.293 [3.82]	-.132 [0.20]	-2.116 [1.22]	-1.090 [2.61]	-4.347 [4.23]	.648 [1.43]	1.481 [1.38]	296.441 [7.41]	429.588 [4.28]
-2 log likelihood/ F-statistic	(1.3)	1.6	20.7	19.3	20.4	31.2	41.9	41.5	2.0	2.2
Sample Size	156	156	174	172	339	336	338	336	172	172
# Engaging in Practice	---	---	130	129	184	163	89	88	166	166
Estimator	OLS	OLS	Probit	Probit	Probit	Probit	Probit	Probit	OLS	OLS

Notes: [a]Level of observation is the cultivar.
[b]Omitted micro region is Paranaiba.

TABLE 4.2

Upland Rice Technology and Cultivation Practice Adaption Regressions

	Soil Analysis		Use Certified Seed		Use Cover Fertilizer		Total Fertilizer/Ha		Brusone Control[a]	
Total Area Owned Ha/1000	.151	.149	.279	.238	.085	.100	-2.802	-5.106	-.037	-.112
	[1.42]	[1.40]	[2.44]	[2.11]	[0.77]	[0.82]	[0.37]	[0.63]	[0.18]	[0.57]
Age of Operator yrs/100	.436	.888	.127	-.381	1.806	1.762	-18.183	-16.911	-1.831	-1.880
	[0.43]	[0.67]	[0.11]	[0.34]	[1.42]	[1.37]	[0.232]	[0.21]	[1.17]	[1.24]
Education of Operator (years)	.102	.106	.025	.022	.059	.063	2.480	2.700	-.002	.009
	[3.83]	[3.83]	[0.94]	[0.85]	[1.88]	[1.97]	[1.24]	[1.33]	[0.06]	[0.24]
Regional Experience of Operator, years/100	.481	.853	-.778	.225	-.702	-.779	-37.944	14.728	3.591	4.783
	[0.41]	[0.75]	[0.88]	[0.20]	[0.50]	[0.54]	[0.44]	[0.17]	[2.47]	[3.17]
Land Inclined 3-8°	-.088	-.077	-.278	-.257	-.005	-.080	1.561	-1.846	.102	-.040
	[0.38]	[0.33]	[-1.18]	[-1.06]	[0.02]	[0.21]	[0.09]	[0.10]	[0.30]	[0.12]
Land Inclined > 8°	-.510	-.530	.022	.451	1.595	1.460	7.213	17.587	-.097	.069
	[0.77]	[0.71]	[0.03]	[0.82]	[2.20]	[2.00]	[0.15]	[0.36]	[0.11]	[0.08]
Erosion Present	.348	.480	.184	-2.54	-1.028	-.906	-50.757	-56.395	1.127	.909
	[0.86]	[1.11]	[0.45]	[0.61]	[1.58]	[1.37]	[1.82]	[1.79]	[2.10]	[1.74]
Microregion:[b]										
Rodonopolis (MT)	.827		1.837		.384		94.060		1.704	
	[2.33]		[3.39]		[0.84]		[3.49]		[0.66]	
Alto Taquari (MS)	.260		1.485		.508		-22.169			
	[0.59]		[2.49]		[0.93]		[0.68]			
Planalto Goiano (GO)	.789		2.590		.976		123.110		3.667	
	[1.82]		[3.80]		[1.72]		[3.32]		[1.41]	
Serra do Caiapo (GO)	.574		1.740		.394		21.833		2.642	
	[1.35]		[2.94]		[0.76]		[0.68]		[1.02]	
Meia-Ponte (GO)	1.024		1.694		-.008		36.552			
	[2.02]		[2.63]		[0.01]		[0.87]			
Vertente Goiana do Paranaiba (GO)	.565		1.856		.227		46.747		2.359	
	[1.53]		[3.36]		[0.47]		[1.67]		[0.92]	
% Farmers with EMBRAPA Contact		.852		2.843		2.353		230.318		2.532
		[0.70]		[2.22]		[1.72]		[2.61]		[1.71]
% Farmers with EMATER Contact		1.614		2.752		-.890		81.059		.425
		[2.22]		[3.69]		[1.01]		[1.58]		[0.41]
% Farmers w/ Coop Association		-3.191		-3.380		.852		-295.306		-2.256
		[2.62]		[2.85]		[0.63]		[-3.50]		[-1.28]
Municipio:[b]										
Mean Rice Yields (1979/80-1985/6)		-3.010		-2.824		2.680		-65.663		-2.498
		[1.96]		[1.86]		[1.53]		[0.65]		[1.28]
Standard Deviation of Rice Yields (1979/80-1985/6)		-.913		1.037		.921		-28.962		1.114
		[0.95]		[1.19]		[0.93]		[0.43]		[0.90]
Modern Storage Capacity, tons/1000		-.835		-2.635		.926		66.740		-2.203
		[0.61]		[1.47]		[0.63]		[0.83]		[0.67]
Constant	-1.653	2.705	-2.043	1.600	-2.442	-5.763	149.103	315.647	-3.527	1.352
	[2.79]	[1.30]	[2.54]	[0.81]	[3.21]	[2.37]	[3.41]	[2.18]	[1.32]	[0.48]
-2 log likelihood/ F-statistic	29.8	35.4	36.9	36.7	16.4	19.7	2.9	2.5	38.8	35.6
Sample Size	175	173	175	173	175	173	175	173	189	187
# Engaging in Practice	83	83	79	77	29	29	160	160	20	19
Estimator	Probit	Probit	Probit	Probit	Probit	Probit	OLS	OLS	Probit	Probit

Notes: [a]Level of observation is the cultivar.
[b]Omitted micro region is Paranaiba.

TABLE 4.3

Shares of Annual Crops and Yield Regressions

	Upland Rice Area Share		Soy Area Share		Maize Area Share		Upland Rice Yields		Soy Yields	
Total Area Owned Ha/1000	.011	.014	-.017	-.013	.008	-.001	-40.246	-10.782	59.551	39.659
	[0.53]	[0.86]	[0.72]	[0.52]	[0.48]	[0.11]	[0.50]	[0.14]	[0.85]	[0.89]
Age of Operator yrs/100	-.188	-.187	.338	.288	-.148	-.101	184.583	337.282	-203.966	-222.15
	[0.81]	[0.90]	[1.45]	[1.22]	[1.29]	[0.80]	[0.23]	[0.43]	[0.31]	[0.34]
Education of Operator (years)	.002	.002	.005	.007	-.008	-.009	-32.778	-28.830	-1.860	-4.79
	[0.47]	[0.34]	[0.90]	[1.18]	[2.48]	[2.74]	[1.59]	[1.42]	[0.12]	[0.03]
Regional Experience of Operator, years/100	.347	.253	-.539	-.378	.192	.001	-1540.190	-1410.478	-528.978	-336.777
	[1.48]	[1.08]	[2.02]	[1.43]	[1.35]	[0.88]	[1.69]	[1.64]	[0.79]	[0.53]
Region of Origin:										
Rio Grande do Sol	-.198	-.211	.258	.320	-.060	-.109	-165.853	-143.898	147.193	104.559
	[2.88]	[2.91]	[3.31]	[3.90]	[1.44]	[2.46]	[0.58]	[0.57]	[0.70]	[0.53]
Parana	-.199	-.204	.257	.323	-.058	-.119	-369.877	-336.058	-5.587	-58.018
	[2.54]	[2.65]	[2.89]	[3.73]	[1.22]	[2.55]	[1.13]	[1.17]	[0.05]	[0.28]
Santa Catarina	.005	-.001	.019	.052	-.024	-.052	117.238	33.497	-20.185	-108.503
	[0.04]	[0.00]	[0.14]	[0.38]	[0.33]	[0.66]	[0.25]	[0.08]	[0.05]	[0.29]
Sao Paulo	-.001	-.002	.041	.096	-.040	-.074	-387.820	-373.374	-87.303	-73.610
	[0.01]	[0.31]	[0.51]	[1.19]	[0.94]	[1.70]	[1.49]	[1.47]	[0.41]	[0.35]
Minas Gerais	-.030	-.026	.054	.031	-.024	-.006	154.723	-115.152	389.042	532.839
	[0.40]	[0.32]	[0.84]	[0.34]	[0.54]	[0.11]	[0.53]	[0.35]	[1.77]	[2.28]
Land Inclined 3-8°	.025	.020	-.005	-.008	-.020	-.012	115.238	170.144	38.844	41.140
	[0.61]	[0.46]	[0.11]	[0.17]	[0.80]	[0.45]	[0.57]	[0.88]	[0.32]	[0.34]
Land Inclined > 8°	.028	.017	-.091	-.055	.065	.038	-162.217	-113.209		
	[0.30]	[0.19]	[0.90]	[0.53]	[1.20]	[0.68]	[0.38]	[0.27]		
Erosion Present	.004	.002	-.004	-.010	.000	.008	-404.745	-443.333	64.738	-4.899
	[0.06]	[0.04]	[0.06]	[0.15]	[0.01]	[0.21]	[1.29]	[1.46]	[0.35]	[0.02]
Micro-region:[b]										
Rodonopolis (MT)	.002		.006		-.007		88.366		291.234	
	[0.02]		[0.07]		[0.18]		[0.29]		[1.41]	
Alto Taquari (MS)	.011		-.010		-.001		566.957		75.99	
	[0.13]		[0.11]		[0.02]		[1.40]		[0.31]	
Planalto Goiano (GO)	.083		-.040		-.023		52.999		-271.653	
	[0.85]		[0.37]		[0.39]		[0.13]		[0.82]	
Serra do Caiapo (GO)	-.001		-.005		.057		256.685		425.542	
	[0.02]		[0.57]		[1.10]		[0.75]		[1.64]	
Meia-Ponte (GO)	-.103		-.158		.260		316.987		-134.381	
	[0.98]		[1.33]		[4.11]		[0.78]		[0.42]	
Vertente Goiana do Paranaiba (GO)	-2.09		.034		.175		212.987		275.157	
	[2.46]		[0.35]		[3.41]		[0.82]		[1.05]	
% Farmers with EMBRAPA Contact		.306		-.307		.000		104.827		-1009.681
		[1.10]		[0.98]		[0.00]		[0.13]		[1.82]
% Farmers with EMATER Contact		-.332		.113		.218		109.703		70.274
		[1.87]		[0.57]		[2.02]		[0.58]		[0.18]
% Farmers with Coop Association		-.077		-.321		.397		343.359		46.572
		[0.34]		[1.25]		[2.87]		[0.58]		[0.11]

TABLE 4.3 (continued)

	Upland Rice Area Share		Soy Area Share		Maize Area Yields		Upland Rice Yields		Soy Yields	
Municipio:										
Mean Rice Yields (1979/80-1985/6)		.174 [0.80]		-.581 [1.71]		.387 [2.19]				
Standard Deviation of Rice Yields (1979/80-1985/6)		-.183 [0.85]		.114 [0.53]		.047 [0.42]				
Mean Soy Yield (1979/80-1985/6)		.139 [1.42]		-.057 [0.52]		-.081 [1.37]				
Standard Deviation Soy Yield (1979/80-1985/6)		.110 [0.48]		-.154 [0.59]		.043 [0.31]				
Modern Storage Capacity, tons/1000		.135 [0.46]		.301 [0.91]		-.438 [2.43]		1896.028 [1.38]		-1234.041 [1.53]
Constant	.317 [2.55]	.076 [0.16]	.521 [3.71]	1.350 [2.49]	.182 [2.16]	-.426 [1.46]	1649.277 [3.44]	1388.342 [2.19]	1825.199 [4.67]	2197.972 [4.09]
F-statistic	1.9	1.7	3.0	2.7	5.5	4.8	0.8	1.0	1.0	0.9
R^2	.19	.19	.28	.29	.42	.41	.14	.14	.12	.09
Sample Size	158	158	158	158	158	158	110	110	149	149
# Farms > 0	110	110	149	149	71	71	110	110	149	149

Notes: [a]Omitted region of origin is Center-West.

[b]Omitted micro region is Paranaiba.