Forecasting Food Crop Production: An Application to East Java

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ESTIMATED PARAMETERS AND SUMMARY STATISTICS

Note: These data have been compiled by season, crop yields, harvest areas, and 1991 projections. For simplicity, these summaries are numbered sequentially, and are cross-referenced in the text as Summary *plus a number.*

ABSTRACT

A framework for seasonal crop forecasting was developed and applied to East Java. The model includes seasonal areas and yields of rice and the major secondary crops on the basis of lagged data on rainfall, prices, crop areas, and intensification targets. Overall, rainfall, lagged crop areas, and intensification programs are observed to be strong predictors of production. The analysis also indicated that price effects were generally not statistically significant for area but were important in determining rice, corn, and soybean yields. The model performed well in out of sample projections.

FORECASTING FOOD CROP PRODUCTION: AN APPLICATION TO EAST JAVA

A variety of important short-run policy decisions are made on the basis of early food crop production estimates. These decisions cover Badan Urusan Logistic (BULOG) rice procurement and buffer stock management, planning for crop intensification targets and food imports, and interventions to reduce rural income fluctuations in the event of crop failure and employment losses. The early estimates are derived from long-range (three- to six-month) weather forecasts and initial field reports on crop areas planted and growing conditions. But weather forecasts are, of course, subject to wide confidence bands, while field reports may provide conflicting information since food crop production estimates are made by multiple agencies. Even if these agencies could coordinate perfectly, the task of compiling subdistrict-level production data into national production estimates is a daunting task in a country as large and diverse as Indonesia.

Short-run decision making will be facilitated if objective, readily available information on meteorological, economic, and programmatic determinants of seasonal food crop supply can be exploited for crop forecasts prior to the availability of production estimates from the field. Work in this area has been undertaken by Mitchell (1990a, b), who developed a model to forecast rice harvest areas and BULOG's seasonal procurement on the basis of data on rainfall and rice prices. That study used simple time trends to estimate rice yields, but there is sufficient seasonal and year-to-year variability around these trends to warrant a more sophisticated analysis. We will also extend Mitchell's efforts by investigating seasonal determinants of palawija supply (corn, soybeans, and cassava) and by making, where appropriate, adjustment for autocorrelated errors that are common with time series data.

Our goal is to provide a simple, spreadsheet-based "timely warning" system that reliably predicts the direction (increase or decrease) of production changes from year to year. Rather than substituting for routine monitoring of actual crop production estimates, such a system will indicate when and where more careful (and costly) field-based information is desirable to confirm the model's forecasts.

This paper assesses the predictive value of rainfall, price, and other information that has been compiled in the Indonesian National Planning Agency (BAPPENAS) Food Crop Sector Database. In principle, most of this information should be available in Jakarta one or more months before the earliest estimates of seasonal crop harvest areas and yields. Applications are provided to East Java crop supply between 1977 and 1990, with production levels forecast for the three quadrimesters of 1991 (January-April, May-August, and September-December).[1] Software and data are in place for estimates from the remainder of Java. Information on prices remains to be assembled for the Off-Java provinces, while further refinement of rainfall and price variables could be undertaken for Java.

Determinants of Food Crop Areas and Yields

Water availability is the key factor affecting the timing of food crop planting in tropical agriculture. In much of Indonesia, the annual cycle of planting and harvest is determined by seasonal rainfall that is highest in December to March of each year and declines sharply between May and August. As compared with rain-fed agriculture, dam-fed irrigation systems are more immune to rainfall fluctuations, but most of Indonesia's irrigated farming depends upon downstream runoff that varies seasonally (Varley 1990). Even for drought-tolerant crops such as cassava, data on rainfall timing and intensity should provide a powerful predictor of planting and, hence, harvest decisions.

Farmers make planting decisions based on the adequacy of current soil moisture and expectations about future rainfall. Cutoff values for crop water requirements have been defined by Oldeman (1975): over an average 30-day period, at least 100 mm are necessary to sustain evapotranspiration in palawija crops, while 200 mm are needed to support rice in the absence of irrigation. During months when rainfall is typically well below these levels, unusually high rains (greater than 100 mm) can significantly shift the normal pattern of seasonality in planting. For a number of crops, cutoff values like these prove to be useful predictors of harvest areas and yields.

Other climatic characteristics—solar radiation, temperature, and relative humidity—also influence crop production. Irawati (1988) found significant effects for these variables in an analysis of kabupaten-level rice data from the Jatiluhur Reservoir region of West Java. At the provincial level, however, these factors are either highly collinear with rainfall or vary too little by season to provide significant statistical effects for this aggregate analysis.

Seasonal rainfall and planting patterns often do not coincide with either the calendar year or the statistical boundaries that define production seasons. For example, Java's main corn harvest generally occurs in either December or January depending upon the onset of the wet season. Similarly, the peak rice harvest may take place in April or May, overlapping the first and second quadrimesters of production data. In addition, planting decisions in one season can constrain crop supply later in the year. For example, soybeans or corn planted in May reduce cassava harvest areas during the September to December period. In cases like these, lagged and current harvest areas are often highly correlated from one season to the next, particularly for rice and corn.

In a particular climatic situation, planting decisions are influenced by farmer expectations about relative returns from alternative crops. Input use and crop productivity per hectare are determined by land resources, the available technology, and relative input-output prices. Price expectations are likely to be based on an assessment of current and past (lagged) market conditions. National Biro Pusat Stastic (BPS), the Central Bureau of Statistics, crop production cost surveys provide detailed information on costs and returns, but the published figures show only annual averages. Lacking seasonally disaggregated data on inputs and crop income, we use monthly producer prices to proxy the decision variables considered by farmers.[2]

Government policies with respect to irrigation investment, intensification programs, floor prices, and fertilizer subsidies are additional determinants of crop supply. Consistent data on irrigation investments are scarce, but, for rice at least, these investments should be reflected in seasonal intensification targets. The impact of intensification areas is explored in the analysis to allow policymakers to assess the influence of positive government interventions on crop supply. Chemical fertilizers have made a major contribution to yield growth during the past 15 years, so relative prices of urea and TSP are used as well, primarily in yield response analysis.

Pests and diseases can also have a significant impact on crop yields and areas. Between 1976 and 1978, *hama wereng* (the brown planthopper) caused major problems in rice production until IR-36 and other resistant varieties were widely adopted. Downy mildew is a major source of corn losses, while soybeans are subject to a large variety of pests and diseases. BPS publishes data on the severity of these problems, but most recent information had not been compiled at the time of our analysis. Such data might add explanatory power to the equations for soybeans and corn.

Model, Data, and Methods

The model involves one equation to predict harvest areas based on planting decisions, and a second equation to predict productivity. The yield and area equations are estimated for each four-month round of BPS data compilation. As in the BAPPENAS national food crop sector model, total output is estimated as the product of predicted area and yield. As will be shown, this provides reasonable estimates of seasonal supply. Although it is logical to aggregate the seasonal estimates into an annual total, the cumulative effect of small prediction errors in six separate equations can, at times, produce rather large errors in the annual estimates. As suggested by this discussion, the following general formulations are used for harvest areas and yields:

$$HA_{it} = f(R_{t-x}, DR_{t-x}, P_{et}, HA_{t-1}, IP, PD, T)$$

and

$$Y_{it} = f(R_{t-1}, P_{et}, IP, PD, T),$$

where

HA_{it} = harvest area for crop i in season t;

Y_{it} = yield per hectare in season t;

R_{t-x} = monthly rainfall in millimeters, with a lag of x months determined in stepwise fashion;

DR_{t-x} = dummy variable for rain greater than 100 mm in the normally dry months of May, June, and September;

P_{et} = expected relative farm-level crop price in harvest season t;

HA_{t-1} = lagged seasonal harvest areas, both for crop i and competing or rotational crops;

IP = government intensification programs (areas targeted and/or realized by intensification round);

PD = pests and diseases, at present limited to a dummy variable for the infestation of *hama wereng* in rice during 1976 through 1978; and

T = time trend for years 1 to 16, 1975 to 1990.

The dependent variables are the provincial quadrimester crop area and yield figures published by BPS. Hence, it should be kept in mind that our results and forecasts are derived from and apply only to BPS production estimates, not to secondary figures compiled by regional offices of Dinas Pertanian, nor to figures from the Dologs. The latter are processed at the district or subdistrict level and often reveal a higher degree of variability than is shown [illegible]PS figures. It would be quite legitimate to work with more disaggregated data for forecasti[illegible]urposes—indeed, we would recommend that this be attempted in key producing regions—and this might produce somewhat different patterns of variable relationships than are described here.

The time trend captures effects of omitted explanatory variables, particularly changes in technology (irrigation, seeds, and fertilizer) for which seasonal data are unavailable. It is not an ideal proxy for these factors, since it provides an invariant momentum that is unrealistic in forecasting. For this reason, use of the trend variable is limited primarily to yield and, for cassava, area equations where the available data on intensification do not produce satisfactory results. Given the relatively short time series, we would recommend reestimating all equations on a regular basis as new data become available. This would be especially true for the models with time trends if alternative information on technology can be identified.

Data on farm-level crop prices are from the BPS division of producer prices and finance. For fertilizer, prices are those officially announced each year prior to the main planting season. Intensification areas planned and realized are from Badan Pengendalian Bimas. Finally, data on rainfall are from the Badan Meteorologi dan Geofisika (BMG) Department Perhubungan.

Price expectations are modeled as a weighted average of relative producer prices at the time of planting and prices at the time of the last harvest for a given crop,

$$P_{et} = a_i * P_p + a_2 * P_{t-x} ,$$

where

P_{et} = expected relative price at harvest time t, with

P = $(P_i/P_j)*100$ for crops i and j;

P_p = relative price at time of planting;

P_{t-x} = relative price at time of previous harvest, with the lag x depending upon seasonal cropping patterns and each crop's growing period; and

a_i = weights chosen by experimentation ($0 <= a_i <= 1$ and $a_1 + a_2 = 1$).

The choice of rainfall data is problematic. Ideally, we would use measurements from key production regions for each important crop. BMG compiles rainfall data from more than 2,000 locations throughout Indonesia, but much of this information is incomplete and slow to reach Jakarta. The most timely and complete climatic data are recorded at BMG's own stations. But since these stations are generally located in lowland coastal areas near provincial capitals, there is the concern that the data may not reflect inland conditions and higher elevations where agricultural activity is concentrated.

However, abnormal rainfall generally affects wide areas rather uniformly, particularly for drought conditions that are the primary cause of periodic crop losses in Indonesia. Rozari (1991) has suggested that rainfall measurements at BMG stations should, over the course of a growing season, move fairly closely with rainfall levels at other locations within a province. Inland data might better reflect growing conditions, but BMG station figures are the most timely so we used them, because timeliness is a key objective of our analysis.

Yield and area equations have been estimated using both ordinary least squares (OLS) and Cochrane-Orcutt (CO) procedures, with the latter improving the "fit" in some, but not all, cases with extreme Durbin-Watson diagnostics. Results for both estimation methods are presented. With the primary exception of cassava, first-order autocorrelation problems were, by and large, either minor or correctable. Despite the small number of observations (14 following calculation of lagged variables), degrees of freedom did not prove to be a limiting factor in the analysis. Since areas and yields for individual crops are influenced by a variety of heterogeneous factors, the mix of explanatory variables is generally unique for each equation.

In a short time series with many potential explanatory variables, it is possible to find combinations of predictor variables that "explain" historical patterns perfectly, yet fail to produce reliable forecasts of the future. In choosing among alternative specifications, one must seek variables that are statistically sensitive and have practical meaning. This process requires knowledge of agro-climatic characteristics and farmer decision making in the field.

Historical Simulation Results

Results are graphed in Figures 1 through 16, with statistical estimates displayed in the Estimated Parameters and Summary Statistics (Summaries) 1 through 12. Figure 17 and Tables 1 and 2 show the basic rainfall and intensification data used in the analysis. All equations show highly significant R-square and F statistics, with most explanatory variables significant at the .05 level or above. As shown in the graphs, the estimated production figures track seasonal yields and areas closely.

Overall, rainfall, lagged crop areas, and intensification programs are the strongest predictors of production. Simple time trends are particularly important in the case of cassava. The effects of relative crop and fertilizer prices are, in general, quantitatively small and comparatively low in statistical significance. Relative prices other than with respect to fertilizer enter the yield equations for rice, corn, and soybeans. We interpret such results to reflect movements in own real prices for these crops rather than any incentive effect of relative crop prices per se on yields.

Rice

For sawah rice (Figures 1 through 4 and Summaries 1 through 3), rainfall and intensification targets proved to have significant explanatory power for both areas and yields in most seasons. Relative paddy/urea prices are significant determinants of yield changes in the first two seasons, but have less impact during the September through December off-season.

In general, food crop areas are far more variable than crop yields. Hence, errors in the area estimates are more important than errors in yields for determining the divergence between actual and estimated production. For rice (Figure 1), the year-to-year direction of changes in areas by season are predicted correctly, but the largest absolute errors arise in the first season, most notably for 1984. With somewhat different variable specification, it is possible to reduce these absolute errors, but at the cost of lower sensitivity of the model to the direction of change. Since the model's purpose is to provide timely warning of production declines, we view this cost to be unacceptable.

With two exceptions, all rainfall variables have positive signs in the rice equations. February rainfall is negatively related to first season harvest areas (Summary 1), reflecting flooding and other wet soil conditions that adversely affect rice near the time of harvest. In the East Java sample, such an effect was strongest in 1978, when torrential rainfall (more than two standard deviations above normal) occurred in both January and February, and the first season harvest area fell to the lowest level of the 1975-90 period (Figure 1). The negative coefficient for the September rainfall dummy on third season yields (Summary 3) may reflect the effects of excessive soil moisture and reduced solar radiation due to unusually high rains late in the growing season.

The third season area equation reproduces BPS figures quite well, but with relatively low explanatory power (Summary 3). The results were sensitive both to variable selection and to the method used to impute 1990 values for intensification program areas (Table 2). Fortunately, the third season rice crop is quantitatively small, but further work should attempt to reduce the unexplained variance in this equation.

Corn

The corn equations (Summaries 4 through 6 and Figures 5 through 8) accurately reproduce both the direction and absolute levels of seasonal production. Relative crop prices have many significant effects that reflect planting decisions made by East Java farmers; for example, the area substitutions among corn and soybeans in all three seasons. Corn intensification targets and the relative price of urea are strongly associated with corn yields and harvest areas in the first and third seasons when production is highest.

Some of the rainfall coefficients are puzzling and deserve comment. The heterogeneity of corn production complicates an analysis based on quadrimester data. Farmers plant corn varieties that require 70 to 95 days to mature (as much as 120 days at high elevations) and that have yield potential generally proportional to the length of the growing season. Hence, data for a given quadrimester reflect a wide variety of planting conditions. The first quadrimester captures the harvest of corn planted between October, when the rains usually begin, to late January, when monthly rainfall peaks. As shown in Summary 4, lagged September rainfall is negatively associated with both corn areas and yields. For areas, this clearly illustrates how the early onset of the rainy season leads to early planting, with the result that large East Java harvests occur in the last quadrimester of the calendar year. This can also be inferred by the positive coefficient on September rainfall in the third season area equation (Summary 6) and by the alternating peaks and troughs of third and first season harvest areas shown in Figure 5, especially in 1975/76, 1981/82, and 1984/85.

The negative rainfall coefficients in the first season yield equation probably reflect several causes. September rainfall is, in the years of our sample, characterized by the highest coefficient of variation (Figure 17). In two of the 15 years—1981 and 1984 (Table 1)—September rains exceeding 100 mm were followed by dry months in October and/or November. Farmers who planted too early during the September rains would be forced to plant again if drought led to poor crop establishment in later months. Replanting late in the season would reduce yields. High September rains may also contribute to the conditions of nighttime humidity and dry daytime heat that cause downy mildew early in corn's growth cycle (Mink and Dorosh 1987).

Rainfall in January has opposite effects on yields and areas in the first quadrimester. For corn planted early in the rainy season, heavy rainfall during January and February should reduce yields due to corn's inability to withstand excess moisture in the root zone. In years when the rain comes later—beginning in December, for example—high January rain appears to reflect late corn planting and, hence, it predicts relatively large harvest areas in the first quadrimester. Investigation of monthly production data might better clarify the underlying relationships.

From May to August, late and dry season rainfall are positively related to corn yields (Summary 5). Rain during February through June is negatively associated with corn areas, suggesting a substitution of rice and other crops in place of corn in years when rainfall permits. As would be expected, third season corn areas are strongly influenced by dry and early wet season rainfall. Yields are sensitive to rain in November and December, but with coefficients of opposite sign. Although rainfall from the last month of the season is not an ideal "timely warning" indicator, a value for December can, in practice, be assumed for forecast purposes.

Soybeans

The soybean equations track past harvest areas quite closely in all seasons (Figure 9). Significant price effects for soybeans and cassava suggest that there is an interaction between relative prices, cassava areas planted in the wet season, and soybean harvest areas during the subsequent second and third quadrimesters. The lagged cassava harvest variable provides considerable explanatory power in the second season soybean area equation. Future work should investigate the impact of lagged cassava plantings as a determinant of second and third season soybean areas. The use of corn harvest areas predicted by the corn equation added substantially to the overall explanatory power of the second season soybean area model. Corn and soybeans are commonly intercropped in East Java, and the coefficient signs suggest that soybean areas tend to increase both with corn areas and with the relative price of soybeans to corn. In the first season, high September rainfall leads to significantly larger soybean areas, perhaps a response to the risk of downy mildew in corn that was noted earlier.

A somewhat surprising result is that the relative price of soybeans with respect to TSP is a highly significant predictor of third season soybean areas. As compared with the cereal crops, TSP is a relatively important input for East Java soybeans, but input prices should normally have their major impact on crop yields rather than on planting decisions. Nonetheless, excluding the TSP variable greatly reduces the significance of variables remaining in the model. We suspect this variable reflects soybean's own real price, which rose in East Java during much of the 1980s, while real fertilizer prices declined.

Cassava

Forecasting cassava has proven difficult. Since the mid-1970s, cassava areas on Java have been on a pronounced downward trend, while reported yields have grown steadily. The simple time trend proved to be the most consistent instrument for capturing these contrasting patterns (Summaries 10 through 12 and Figures 13 through 16), but this was accompanied by autocorrelated errors that could not be improved satisfactorily with either CO or maximum likelihood methods. While the cassava equations reproduce seasonal areas and yields reasonably well, the annual production estimates are the poorest of all four crops. The CO estimates show the correct direction of most year-to-year changes, but with relatively large absolute errors, most notably in 1986/87.

Rainfall and lagged crop areas were the most useful variables for explaining production deviations around the trend. Despite considerable price volatility over the past decade, we could not establish any meaningful effects of relative cassava prices on East Java production. This may be due, in part, to the BPS price data, which measure "sweet" varieties (low in hydrocyanic acid content), rather than the "bitter" varieties that are more commonly planted on Java (Roche 1984).

Since cassava generally has a growing season between 8 and 11 months, the appropriate rainfall and crop area lags are relatively long. Cassava intercropping with corn and soybeans implies that there are complementarities in areas for these crops, whereas rainfall late in the wet season (March and April) will lead to substitutions between cassava and rice. The first season equation, for example, shows that cassava areas are influenced by rainfall during the April planting period of the previous year (Summary 10). Because cassava can survive drought, albeit with reduced yields, the negative rainfall coefficients reflect the harvest timing decisions and crop substitutions that occur in different seasons. In the second season area equation, the negative coefficient on August rainfall shows that rain at the peak of the dry season leads farmers to delay harvest until the following quadrimester in the expectation of further yield growth. Such behavior is reflected in the second season, when rain in July and August contribute positively to cassava yields, as well as in the third season area equation, where the lagged cassava harvest and July rainfall are important predictor variables.

The negative effect of April rainfall in the second season yield equation suggests that cassava is harvested at a relatively immature stage in years when high precipitation late in the wet season permits planting of more profitable crops. High April rains may imply lower yields for immature cassava harvested in the second quadrimester, but are also associated with cassava planting late in the rainy season that leads to higher cassava harvest areas in the third quadrimester.

1991 Forecasts

Most data values needed for forecasting 1991 production are either available or can be assumed to follow past levels. When lagged 1991 crop production data are necessary for a forecast, we use predicted values from the first and second season equations. In this sense, the forecast model becomes dynamic. In Figures 4, 8, 12, and 16, we compare our results with the Ramalan II figures that constitute the second of three forecasts preceding the publication of final BPS production statistics.

It is assumed that first season (MT 1990/91) intensification targets are the same as in 1989/90, but the second season (MT 1991) target for rice is reduced to 90 percent of the 1990 level as a result of the current drought. At the time this report was written, BMG rainfall data from Surabaya were available through June 1991. In view of the current drought, rainfall levels for July and August are set at zero. For the third season crops, it is assumed that rainfall from September onward will be average for the 1976-90 period. BPS crop price data through May are in the database. For the later months, we assume that relative monthly price ratios in 1991 will be similar to those prevailing in 1990. Given that price effects tend to be absolutely small, our assumptions about prices have a lesser impact on predicted production that do assumptions about rainfall and intensification programs.

Overall, the models predict that East Java rice production will decline by 3.6 percent in 1991 as compared with 1990 because of the combination of lower areas and yields. A production decline of less than .5 percent is projected by the BPS Ramalan II, which speaks to the remarkable resilience of East Java's farmers in spite of a serious drought. Our model predicts reduced rice areas from poor rains during the early 1990/91 wet season, while lower yields are forecast because of rainfall amounts and increased urea prices.

The implicit elasticity of rice yield with respect to the relative price of paddy to urea is about 0.33 in our model, a result that is consistent in both the first and second season equations in which the urea price emerged as significant. In the first season of 1991, a yield decline of 2 percent is projected due to the impact of this relative price alone (Summary 1 and Table 3). This responsiveness is much higher than that shown by the own-price and fertilizer price elasticities calculated in the BAPPENAS food crop sector model (0.15 and 0.06, respectively). There could well be an interaction between rainfall and decisions on fertilizer use that has not yet been captured in the forecast model; that is, farmers may use less fertilizer when rainfall is poor. It may also be that our specification of the relative paddy/urea price ratio leads to an upward bias in the estimate since production inputs such as labor are, by necessity, omitted in the forecast model. Since fertilizer pricing is still a major topic of policy discussion, this issue will be examined more closely in the future.

Both the model and Ramalan II predict that corn production in 1991 should be at a level similar to that of 1990. In contrast, cassava production will rise slightly according to the model. Due to the extreme dry season, the cassava harvest should peak during the second quadrimester. Yields are projected to be off-trend for the year as a result of poor rainfall and somewhat premature harvesting during the second season.

The two forecasts for soybeans diverge in direction, although they are close in magnitude. Note that we have assumed that the second season intensification target will be at the same level as in 1990. If, in fact, intensification and planted areas have been higher due to crop substitutions induced by drought, then our forecast is an underestimate.[3] Should September rainfall and relative prices turn out to be higher than we have assumed, third season production could rebound sufficiently to raise slightly the model's projected 1991 total as compared with 1990.

Conclusions

The East Java models show that readily available data reproduce past patterns of food crop production in a manner that is largely consistent with our knowledge of seasonality in the province's agriculture. Hence, the results provide a strong basis for crop forecasting. Future work should logically expand first to include the other provinces of Java, and then the major producing regions of Sumatera, South Sulawesi, Bali, and Nusa Tenggara.

Given the short nature of the time series, we recommend that parameter estimates be updated annually. Most of the computer procedures for estimation and forecasting can be automated to facilitate updating. Data compilation will be straightforward if the food crop sector database is maintained routinely. To ensure that the necessary information on rainfall and crop intensification is available on a timely basis, it would be desirable to formalize a data sharing relationship among BMG, Badan Pengendalian Bimas, and BAPPENAS to support the forecasting effort.

Although our data set produces generally satisfactory results for East Java and would likely do so for Java's remaining provinces, alternative data sources will be needed for the Outer Islands. In particular, information on rainfall should be attuned to the more varied agro-climatic conditions of regions such as South Sulawesi. Time series data on Off-Java prices are scarce in Jakarta, but should be more plentiful in provincial capitals. Finally, it should be clear from this discussion that interpreting results and selecting explanatory variables must be guided by knowledge of provincial conditions at the field level. For all of these reasons, it would be highly appropriate to involve staff from the regional planning offices (Kanwil) in future model development.

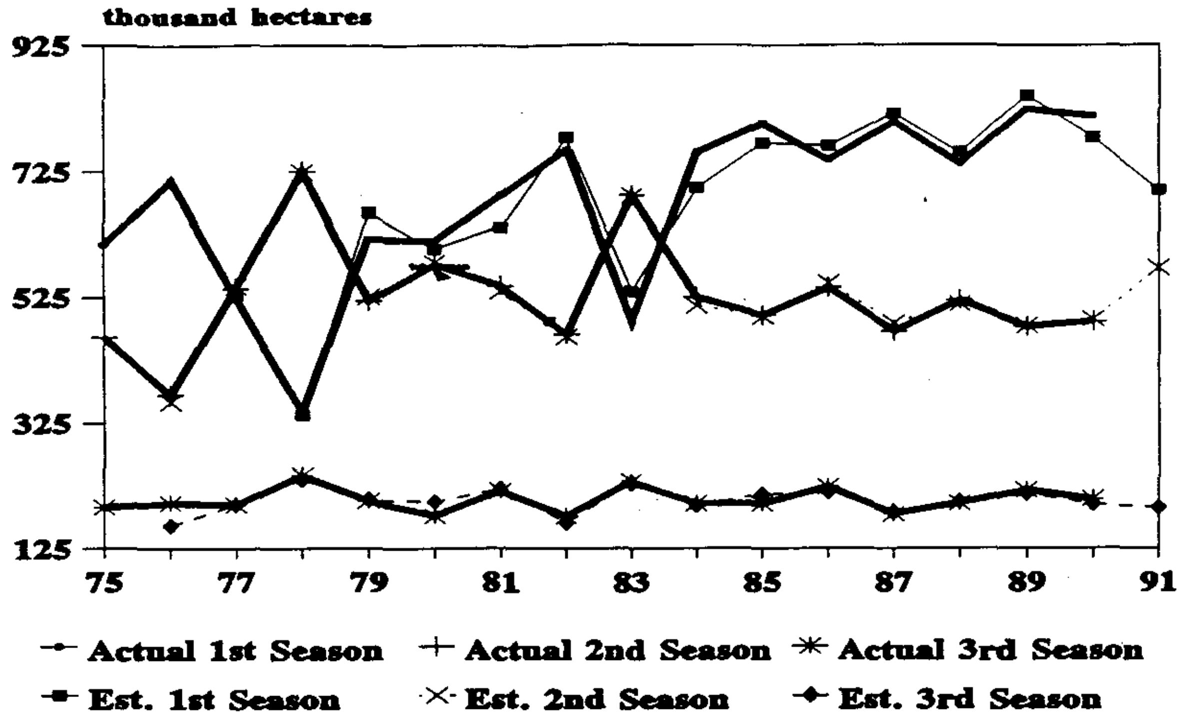

Figure 1. Sawah rice harvest areas

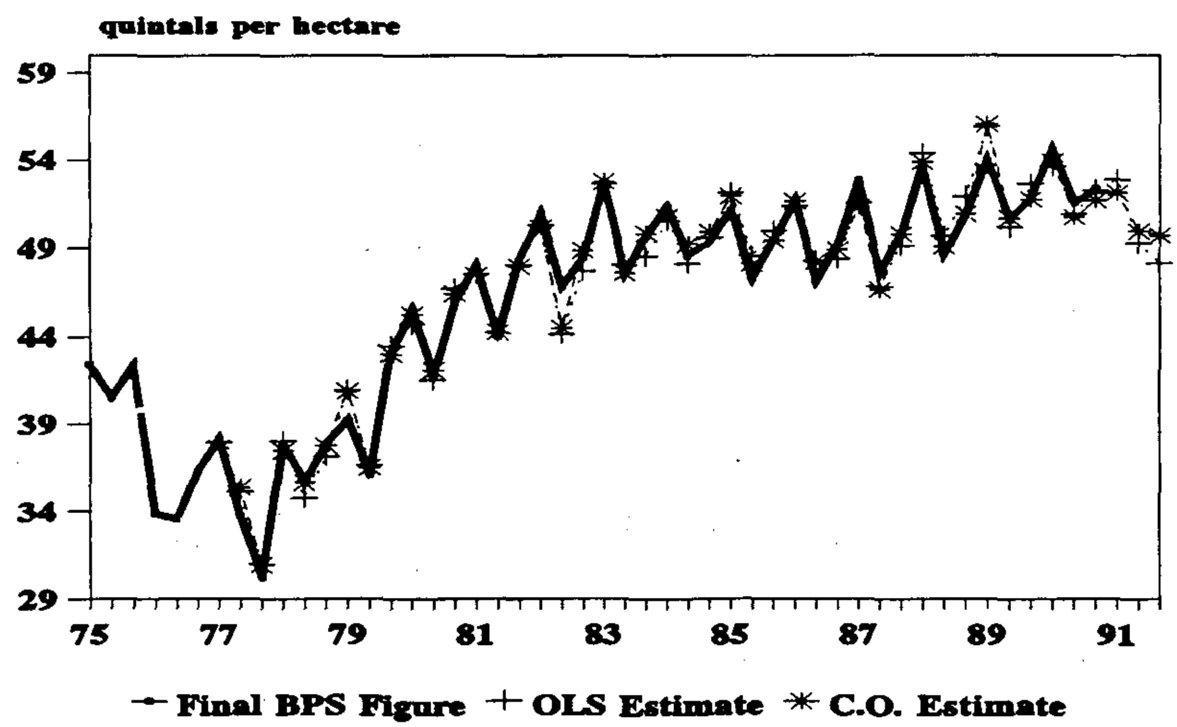

Figure 2. Sawah rice yields by season

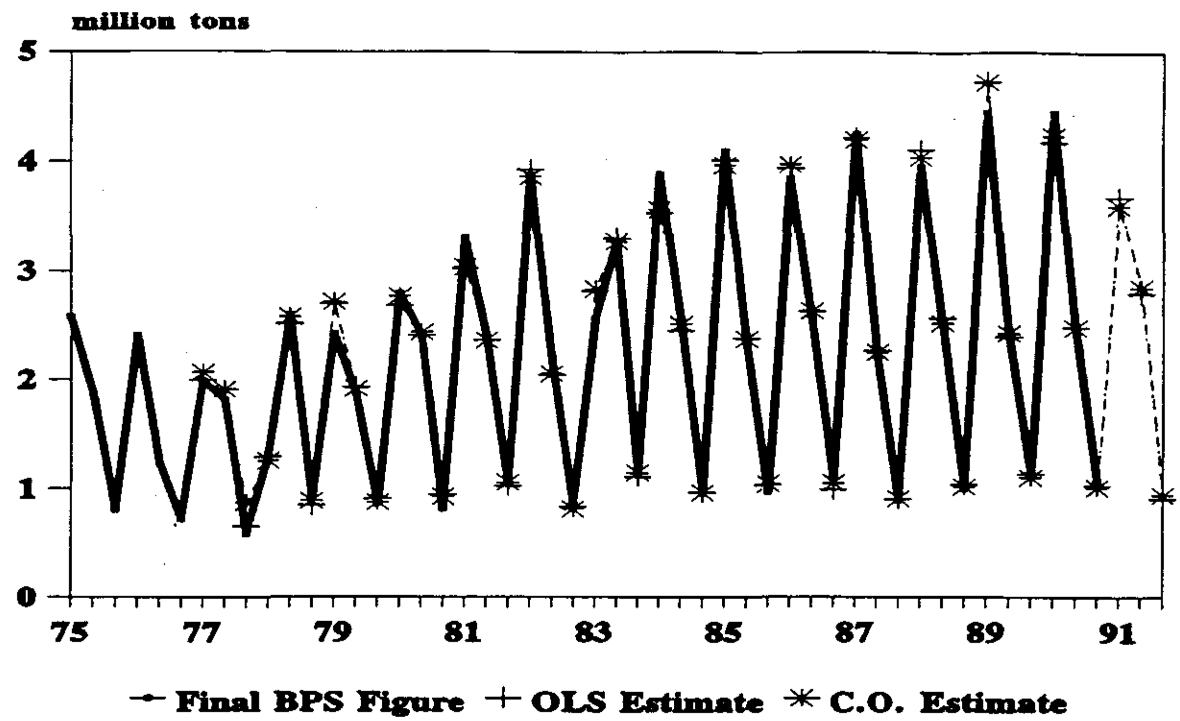

Figure 3. Seasonal sawah rice production

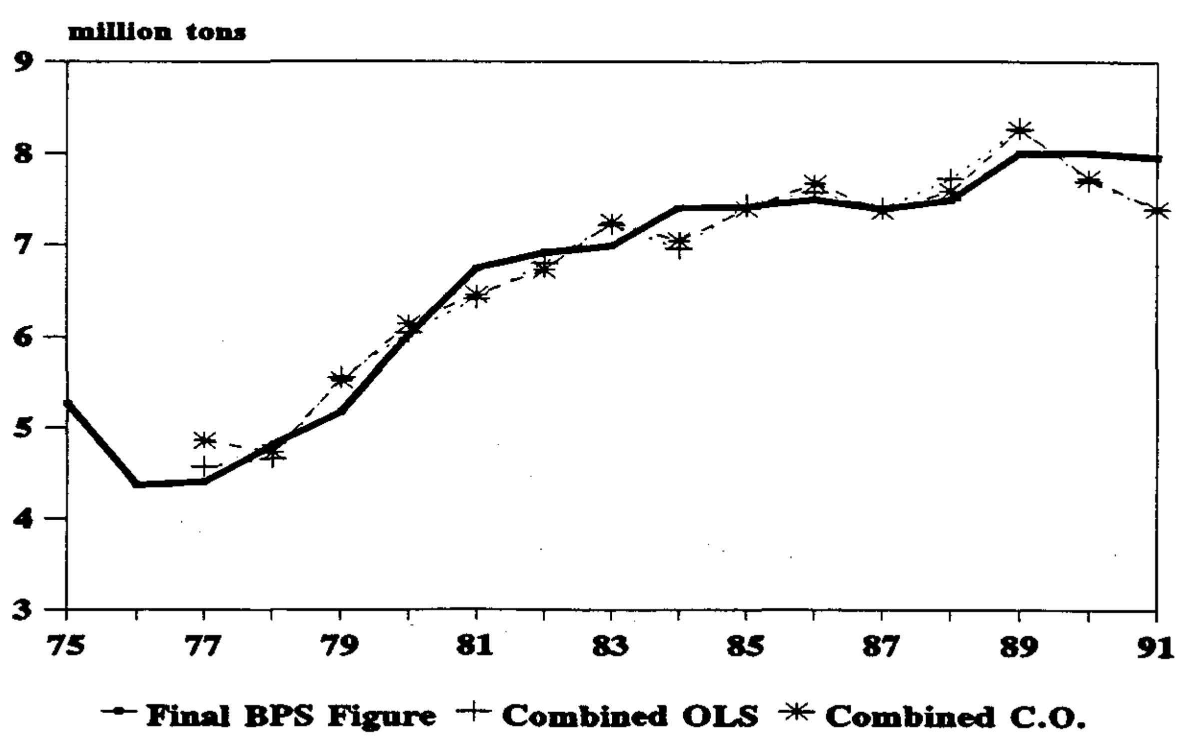

Figure 4. Annual sawah rice production

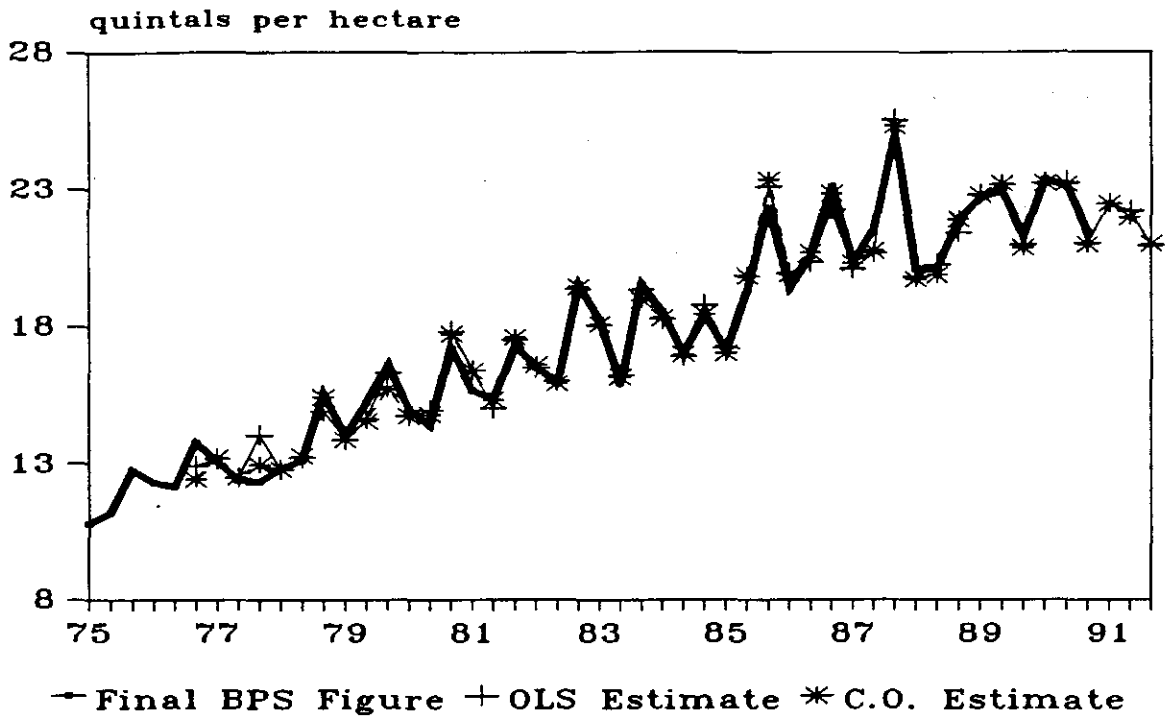

Figure 5. Corn harvest areas

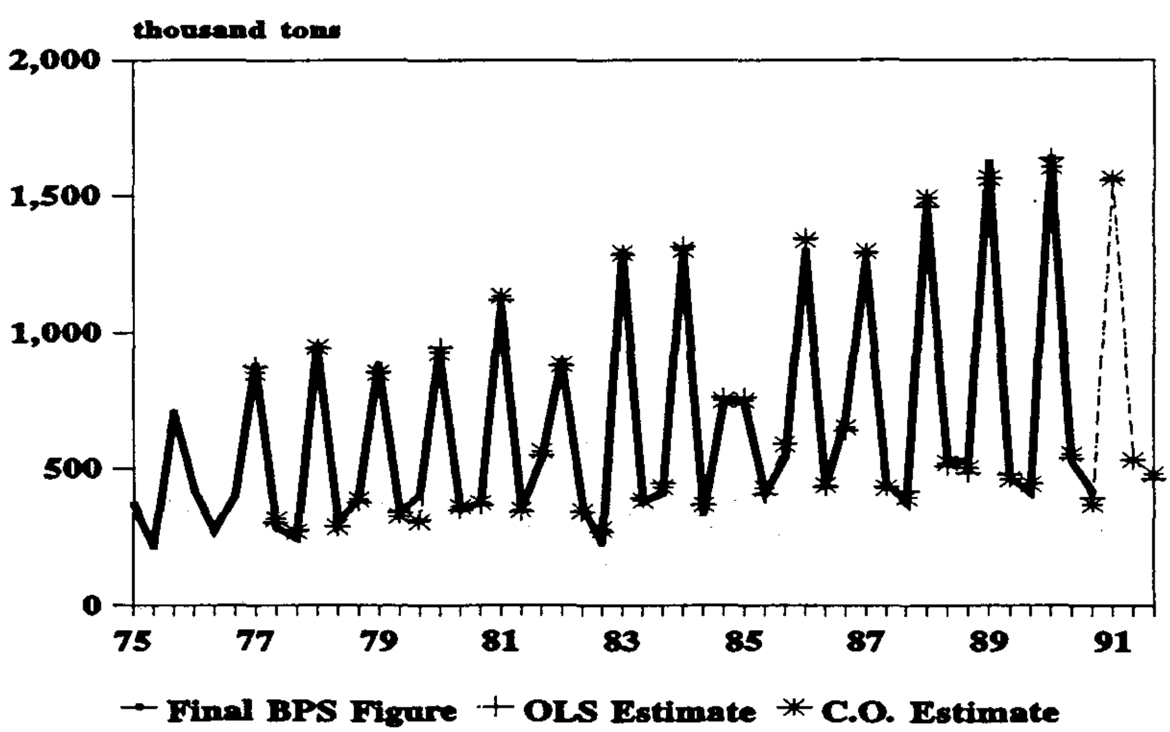

Figure 6. Corn yields by season

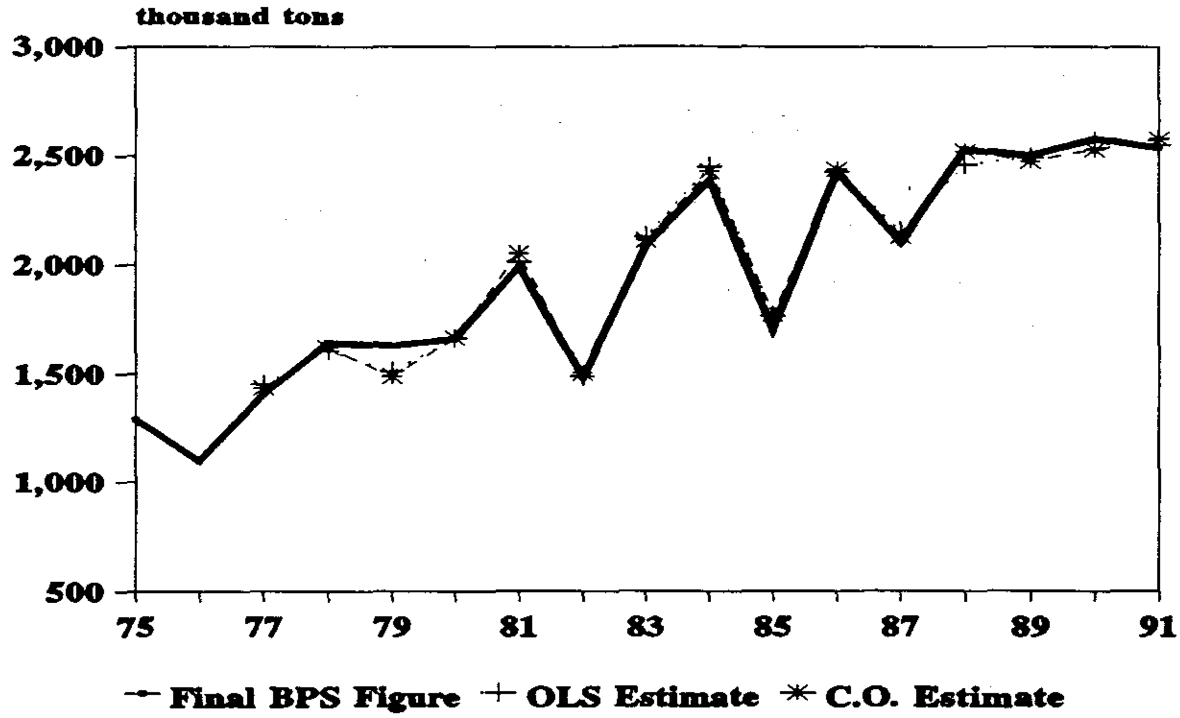

Figure 7. Corn production by season

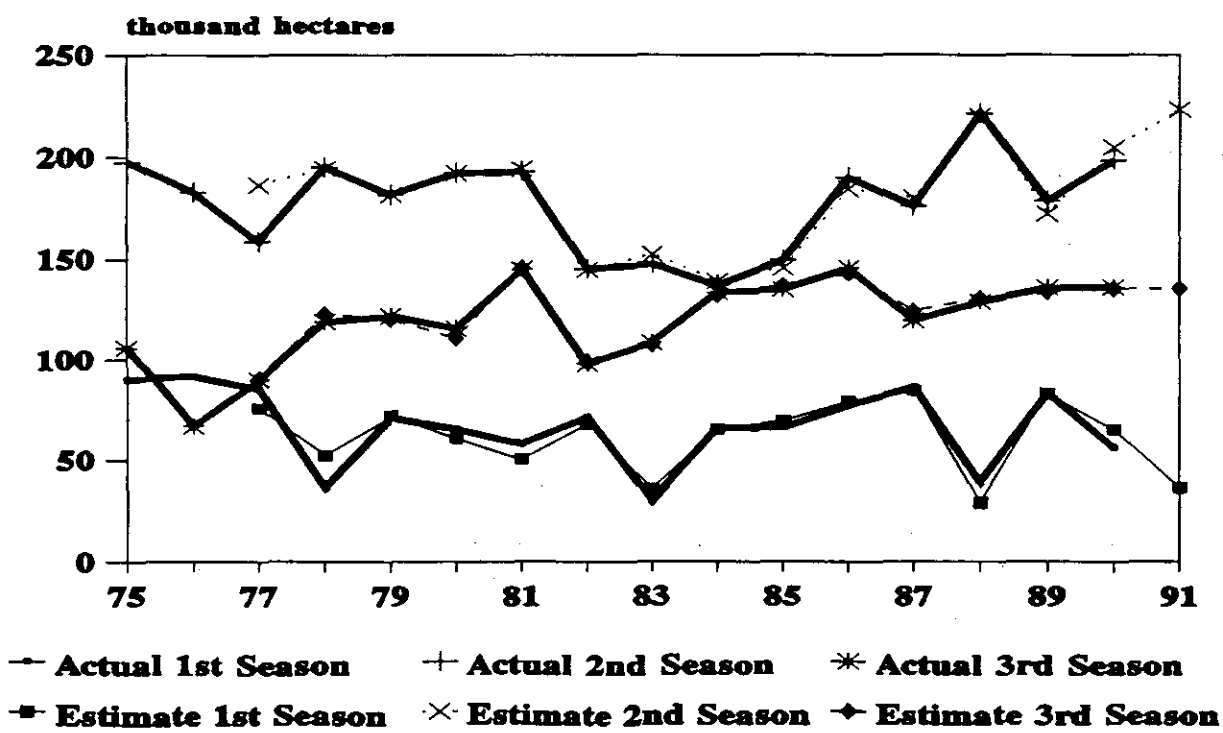

Figure 8. Annual corn production

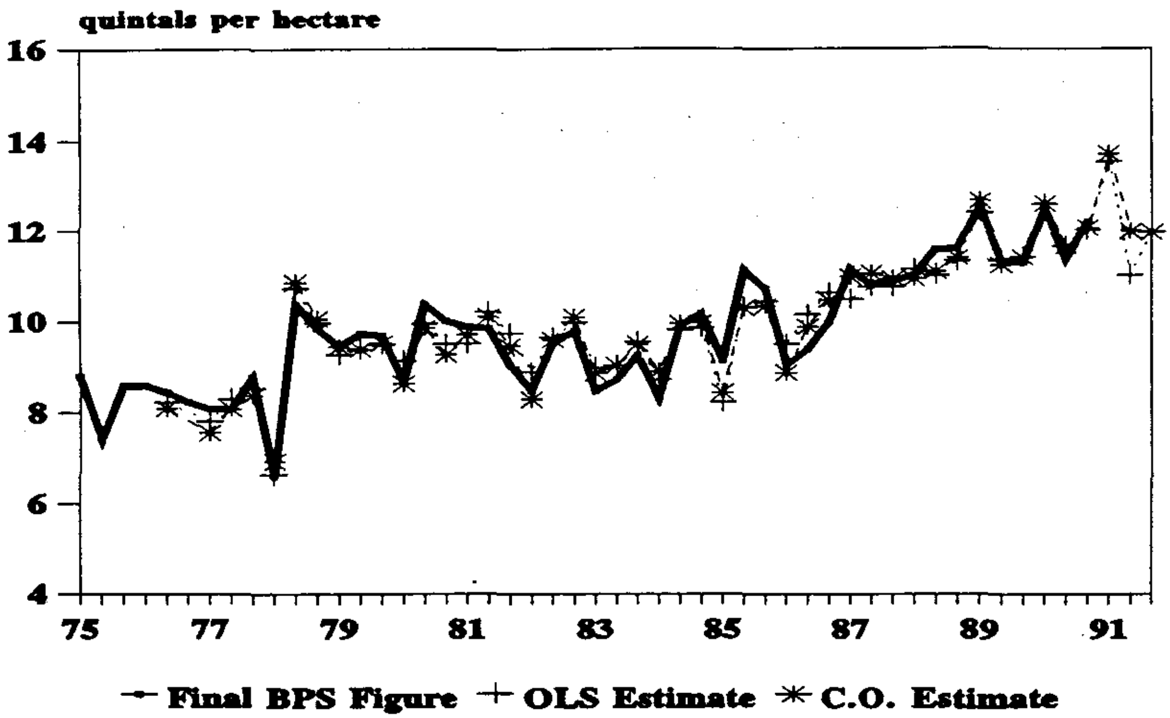

Figure 9. Soybean harvest areas

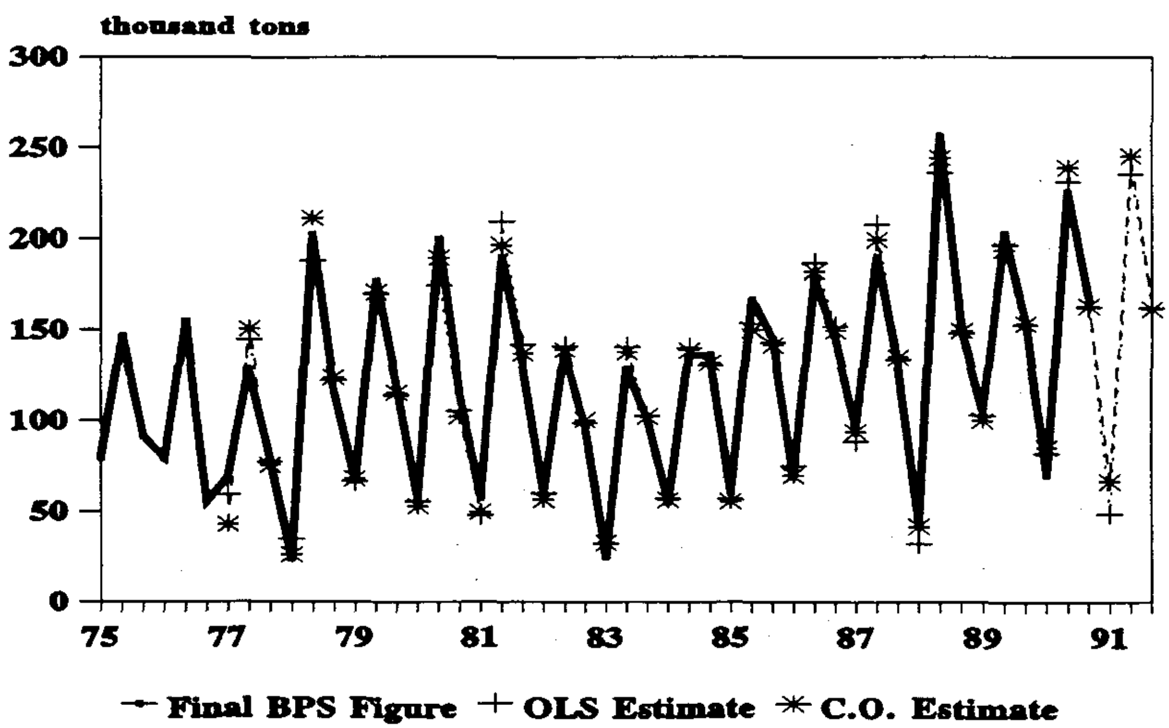

Figure 10. Soybean yields by season

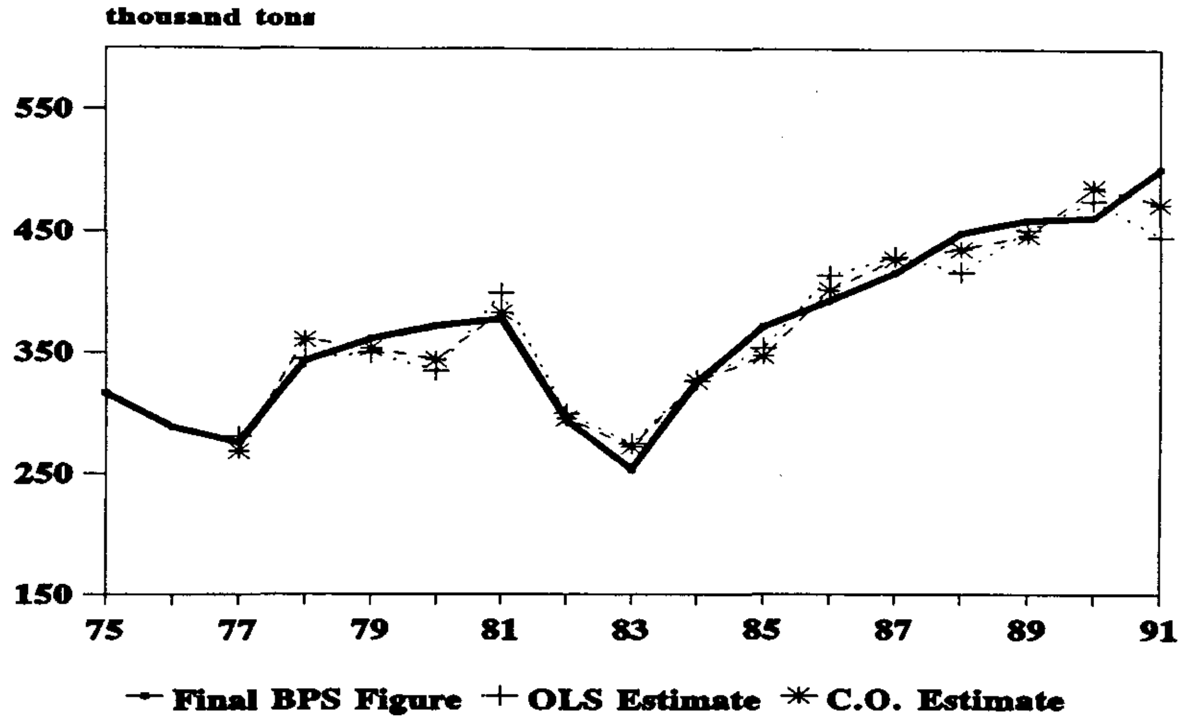

Figure 11. Soybean production by season

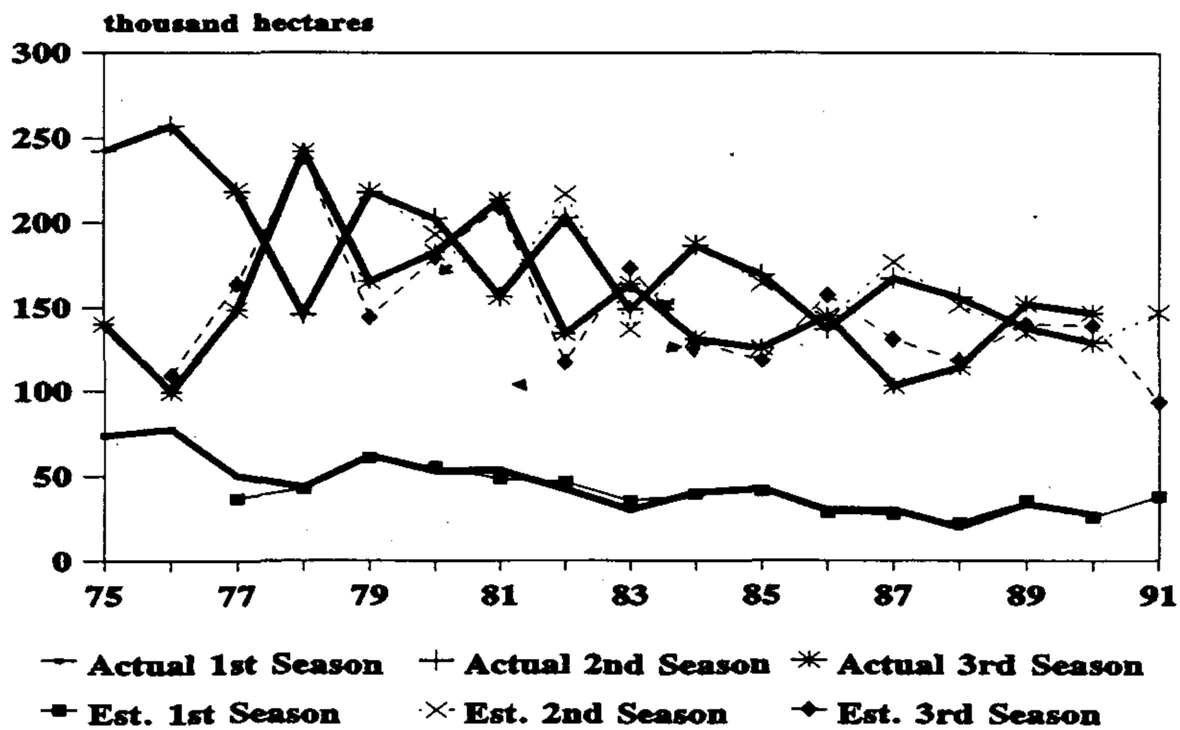

Figure 12. Annual soybean production

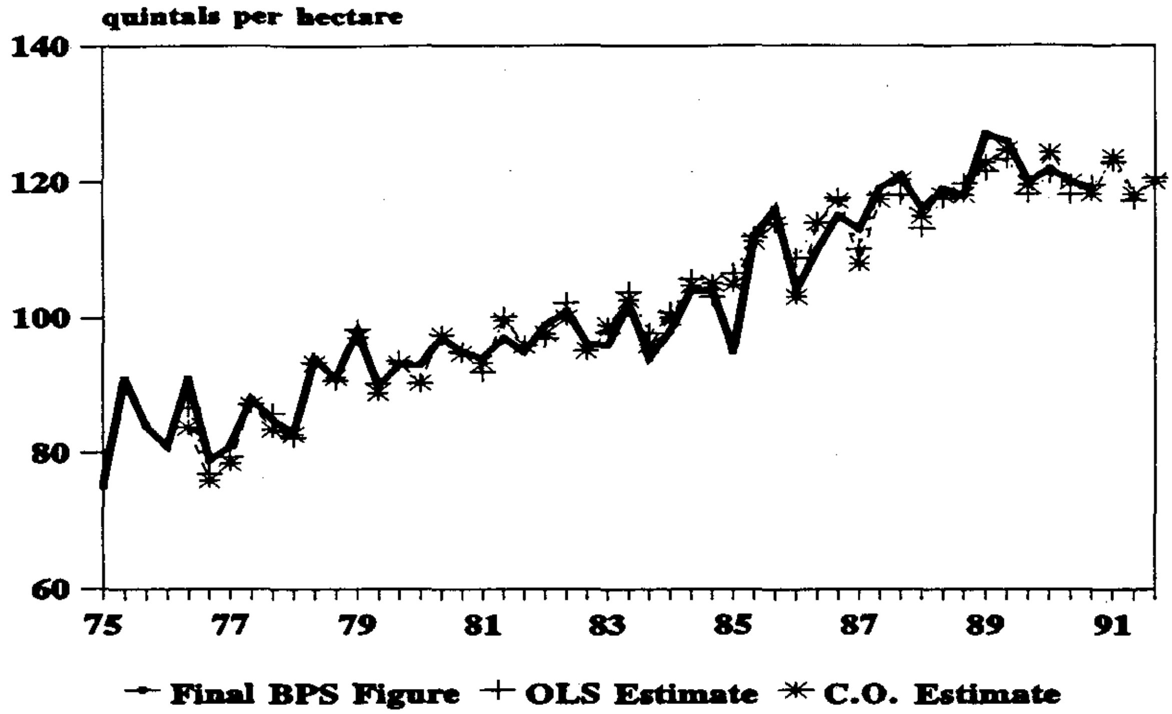

Figure 13. Cassava harvest areas

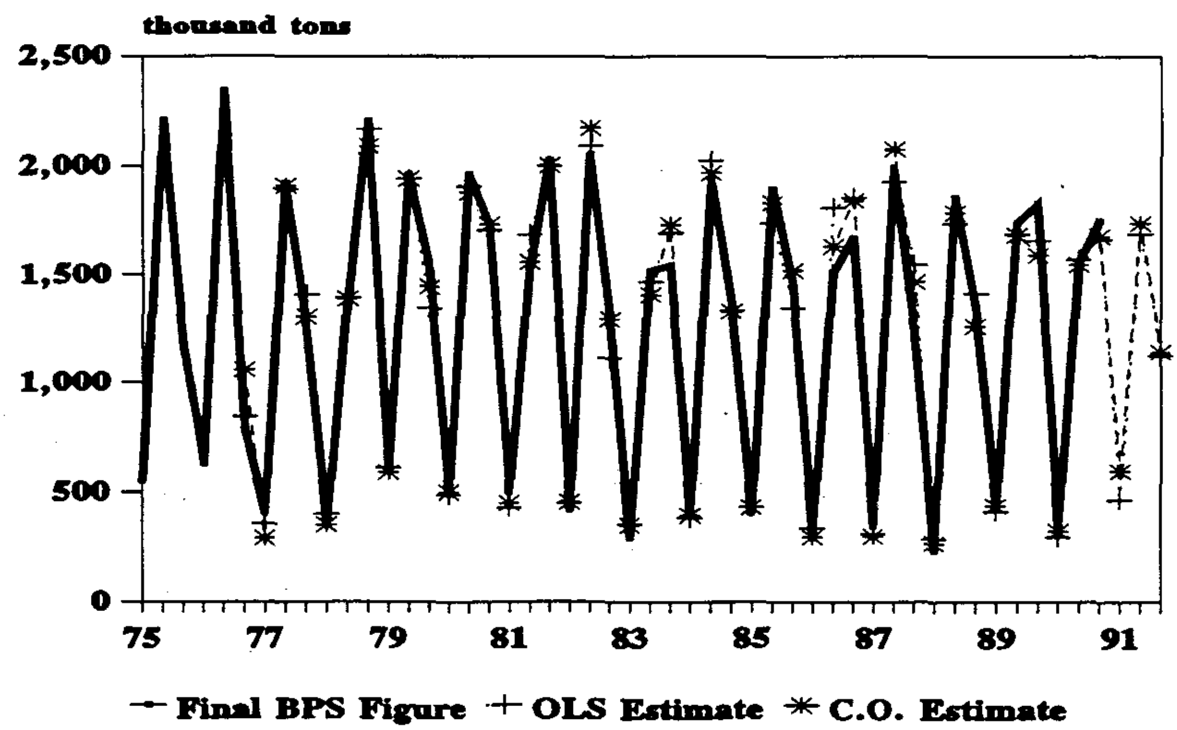

Figure 14. Cassava yields by season

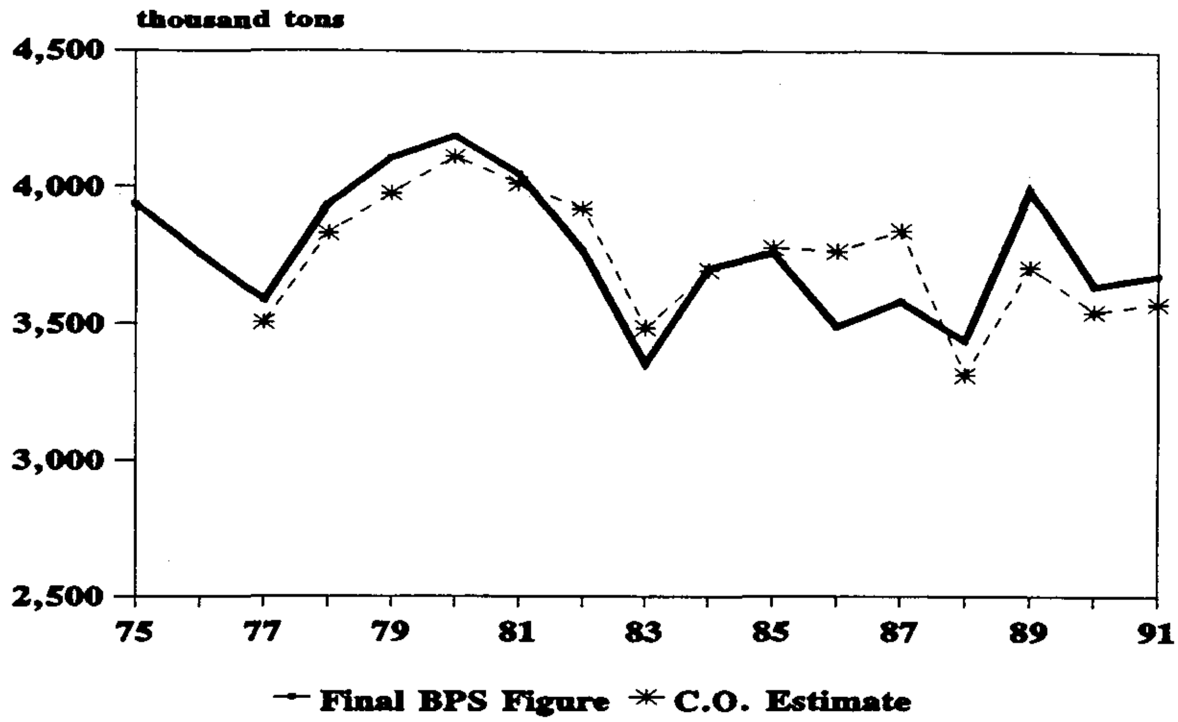

Figure 15. Cassava production by season

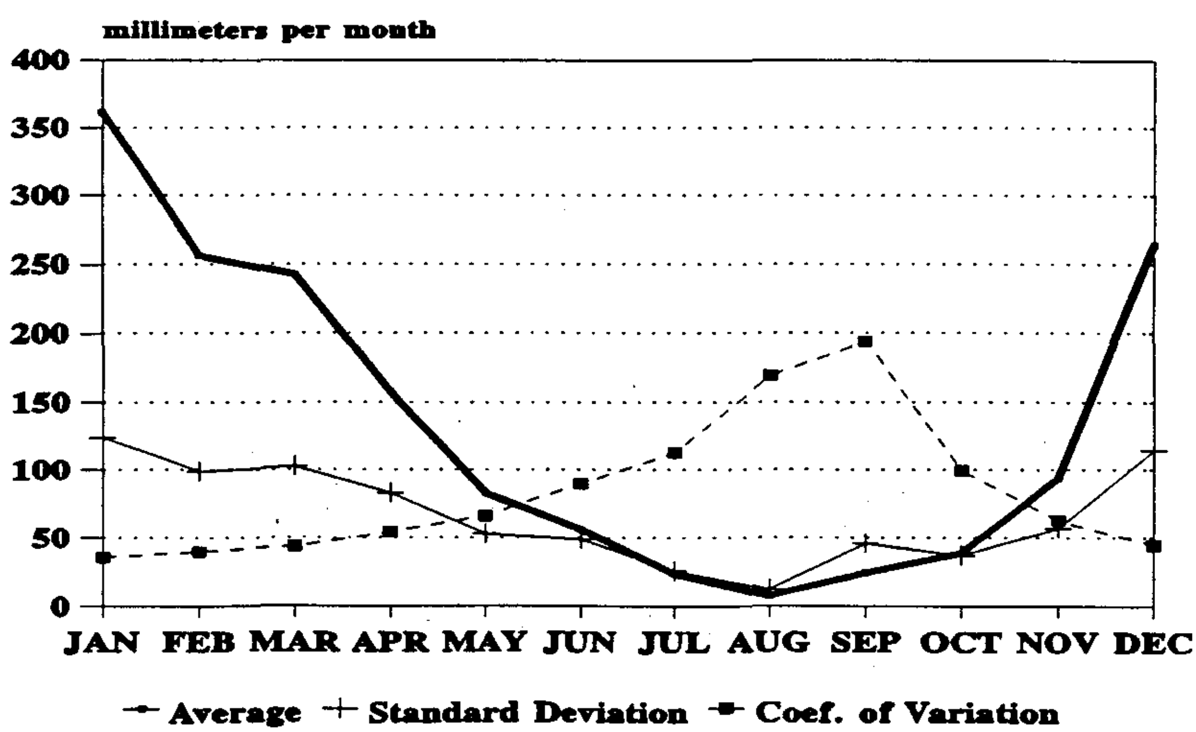

Figure 16. Annual cassava production

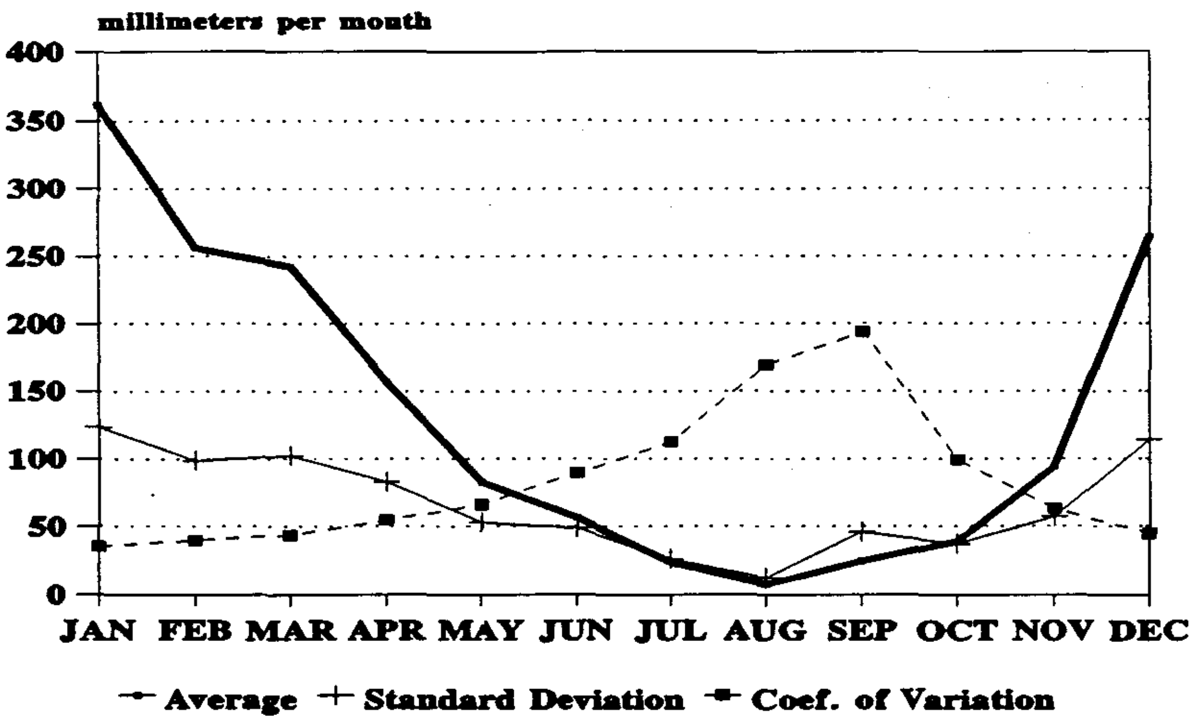

Figure 17. Rainfall at BMG-Surabaya

Table 1. Rainfall data from the BMG station in Surabaya, 1975-91

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
						(Millimeters)							
1976	151	117	271	93	2	4	0	1	0	27	139	242	1,047
1977	394	147	343	174	71	57	0	0	0	0	102	227	1,515
1978	719	490	138	134	109	19	25	50	45	43	86	344	2,202
1979	360	234	311	287	161	10	8	7	18	30	73	273	1,772
1980	381	273	147	201	22	41	85	2	0	9	25	373	1,559
1981	400	211	115	171	84	112	58	9	112	12	189	396	1,869
1982	443	296	441	108	0	0	0	0	18	0	0	132	1,438
1983	247	260	332	153	156	9	0	0	0	75	203	252	1,687
1984	324	345	170	204	51	7	10	159	41	53	133	545	1,545
1985	349	218	399	75	101	153	19	7	1	93	69	83	1,567
1986	340	201	275	82	43	159	16	0	8	112	80	274	1,590
1987	336	353	146	78	67	68	55	0	0	0	177	545	1,825
1988	456	146	157	158	94	38	0	21	0	96	67	244	1,477
1989	221	380	140	66	173	70	39	7	0	45	55	167	1,363
1990	299	177	255	374	112	53	45	2	6	0	92	283	1,697
1991	266	280	48	452	49	11	---[a]	---	---	---	---	---	---
Avg. 75-90	361	257	243	157	83	56	24	8	24	39	94	265	1,610
S.D.	123	96	110	90	54	52	27	14	50	40	62	127	221
						(percent)							
C.V.	34.1	37.3	45.3	57.5	64.7	92.7	113.2	178.3	205.0	102.2	66.2	47.8	13.7

[a] --- indicates data not available.

Table 2. Food crop intensification programs in East Java

Year	Sawah Rice				Corn			
	1st season		2nd season		1st season		2nd season	
	Target	Realized	Target	Realized	Target	Realized	Target	Realized
1974	895.0	784.6	215.0	240.0	n.a.	n.a.	62.3	69.7
1975	925.0	789.4	240.0	199.3	180.0	75.3	90.0	86.0
1976	954.5	741.0	240.0	256.3	225.0	117.9	160.0	136.0
1977	955.0	859.2	250.0	317.7	338.0	270.6	225.0	177.4
1978	970.0	916.3	260.0	343.0	400.0	373.9	200.0	154.3
1979	960.0	934.9	265.0	377.0	400.0	399.0	197.1	187.1
1980	1000.0	1050.7	350.0	407.3	411.3	493.3	188.5	188.5
1981	1020.0	1086.8	371.2	457.8	535.5	659.4	208.5	245.7
1982	1104.8	1106.3	371.0	412.8	564.5	386.1	220.0	183.0
1983	1050.0	1071.0	365.7	468.1	600.0	739.8	220.1	232.4
1984	1058.9	1104.5	415.8	499.7	608.1	744.1	222.1	257.9
1985	1115.5	1150.4	460.0	474.6	608.1	646.3	481.3	243.2
1986	1120.0	1149.1	473.0	506.1	624.0	804.1	350.0	294.1
1987	1150.0	1163.2	450.0	438.7	702.0	763.2	275.0	245.2
1988	1170.0	1147.5	446.0	474.3	650.0	876.3	326.0	359.0
1989	1201.0	1154.2	464.1	484.4	800.0	888.1	381.4	325.8
1990	1210.8	1182.4	469.1	488.3	767.1	898.3	402.2	341.0
Trend from:	1980	1980	1984	1980	1983	1983	1981	1981

Table 2. Continued

Year	Soybeans				Cassava			
	1st season		2nd season		1st season		2nd season	
	Target	Realized	Target	Realized	Target	Realized	Target	Realized
	Thousand Hectares							
1974	n.a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
1975	4.4	2.3	55.0	36.7	6.3	4.7	1.0	0.4
1976	7.0	2.7	150.0	97.5	19.9	12.6	3.0	1.6
1977	10.7	6.2	220.0	151.6	45.5	27.3	5.0	25.1
1978	20.0	16.0	200.0	198.2	75.0	83.2	12.0	20.0
1979	20.0	25.0	195.8	193.6	101.0	118.1	41.9	28.6
1980	17.1	50.2	198.0	232.5	86.6	153.7	12.0	26.7
1981	24.0	61.8	192.9	293.6	87.5	192.5	19.5	37.3
1982	42.7	70.5	210.0	201.6	91.5	198.0	21.5	30.3
1983	100.0	63.4	218.9	216.8	94.7	207.7	21.0	33.2
1984	99.3	82.0	150.6	225.1	119.2	198.4	19.8	57.6
1985	100.3	96.5	227.0	264.4	126.6	201.8	19.9	39.8
1986	120.5	154.5	356.8	263.2	146.1	206.6	20.0	22.1
1987	120.5	156.1	317.0	226.5	167.0	218.3	32.0	20.4
1988	156.0	151.0	275.9	259.2	170.0	252.7	26.0	27.4
1989	170.0	178.3	304.8	261.0	163.2	242.2	28.0	27.9
1990	172.9	170.0	317.0	265.5	175.2	239.3	29.3	27.0
Trend from:	1980	1980	1984	1980	1983	1983	1981	1983

SOURCE: Data provided by Badan Pengendalian Bimas

Notes: Missing observations for cassava are interpolated for years 1975/76 and 1985. For all crops, all 1990 figures and 1989 second season target and realization figures estimated from least squares trends starting in indicated years. Base years are chosen to reflect periods of comparatively smooth program expansion.

Table 3. Composition of 1991 rice production changes

	1990	1991	Abs. Change	Percentage Change
Areas	-------------------------(Hectares)-------------------------			
Season 1	779,155	695,403	(83,752)	-10.7
Season 2	487,827	570,756	82,929	17.0
Season 3	197,788	190,980	(6,800)	-3.5
Total	1,464,770	1,457,067	(7,703)	-0.5
Yields	------------------(Quintals per Hectare)----------------			
Season 1	53.93	52.86	-1.07	-2.0
Season 2	50.92	49.93	-.99	-1.9
Season 3	52.27	48.13	-4.14	-7.9
Total	52.70	51.09	-1.61	-3.1
Production	--------------------(Thousand Tons)----------------------			
Season 1	4,202	3,676	-525.1	-12.5
Season 2	2,484	2,850	365.8	14.7
Season 3	1,034	919	-115.0	-11.1
Total	7,720	7,445	-275.3	-3.6

ESTIMATED PARAMETERS AND SUMMARY STATISTICS

SUMMARY 1.

SEASON 1 SAWAH RICE YIELDS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.973		0.980		
Adjusted R Square	0.965		0.971		
Standard Error	1.140		1.223		
Durbin-Watons	2.301		2.283		
F (3,10)	119.0				
Sig. F	0.000				
Estimated Rho			-0.292		
S.E. Rho			0.319		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	8.37	1.68	10.30	2.26	1
Wereng (1976-78=1)	-2.99	-2.52	-3.35	-2.52	0
Lag Oct. Paddy/Urea Price	0.0835	5.72	0.0883	6.01	158.2
Rice Int. Target S1	0.0258	4.59	0.0230	4.36	1211
1991 Jan.-April Yields (QU/HA):		52.86		52.12	

SEASON 1 SAWAH RICE HARVEST AREAS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.948		1.956		
Adjusted R Square	0.888		0.869		
Standard Error	48,589		58,310		
Durbin-Watson	2.152		2.183		
F (5,8)	15.7				
Sig. F	0.002				
Estimated Rho			-0.232		
S.E. Rho			0.435		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	-422237	-1.43	-400601	-1.23	1
Rice Int. Target S1	743.1	3.73	713.2	3.19	1211
Lagged September Rainfall	591.7	1.98	630.9	1.69	6
Lagged October Rainfall	1847.5	4.17	1939.8	2.85	0
Lag Sum Nov+Dec Rainfall	196.3	2.20	181.8	1.57	375
February Rainfall	-383.80	-2.53	-472.0	-1.32	280
Lag Dec. Paddy/Corn Price	1822.8	1.45	2105.9	1.32	136.2
Wereng (1976-78=1)	-103022	-2.13	-94023.8	-1.09	0
Jan.-April Harvest Areas (Ha):		695,403		689,569	
" Production (tons):		3,676,021		3,593,812	

SUMMARY 2.

SEASON 2 SAWAH RICE YIELDS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.963		0.987		
Adjusted R Square	0.952		0.981		
Standard Error	1.265		1.105		
Durbin-Watson	2.515		1.895		
F(3,10)	86.1				
Sig. F	0.000				
Estimated Rho			-0.556		
S.E. Rho			0.277		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	16.70	8.25	16.97	10.92	1
Lag Oct. Paddy/Urea Price	0.0810	4.79	0.0955	8.39	158.2
April Rainfall	0.0099	2.34	0.0124	3.24	452
Rice Int. Target S2	0.0362	4.58	0.0290	5.24	422.2
1991 May-Aug. Yields (Qu./Ha):		49.25		49.93	

SEASON 2 SAWAH RICE HARVEST AREAS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.993		0.992		
Adjusted R Square	0.988		0.983		
Standard Error	9,349		10,420		
Durbin-Watson	1.658		1.754		
F (6,8)	199.0				
Sig. F	0.000				
Estimated Rho			0.166		
S.E. Rho			0.373		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	839203.0	31.40	833799.6	27.21	1
Rice Int. Target S2	567.5	8.85	583.8	7.69	422.2
February Rainfall	104.1	3.49	113.3	3.14	280
April Rainfall	66.0	1.92	78.0	1.85	452
June Rainfall	142.5	2.09	161.8	1.93	11
Lagged Rice area	-821.9	-27.96	-831.6	-22.09	695.4
Wereng (1976-78=1)	-44421.4	-4.43	-46106.6	-3.15	0
May-Aug. Harvest Areas (HA:		567,834		570,756	
" Production (tons):		2,769,569		2,849,736	

SUMMARY 3.

SEASON 3 SAWAH RICE YIELDS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.986		0.736		
Adjusted R Square	0.973		0.367		
Standard Error	0.994		0.536		
Durbin-Watson	1.834		1.027		
F (6,7)	80.7				
Sig. F	0.000				
Estimated Rho			0.592		
S.E. Rho			0.329		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	13.95	2.29	31.73	5.71	1
Rice Int. Target S2	0.0452	8.12	0.0180	2.45	422.2
Wereng (1976-78=1)	-16.27	-9.91	-6.18	-2.64	0
August Rainfall	0.1996	6.07	0.0824	2.53	0
Sept Rain Dummy (>100=1)	02.16	-2.33	-1.1267	-2.16	0
October Rainfall	-0.0240	-2.77	-1.0140	-2.55	38
Lag Sept. Paddy/Soy Price	0.4655	3.50	0.3167	3.57	34.4
1991 Sept.-Dec. Yields (Qu/Ha):		48.13		49.69	

SEASON 3 SAWAH RICE HARVEST AREAS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.638		0.745		
Adjunsted R Square	0.540		0.632		
Standard Error	13,159		10,916		
Durbin-Watson	2.643		1.483		
F(3,11)	6.5				
Sig. F	0.009				
Estimated Rho			-0.302		
S.E. Rho			0.301		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	40537.0	0.80	60309.0	1.48	1
Lagged Rice Area	130.57	3.12	162.49	4.08	570.8
Summed May+June Rainfall	162.23	2.74	180.19	3.36	50.3
July Paddy/Soy Price	2025.45	1.86	867.28	0.92	33.2
Sept.-Dec. Harvest Areas		190,465		190,908	
" Production (tons):		916,796		948,651	

SUMMARY 4.

SEASON 1 CORN YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.992	0.994
Adjusted R Square	0.986	0.988
Standard Error	0.392	0.441
Durbin-Watson	2.29	2.23
F (5,8)	186.6	
Sig. F	0.000	
Estimated Rho		-0.290
S.E. Rho		0.362

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	-0.3729	-0.22	0.2409	0.12	1
Corn Int. Target S1	0.0176	10.74	0.0176	8.12	767.1
Lagged Sept. Rainfall	-0.0117	-5.01	-0.0127	-4.34	6
January Rainfall	-0.0041	-3.64	-0.0043	-2.91	266
Corn/Urea Price*	0.0371	3.36	0.0355	2.57	113.2
Lag Dec. Corn/Cass Price	0.0209	5.07	0.0198	3.71	300.5
1991 Jan.-April Yields (Qu/Ha):		22.45		22.46	

SEASON 1 CORN HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.971	0.974
Adjusted R Square	0.952	0.948
Standard Error	18,222	19,696
Durbin-Watson	2.26	1.84
F (5,8)	52.8	
Sig. F	0.000	
Estimated Rho		-0.453
S.E. Rho		0.337

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	541493.1	5.12	570563.5	5.72	1
Lagged Corn Area	-543.3	-4.95	-619.8	-5.72	193.4
Corn Int. Target S1	117.7	2.09	131.2	2.50	767.1
Lagged Sept. Rainfall	-887.4	-5.03	-835.6	-4.83	6
January Rainfall	141.9	2.55	193.8	2.88	266
Corn/Soybean Price**	5227.1	2.05	3815.9	1.53	26
Jan.-April Harvest Areas (Ha):		695,012		697,055	
" Production (tons):		1,560,117		1,565,408	

* Weighted average of January Corn/Urea price ratio plus March ratio lagged one year. Respective weights are .33 and .67.

** Weighted average of October Corn/Soybean price ratio plus January ratio lagged one year. Respective wieghts are .33 and .67

SUMMARY 5.

SEASON 2 CORN YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.988	0.993
Adjusted R Square	0.977	0.984
Standard Error	0.537	0.589
Durbin-Watson	2.59	2.30
F (6,7)	94.7	
Sig. F	0.000	
Estimated Rho		-0.419
S.E. Rho		0.371

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	-1.8460	-0.58	-2.1827	-0.70	1
Period (1975=1)	0.8306	19.84	0.8255	19.51	17
April Rainfall	-0.0040	-2.18	-0.0047	-1.97	452
May Rainfall	0.0054	1.74	0.0047	1.16	49
July Rainfall	0.0099	1.65	0.0114	1.67	0
April Corn/Cass. Price	0.0178	4.30	0.0181	4.11	259.7
Corn/Paddy Price*	0.0825	2.65	0.0880	2.82	82.8
1991 May-Aug. Yields (Qu/Ha):		22.18		21.95	

SEASON 2 CORN HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.687	0.801
Adjusted R Square	0.548	0.658
Standard Error	11804.8	10465.0
Durbin-Watson	2.52	1.93
F (4,9)	4.9	
Sig. F	0.022	
Estimated Rho		-0.595
S.E. Rho		0.284

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	214577.7	5.23	246851.8	7.39	1
Jan. Corn/Soy Price	2484.3	1.90	2286.3	1.74	25.9
February Rainfall	-127.0	-3.32	-208.0	-3.76	280
March Fainfall	-65.2	-1.96	-71.3	-2.55	48
June Rainfall	-129.8	-1.66	-172.25	-2.88	11
May-Aug. Harvest Areas (Ha.):		238,779		242,489	
" Production (tons):		529,537		532,211	

* Weighted average of March Corn/Paddy price ratio plus June ratio lagged one year. Respective weights are .25 and .75.

SUMMARY 6.

SEASON 3 CORN YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.962	0.990
Adjusted R Square	0.947	0.984
Standard Error	0.822	0.659
Durbin-Watson	2.83	2.14
F (4,10)	64.0	
Sig. F	0.000	
Estimated Rho		-0.543
S.E. Rho		0.280

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	4.7106	4.48	4.0631	5.67	1
Nov. Corn/Urea Price	0.0736	9.80	0.0771	15.92	125.8
Corn Int. Target S2	0.0146	4.98	0.0154	7.63	362.0
November Rainfall	-0.0084	-1.90	-0.0115	-2.47	94
December Rainfall	0.0093	4.06	0.0104	7.10	264
1991 Sept.-Dec. Yields (Qu/Ha):		20.94		20.98	

SEASON 3 CORN HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.922	0.945
Adjusted R-Squared	0.887	0.906
Standard Error	23785.7	26146.7
Durbin-Watson	1.80	1.71
F (4,9)	26.6	
Sig. F	0.0001	
Estimated Rho		0.419
S.E. Rho		0.321

Varibale	Coef.	t	Coef.	t	1991 Data Points
Constant	-37697.5	-0.56	-50595.3	-0.56	1
July Rainfall	663.3	2.34	426.4	1.39	0
September Rainfall	1240.4	9.08	1290.1	9.78	24
October Rainfall	1066.4	5.72	1091.4	5.22	38
Corn/Soybean Price*	6266.5	2.87	6908.9	2.07	29.9
Sept.-Dec. Harvest Area (Ha):		219.712		228,141	
* Production (tons):		460,052		478,663	

* Weighted average of August Corn/Soybean price ratio plus price ratio lagged one year. Respective weights are .25 and .75.

SUMMARY 7.

SEASON 1 SOYBEAN YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.932	0.985
Adjusted R Square	0.889	0.970
Standard Error	0.575	0.461
Durbin-Watson	2.90	2.12
F (5,8)	21.8	
Sig. F	0.0002	
Estimated Rho		-0.745
S.E. Rho		0.252

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	3.98	2.44	3.30	2.85	1
Soybean Int. Target S1	0.0234	6.60	0.0262	11.48	172.9
Soy/Cassava Price*	0.0054	4.66	0.0054	7.59	1180
Lagged Dec. Rainfall	0.0035	2.48	0.0028	2.81	283
January Rainfall	-0.0062	-3.74	-0.0040	-3.18	266
March Rainfall	-0.0037	-2.36	-0.0046	-3.74	48
1991 Jan.-April Yields (Qu/Ha):		13.53		13.70	

SEASON 1 SOYBEAN HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.840	0.949
Adjusted R Squared	0.768	0.831
Standard Error	8,733	6,405
Durbin-Watson	2.01	1.31
F (4,9)	11.8	
Sig. F	0.001	
Estimated Rho		-0.317
S.E. Rho		0.335

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	21302.9	1.00	-1546.0	-0.10	1
Lagged Soybean Area	-349.3	-2.33	41.3	0.29	135.9
Lag Sept Rain Dummy (>100=1)	22886.9	2.83	12810.1	1.99	0
Lagged Oct. Rainfall	546.4	6.45	382.9	5.00	0
Soy/Cassava Price*	52.6	3.35	37.5	3.35	1180
Jan.-April Harvest Areas (Ha):		35,889		48,265	
" Production (Tons):		48,568		66,104	

* Weighted average of January Soy/Cassava price ratio plus January ratio lagged one year. Respective weights are .67 and .33.

SUMMARY 8.

SEASON 2 SOYBEAN YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.854	0.890
Adjusted R Square	0.796	0.822
Standard Error	0.498	0.523
Durbin-Watson	2.45	2.35
F (4,10)	14.6	
Sig. F	0.0004	
Estimated Rho		-0.312
S.E. Rho		0.317

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	6.45	6.96	6.57	6.91	1
Period (1995=1)	0.2005	6.05	0.2054	6.57	17
July Rainfall	0.0109	2.07	0.0128	2.25	0
August Rainfall	0.0369	3.57	0.0406	3.59	0
March Soy/Cass. Price	0.0011	1.57	0.0009	1.18	1060
1991 May-August Yields (Qu/Ha):		11.02		10.99	

SEASON 2 SOYBEAN HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.801	0.990
Adjusted R Square	0.677	0.979
Standard Error	14088.1	5340.7
Durbin-Watson	2.61	1.50
F (5,8)	6.5	
Sig. F	0.011	
Estimated Rho		-0.796
S.E. Rho		0.229

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	-289132.3	-3.22	-368706.6	-13.22	1
Soybean Int. Target S2	139.9	1.44	245.0	6.98	317
Forecast Corn Area S2	579.8	2.60	816.6	6.48	242.5
Lagged Cassava Area	358.2	0.77	1063.5	7.36	48.1
May Rainfall	157.3	1.96	254.7	8.29	49.4
May Soy/Corn Price	700.6	3.96	604.2	8.58	417.5
May-August Harvest Areas (Ha):		213,279		223,002	
" Production (tons)		235,096		245,094	

SUMMARY 9.

SEASON 3 SOYBEAN YIELDS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.864		0.910		
Adjusted R Square	0.824		0.865		
Standard Error	0.421		0.434		
Durbin-Watson	2.43		2.26		
F (3,10)	21.3				
Sig. F	0.0001				
Estimated Rho			-0.369		
S.E. Rho			0.310		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	6.0006	6.42	5.8706	6.56	1
Period (1975=1)	0.2338	7.95	0.2462	8.92	17
August Rainfall	0.0208	2.32	0.0288	2.86	0
Soybean/Cassava Price*	0.0018	2.25	0.0017	2.34	1120
1991 Sept.-Dec. Yields (Qu/Ha):		11.96		11.96	

SEASON 3 SOYBEAN HARVEST AREAS AND 1991 PROJECTION

	OLS		C.O.		
R Square	0.976		0.968		
Adjusted R Square	0.948		0.903		
Standard Error	3809.1		4594.9		
Durbin-Watson	2.23		2.16		
F (7,6)	34.9				
Sig. F	0.0002				
Estimated Rho			-0.199		
S.E. Rho			0.438		
Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	-54416.2	-3.01	-52725.9	-2.45	1
Sept. Soy/Paddy Price	275.9	4.02	265.6	3.41	290.7
Lagged Soybean Area	234.5	4.43	231.5	2.83	223.0
Lag May Rain Dummy (>100=1)	5702.2	2.27	6138.0	1.62	0
Lag June Rain Dummy (>100=1)	8512.2	2.75	8787.0	2.26	0
September Rainfall	129.8	5.13	132.1	3.57	24
Soybean/TSP price**	72.6	5.47	73.4	4.49	391.7
Sept. Soy/Cass. Price	22.3	2.46	23.3	1.95	1143
Sept.-Dec. Harvest Areas (Ha):		135,134		134,685	
" Production (tons):		161,662		161,087	

* Weighted average of August Soybean/Cassava price ratio plus October price ratio lagged one year. Respective weights are .25 and .75.

** Weighted average of August Soybean/TSP price ratio plus October price ratio lagged one year. Respective weights are .25 and .75.

SUMMARY 10.

SEASON 1 CASSAVA YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.905	0.767
Adjusted R Squared	0.887	0.689
Standard Error	4.570	4.341
Durbin-Watson	1.011	1.682
F (2,11)	52.3	
Sig. F	0.000	
Estimated Rho		0.508
S.E. Rho		0.272

Variable	Coef	t	Coef.	t	1991 Data Points
Constant	70.0	21.13	68.7	8.81	1
Lagged August Rain	0.2578	2.72	0.2324	3.02	2
Period (1975=1)	3.0786	10.10	3.2058	4.86	17
1991 Jan-Apr Yields (Qu/Ha):		122.86		123.64	

SEASON 1 CASSAVA HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.889	0.956
Adjusted R Squared	0.839	0.924
Standard Error	4723.5	3829.6
Durbin-Watson	2.407	1.398
F (4,9)	18.0	
Sig. F	0.0003	
Estimated Rho		-0.250
S.E. Rho		0.342

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	41539.6	4.96	25346.6	2.67	1
Lagged August Rain	282.4	2.34	236.8	2.43	2
Lagged April Rain	54.4	2.30	81.4	3.86	374
Lagged Cassava Area	31.5	0.72	72.7	1.75	146.7
Period (1975=1)	-1707.4	-4.75	-1107.7	-3.08	17
Jan.-April Harvest Areas (Ha):		38,032		48,111	
" Production (tons):		467,274		594,857	

SUMMARY 11.

SEASON 2 CASSAVA YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.969	0.965
Adjusted R Square	0.960	0.949
Standard Error	2.448	1.912
Durbin-Watson	1.10	1.49
F (3,11)	114.0	
Sig. F	0.000	
Estimated Rho		0.347
S.E. Rho		0.297

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	83.8	43.70	80.4	33.00	1
Period (1975=1)	2.6471	17.98	2.8978	14.90	17.0
April Rainfall	-0.0255	-3.31	-0.0255	-4.39	452
Sum July+Aug. Rainfall	0.0322	1.42	0.0473	2.73	0
1991 May-Aug. Yields (Qu/Ha):		117.32		118.14	

SEASON 2 CASSAVA HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.915	0.959
Adjusted R Squared	0.861	0.917
Standard Error	11431.3	10115.1
Durbin-Watson	3.00	2.61
F (5,8)	17.2	
Sig. F	0.001	
Estimated Rho		-0.762
S.E. Rho		0.245

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	144607.7	4.25	122518.6	4.39	1
Cass. Int. Target S1	470.5	1.58	500.1	2.66	175.2
Lagged Cassava Area	806.8	1.56	987.3	2.55	38.0
Lagged Nov. Rainfall	248.2	4.62	341.8	4.64	92
August Rainfall	-1185.0	-4.18	-1170.8	-4.33	0
Period (1975=1)	-8036.7	-2.25	-7773.6	-3.34	17
May-Aug. Harvest Areas (Ha):		143,904		146,952	
* Production (tons):		1,688,332		1,736,021	

ENDNOTES

1. The same general approach has been applied to data from West Java and NTT with satisfactory results, although these are not presented here.

2. Although it is more logical for farmers to base decisions on expected returns rather than simple relative prices, experimentation with a gross income variable (expected harvest price times lagged yield) did not improve upon relative prices alone.

3. This supposition could logically be tested by looking for significant effects of predicted rice or corn areas in the second season soybean area equation. However, we could find no such effects and it may be that alternative crops (e.g., groundnuts) would be better reflect underlying substitutions.

SUMMARY 12.

SEASON 3 CASSAVA YIELDS AND 1991 PROJECTION

	OLS	C.O.
R Squared	0.983	0.997
Adjusted R Squared	0.970	0.993
Standard Error	2.472	1.820
Durbin-Watson	3.18	2.26
F (6,8)	75.3	
Sig. F	0.000	
Estimated Rho		-0.666
S.E. Rho		0.282

Variable	Coef.	t	Coef.	t	1991 Data Points
Constant	67.9	22.20	66.7	37.31	1
Cassava Int. Target S1	0.1374	2.29	0.1450	3.86	175.2
Period (1975=1)	1.4554	2.26	1.4036	3.62	17
June Rainfall	0.0773	3.58	0.0849	6.99	11
August Rainfall	0.1060	1.42	0.1211	2.34	0
May-Aug Rain Dummy (<200=1)	3.0239	1.34	3.1403	2.29	1
Sept. Rain Dummy (>100=1)	-3.7602	-1.89	-3.6507	-2.60	0
1991 Sep[t.-Dec. Yields (Qu/Ha):		120.55		120.03	

SEASON 3 CASSAVA HARVEST AREAS AND 1991 PROJECTION

	OLS	C.O.
R Square	0.885	0.912
Adjusted R Square	0.839	0.857
Standard Error	15640.9	14334.2
Durbin-Watson	1.47	1.14
F (4,10)	19.2	
Sig. F	0.000	
Estimated Rho		0.482
S.E. Rho		0.292

Variable	Coef.	t	Coef	t	1991 Data Points
Constant	342724.6	4.70	395259.8	6.40	1
Period (1975=1)	-9987.2	-6.93	-10640.4	-5.36	17
Lagged Cassava Area	0944.0	-4.30	-954.1	-5.96	147.0
Lag First Season Corn Area	85.3	1.68	30.4	0.87	695.0
July Rainfall	409.2	2.51	240.6	1.67	0
Sept.-Dec. Harvest Areas (Ha):		93,496		95,276	
" Production (tons):		1,127,128		1,143,644	

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