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BRAZIL 1 - Production. The Production Module of the Brazilian General Equilibrium Model

Lopuch, B. and McCarthy, F.D.

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FOREWORD

Understanding the nature and dimensions of the world food problem and the policies available to alleviate it has been the focal point of the IIASA Food and Agriculture Program since it began in 1977.

National food systems are highly interdependent, and yet the major policy options exist at the national level. Therefore, to explore these options, it is necessary both to develop policy models for national economies and to link them together by trade and capital transfers. For greater realism the models in this scheme are being kept descriptive, rather than normative. In the end it is proposed to link models to twenty countries, which together account for nearly 80 per cent of important agricultural attributes such as area, production, population, exports, imports and so on.

This report presents the results of work on the agricultural production module for Brazil; it is part of the work devoted to building an agricultural policy model for that country. As understanding supply responses to various possible policy instruments is a critical part of much of agricultural policy analysis, this work is a significant element of the IIASA agricultural policy model for Brazil.

Kirit S. Parikh
Acting Program Leader
Food and Agriculture Program

PREFACE

Brazil has one of the world's most dynamic economies, with sustained high growth since 1964. The agricultureal sector has made a substantial contribution to this. Much of the growth here has been achieved by increasing the cropped area with relatively modest increases in yield.

This paper analyzes overall growth performance of this sector and provides estimates of supply functions for 19 commodities. These estimates are based primarily on time series data over the period 1964-1977.

The results form a basis for the agricultural production module which is used in the Brazil general equilibrium planning model.

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CONTENTS

BRAZIL 1 - PRODUCTION
The Production Module of the Brazilian General Equilibrium Model

Bozena Lopuch
Desmond McCarthy

1. INTRODUCTION

This working paper discusses agricultural production in Brazil. It is one of a series of working papers leading to a general equilibrium model for the Brazilian economy.

This model is macro but places particular emphasis on the agriculture sector. In this sector twenty commodities are treated separately. In view of the rather limited resources available for the overall exercise, the treatment of some of these commodities may not be detailed enough. However, the modular design of the program allows one to replace any of the existing subsystems with an improved one relatively easily. The current working paper should be reviewed as simply a record of the first approximation to modelling the production structure.

The paper has four main parts.

- Agriculture and the National Economy:
  Here the contribution of agriculture to the economy and in particular its role in production, demand and foreign trade are discussed.
- Resource Base:
  This section discusses extremely briefly some of the resources which give Brazilian agriculture its particular character, the land and labor force. Technology is particularly important but is not discussed at this stage.
- Supply Functions:
  A number of supply functions were estimated for 19 of the principal commodities. These are plotted in the Appendix.
- Trends:
  Recent trends are summarized and selected policy issues are discussed. These policies are later analysed in the context of the overall macro studies.

2. ROLE OF AGRICULTURE IN NATIONAL ECONOMY

The contribution of agriculture to the national economy is summarized in Table 2.1. It is seen that this contribution was about 10% in 1977, down from 18.5% in 1960. This falling share of agriculture is observed in most countries during the process of development.

The growth of agriculture at constant prices is given in Table 2.2. It is seen that over the period 1970 to 1977 agriculture increased by 54% while the gross domestic product increased by 91%. This was achieved despite the strong contractionary impact of the 1973-74 oil price rise.

2.1. International Role

Brazil is a major exporter of agricultural goods. Historically coffee dominated exports, but in recent years processed and semi-processed commodities have contributed larger shares as shown in Table 2.3. Within agriculture exports have also become more diversified. It is to be noted that soya has increased dramatically but also items such as orange juice are growing rapidly. One also notes the increasing contribution of semi-manufactured agricultural products. This has a particularly favourable impact on domestic employment.

On the import side the principal agricultural commodity is wheat, which typically accounts for about 3% of imports (370 million U.S.$ in 1975). Fertilizers also constitute an important import item. In 1975 this item accounted for about 300 million U.S. $ of imports.

2.2. Domestic Demand

Most agricultural output goes to satisfy food needs and industrial demand within Brazil. Demand is discussed in detail in the working paper on consumption. In 1975 the average share of income spent on food is 0.24 and the income elasticitiy is estimated at 0.49 (Based on ENDEF data).

The principal food items in value terms are wheat, rice, dairy and beef products, which account for 9.4, 9.5, 8.2 and 17.1 per cent of total food expenditure. The large beef component is particularly striking since pork, poultry and eggs account for a further 14%.

Agriculture also provides significant levels of raw materials for industry. These include cotton and more recently sugar for the gasahol program.

In summary agriculture in Brazil plays a number of roles.

- satisfy domestic food needs
- supply raw materials for industry
- make a substantial contribution to balance of payments
- provide significant amount of employment.

The first three are usually adressed by direct policy measures. Inevitably particular policies may be more suited to meeting one or other of these goals. In some instances a policy may make a positive contribution to one while having a negative effect on another. However, an appropriate policy package would seek to meet all goals. In order to address some of these issues the agriculture sector is now considered in more detail.

3. RESOURCES FOR AGRICULTURE

3.1. Labor Force

Population and labor force statistics are summarized in Table 3.1. It is seen that the agriculture labor force in 1977 is more than 40% of the total labor force. Thus agriculture plays a major role in employment. Since this 40% accounts for is only 10% of G.D.P., it follows that there is a wide disparity between average incomes in agriculture and nonagriculture.

TABLE 2.1. Gross Domestic Product by Kind of Economic Activity, In Producers' Values, at Current Prices

Brazilian cruzeiros

	1960	1963	1965	1969	1970	1971	1972	1973	1974	1975	1976	1977
a) Industries												
1. Agriculture, hunting, forestry and fishing	508	1981	6708 5834	14336	17127	23973	30560	44271	65657	87821	137703	236849
a) Agricultural and livestock production	462	1843	6275 -	-	-	-	-	-	-	-	-	-
b) Agricultural services, hunting, etc.	-	-	- -	-	-	-	-	-	-	-	-	-
c) Forestry and logging	38	98	319 -	-	-	-	-	-	-	-	-	-
d) Fishing	8	40	114 -	-	-	-	-	-	-	-	-	-
2. Mining and quarrying	10	34	89 287	936	1327	1740	2219	2871	7420	11361	15271	19326
3. Manufacturing	483	2337	6297 9091	34649	45802	62154	83780	118820	179255	251935	380304	543838
4. Electricity, gas and water	39	170	633 608	2516	3575	4775	6737	8630	11925	18168	26467	40095
5. Construction	33	142	341 1946	8083	9934	12555	16649	22944	34988	47398	70684	108889
6. Wholesale and retail trade, restaurants and hotels[a]	338	1494	4059 5521	20045	26283	35367	46571	64710	95819	132829	201289	296735
7. Transport, storage and communication	145	677	1998 2293	6919	8740	11236	15004	21040	29682	42620	66833	102822
8. Finance, insurance, real estate and business services[b]	220	969	3126 4167	17823	23131	31827	40490	54076	73006	114488	189697	311642
9. Community, social and personal services[abc]	287	1222	4042 4499	12557	15984	20487	25614	32104	44608	60671	91164	135847
10. Less: Imputed bank service charges (present SNA)	-	-	-	-	-	-	-	-	-	-	-	-
Domestic product of industries	2001	8807	26593 33545	117865	151903	204115	267624	369464	542360	767291	1179417	1796046
b) Producers of Government Services												
Domestic product of government services	184	993	2854 3122	11323	15326	20309	25742	32980	44396	66694	103982	143395
c) Summation												
1. Domestic product excluding import duties[d]	2246	10017	30147 36667	129188	167229	224423	293366	402444	586756	833985	1283400	1939442
2. Import duties	-	-	- -	-	-	-	-	-	-	-	-	-
Statistical discrepancy	505	1912	6671 7406	32713	41072	52385	69802	95863	132763	175394	276871	413333
Gross domestic product in purchasers' values	2751	11929	36818 44073	161900	208301	276808	363167	498307	719519	1009380	1560271	2252775

a) Item 'Restaurants and hotels' is included in item 'Community, social and personal services'.
b) Business services are included in item 'Community, social and personal services'.
c) Item 'Domestic services of households' is included in item 'Community, social and personal services'.
d) Net domestic product in factor values.
e) Relating to depreciation and indirect taxes net of subsidies.

SOURCE: based on U.N. Yearbook of National Account Statistics, 1978.

TABLE 2.2. Gross Domestic Product by Kind of Economic Activity, In Producers' Values, at Constant Prices

Index numbers 1970 = 100

	1960	1963	1965	1969	1970	1971	1972	1973	1974	1975	1976	1977
					At constant prices of:1970							
					a) Industries							
1. Agriculture, hunting forestry and fishing	-	-	97.9	99.0	100.0	111.4	116.0	120.1	130.3	134.7	140.3	153.8
2. Mining and quarrying	-	-	56.8	85.5	100.0	103.7	115.0	129.2	183.5	195.5	197.2	187.9
3. Manufacturing	-	-	61.7	89.4	100.0	115.2	132.0	153.3	166.2	173.6	191.9	196.3
4. Electricity, gas and water	-	-	63.4	90.1	100.0	112.3	125.0	143.8	161.7	178.2	196.2	221.5
5. Construction	-	-	69.4	97.0	100.0	112.5	122.2	140.6	157.6	178.5	201.3	219.5
6. Wholesale and retail trade. restaurants and hotels	-	-	65.9	90.7	100.0	114.1	126.6	147.6	161.3	166.9	181.4	187.7
a) Wholesale and retail trade	-	-	65.9	90.7	100.0	114.1	126.6	147.6	161.3	166.9	181.4	187.7
b) Restaurants and hotels	-	-	-	-	-	-	-	-	-	-	-	-
7. Transport, storage and communication	-	-	64.8	90.5	100.0	107.4	120.2	140.8	158.7	177.4	190.6	198.4
					b) Summation							
1. Domestic product excluding import duties[a]	-	-	69.1	91.9	100.0	113.3	126.6	144.2	158.3	167.3	182.7	190.8

SOURCE: U.N. Yearbook of National Account Statistics, 1978.

Table 2.3. Brazil: Export by Principal Commodity Groups

	1975	1976	1977	1978	1979
	(In billions of U.S. dollars)				
Total exports, f.o.b.	8.67	10.13	12.12	12.66	15.24
Primary products	5.03	6.12	6.96	5.98	6.51
Coffee beans	0.85	2.17	2.32	1.94	1.89
Sugar (excluding processed sugar)	0.77	0.15	0.27	0.20	0.25
Raw cotton	0.10	0.01	0.04	0.05	-
Iron ore	0.92	0.99	0.91	1.03	1.29
Soybean (grain, cake and meal)	1.15	1.58	1.86	1.22	1.32
Beef (chilled and frozen)	0.01	0.02	0.04	0.02	-
Cocoa beans	0.22	0.22	0.44	0.46	0.49
Manganese ore	0.08	0.07	0.03	0.05	0.06
Corn	0.15	0.17	0.14	-	-
Sisal	0.03	0.04	0.05	0.03	0.05
Tobacco leaf	0.14	0.16	0.19	0.24	0.28
Fruits and nuts	0.12	0.08	0.10	0.11	0.11
Petroleum crude	0.08	0.04	0.01	-	-
Other	0.41	0.42	0.56	0.63	0.77
Semimanufactures	0.84	0.84	1.04	1.42	1.89
Crystal sugar	0.20	0.05	0.06	0.03	0.02
Sawn wood	0.08	0.05	0.06	0.05	0.05
Castor oil	0.05	0.08	0.09	0.11	0.12
Cocoa butter	0.06	0.07	0.10	0.08	0.12
Peanut and soybean oil	0.18	0.23	0.31	0.33	0.40
Other	0.27	0.36	0.42	0.82	1.18
Manufactures	2.59	2.79	3.84	5.08	6.68
Soluble coffee	0.08	0.23	0.33	0.35	0.43
Sugar (refined)	0.13	0.11	0.13	0.12	0.09
Office appliances	0.11	0.08	0.11	0.13	0.15
Nonelectric machinery	0.30	0.30	0.47	0.64	0.82
Electric machinery	0.16	0.19	0.28	0.32	0.34
Transport equipment	0.32	0.37	0.49	0.83	1.10
Cotton fabrics and yarn	0.12	0.12	0.19	0.18	0.27
Other textiles (including synthetics)	0.18	0.17	0.18	0.24	0.27
Processed beef	0.07	0.11	0.12	0.10	0.13
Iron and steel products	0.07	0.08	0.10	0.21	0.45
Vegetable and fruit juices	0.09	0.10	0.18	0.35	0.31
Footwear	0.17	0.18	0.17	0.28	0.35
Other	0.79	0.75	1.09	1.33	1.97
Other exports	0.21	0.38	0.28	0.18	0.16
	(Percentage changes)				
Total exports, f.o.b.	11.4	16.1	19.8	4.5	20.2
Primary products	9.8	21.7	13.7	-14.1	8.9
Semimanufactures	-3.4	-	23.8	36.5	33.1
Manufactures	12.6	7.7	37.6	32.3	31.5

SOURCE: Central Bank of Brazil.

3.2. Land Use

Land utilization is summarized in Table 3.2. It is noted that Brazil is one of the few remaining countries in the world with a large land area that has not yet been cultivated. Thus most of the increase in agricultural production has been achieved through area expansion. It is not clear how much longer this relatively easy option may be available. Scholars such as Homen de Melo suggest that after a further 10 years other means will need to be emphasized to increase production.

The composition of agricultural production is given in Table 3.3 for 1975.

One notes the large areas allocated to maize and soyabeans in 1975. These have undergone further substantial increase since that time. Similarly the area under sugar has increased under the recent energy substitution policies.

3.3. Supply estimates

Supply functions were estimated for nineteen of the twenty items listed in Table 3.3. The major sources of data used in the analysis were:

- FAO Supply Utilization Accounts containing information on production, usage, trade and producer prices of agricultural commodities;
- various issues of Anuario Estatistico do Brazil, used to correct and extend time series given by FAO and for data on items such as credits;
- various volumes of Conjuntura Economica, used for data on price indices,

The FAO supply Utilization Accounts contain data on about 600 commodities related to agriculture. Those commodities were aggregated to 19 aggregate commodities of FAP (table 3.5) and for each of them one quantitative measure was chosen. The measure metric tons is used for homogeneous commodities such as grains, bovine and ovine meat and milk. For commodities covering a wide range of different products (e.g. vegetables, fruits) the measure is U.S. $ of 1970. (See Table 3.3 for complete list of units.) Oil crops are expressed in terms of oil and protein components. For each of these the measure is metric ton of oil equivalent and metric ton of protein equivalent. Poultry and eggs are expressed in metric ton of protein equivalent. Fish is also quantified this way. The detailed description of the aggregation can be found in Fischer and Frohberg (1980) and also in Fischer and Sichra (forthcoming). The algorithm they use to aggregate data is flexible enough to modify the number and choice of commodities. For Brazil, commodities such as vegetables has been split into roots and tubers, pulses and vegetables. A common measurement unit U.S. $ (1970) is then used. Oilcrops were split into soyabean expressed in metric tons and the remainder of the oilcrops were expressed in U.S. $ (1970). Cottonseed was removed from the oil crops and is treated as a joint product with seed cotton.

In most instances the data covered the years 1964 to 1976 with a few years at either end for some commodities. This limited time series of approximately 12 years limited the number of explanatory variables for regression estimates. Also the supply functions are chosen to fit in with the overall general equilibrium model so that the introduction of additional variables was kept to a minimum. Most crops are modelled by two equations, one for area and the other for yield. In most instances the area variable is assumed to be a function of previous year's area, relative price of the particular commodity and credit availability. The specific details are given in Tables 4.1 to 4.8. In many instances the yield function is a time trend. This variable should be interpreted rather carefully. It serves as a surrogate for other variables which were increasing steadily over time, such as improved input ; fertilizer, pesticides, seeds. A number of

these technological factors are discussed by Homen de Melo (1980). At this stage of agricultural development, Brazil achieves most growth through increased area, so that more detailed yield functions are not deemed necessary for most commodities. For meat production herd size and slaughter estimates were made. Ideally one would like a more elaborate estimation scheme. In particular the modelling of substitution effects could be improved. The present system only treats this through composite price indices in most instances. Similarly land substitution is not treated at this stage. However in the general equilibrium model land constraints are introduced.

Individual commodity estimates are now discussed.

4. COMMODITY ESTIMATES

Note: all variables and units are given in Table 3.3.

4.1. Wheat

Area - Table 4.1, Yield - Table 4.2, Plot - Figure 4.1.

Wheat is particularly interesting from a policy point of view. It is the principal agriculture import and has been the subject of many government attempts to stimulate wheat area. (Area is a function of previous year area, relative prices of wheat and credit.) Wheat production has experienced large fluctuations due to disease and weather effects. This has been treated by using a dummy variable for the yield function. The three plots for area, yield, output are given in Figure 4.1.

4.2. Rice

Area - Table 4.1, Yield - 4.2, Plot - Figure 4.2

Rice is a staple that typically provides about 25% of the calorie and 15% of the protein intake. Rio Grande do Sol, Parana and Minas Gerais have been traditional rice growing areas. (In 1976 they accounted for 20, 10 and 11 % respectively of total rice production.) In recent years the area under rice in Mato Grosso has expanded rapidly, to account for 16 % of output in 1976. However, the yield here has been around 1.3 MT/ha compared to 3.7 MT/ha in Rio Grande do Sol. Ideally one should estimate a yield function for each of these regions. At the present stage of the analysis an average value of 0.98 MT/ha was chosen.

4.3. Maize

Area - Table 4.1, Yield - Table 4.2, Plots - Figure 4.1.

The rapid expansion of maize production has been one of the big success stories in recent years. This has been achieved through a significant area expansion while yields have increased from 14 to 16 MT/ha.

4.4. Roots and tubers

Area - Table 4.1, Yield - Table 4.2, Plots - Figure 4.4.

Roots make a major contribution to the diet of low income groups, particularly in the Northeast where they account for 25% of the calorie intake. Roots are difficult to estimate in most countries. In this instance the yield is estimated by step function. It is 2.3 MT/ha for the period 1967-72 and falling to 2.0 for the period 1973-77. It is not clear whether this fall in value may be attributed to real effects rather than a "data problem".

TABLE 3.1. POPULATION AND LABOUR FORCE IN 1000S

		AGR LABOUR FORCE	TOTAL LABOUR FORCE	POPULATION
BRAZIL	1962	12177	24100	
	1963	12351	24748	
	1964	12537	25420	
	1965	12742	26129	
	1966	12927	26852	
	1967	13119	27612	
	1968	13313	28396	
	1969	13511	29211	
	1970	13710	30052	
	1971	13888	30908	95993
	1972	14058	31790	98690
	1973	14221	32698	101432
	1974	14380	33642	104243
	1975	14533	34626	107145
	1976	14678	35604	110123
	1977	14818	36611	113208
	1978			116393
	1979			119670
	1980			123032

SOURCE: 1. Column 1 and 2; UNIDO based on UN statistics.
2. Column 3; Annuario Estatistico Do Brasil, 1978, IBGE

TABLE 3.2. LAND UTILIZATION

1000 HA

	1961-65	1966	1970	1975
BRAZIL				
Total Area	851197	851197	851197	851197
Land Area	845651	845651	845651	845651
Arab and Perm CR	30254	31910 F	33984	36600 F
Arable Land	22400	24000 F	26000	28500 F
Perm Crops	7854	7910 F	7984	8100 F
Perm Pasture	131880	141400 F	154138	170000 F
Forest and Wool	526800	522600 F	517000 F	510000 F
Other Land	156717	149741	140529	129051

SOURCE: FAO Production Yearbook. 1976
F Fao estimate

TABLE 3.3. Composition of Agricultural Production (1975)

	Unit	Quantity 10^6	Area 10^6 ha	Gross Production Producer price 10^9 Cr
1. Wheat	[MT]	1.788	2.932	2.77
2. Rice paddy	[MT]	5.19	5.306	12.78
3. Maize & oth. grains	[MT]	16.625	11.031	9.9
4. Roots & tubers	[US$]	4.965	2.386	7.31
5. Sugar cane	[MT]	91.525	1.969	6.49
6. Pulses	[US$]	0.465	4.345[1)]	4.38
7. Vegetables	[US$]	0.369	0.115[1)]	5.08
8. Fruits	[US$]	2.17	0.458	7.85
9. Bovine & ovine	[MT]	2.7	(85.4)[2)]	11.67
10. Pork	[MT]	0.822	(37.6)[2)]	2.64
11. Poultry & eggs	[MT]	0.121		7.23
12. Fish	[MT]	0.080		2.29
13. Dairy product	[MT]	10.048		14.96
14. Soybeans	[MT]	9.892	5.824	11.95
15. Oil crops	[US$]	0.435	1.471	1.62
16. Coffee green	[MT]	1.056	2.271	10.07
17. Cocoa & tea	[US$]	0.289	0.456	1.95
18. Industrial crops	[US$]	0.580	0.667	2.04
19. Cotton	[MT]	0.328	2.941	7.11
20. "Wood"				2.60
TOTAL				132.90

SOURCE: based on FAO supply utilization accounts
The unit US$ is in U.S. dollars 1970 see Table 3.4 for description of units.

[1)] The reported area of vegetables covers approximately 50% of the reported production. The reported area for fruits covers only the banana and melon component ofthe reported production.

[2)] million head

TABLE 3.4. BPM Commodity Aggregates

Commodity	Unit of measurement	Most important commodities included
1. Wheat	10^3 ton	Wheat
2. Rice	10^3 ton milled rice	Rice
3. Maize & other grains	10^3 ton	Maize, Oats, Rye, Barley, sorghum
4. Roots & tubers	10^6 US$ (1970)	Sweet potatoes, Potatoes, cassava
5. Sugar cane	10^3 ton	Sugar cane
6. Pulses	10^6 US$ (1970)	Beans, Broad Beans, Peas
7. Vegetables	10^6 US$ (1970)	Garlic, Onion, Tomatoes, Pepper, other vegetables and condiments
8. Fruits	10^6 US$ (1970)	Fruits, Nuts (not for oil)
9. Bovine	10^3 ton (carcass weight)	Cattle, Buffalo, Mutton, Goat
10. Pork	10^3 ton (carcass weight)	Pork
11. Poultry	10^3 ton (protein e.g.)	Poultry, Eggs 1/
12. Fish	10^3 ton (protein e.g.)	Fish inland and 2/
13. Dairy products	10^3 ton (milk e.g.)	Milk
14. Soybeans	10^3 ton	Soybeans
15. Oil crops	10^6 US$ (1970)	Groundnuts, coconuts, palm kernels, olives, castor beans
16. Coffee	10^3 ton green coffee	
17. Cocoa	10^6 US$ (1970)	Cocoa, Tea
18. Industrial crops	10^6 US$ (1970)	Tobacco, sisal
19. Cotton	10^3 ton	Seed cotton

1/ 1 MT of protein equivalent equals 8.3 MT of chicken meat or 9 MT of eggs

2/ 1 MT of protein equivalent equals 10 MT of fish

3/ U.S.$ units refer to value of commodity aggregated by using average 1969-71 world export prices.

TABLE 3.5. IIASA and BPM Classification

The correspondence between IIASA and BPM classification:

IIASA commodities	BPM commodities
1. Wheat	1. Wheat
2. Rice	2. Rice
3. Coarse grain	3. Maize and other grains
4. Animal fats and oils vegetable oils	15, 14, 19, oilcrops, soybean, cotton seed
5. Protein feed	15, 14, 19, oilcrops, soybean, cotton seed
6. Sugar	5. Sugar cane
7. Bovine and ovine	9. Bovine and ovine
8. Pork	10. Pork
9. Poultry and eggs	11. Poultry and eggs
10. Dairy product	13. Dairy product
11. Vegetables	7, 4, 6, vegetables, roots, tubers, pulses
12. Fruits	8. Fruits
13. Fish	12. Fish
14. Coffee	16. Coffee
15. Cocoa, tea	17. Cocoa, tea
16. Alcoholic beverages	39. Alcoholic beverages
17. Clothing fibres	19, 9, 10, seed cotton, cattle hides, pig hides
18. Industrial crops	18. Industrial crops
19. Non-agriculture	20, 21-46 Wood, agro-food industry, industry, fertilizer, manufacturing, services, construction, transportation, energy

4.5. Sugar

Area - Table 4.5, Yield - Table 4.6, Plot - Figure 4.5.

Area under sugarcane rose steadily in the 1970's to 2.5 million ha in 1979. However the recent energy policy initiatives suggest that these may be doubled by 1985. Yield estimation poses a number of difficulties. About 50% of the production in the 1970's comes from Sao Paulo where yields are relatively high, around 65 MT/ha. Much of the future expansion can be expected from new land with yields around 40 MT/ha. The functional form chosen has both a time trend and a price variable. The latter reflects the price received by sugar producers discounted by an index of input costs.

4.6. Pulses

Area - Table 4.1, Yield - Table 4.4, Plots - Figure 4.6.

Pulses pose a dilemma for long term modelling. The area under pulses has shown modest increase in the early seventies; however, the yield has been falling. The area is modelled by a linear form while yield is assumed to remain constant at the average 1973-77 level.

4.7. Vegetables

Area - Table 4.5, Yield - Table 4.6, Plots - Figure 4.7.

The area under vegetables has remained relatively stable, while yields in recent years have shown some increases. Ideally one should disaggregate to capture varying composition effects.

4.8. Fruits

Production Table 4.7, Plot - Figure 4.8.

Fruits are one of the great success stories in recent years, with Brazil now achieving a major share of world exports of bananas and citrus fruits and a dominant role for orange juice.

4.9. Bovine and Ovine Animals

Production Table 4.8, Plot - Figure 4.9.

Bovine and ovine animals are modelled by two equations. The herd size is largely determined by that of the previous year together with various credits, while the quantity of meat produced (slaughtered) is largely determined by the herd size. The production structure in Brazil is primarily range feeding, so that rainfall and the relation to grazing availability might be added in a more sophisticated analysis.

4.10. Pork

Production Table 4.5, Plot - Figure 4.10.

Pork forms a major component of the meat intake of low income groups. Again, herd size is largely determined by previous year herd size, price and credit availability, while production is taken as a fixed proportion of herd size.

4.11. Poultry and Eggs

Production Table 4.8, Plot - Figure 4.11.

Poultry and eggs production is modelled by lagged price and credit availability. This production complements the rapid rise in feed grain availability and also is quite suited to the Northeast, where there have been substantial gains in

recent years. The domestic demand has also risen due to higher income levels and expenditure elasticity close to one.

4.12. Fish

Production Table 4.8, Plot - Figure 4.12.

Fish production is modelled by lagged price and a time trend which is reasonably close to population growth rate. There have been a number of recent efforts to increase both inland and offshore production. It is not evident at this writing that these attempts will fulfill their aspirations.

4.13. Dairy

Production Table 4.8, Plot - Figure 4.13.

Dairy is modelled by first estimating herd size and generating the milk output from this. Herd size is a function of previous year herd, credit and lagged price. Credit policy is a major instrument to stimulate output and to stabilize incomes of milk producers.

4.14. Soya

Area - Table 4.3, Yield - Table 4.4, Plot - Figure 4.14.

Soya has undergone a phenomenal growth in the 1970s. This has been achieved by both area and yield expansion. Area expansion has been achieved by government providing infrastructure, favourable prices and credit availability. The investment in infrastructure is not modelled directly. A nonlinear functional form is used for the yield estimate on the assumption that the recent sharp increase will approach 2 MT/ha asymptotically. This value is based on current estimates for world yield.

4.15. Oil Crops

Area - Table 4.3, Yield - Table 4.4, Plot - Figure 4.15.

The area under oil crops has been declining since 1970-72 partly due to substitution for soya. The model assumes a constant level of 1.55 million ha. based on the last four years of data, 1973-76. This pragmatic approach is used for the overall model runs over the time span 1975 onwards.

4.16. Coffee

Area - Table 4.5, Yield - Table 4.6, Plots - Figure 4.16.

Coffee plays a critical role in the Brazilian economy. Brazil is the world's largest exporter and as such plays a leading role in establishing price levels. Domestic policy is designed to adjust stocks to take advantage of this market leader position. Weather has also played a major role in both the area harvested and yield. The area is estimated by using the previous year's area and price. Yield variations are treated by including a dummy. This, for instance, picks up the sharp fall due to the frost of 1974-1975. Stock adjustments are included in the overall model.

4.17. Cocoa

Production - Table 4.7, Plot - Figure 4.17.

Cocoa is a relatively specialized commodity controlled by an extremely limited number of producers. Total production is estimated as a function of the previous year output, a time trend and lagged price ratio. Ideally one would like to include longer lags to allow for the time required to reach fruit bearing age

but data availability did not permit this.

4.18. Industrial Crops

Area - Table 4.5, Yield - Table 4.6, Plots - Figure 4.18.

Industrial crops refer primarily to tobacco; the area estimate includes a modest positive time trend of 0.01 MT/ha per year and a relatively strong positive price coefficient of 0.18. The yield is modelled by choosing the average value over the 1967-1976 period.

4.19. Cotton

Area - Table 4.5, Yield - Table 4.6, Plot - Figure 4.19.

Cotton is a major crop. It provides significant employment both directly in production and also through its role as a raw material for the textile industry. It also has a number of important joint and byproducts which include cottonseed oil, and cake used extensively for animal feed. Again there are strong regional differences in production technique. Arboreal cotton is mostly produced in Ceara and the northeast where yields average 170 kg/ha. while the herbaceous variety produced mainly in Sao Paulo and Parana has yield of around 1 MT/ha. In this analysis the area is a function of previous year's area and price while sharp changes in yield due to disease, for instance, are picked up by a dummy variable. In the general model some of the linkages are modelled through an input-output type of approach.

4.20. Wood

This item is used primarily as a residual in the general framework. In the overall economy a substantial amount of energy is provided by charcoal. The total contribution is estimated at 2.2×10^9 cr. for 1975 by using the input output framework. This is discussed further in the working paper on the Social Accounting Matrix.

The set of figures given shows the observed (OBS) and computed (COM) values for most commodities. They indicate how much the agricultural output has been changing, both in overall quantity and in terms of its composition. Some of these trends are now discussed.

5. TRENDS

Most of the gains in agricultural output have been achieved through increased acreage while yield improvements have not contributed very much in most instances. Individual commodities are first discussed. Trends are based on the period 1967-1977 unless otherwise stated.

5.1. Wheat

Figure 4.1.

Acreage has increase from 1 to 3 million ha. over the period 1967-77. Production has varied erratically due to disease and weather primarily. Average yields have rarely gone above the 1 MT/ha level.

5.2. Rice

Figure 4.2.

Acreage has increased from 4.5 to over 6 million ha, with production going from 4.5 to around 6 million tons. Average yield gain was negligible. This was partly due to different regional effects, when much of the expansion was in new

Table 4.1. Cereals and roots. Area estimation.[1)]

Dependent Variable	Area $_{t-1}$	Price $_{t-1}$	Credit $_{t-1}$	Time	Dummy	Constant	$\bar{R}^2$ (DW)	SE
Wheat	0.6214	0.3282	3.337					0.3706
	(0.2742)	(0.1942)	(2.518)				(1.99)	
Rice	0.8262	1.911		0.1369		-2.987	0.75	0.3637
	(0.3286)	(0.7397)		(0.0549)		(2.143)	(1.79)	
Maize	0.7432	2.141[2)]	17.86					0.3323
	(0.166)	(1.417)	(8.138)				(2.45)	
Roots	0.8660	0.3472			-0.1957[3)]			0.0249
	(0.0228)	(0.0533)			(0.0256)		(2.3)	

[1)] This note applies to Tables 4.1 and 4.3.
All equations are estimated in the linear form unless stated otherwise.
Area is harvested area expressed in 10^6 ha. Price is a ratio of the price received by farmers for a given commodity to total price received by farmers for the crops unless stated otherwise. Credit is value of credit for a given commodity expressed in mill. current cruzeiros discounted by the GDP implicit price deflator, divided by harvested area of the commodity. The variable Time equals 0 for the year 1960 and increases by one per year. It is a proxy for such monotonic time-related effects as growth in infrastructure, mechanization. The dummy variable reflects weather and disease effects.

[2)] Price is a ratio of the prices received by farmers for maize to the total price received by farmers for all agricultural output.

[3)] Dummy = 1 for 1974, otherwise zero.

Table 4.2. Cereals and roots. Yield estimation.[1)]

Dependent Variable	Time	Dummy	Constant	$\bar{R}^2$ (DW)	SE
Wheat	0.02583	-0 4908[2)]	0.6749	0.78	0.0979
	(0.0096)	(0.076)	(0.105)	(2.0)	
Rice[3)]			0.978		
Maize	0.02078		1.202	0.71	0.0669
	(0.003)		(0.034)	(1.9)	
Roots[4)]	for 1967-72		2.331		
	for 1973-74		2.019		

[1)] This note applies to tables 4.2., 4.6.
All equations are estimated in the linear form.
Yield is expressed in units as described in Table 3.3. per ha.
Time equals 0 for the year 1960 and increases by one per year. It is a proxy for technological advances.
The dummy variable represents weather and major disease effects.

[2)] Dummy equals 1 for the years 1972, 1975, otherwise 0.

[3)] For rice the mean value for the period 1966-1977 is taken.

[4)] For roots two mean values are taken corresponding to the periods 1967-72 and 1973-77.

Table 4.3. Pulses and Oilcrops. Area estimation.

Dependent Variable	Area $_{t-1}$	Price $_{t-1}$	Credit $_{t-1}$	Time	Dummy	Constant	$\bar{R}^2$ (DW)	SE
Soybean	0.5258	4.945	15.43			-5.465	0.99	0.1488
	(0.0678)	(1.044)	(1.041)			(1.081)	(2.37)	
Oilcrops[1)]						1.552		
Pulses[2)]	0.7484	0.2019				0.4034	0.54	0.05258
	(0.2244)	(0.0827)				(0.3085)	(2.4)	

1) For oilcrops the mean value for the period 1972-1976 is taken.

2) Pulses are estimated in logarithmic form.

Table 4.4. Pulses and Oilcrops. Yield estimation.[1)]

Dependent Variable	Form	
Soybean	$1 + 1/(1 + e^{-0.4(t-13.51)})$	
Oilcrops[3)]	0.1086	
Pulses[2)]	1967-72	0.128
	1973-77	0.101

1) Yield is expressed in units as described in Table 3.3 per ha.

2) For pulses mean value for period 1967-72 and 1973-77 is taken.

3) For oil crops mean value for period 1966-76 is taken.

Table 4.5. Non-cereals. Area estimation.

Dependent Variable	Area $_{t-1}$	Price $_{t-1}$	Credit $_{t-1}$	Time	Dummy	Constant	$\bar{R}^2$ (DW)	SE
Sugar cane	0.9289			0.01553				0.06606
	(0.05728)			(0.0081)			(2.13)	
Vegetables	0.6931	0.03591[2)]						
	(0.13)	(0.014)					(2.56)	
Coffee	0.8076	0.5159[2)]			-1.201[4)]			
	(0.0272)	(0.0693)			(0.121)		(1.25)	
Industrial crops	0.01084	0.1834				0.5240	0.77	0.036
	(0.004)	(0.056)				(0.045)	(2.6)	
Cotton[3)]	0.9479	0.7695						0.1009
	(0.0324)	(0.4)					(1.98)	

1) For industrial crops the mean value 0.6297 was chosen based on the period 1967-76.

2) Price is a ratio of prices received by farmers for coffee over the total price received by farmers for all agricultural output.

3) Cotton is estimated in the logarithmic form.

4) Dummy equals 1 for the year 1976, otherwise 0.

Table 4.6. Non-cereals. Yield estimation.

Dependent Variable	Time	Price $_{t-1}$[1)]	Dummy	Constant	$\bar{R}^2$ (DW)	SE
Sugar cane	3.343 (0.657)	10.52 (2.49)		-28.58 (15.1)	0.95 (2.3)	0 68
Vegetables	0.1147 (0.021)			1.482 (0.263)	0.93 (2.11)	
Coffee	0.01716 (0.006)		-0.1874[2)] (0.047)	0.2791 (0.069)	0.61 (1.7)	0.06868
Industrial Crops[1)]				0.6297		
Cotton		0.02204 (0.011)	-0.0104[3)] (0.0045)	0.07814 (0.012)	0.53 (1.96)	0.00558

[1)] Price is a ratio of the price received by farmers for a given commodity to price of inputs for a given commodity.

[2)] Dummy equals 1 for year 1976, otherwise 0.

[3)] Dummy equals 1 for the years 1971, 1976, otherwise 0.

Table 4.7. Cocoa and Fruit. Production Estimate.[1)]

Dependent Variable	Production$_{t-1}$	Price$_{t-1}$	Time	Constant	$\bar{R}^2$ (DW)	SE
Cocoa	0.5347 (0.068)	0.0572 (0.008)	0.004518 (0.001)		(2.55)	0.00947
Fruit	0.8309 (0.2255)		0.02114 (0.01723)	0.1687 (0.1193)	0.98 (2.75)	68.39

[1)] All equations are estimated in the linear form.
Production is expressed in 10^6 units as described in Table 3.3. Price is a ratio of the price received by farmers for a given commodity to toal price received by farmers for crops. The variable Time equals 0 for the year 1960 and increases by one every year. It is a proxy for infrastructure, mechanization.

Table 4.8. Meat, Dairy, Fish. Production estimate.[1)]

Dependent Variable	Herd $_t$	Herd $_{t-1}$	Credits $_t$	Credits $_{t-1}$	Price $_{t-1}$	Time	Constant	$\bar{R}^2$ (DW)	SE
Bovine:									
a) Herd		0.7678		8.924[2)]			16.58	0.99	0.8229
		(0.0714)		(2.59)			(4.58)	(1.66)	
b) Meat		0.02206			0.8199[5)]				0.09726
		(0.006)			(0.4228)			(2.38)	
Pork:									
a) Herd		0.8339		0.3852[2)]	4.293[6)]				0.6499
		(0.0937)		(0.1332)	(2.353)			(2.22)	
b) Meat[8)]	0.217								
Dairy products:									
a) Herd		0.6575		0.005878[3)]	2.316[6)]				
		(0.2989)		(0.0025)	(2.114)			(2.34)	
b) Milk[9)]	0.963								
Poultry and Eggs			0.07534[4)]		0.04397[6)]				0.003302
			(0.0043)		(0.0052)			(2.7)	
Fish					0.01982[7)]	0.02322	0.116	0.98	0.0146
						(0.0044)	(0.0043)	(0.014)	(2.3)

[1)] All equations are in the linear form.
Herd is expressed in 10^6 heads. Production is expressed in 10^6 units as described in Table 3.3. Credit is either in mill. or thousand cruzeiros per MT.

[2)] Credit is total value of credit in mlln. current cruzeiros for acquisition of animals for meat production discounted by the GDP implicit price deflator.

[3)] Credit is a total value of credit in mlln. current cruzeiros for acquisition of animals for milk production discounted by the GDP implicit price deflator.

[4)] Credit is a total value of credit in mlln. current cruzeiros for improved production discounted by the GDP implicit price deflator, divided by total meat production.

[5)] Price is a ratio of the price received by farmers for the particular meat over the total price for meat.

[6)] Price is a ratio of the price received by farmers for the particular meat over the total price for all agricultural output.

[7)] Price is a ratio of the producer price of fish over the general

[8)] Estimated as a proportionality constant for 1975, 1976.

[9)] Estimated as a proportionality constant for 1967-1976.

lands with relatively low yields.

5.3. Maize

Figure 4.3.

Here production increased from 13 to 20 million MT. This gain of 54% was accomplished by a 28% increase in area and a 26% increase in yields.

5.4. Roots

Figure 4.4.

Here there was some fall in production from 5.6 to 4.8 million units. Most of this may be attributed to a fall in yield of 15% over this period.

5.5. Sugar

Figure 4.5.

Production increased from around 60 to 140 million MT of cane over the period 1961-1969. During this period the area went from 1.4 to 2.5 million ha. Yields showed only slight gains up to 1975 when the average was 46.5 MT/ha. However, in recent years they have begun to increase steadily to 55 MT/ha (1979). In view of the high degree of interest in expanding sugar production further, this commodity needs more detailed analysis.

5.6. Pulses

Figure 4.6.

Here output has shown a modest decline from 0.49 to 0.46 million units. This resulted from a 14% decline in yield over the period, which was partly offset by some increase in area.

5.7. Vegetables

Figure 4.7.

Vegetable production increased by about 50% over this 10-year period. For this commodity most of the gain was achieved through yield improvement, which accounted for 80% of this increased production.

5.8. Fruits

Figure 4.8.

Production increased by almost 100% over the period 1967 to 1976. This was due to substantial increases in banana and citrus fruits. The government provided strong incentives to stimulate these commodities, particularly wth a view to exploiting the export potential.

5.9. Bovine and Ovine Animals

Figure 4.9.

Generally, improved production can be achieved by increasing the herd size and improving individual animals. These two approaches roughly correspond to capital widening and capital deepening. In most instances both are used. However in the Brazilian situation the increase of 30% in production was achieved almost completely by increasing the herd size. This is in turn attributable to the technology of beef production in Brazil, which predominately is range fed.

5.10. Pork

Figure 4.10.

Here production increased by 24% over the period. Again most of this was achieved by increasing the stock size, while carcass weight remained virtually unchanged.

5.11. Poultry and Eggs

Figure 4.11.

Production increased steadily over the period for an overall gain of 90%. Again the gain in meat and egg production was achieved through increase in stock with average carcass weight and egg yield per bird showing little change.

5.12. Fish

Figure 4.12.

Fish shows a steady increase over the period of 1968 to 1975. However, data for this commodity poses many difficulties due to the wide variety of species and the absence of an accurate reporting system.

5.13. Dairy

Figure 4.13.

Dairy production increased by 70% over the period (1964-76) This was achieved by increasing the dairy herd. The yield per animal remained essentially unchanged during this period at 800 kg/animal.

5.14. Soya

Figure 4.14.

Soya is another of the great success stories of the 1970s. In 1970 the area under soya beans was less than 1 million ha. This had increased to more than 6 million ha by 1977. Yield also increased substantially during this period, by about 8% annually.

5.15. Oil Crops

Figure 4.15.

Oil crops output fell by 20% over this period. Most of this fall may be attributed to lower acreage over this period, with yields showing a cyclical behaviour around 0.108 units/ha.

5.16. Coffee

Figure 4.16.

For coffee the harvested area has been falling steadily at around 2% per annum over this period, while yields have varied erratically but with an underlying upward trend of about the same magnitude.

5.17. Cocoa

Figure 4.17.

The harvested cocoa production has an underlying upward trend. However, strong variations in international prices are reflected in output level fluctuations. Production in the period 1967 to 1976 has gone from around 0.23 to 0.28 million units.

5.18. Industrial Crops

Figure 4.18.

Here the output remained around the 4.5 million unit level up to 1974. Since then it has increased rapidly, primarily due to increases in tobacco, for which acreage rose to 311,000 ha in 1977.

5.19. Cotton

Figure 4.19.

Cotton does not follow as clear-cut a pattern as most of the other crops. From 2.7 million ha in 1967 it rose rapidly to 3.8 million ha in 1970. Since then the acreage has fallen steadily to 2.5 million ha in 1976. Yields have fluctuated erratically during this period from 0.085 to 0.110 MT/ha. Production accordingly has varied to a high of 0.4 million in 1969 back down to 0.24 in 1976.

6. SUMMARY

From this admittedly cursory analysis a few broad features appear. First is that agriculture in Brazil is an extremely vital sector with a strong growth record and potential for further substantial increase.

Crops

For most commodities production has increased substantially during the period 1967 to 1976. The more notable exceptions are roots, pulses, cotton and oil crops.

Production gains have been achieved through area expansion with yields generally showing little increase. Here the exceptions were vegetables and soya beans, which experienced significant yield gains.

Meat and Dairy

Substantial gains were achieved largely through increases in stock numbers. In most instances yield per unit has not changed significantly.

The overall implications are twofold. During the immediate future, say 5 to 10 years, production can be increased by bringing more land under cultivation or, in the case of beef, increasing the range land available. Increasing this land area requires substantial investment in infrastructure. Ironically the relatively low yields may be considered in a positive light. They offer excellent opportunity for increase by using improved but also costlier inputs such as fertilizers, pesticides and herbicides.

From the supply side prospects are that agriculture can continue to grow at approximately the rate of the period 1966-76 when annual growth was around 5%. This will be achieved by continued investment in infrastructure, attractive producer prices and credit availability, and availability of inputs.

This supply will need to be complemented by an appropriate demand policy. Here the problem may be complex. While much of the effective demand can be generated domestically, there will be increasing dependence on export markets. Demand will be addressed in a separate working paper, while both sides are equilibriated in the general equilibrium model in a further paper.

Policy Issues

These supply functions suggest a number of policy issues. At one level one may indicate what output changes can be expected from changes in producer prices or level of credits. Since much of the gains have been achieved through area expansion, it is of interest to estimate how much more investment will be needed to continue along these lines.

An alternate question is to evaluate the costs required to increase yield levels. This would require significant technological shifts, which would need higher usage of fertilizer, pesticides and herbicides. It seems that Brazil will be obliged to face this issue within the next ten years.

A next set of issues of immediate concern are the prospective increases in the use of crops such as sugar and soya for energy.

At the macro level one may ask: what are the advantages and disadvantages of government production subsidies to agriculture vis-a-vis manufacturing? Similary, one may investigate consumption subsidies. Currently wheat is the most important commodity in this category.

These policy issues will be addressed in the general equilibrium model framework.

APPENDIX

Plots of Supply Function

Unless otherwise specified, units are as defined in Table 3.3. for output. Yields are given in corresponding units per hectare.

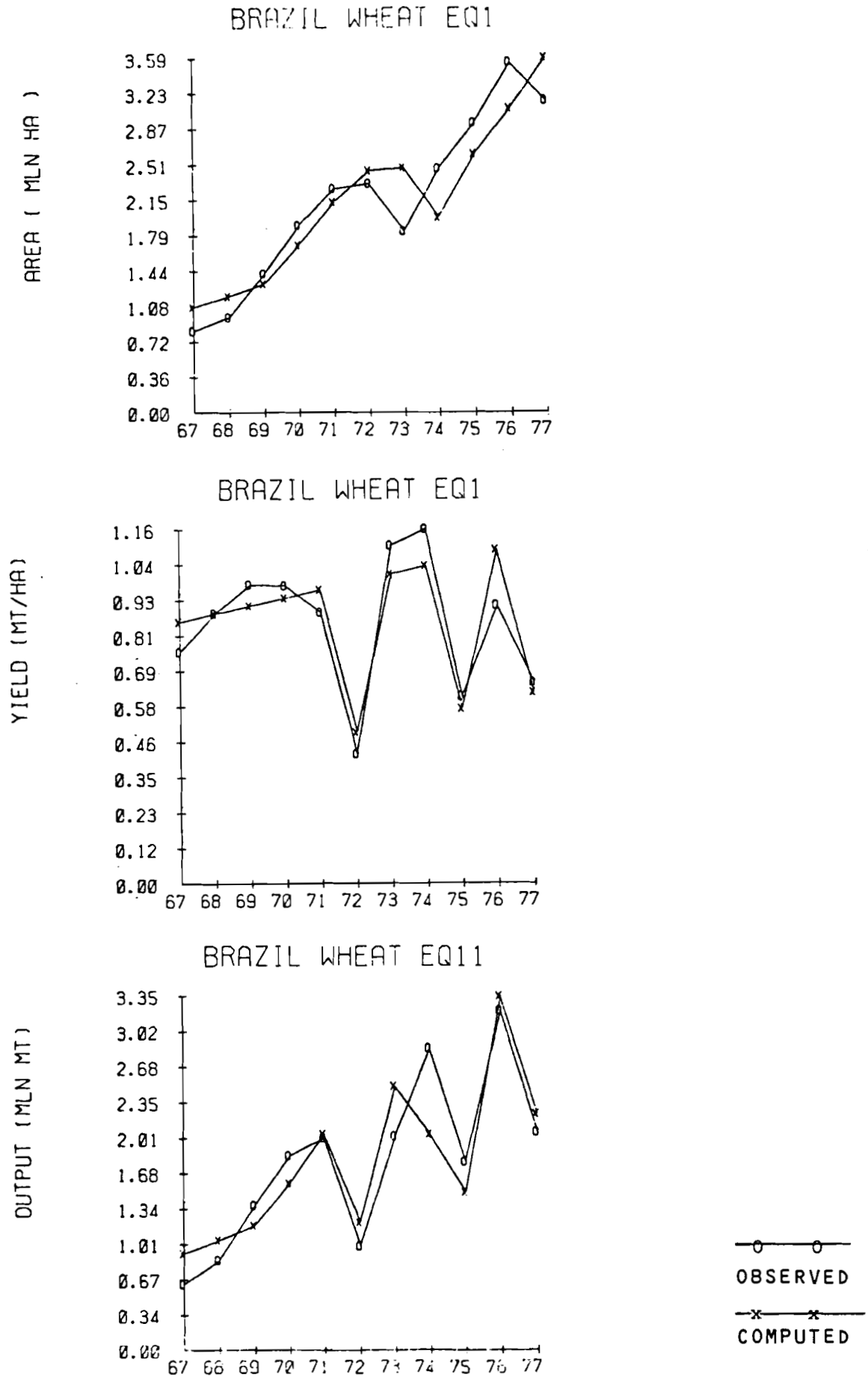


Figure 4.1. Wheat

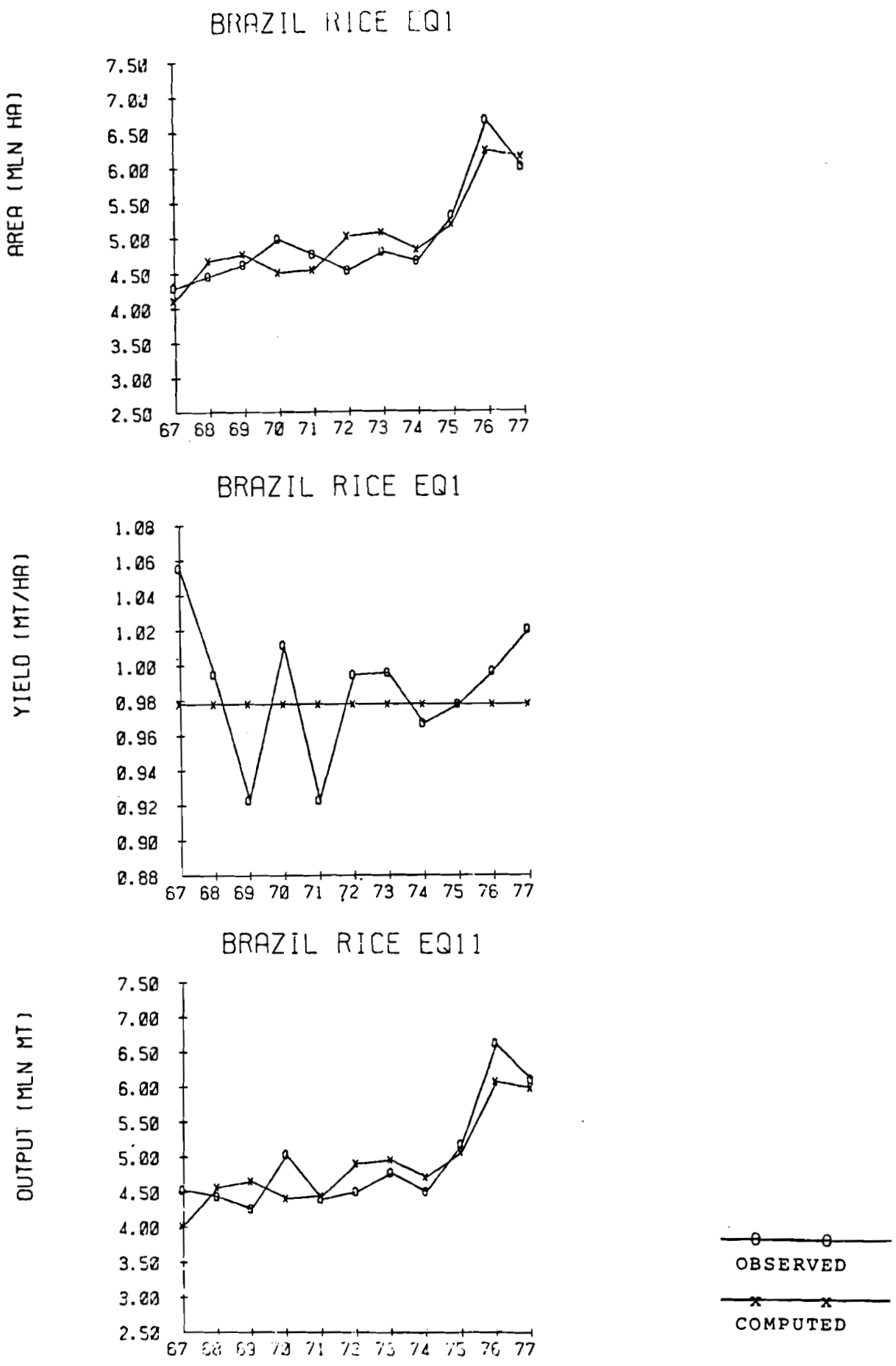


Figure 4.2. Rice

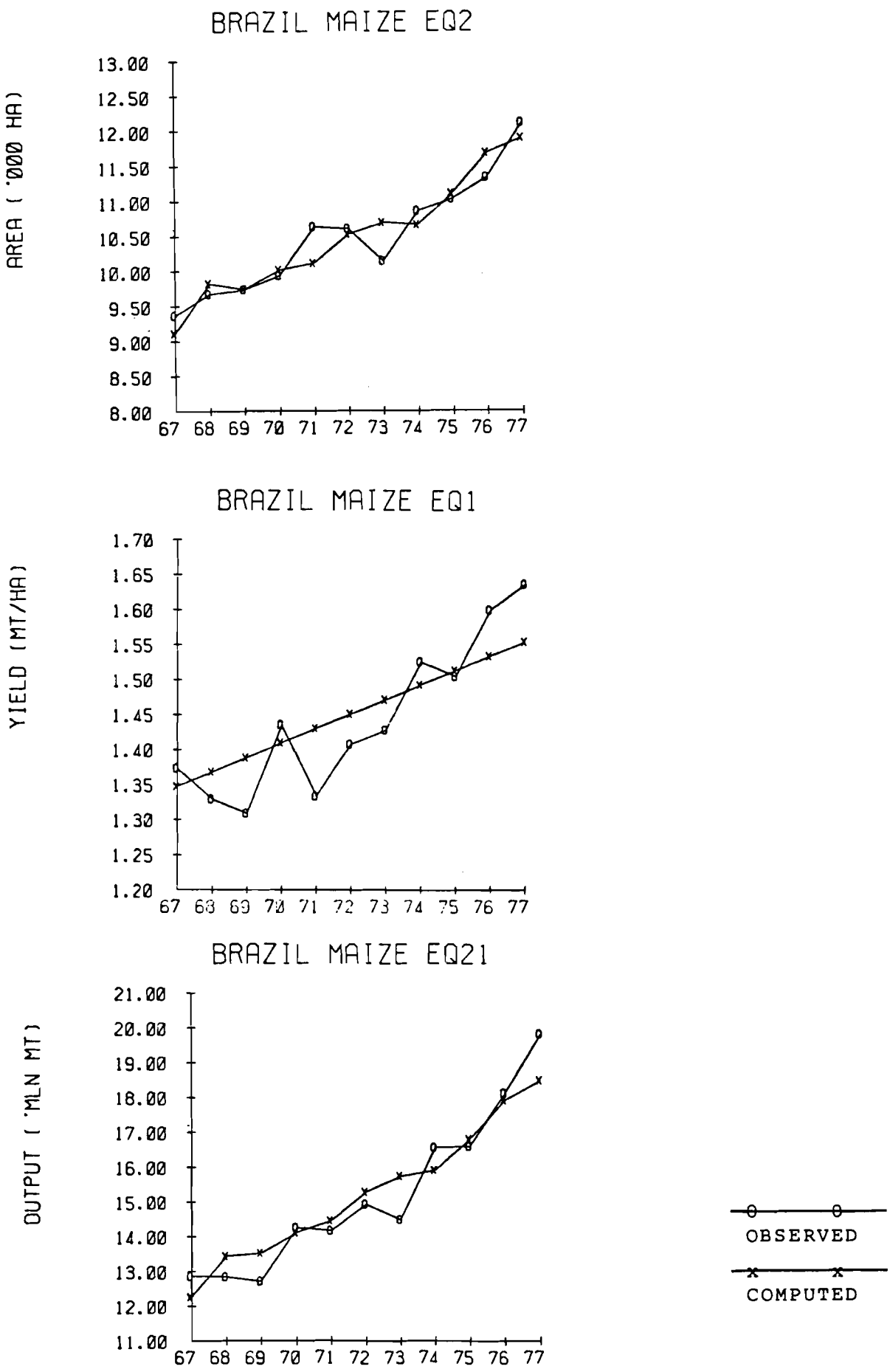


Figure 4.3. Maize

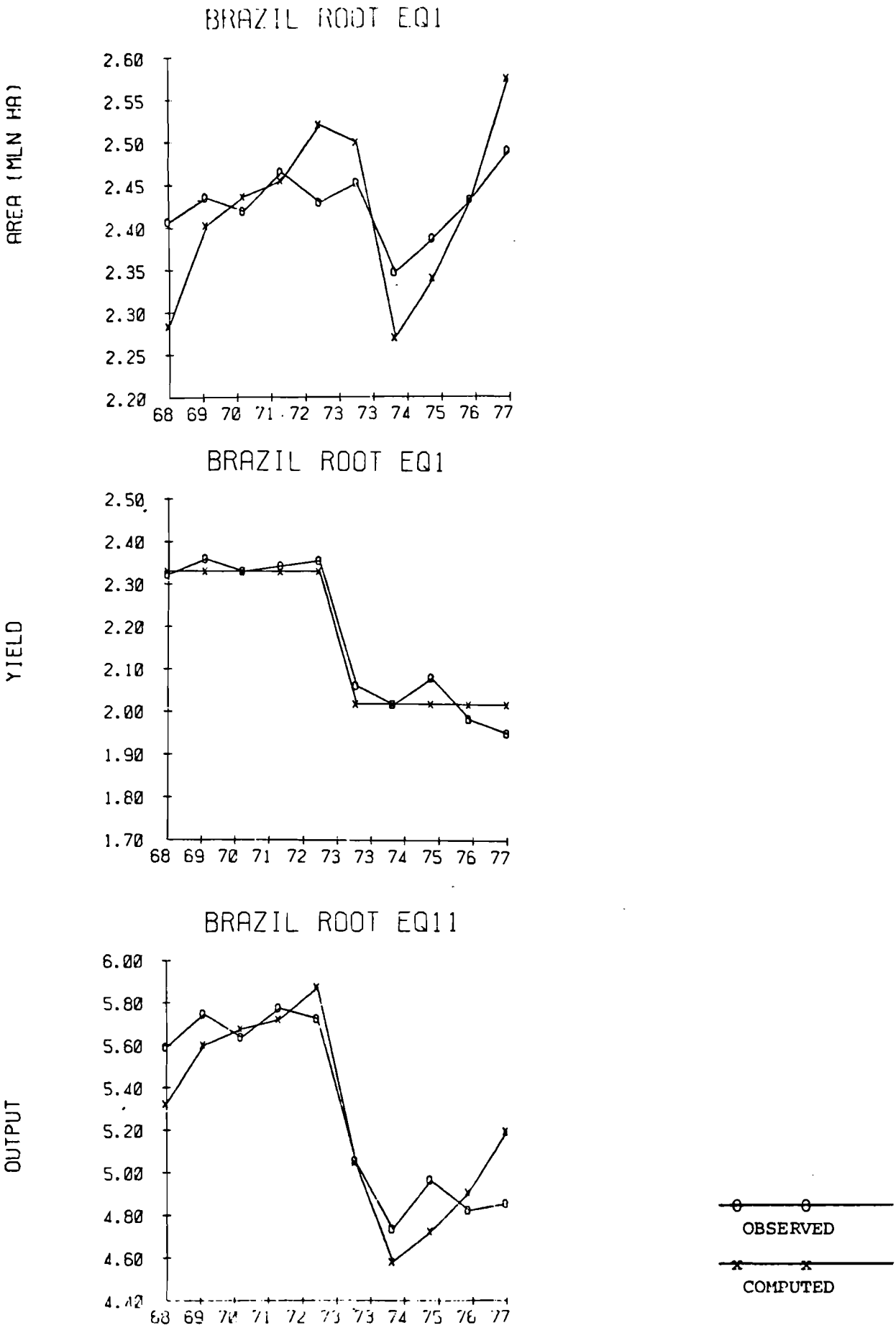


Figure 4.4. Roots

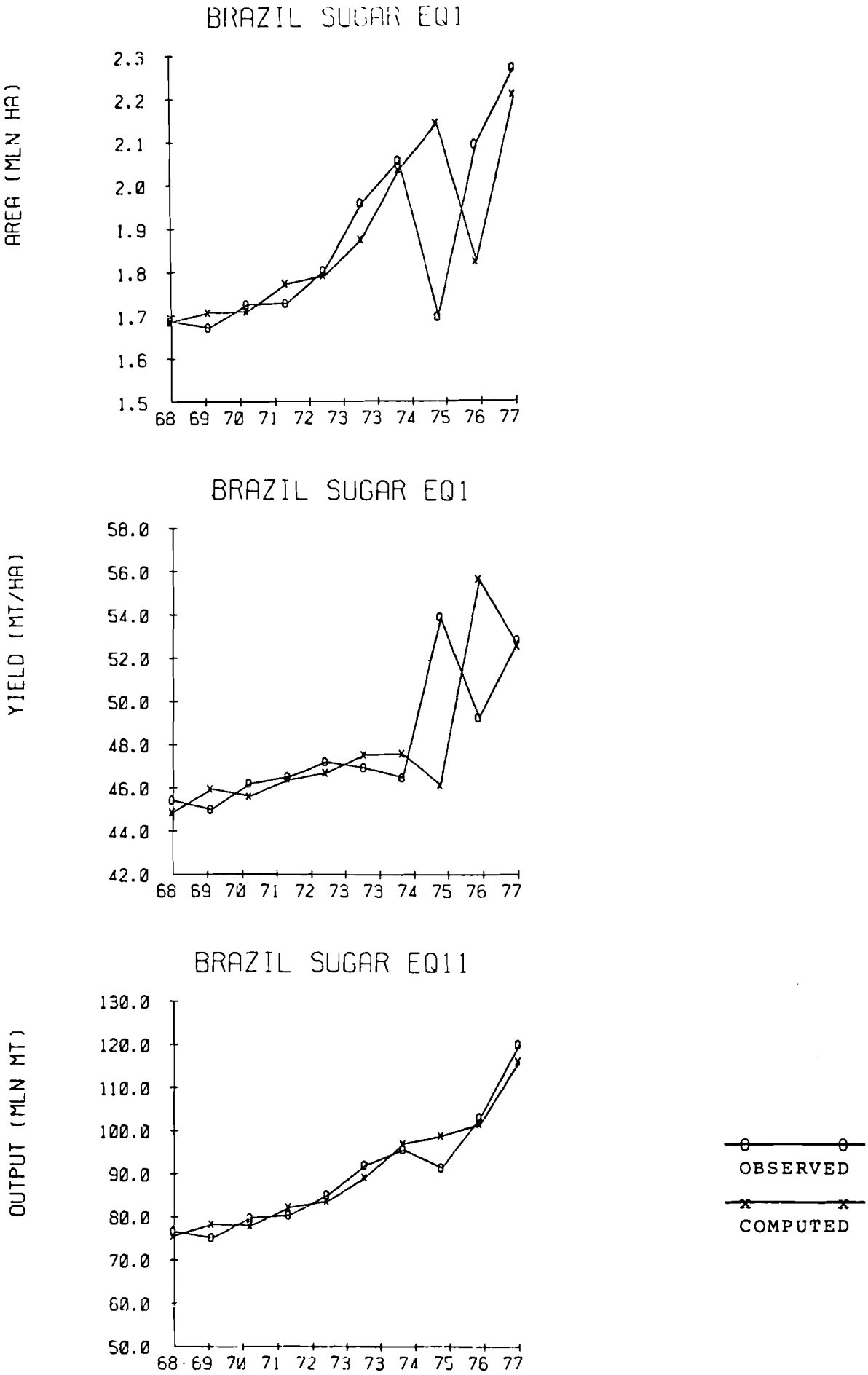


Figure 4.5. Sugar Cane

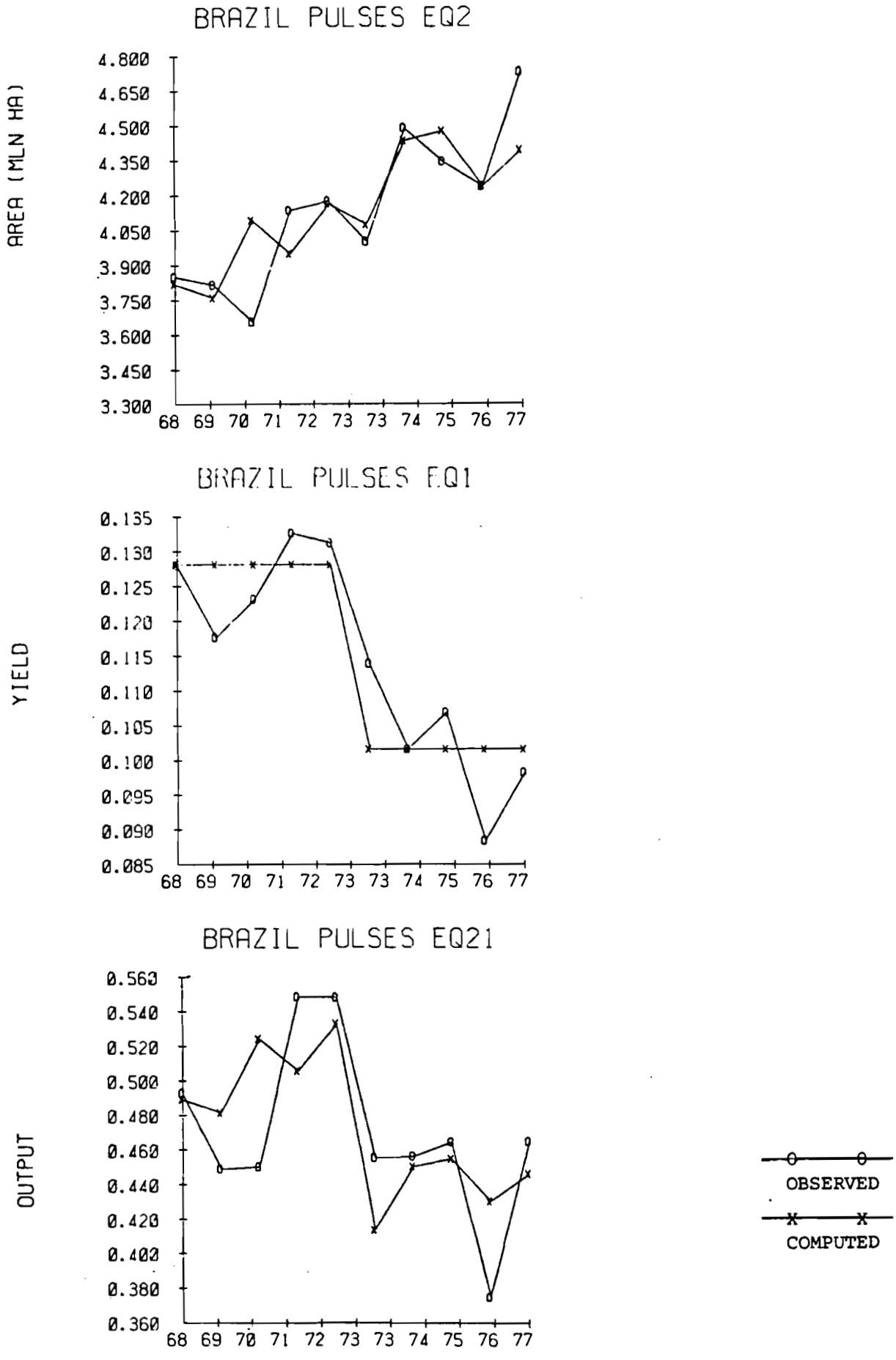


Figure 4.6. Pulses

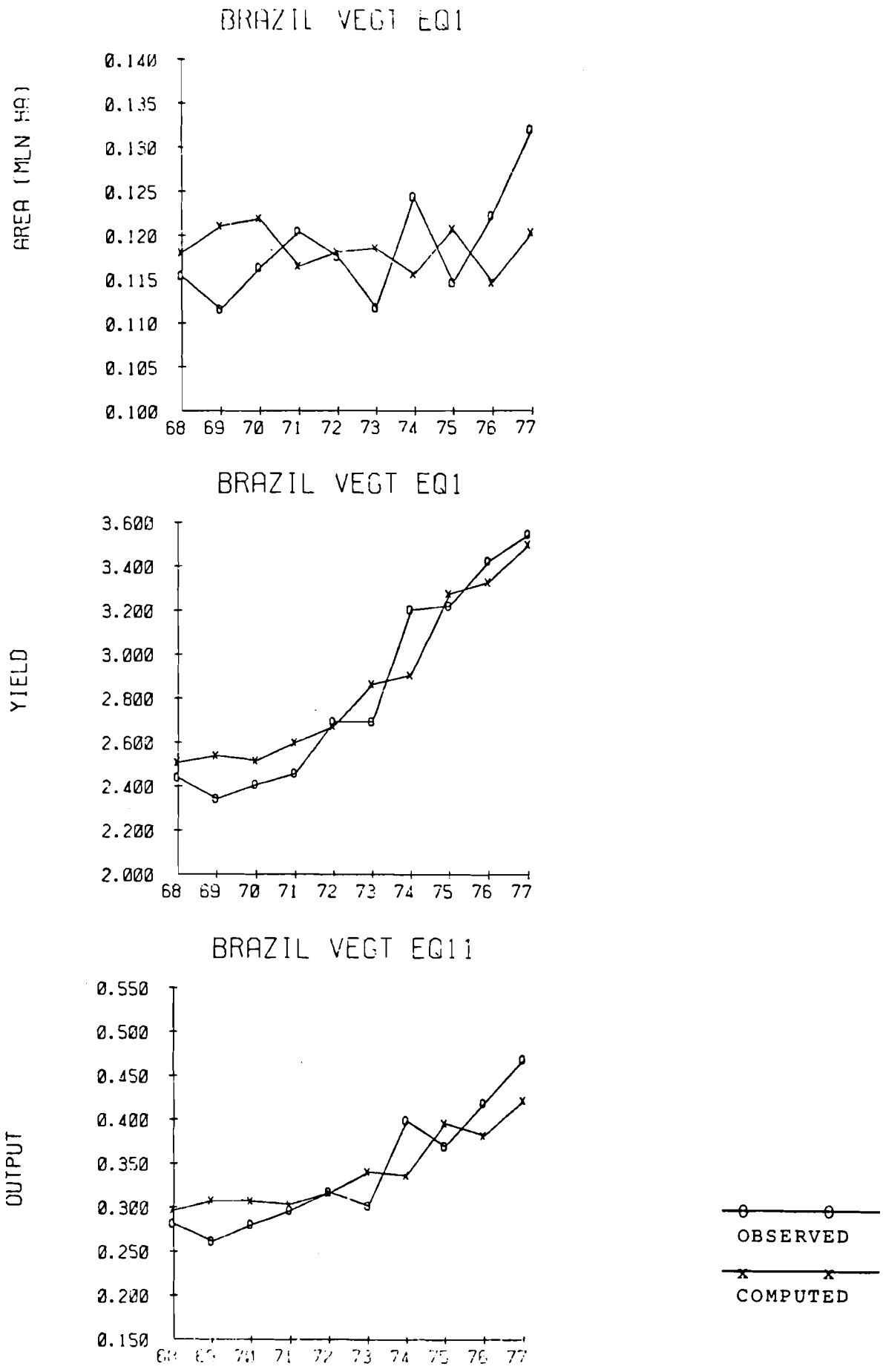


Figure 4.7. Vegetables

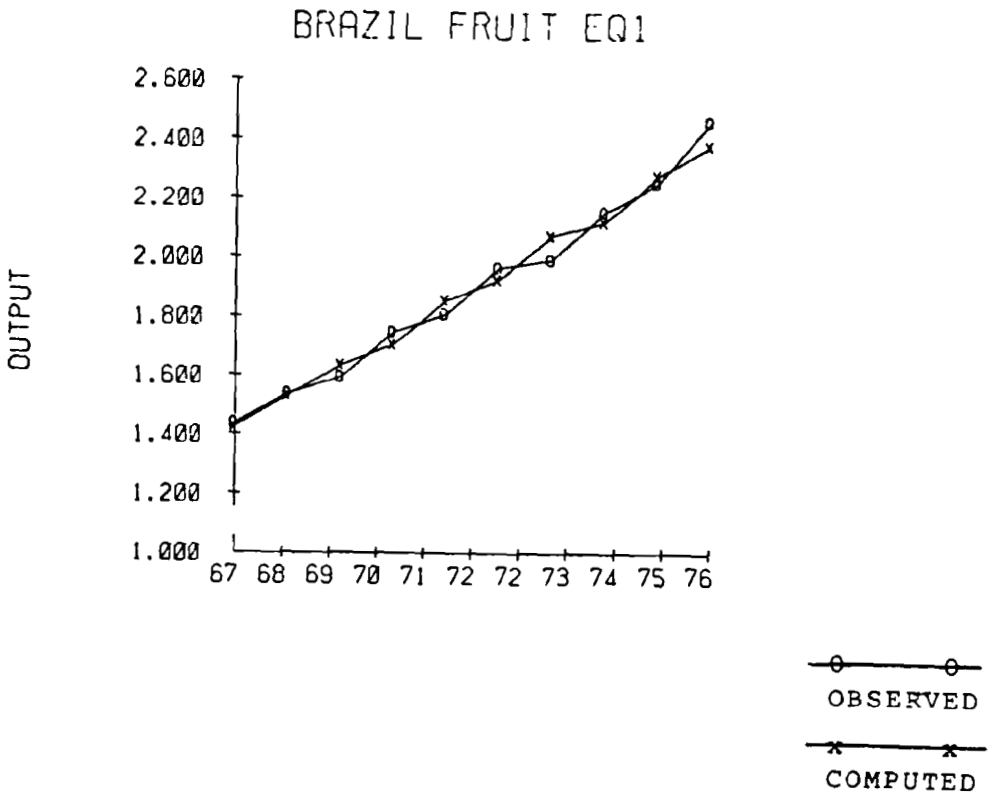


Figure 4.8. Fruits

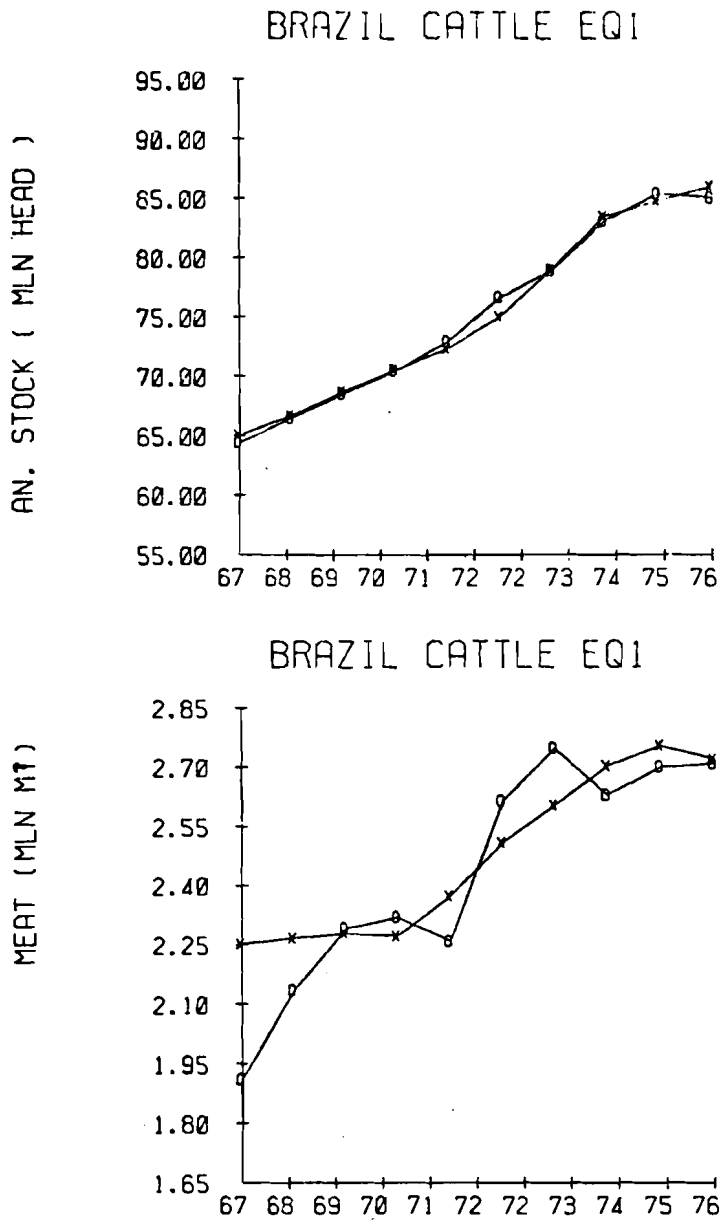
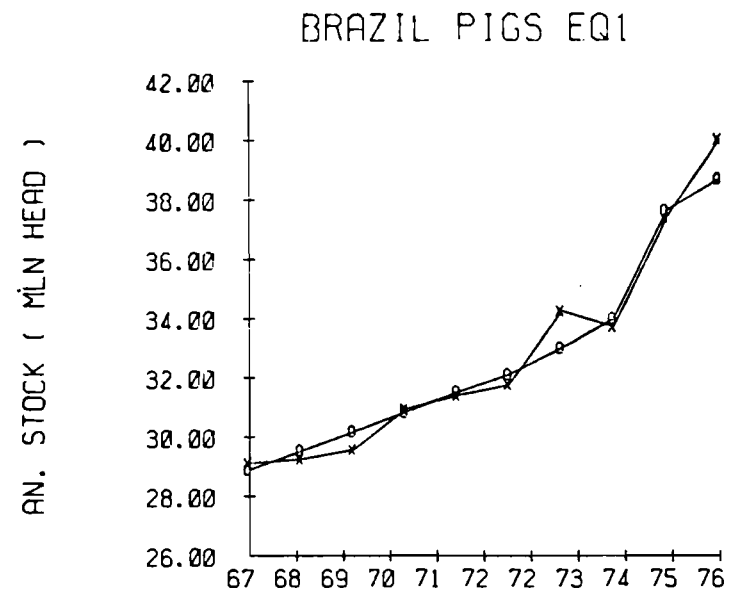
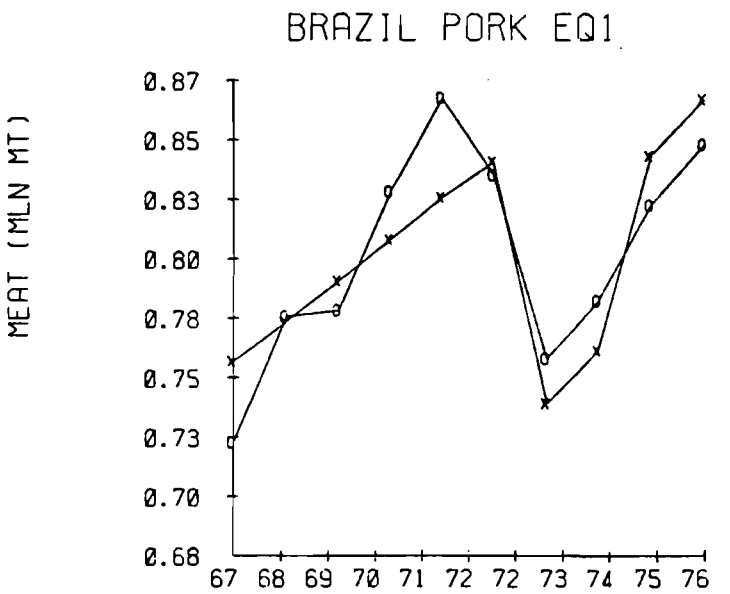


Figure 4.9. Bovine





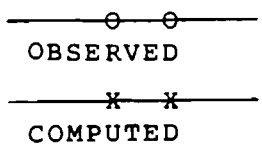


Figure 4.10. Pork

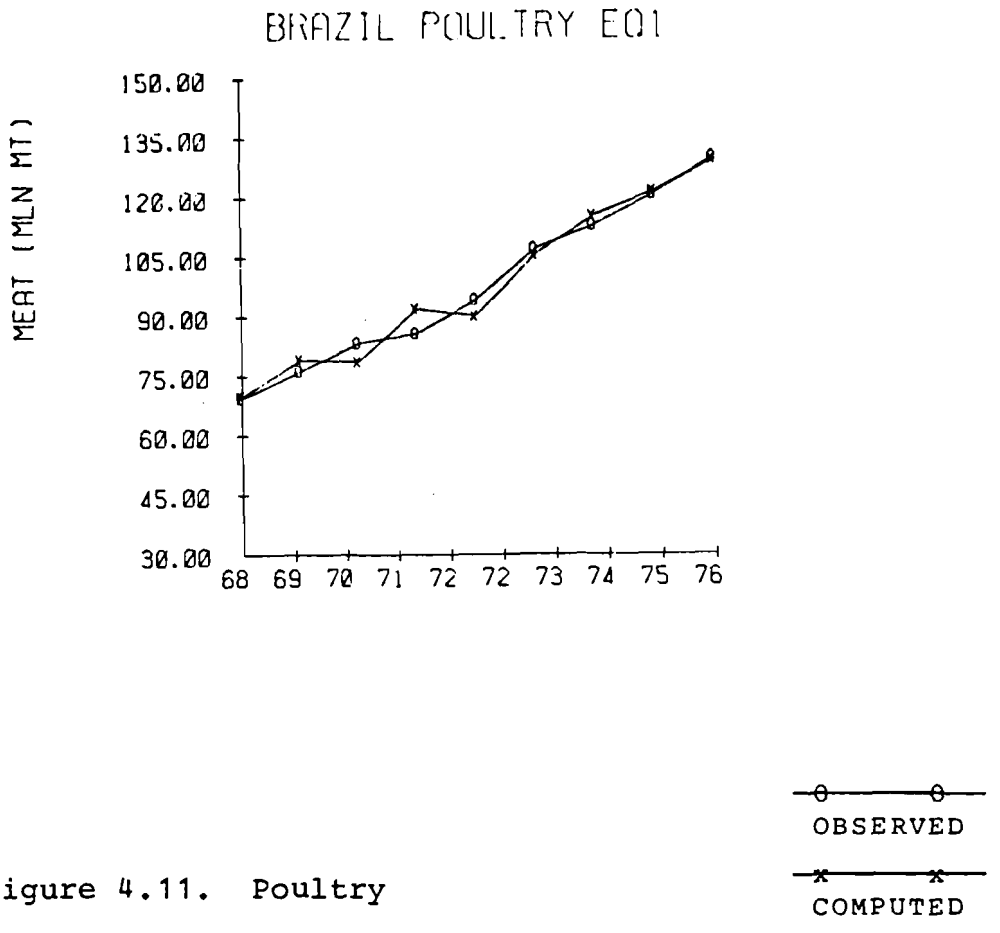


Figure 4.11. Poultry

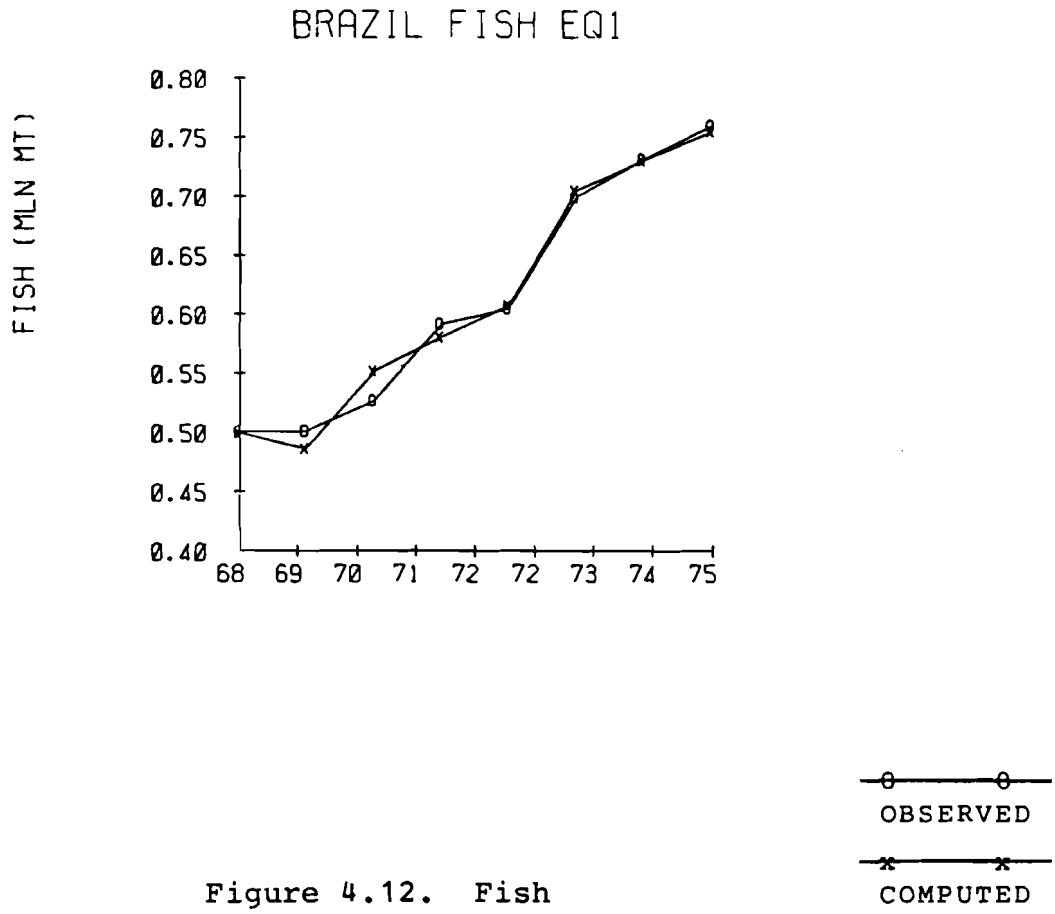
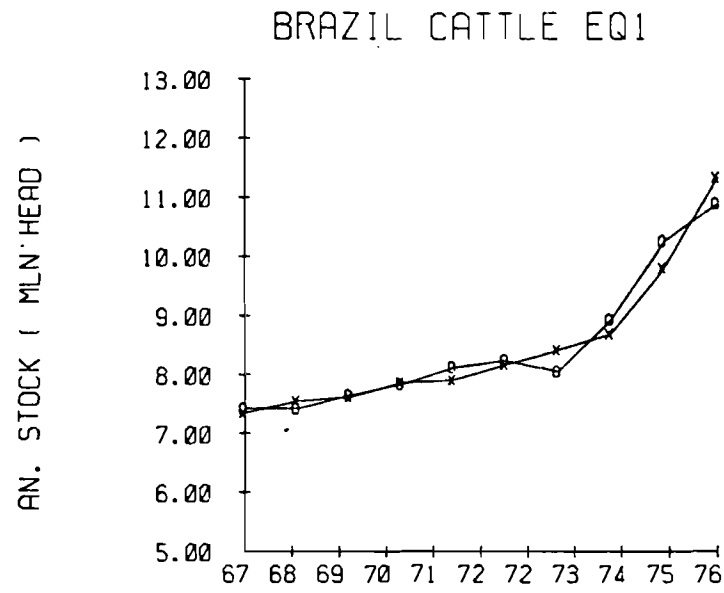


Figure 4.12. Fish



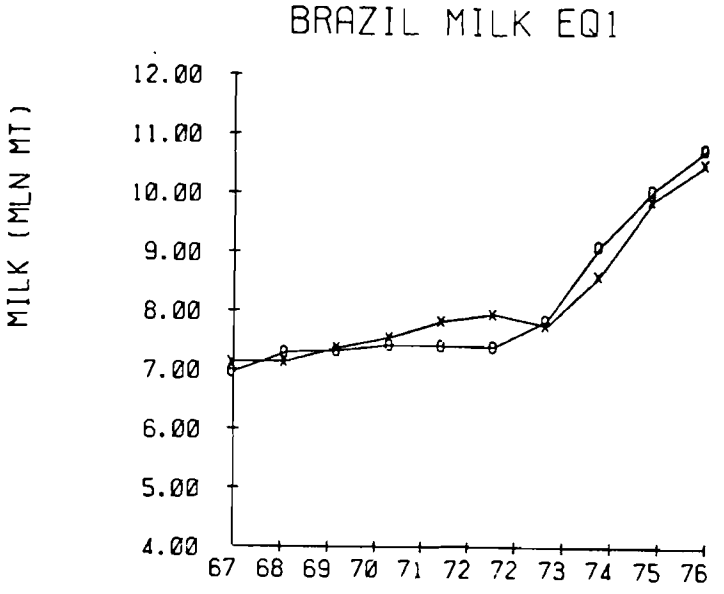


Figure 4.13. Dairy

OBSERVED

COMPUTED

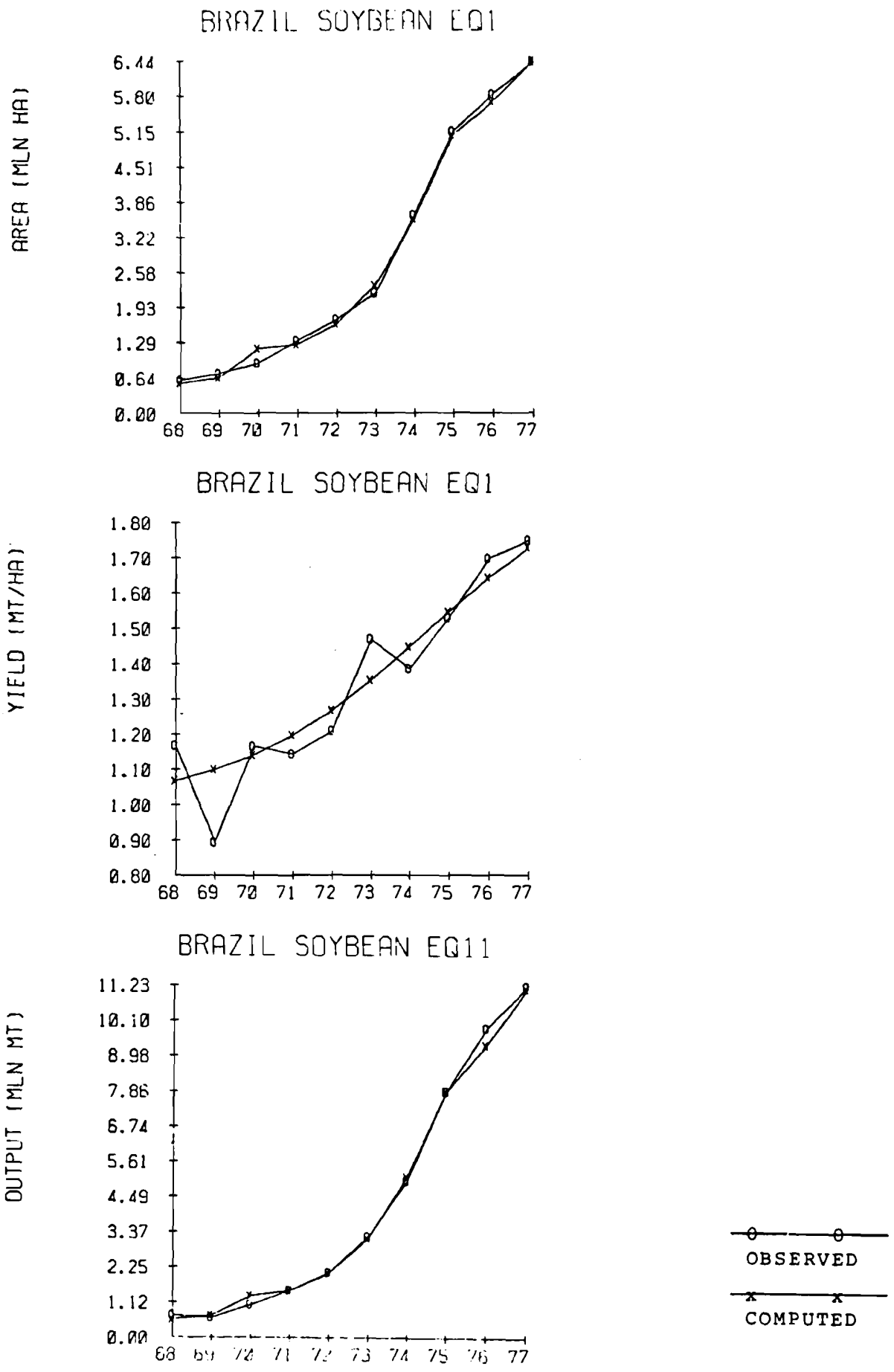


Figure 4.14. Soya

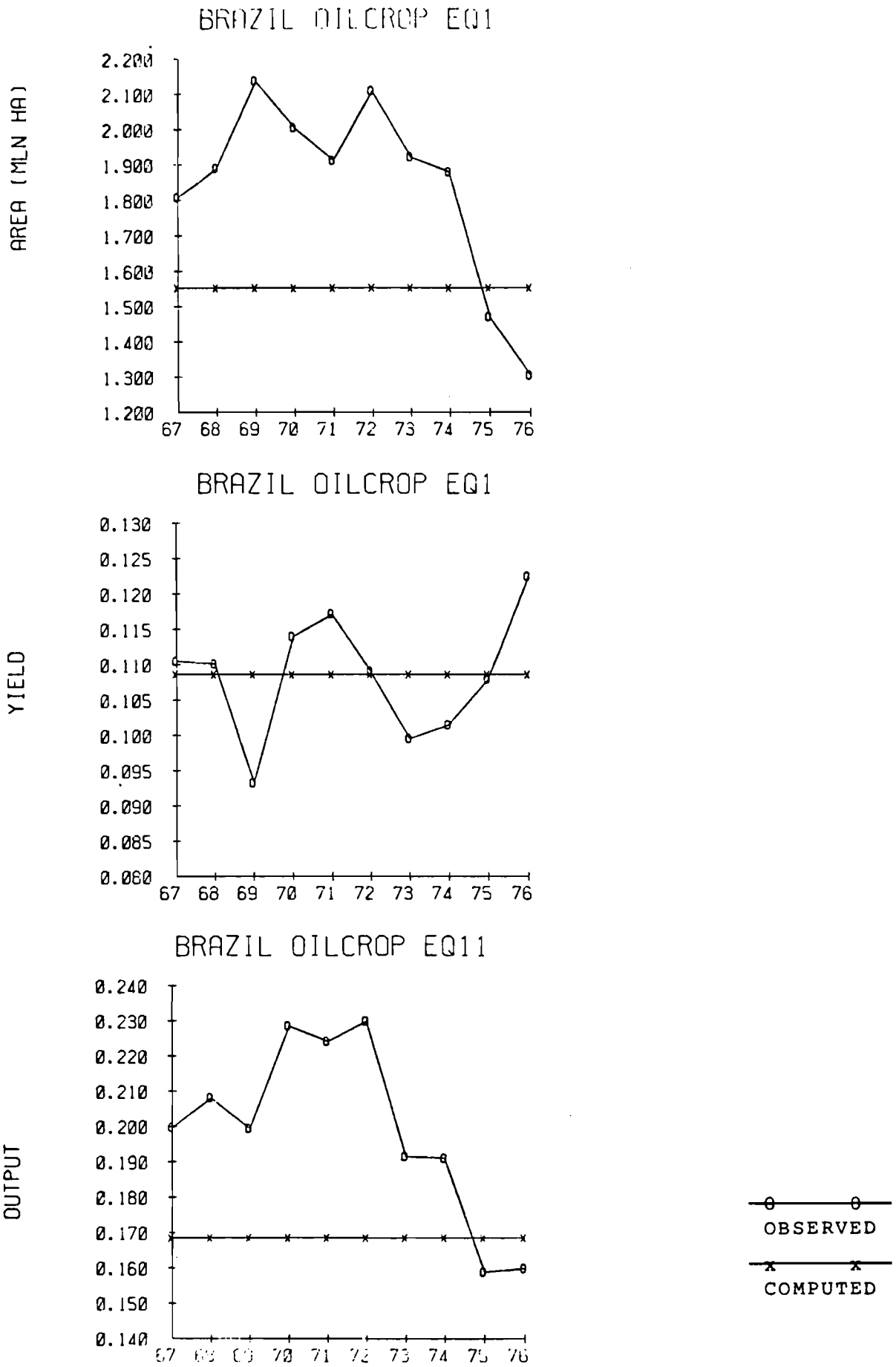


Figure 4.15. Oilcrops

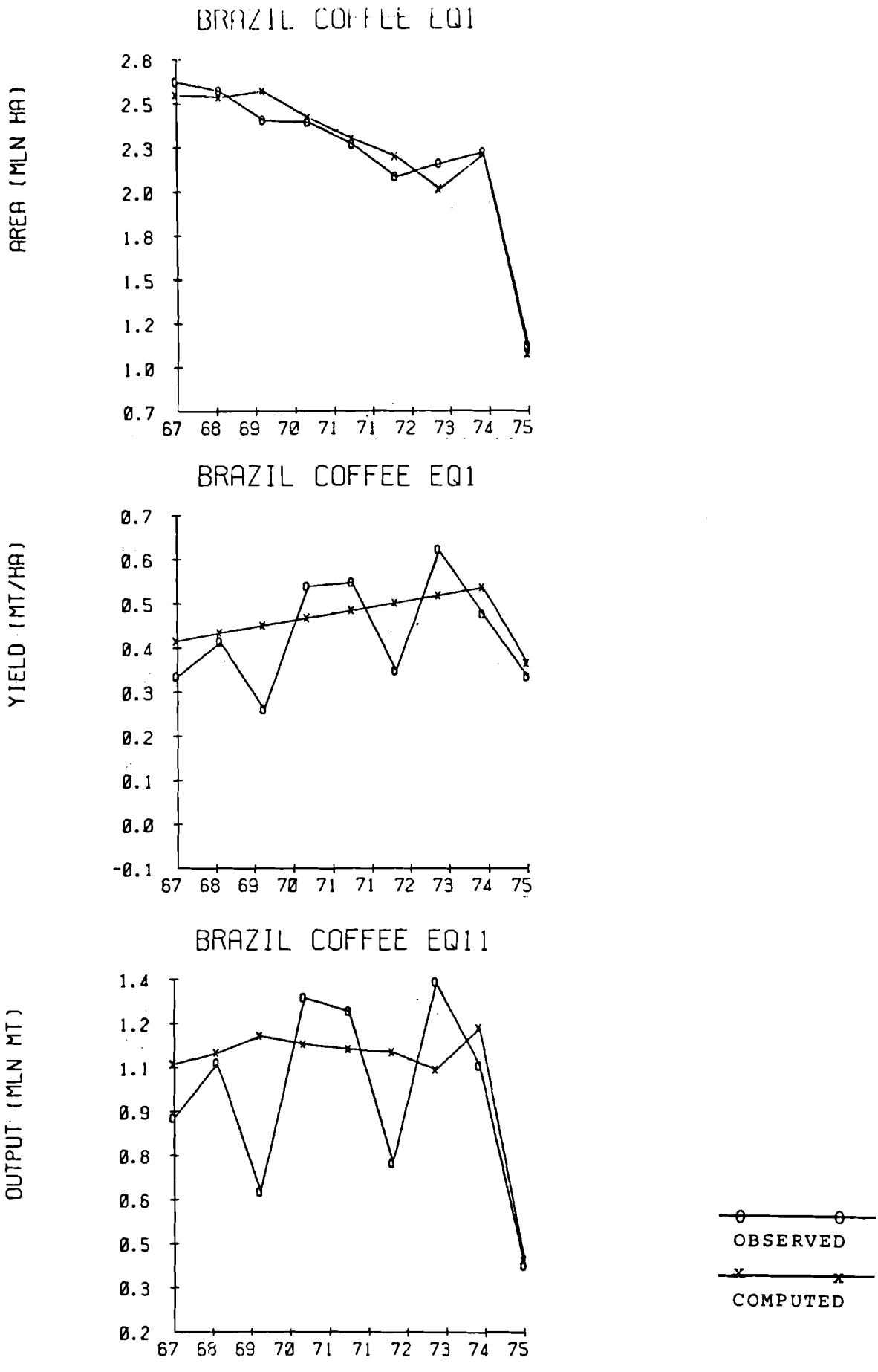


Figure 4.16. Coffee

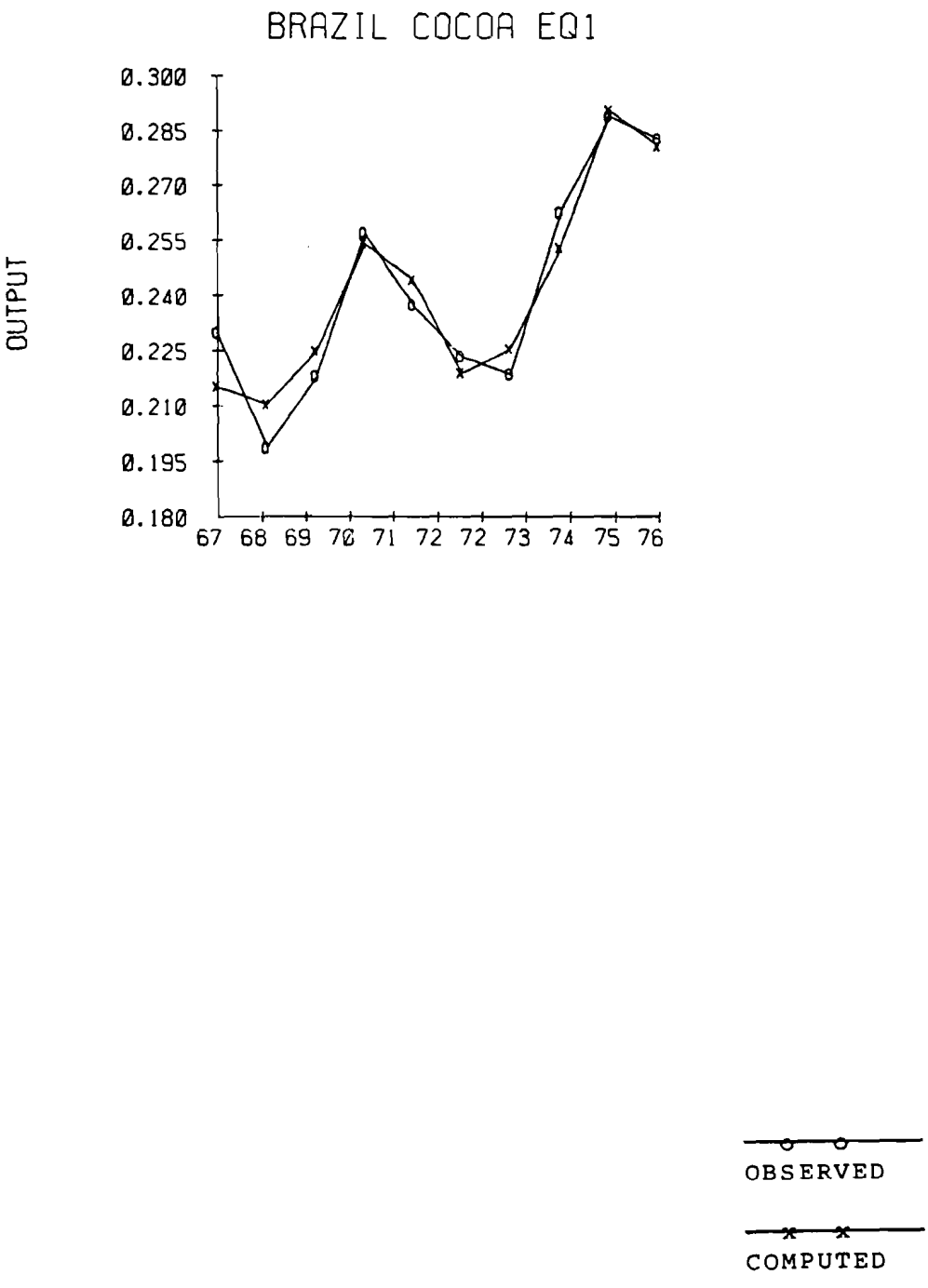


Figure 4.17. Cocoa

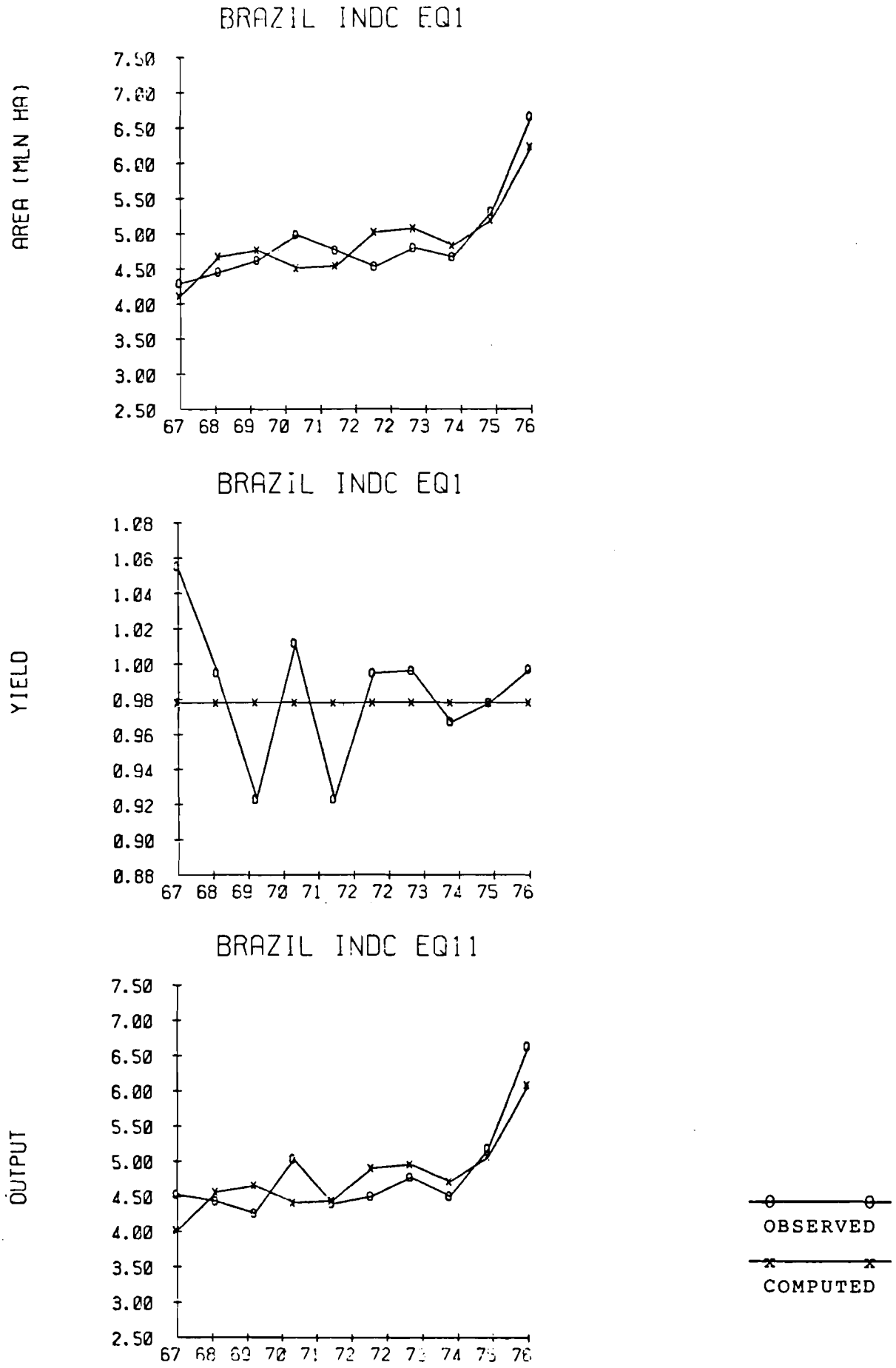


Figure 4.18. Industrial Crops

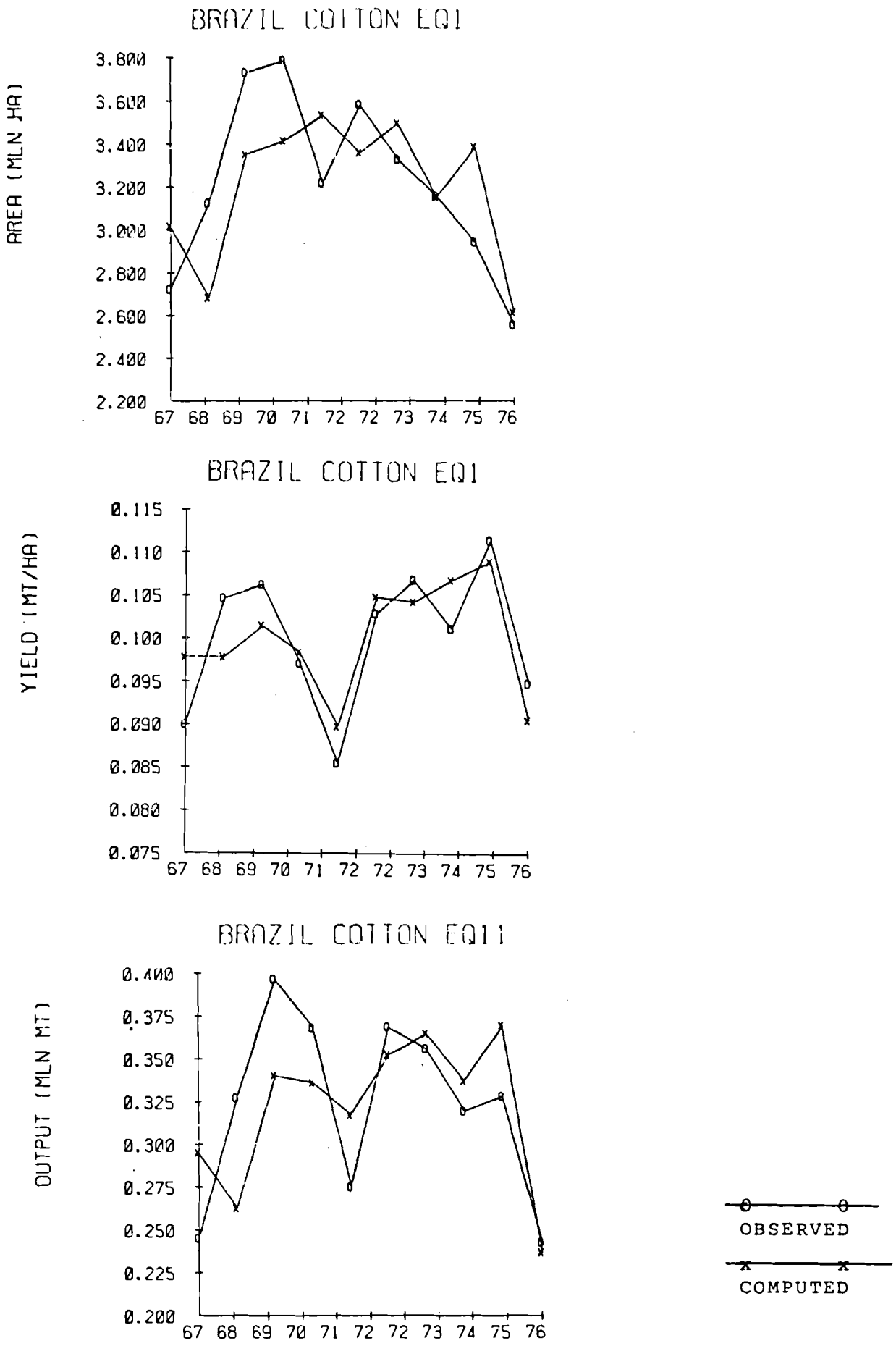


Figure 4.19. Cotton

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