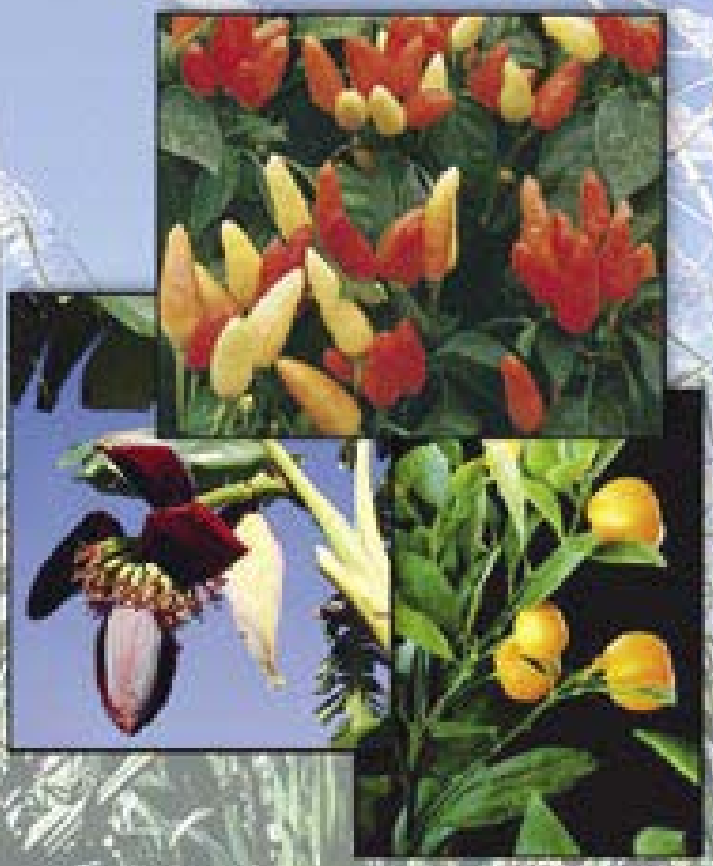
Fertilizer use by crop in Cuba



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Land and Plant Nutrition Management Service
Land and Water Development Division

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Fertilizer use by crop in Cuba
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Abstract

The permanent and temporary crops of the Republic of Cuba cover an area of 3.7 million ha, of which almost half is occupied by sugar cane.

In recent years, there has been a substantial decrease in the use of agricultural inputs in Cuba, with a consequent fall in the yields of most crops. The use of mineral fertilizers fell by 80 percent during the 1990s. The knowledge is available; the Agrochemical Pedological Service, for example, began its activities over a century ago and is still operating. The agro-ecological zones best suited to the different crops have been identified and recommendations are well established. However, in the case of most crops, economic constraints prevent their implementation.

Some priority food crops in Cuba are bananas, potatoes and rice. Despite a reduction in the use of fertilizers, the yield level of the banana crop has been maintained due to improved management and the existence of soil nutrient reserves. The potato crop is given priority by the state; levels of fertilizer application on this crop have remained steady and yield levels have been maintained. The domestic production of rice is far from satisfying domestic demand and there are substantial imports. Yields are well below their potential.

The urban and peri-urban cultivation of crops has been promoted in Cuba in order to alleviate food shortages.

Emphasis is placed on making optimum use of available organic materials and composting. Biofertilizers have been tried as an alternative source of nutrients but their use has declined, apart from Rhizobium.

The fertilizer manufacturing industry of Cuba is no longer operational and all fertilizers are imported.

Acknowledgements

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Preface

The Food and Agriculture Organization of the United Nations (FAO) commissioned this study. It is one of a series of publications on fertilizer use on crops in different countries.

FAO, the International Fertilizer Industry Association (IFA) and the International Fertilizer Development Center (IFDC) issue countrywise statistics on "fertilizer use by crop". The aim of the present series is to examine the agro-ecological conditions, the structure of farming, cropping patterns, the availability and use of mineral and organic plant nutrients, the economics of fertilizers, research and advisory requirements and other factors that have led to present fertilizer usage.

The "fertilizer use by crop" statistics have been related to FAO's forecasts of worldwide crop yield and areas. The results were published in the year 2000 FAO publication *"Fertilizer requirements in 2015 and 2030"*. The reports in the present series examine, country by country, the factors that will or should determine the future development of plant nutrition.

During the past two decades, increasing attention has been paid to the adverse environmental impact of both the under use and the over use of plant nutrients. The efficient use of plant nutrients, whether from mineral fertilizers or from other sources, involves the shared responsibility of many segments of society, including international organizations, governments, the fertilizer industry, agricultural research and advisory bodies, traders and farmers. The publications in the series are addressed to all these parties.

Fertilizer use is not an end in itself. Rather it is a means of achieving increased food and fibre production. Increased agricultural production and food availability can, in turn, be seen as an objective for the agricultural sector in the context of contributing to the broader macroeconomic objectives of society. A review of the options available to policy makers is given in the FAO/IFA 1999 publication entitled *"Fertilizer strategies"*.

The contents of the studies differ considerably from country to country, in view of their different structures, histories and food situation. But in each case the aim of the study is to arrive at a better understanding of the nutrition of crops in the country concerned.

Abbreviations and symbols

A.C.C.	Academia de Ciencias de Cuba
CAI	Agro Industrial Complex
DAP	Diammonium phosphate
FAO	Food and Agriculture Organization of the United Nations
ICGC	Instituto Cubano de Geodesia y Cartografia
IFA	International Fertilizer Industry Association
IFDC	International Fertilizer Development Center
INICA	Instituto Nacional de Investigaciones de la Caña de Azúcar
MINAG	Ministry of Agriculture
MINAZ	Sugar Ministry
SERFE	Fertilizers and Amendments Recommendations Service

Fertilizers

N: Nitrogen
P_2O_5 or P: Phosphate*
K_2O or K: Potash*
NPK: $N+P_2O_5+K_2O$ or compound fertilizers containing the three nutrients

* Phosphate and potash may be expressed as their elemental forms P and K or as their oxide forms P_2O_5 and K_2O. Nitrogen is expressed as N. In this study phosphate and potash are expressed in their oxide forms.

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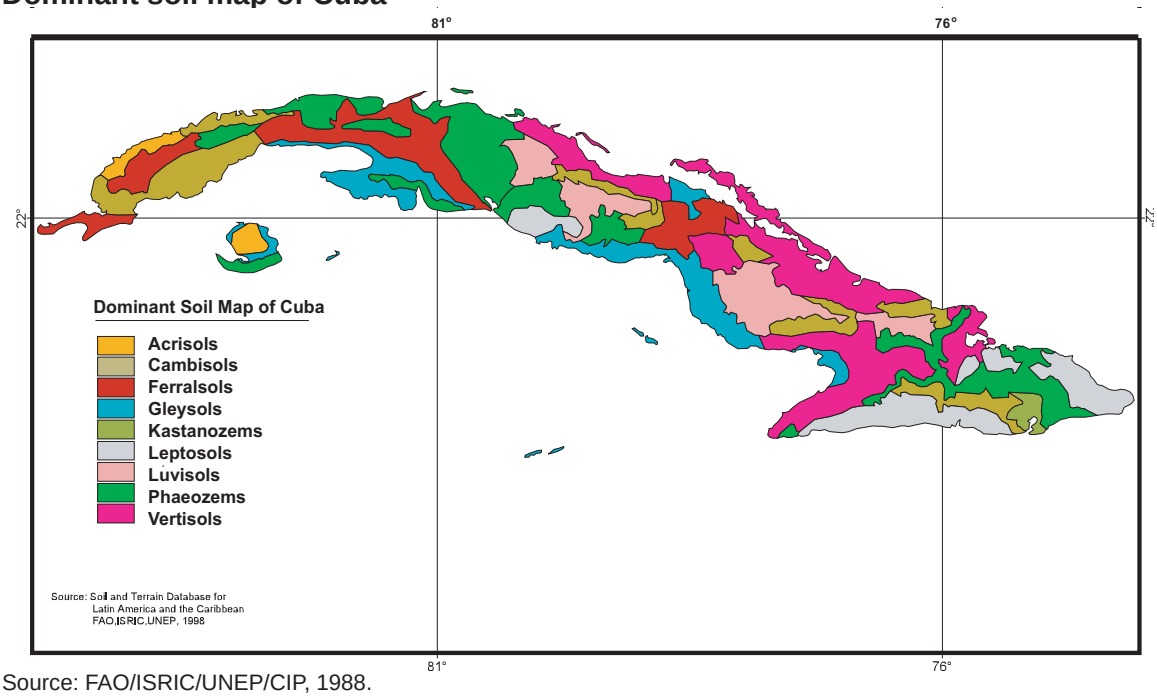
Chapter 1
Introduction

Cuba is 1 250 km long and its width ranges from 32 km at its narrowest point, to 210 km at its widest. It is montainous in the southeast and south-central area, and flat or rolling elsewhere. Total land area is 110 922 km^2. The country is divided into seven agro-ecological zones. A soil map of Cuba is given in Figure 1.

Figure 1
Dominant soil map of Cuba



Source: FAO/ISRIC/UNEP/CIP, 1988.

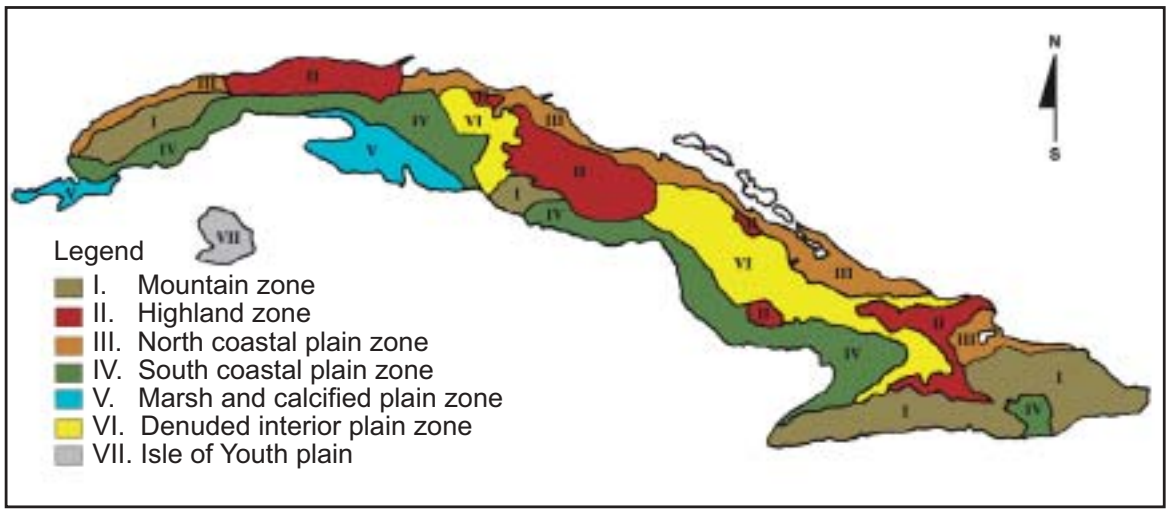
The agro-ecological zones of Cuba

Mountain zone

This zone is composed of five sub-areas. The establishment of plantations in the zone needs to take account especially of soil conservation considerations, in view of the level of rainfall and the topography.

Geology: aleurolite, shales, calcareous schists, quartz and marble
Soil types: Phaeozems, Acrisols, Nitisols and Regosols
Native vegetation: *Pinus caribea* and *Pinus tropicalis*, low altitude

Figure 2
Agro-ecological zones of Cuba



Mesophylls
Rainfall: 1400–1600 mm
Evaporation: 1800-2000 mm
Temperature: 20-25 °C
Days with rainfall over one mm: 40 to >140

Highland zone

This zone is characterized by its geologic variability, resulting from pedological variations. Rainfall increases in general in the western areas of the country but the zone is not influenced by maritime winds. Temperature variations are less marked than elsewhere due to its position, mostly in the center of the island.

Geology: clays, calcareous loams
Soil types: Phaeozems, Cambisols, Nitisols, Plintisols, Ferralsols, Acrisols and Lixisols
Native vegetation: low altitude *Mesophylls*
Rainfall: 1200–1800 mm
Evaporation: 1800–2100 mm
Temperature: 23–26 °C
Days with rainfall over one mm: 40–140

North coastal plain zone

This zone is characterized by relatively low rainfall levels in the Coastal area of Moron-Gibara but with a generally good distribution during the year, especially

in the more western regions. There is a substantial difference between day and night temperatures and the maritime winds have an influence. The geologic material is variable, with several soil types with gley characteristics. In certain areas there may be a risk of salinisation.

Geology: clays, calcilutite, loams, calcareous conglomerate, schists and tuff
Soil types: Vertisols, Gleysols, Phaeozems and Cambisols
Native vegetation: *Pinus caribea* and *Pinus tropicalis*, *Mesophylls*
Rainfall: 1000–1600 mm
Evaporation: 1800-2200 mm
Temperature: 23–27 °C
Days with rainfall over one mm: 1–100

South coastal plain zone

This zone, which excludes the marshlands, is characterized by the presence of alluvial soils and gleys, in some cases of marine origin or with antropic salinity, although loams prevail. The rainfall is relatively low, especially in the eastern region where it amounts to about 600 mm/year.

Geology: clays, sands, pebbles, and tuff
Soil types: Vertisols, Gleysols, Phaeozems, Cambisols and Fluvisols
Native vegetation: *Pinus caribea* and *Pinus tropicalis*, typical *Mesophylls*
Rainfall: 1000-1600 mm
Evaporation: 1800–2200 mm
Temperature: 23–27 °C
Days with rainfall over one mm: 1–80

Marsh and calcified plain zone

Geology: serpentines, aleurolite, shales, calcareous schists, quartz, marble and basalt
Soil types: Gleysols, Fluvisols, Regosols and Histosols
Native vegetation: *Pinus caribea* and *Pinus tropicalis*, low altitude *Mesophylls*
Rainfall:1400–1600 mm
Evaporation: 1800–2000 mm
Temperature: 20–25 °C
Days with rainfall over one mm: 1–80

Denuded interior plain zone

This zone extends over an interior fringe of the central part of the Island. It is characterized by relatively high rainfall, increasing to the east of the country, generally with a good distribution during the year. The temperature differences between day and night are not very marked. The maritime winds have little influence. The geological material is variable, with a predominance of red soils indicating good fertility. There is a large area of sugar cane, with a high degree of mechanization favoured by the topography.

Geology: serpentines, calcilutite, clays, aleurolite, shales, calcareous schists, quartz and marble
Soil types: Ferralsols, Nitisols, Cambisols and Luvisols,
Native vegetation: *Pinus caribea* and *Pinus tropicalis*, low altitude *Mesophylls*
Rainfall: 1400–1600 mm
Evaporation: 1800–2000 mm
Temperature: 20–25 °C
Days with rainfall over one mm: 40–140

Isle of Youth plain zone

Geology: schists, marble, volcanic, clays and carbonated sediments
Soil types: Ferralsols, Nitisols, Cambisols, Phaeozems and Arenosols
Native vegetation: *Pinus caribea* and *Pinus tropicalis*
Rainfall: >1600 mm
Evaporation: 1800–2100 mm
Temperature: 23–26 °C
Days with rainfall over one mm: 40–100

Chapter 2
The fertilizer sector

Today all mineral fertilizers used in Cuba are imported. Table 1 gives the imports of some important products between 1999 and 2001.

Table 1
Fertilizer imports, 1999 to 2001 ('000 tonnes nutrient)

Product	1999	2000	2001	Mean
Nitrogen (N)				
Urea	19.1	21.6	51.2	30.6
Ammonia	9.9	0	0	3.3
Diammonium phosphate	2.0	2.5	4.3	2.9
Total N	31.0	11.0	55.5	36.8
Phosphate (P_2O_5)				
Triple superphosphate	13.2	17.9	27.4	19.5
Diammonium phosphate	5.2	6.4	4.7	5.4
Total P_2O_5	18.4	27.9	32.1	24.9
Potash (K_2O)				
Potassium chloride	46.8	21.6	50.3	39.6
Total NPK	96.2	60.5	137.9	101.3

Source: IFA.

However, it was not always the case that all the fertilizers were imported. In 1989, for example, the production and imports of fertilizers were as shown in Table 2.

Nitrogen fertilizers were produced at a plant at Cienfuegos and compound fertilizers at a plant at Matanzas. These plants have been idle for several years.

Average fertilizer consumption between 1999 and 2001 amounted to less than 20 percent of the 1989 level.

Table 2
Production and imports of fertilizers in 1989 ('000 tonnes nutrient)

Product	Production	Imports	Production + imports
Nitrogen (N)			
Ammonium sulphate	0	57	57
Urea	27	162	189
Ammonium nitrate	104	0	104
Anhydrous ammonia	5	0	5
NPK compounds	10	0	10
Total N	146	219	365
Phosphate (P_2O_5)			
Single superphosphate	0	59	59
Triple superphosphate	0	12	12
NPK compounds	15	0	15
Total P_2O_5	15	71	86
Potash (K_2O)			
Potassium chloride	0	236	236
Potassium sulphate	0	10	10
Total K_2O	0	246	246
Total NPK	161	536	697

Source: IFA.

Chapter 3
Crops and fertilizer consumption

The permanent and annual crops of Cuba cover some 3.7 million hectares. The principal permanent and annual crops, according to the survey of December 31 1997 are shown in Table 3.

Table 3
Principal crops in Cuba at the end of 1997 ('000 ha)

Permanent crops		Annual crops	
Sugar cane	1 770	Rice	224
Coffee	141	Tobacco	67
Banana	123	Grass	10
Citrus	93	Others	794
Fruits	84		
Grass and forage crops	366		
Others	29		
Total	2 606	Total	1 095

Source: Statistical Annual of Cuba, 2001 edition.

Sugar cane dominates agriculture in Cuba, accounting for approximately half of the cultivated area.

In contrast with other countries of the region, the use of fertilizers in Cuba, from the beginning of the eighties in the last century, took account of soil characteristics, particularly the soil nutrient content, the expected yields and other factors involved in the efficient utilization of the products.

For all crops, there are well established fertilizer application standards based on many field experimental results obtained under different conditions (Table 4), although the current financial limitations prevent, in many cases, their implementation.

SUGAR CANE

Sugar cane has historically consumed most of the fertilizers because of its area and the priority given to the crop. It is the principal export crop and is important for the economy of the country.

Table 4
Recommended rates of nutrient application on the principal crops (kg/ha nutrient)

Crop	N	P_2O_5	K_2O
Potato	194	127	179
Banana	340	0	900
Tomato	123	58	62
Maize	85	0	0
Tobacco	90	41	131
Citrus	153	35	90
Rice	138	68	90

Source: Soil Institute of Cuba, MINAG.

Table 5
Sugar cane: percentage of the area fertilized in the different agro-ecological zones

Zone	Number of sugar mills	Percentage of area fertilized		
		N	P_2O_5	K_2O
Mountain	1	73%	20%	30%
Highland	10	70%	60%	31%
North coastal plain	10	67%	58%	28%
South coastal plain	14	70%	76%	63%
Denuded interior plain	10	67%	65%	29%

Table 6
Sugar cane: cropped area, fertilizer application and yields in the different agro-ecological zones

Zone	Cropped area	Rates of nutrient application (kg/ha)			Yield
	('000 ha)	N	P_2O_5	K_20	(tonnes/ha)
Mountain	4.8	63	43	107	36
Highland	57.6	58	38	98	47
North coastal plain	131.3	61	37	84	43
South coastal plain	130.4	64	34	82	47
Denuded interior plain	121.7	58	41	84	42

There is a sophisticated, integrated advisory system for fertilizer recommendations on sugar cane, which includes soil analysis, demonstration plots, advice, annual training courses, recommended rates and other actions associated with efficient fertilizer use. Each producer has a service contract with the Agro Industrial Complex (CAI), representing all the associated producers and INICA, the institution in charge of this activity. At the start of every year the producer pays 3.35 pesos per hectare for this service. Tables 5 and 6 show the percentage of the area fertilized and the application rates with their corresonding yields.

The cultivated arable area in Cuba is about 1.4 millions hectares, with about a million ha harvested every year. Limitations imposed by the crisis faced by the country have had a negative impact on yields. Among the causes of the reduced yields are the aging of plantations, inadequate attention to the crop, shortage of fuel, shortage of herbicides, reduction of water and other limitations. This is in a global environment in which sugar prices scarcely cover production costs. The imports of fertilizers for sugar cane are shown in Table 8.

Table 7
Area under sugar cane ('000 ha)

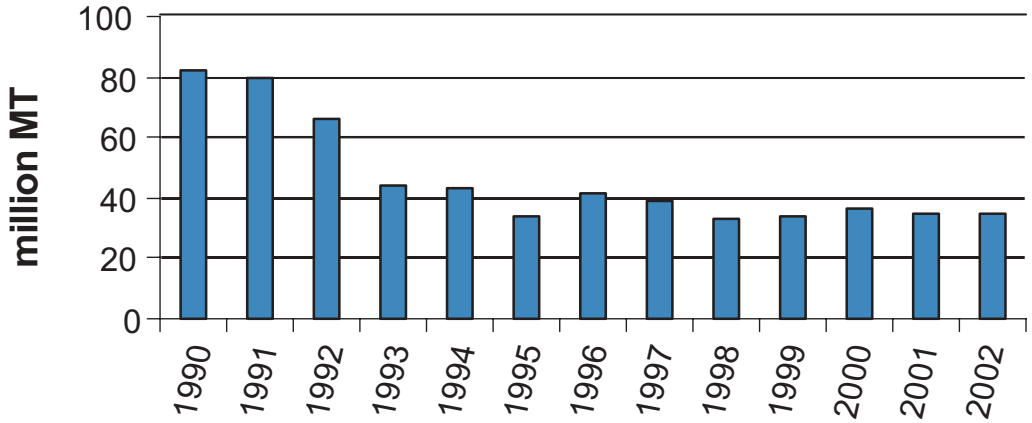
Year	Total area	Cropped area	Percent irrigated
1996	1 515	1 245	15.1%
1997	1 459	1 246	14.6%
1998	1 386	1 049	13.9%
1999	1 384	996	13.8%
2000	1 378	1 041	13.8%

Source: Statistical Annual of Cuba, 2001 edition.

Table 8
Imports of fertilizers for use on sugar cane ('000 tonnes)

Product	Average 1996-1998	1999	2000
Urea	92	87	70
Ammonium nitrate	43	-	8
Anhydrous ammonia	9	17	16
Triple superphosphate	34	16	24
Potassium chloride	80	38	38
Total	245	158	156

Figure 3
Sugar cane production, 1990 to 2002



Source: FAOSTAT.

Tables 9 and 10 present data on nutrients applied and the areas fertilized. Fertilizer is not applied to the entire area since nitrogen is not necessary for newly planted crops. Also nitrogen is not applied on the fields with yields below 25 t/ha, where other factors are limiting production.

Table 9
Proportions of the sugar cane area fertilized

Year	N	P_2O_5	K_2O
1997	43%	15%	26%
1998	65%	43%	53%
1999	56%	52%	37%
2000	64%	60%	45%
2001	65%	60%	44%

Source: SERFE, Minaz.

Table 10
Average rates of nutrient application on sugar cane (kg/ha)

Year	N	P_2O_5	K_2O
1997	66	38	88
1998	66	37	100
1999	63	40	97
2000	63	41	87
2001	63	50	87

Source: SERFE, Minaz.

Phosphorus and potassium are applied where the soil levels are below the critical levels according to soil analyses.

The sugar cane farmers buy fertilizers from a specialized agency of the Sugar Ministry (MINAZ). They pay at the moment of acquisition a nationally fixed price that includes transportation costs. The prices are 420, 355, 302, 322 and 217 Cuban pesos for ammonia, urea, ammonium nitrate, triple super-phosphate and potassium chloride, respectively.

Farmers are obliged to have their plantations checked by the Fertilizers and Amendments Recommendations Service (SERFE), in order to purchase fertilizers.

Tables 11, 12 and 13 show data on nutrient consumption on sugar cane in the different regions of the country.

Table 11
Sugar cane: nitrogen consumption in different regions (tonnes N)

County	Average 1996/1998	1999	2000
Pinar del Río	2 045	1 508	1 966
Havana	5 837	5 092	4 304
Matanzas	9 444	6 736	5 471
Villa Clara	8 006	5 975	5 810
Cienfuegos	3 811	3 067	2 757
S. Spíritus	4 583	4 134	3 399
Ciego Avila	7 720	6 248	4 486
Camagüey	5 768	5 211	4 080
Las Tunas	3 943	4 326	4 445
Holguín	4 873	4 450	4 589
Granma	4 590	3 711	2 566
Santiago Cuba	2 927	2 812	2 704
Guantánamo	1 057	882	766
Total listed	64 604	54 152	47 343
Total country	66 601	56 151	49 343

Table 12
Sugar cane: phosphate consumption in different regions (tonnes P_2O_5)

County	Average 1996/1998	1999	2000
Pinar del Río	392	408	941
Havana	1 324	618	1 178
Matanzas	2 624	1 196	1 272
Villa Clara	1 872	810	1 655
Cienfuegos	1 470	488	845
S. Spíritus	1 023	677	683
Ciego Avila	1 841	1 011	769
Camagüey	1 717	317	1 008
Las Tunas	915	355	899
Holguín	771	327	660
Granma	919	600	444
Santiago Cuba	501	547	767
Guantánamo	148	115	418
Total listed	15 517	7 469	11 539
Total country	17 614	9 468	13 539

Table 13
Sugar cane: potash consumption in different regions (tonnes K_2O)

County	Average 1996/1998	1999	2000
Pinar del Río	2 382	1 270	1 225
Havana	4 799	1 987	2 234
Matanzas	6 698	3 963	3 065
Villa Clara	7 594	2 934	3 156
Cienfuegos	3 755	1 570	1 644
S. Spíritus	3 566	2 797	2 634
Ciego Avila	4 266	2 200	1 011
Camagüey	5 226	2 057	1 714
Las Tunas	2 492	1 375	849
Holguín	1 887	456	1 128
Granma	2 596	644	1 687
Santiago Cuba	2 552	1 471	1 752
Guantánamo	1 172	575	606
Total listed	48 985	23 299	22 705
Total country	50 981	24 698	24 705

Table 14
Areas and fertilization of crops other than sugar cane

Year	Sown area ('000 ha)		Percentage fertilized	
	Year total	Winter crop	Year total	Winter crop
1998	470.9	248.0	18	35
1999	422.5	204.5	23	47
2000	441.3	215.9	9	18

Crops other than sugar cane

This group includes vegetables and cereals, on which fertilizer use has decreased drastically. The only exception is the potato crop. In the 1986 to 1990 period, the crops in this group consumed a total of 856 416 tonnes of complex (NPK) fertilizers, with a maximum of 180 000 tonnes in 1989, but in 1995 the quantity had fallen to 50 843 tonnes and 35 000 tonnes in year 2000. The main grades of complex fertilizers are 9–13–17, 9–10.5–16 and 8–6–15. The areas and percentage fertilized are shown in Table 14.

This situation has made it necessary to optimize the use of fertilizers by concentrating their application on specific areas, adding zeolites to a fifth of the formulations, increasing the use of organic and organo-mineral products and biofertilizers, among other measures.

Fertilizer use on these crops showed average rates of application in 2000/2001 of 9, 11 and 13 kg/ha of N, P_2O_5 and K_2O respectively. This level is far from the established recommendations. The low rates are limiting the yields and progressively exhausting the soil fertility.

Bananas

Bananas constitute an important item for the food security of Cuban people, particularly in the eastern regions of the country, where potato production is limited by conditions not suited to the crop.

For comparison, in 1986 there was no consumption of urea but 35 542 tonnes of compound fertilizers and 31 946 tonnes of potassium chloride were applied to the crop.

Table 15
Fertilizers used on the banana crop*

Year	Area ('000 ha)	Potassium chloride (tonnes)	Urea (tonnes)	Production ('000 tonnes)
1996	116	10 472	8 173**	539
1997	122	10 669	4 084	382
1998	120	7 713	7 952	462
1999	118	14 309	6 520	493
2000	126	672	2 950	587

* The figures exclude direct deliveries to companies and cooperatives
** Includes 3 143 tonnes of ammonium nitrate

Despite limited fertilization, the production level of the banana crop has been maintained or even increased (Table 15). This is remarkable in view of the fact that irrigation was also affected by lack of fuel. This is the result of:

- introduction of new management technologies
- improved clone structure
- better quality seed obtained by tissue culture
- substitution of mineral fertilizers by organic materials
- improved incomes and higher prices for the producer

Another factor that contributed to the maintenance of yields was the presence of nutrient reserves (P and K) in the soil. In the past nutrients had sometimes been applied in quantities that exceeded soil needs. However the national specialists consider that it will not be possible to maintain current production levels if the nutrients needed by the crop are not applied. This observation is supported by the fact that in areas with drip irrigation the yield in year 2000 was only 23 t/ha compared with 37 t/ha in 1992. This reduction is attributed in large measure to the nutrient limitations.

POTATO

The state gives priority to the production of potatoes in view of the importance of the crop to food security. The entire potato area is fertilized. During the five-year period 1997 to 2001 the rates of application of nutrients per ha were stable, averaging 237 kg/ha N, 184 kg/ha P_2O_5 and 230 kg/ha K_2O.

Table 16 gives the figures of the nutrients applied to this crop. The important areas are concentrated in Havana, Matanzas and Ciego de Avila. There is little

Table 16
Potato: sown area, yield and fertilizer use

Year	Sown area	Yield	N	P_2O_5	K_2O
	('000 ha)	(t/ha)	('000 tonnes nutrients)		
1997	17.2	19.2	3.7	3.0	3.8
1998	12.2	17.0	3.1	2.3	2.9
1999	14.0	24.7	3.3	2.5	3.2
2000	13.5	27.3	3.3	2.6	3.3
2001	13.5	27.3	3.2	2.4	3.0

irrigation and the yield levels are acceptable for tropical conditions such as those of Cuba.

Typically some 1 400 to 1 500 kg per ha of complex granulated fertilizers (NPK) are applied, plus a second application of 223 kg per ha of urea. The usual complex fertilizer grades are 9–13–17 and 8–9–14.

RICE

This cereal constitutes the basis of the Cuban diet. The national production does not satisfy domestic demand and there is a high level of imports.

During the period 1994 to 1999, the nutrient application per hectare averaged 234 kg, which is sufficient for a yield of over four t/ha of grain (Table 17). However, the yield was well below this level, which indicates that there were

Table 17
Rice: sown area and fertilizer use

Year	Sown area	N	P_2O_5	K_2O	Yield
	('000 ha)	(kg/ha)			
1995	70.0	129	51	23	1 727
1996	114.6	148	52	39	2 749
1997	116.0	146	56	30	3 156
1998	84.4	152	58	38	2 426
1999	86.7	155	46	44	2 911
Average	94.3	146	53	35	2 594

Note: these figures exclude farmers' home consumption, production by MINAZ and production in domestic gardens.
Source: Department of Soil and Fertilizers, MINAG.

other factors limiting production, such as lack of irrigation, poor weed control, incorrect sowing stage, salinity, shallow soils, etc.

Tables 18 and 19 show the areas, rates of nutrient applied and yields obtained in nine rice zones. Fertilizer efficiency in terms of the ratio of kg grain/kg active nutrient was in all cases inferior to 15, which is considered to be low.

Table 18
Rice: areas in the main locations ('000 ha)

Location	County	Sown area
Los Palacios	Pinar del Río	19.0
Seeds	Habana	0.8
Arrocera del Sur	Matanzas	3.3
Sur del Jíbaro	S. Spíritus	20.5
Chambas	Ciego Avila	1.5
Hermanos Nayo	LasTunas	13.2
CAI Amancio	Holguín	4.6
Fernando Echenique	Granma	19.6
Total listed		82.5
Total country		86.7

Table 19
Rice: rates of fertilizer application and yields (kg/ha)

Location	N	P_2O_5	K_2O	Yields
Los Palacios	141	46	59	2 773
Seeds	175	55	64	3 582
Arrocera del Sur	161	69	70	2 389
Sur del Jíbaro	165	29	37	3 585
Chambas	137	65	54	2 742
Hermanos Nayo	130	44	49	1 872
CAI Amancio	137	51	20	2 842
Fernando Echenique	166	39	33	2 863
Total listed	155	46	44	2 911

Note: excludes farmers' own consumption, MINAZ's production and home gardens.
Source: Department of Soils and Fertilizers, MINAG.

Tobacco

Tobacco has been a crop associated with Cuba, ranking second in importance in the island's agriculture and an important source of income. Cuba has occupied an important place as an exporter not in terms of volume but for the quality of the

tobacco produced. Table 20 chows the area occupied by tobacco, the fertilizer application and related yields.

Table 20
Tobacco: area, fertilizer application and yields.

Season	Sown area	Fertilizer application (kg nutrient/ha)			Yield
	('000 ha)	N	P_2O_5	K_2O	(kg/ha)
1997-98	54.3	104	55	136	698
1998-99	54.1	116	61	150	696
1999-00	52.7	116	62	153	760
2000-01	48.5	116	63	154	781
2001-02	42.9	117	63	156	846

Note: the season refers to the period between planting in the nursery and harvesting

CITRUS

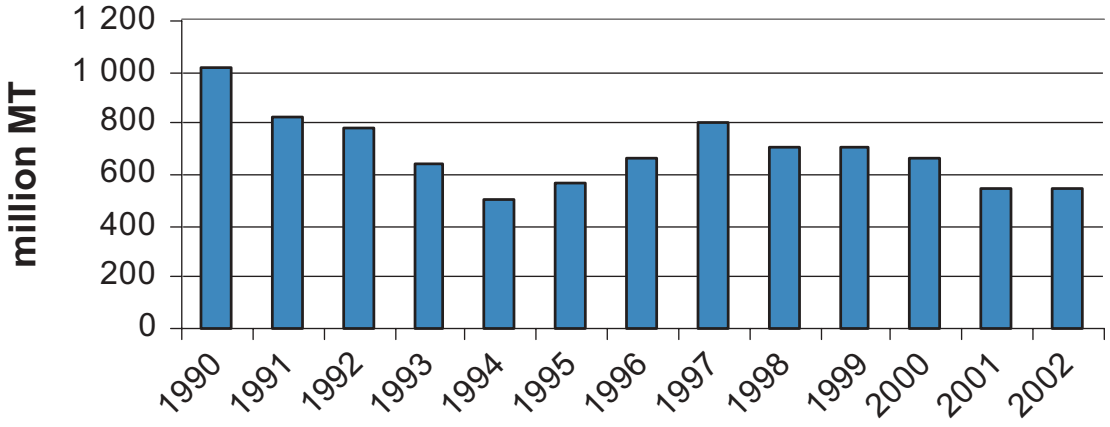
Citrus is a major commercial crop and generates significant revenues for Cuba. On average between 1999 and 2002, there were 58 249 ha of citrus fruits, with a production of 614 thousand tonnes, that is, 10.5 t/ha (Table 21).

In the first half of the 1990s citrus production fell by about 55 percent (Figure 4).

Table 21
Citrus: main fertilizers and amendments used (tonnes)

Fertilizer	1999	2000	2001
Ammonium nitrate	9 705	9 629	8 436
Triple superphosphate	729	225	409
Potassium chloride	1 188	1 959	827
Potassium nitrate	302	300	99
Potassium sulphate	95	94	0
Zinc sulfate	80	103	87
Manganese sulphate	33	29	58
Grumifol	32	32	26
Lime	15 453	18 311	4 434
Magnesium sulphate	84	78	0
Complex (NPK)	172	160	11
Urea	704	329	368
Total	28 577	31 249	14 755

Figure 4
Citrus fruit production



Source: FAOSTAT.

VEGETABLES

The main vegetables produced in Cuba are onions, peppers and tomatoes. Tables 22 to 24 show the areas sown, fertilizer applications and related yields.

Onions

Table 22
Onions: area, rates of fertilizer application and yield

Year	Total area	N	P_2O5	K_2O	Yield
	(ha)		(kg/ha)		(t/ha)
1999	2 638	106	33	54	12.3
2000	3 181	106	33	54	13.92

Peppers

Table 23
Peppers: area, rates of fertilizer application and yield

Year	Total area	N	P_2O_5	K_2O	Yield
	(ha)		(kg/ha)		(t/ha)
1999	1 747	142	67		11.60
2000	2 135	142	67		13.14

Tomato

Table 24
Tomato: area, rates of fertilizer application and yield

Year	Total area	N	P_2O_5	K_2O	Yield
	(ha)		(kg/ha)		(t/ha)
1999	26 819	123	50	80	10.6
2000	25 631	123	50	80	13.2
2001	27 041	123	50	80	16.6

URBAN AND PERI-URBAN AREAS, VARIOUS CROPS

The success of Cuba's national transformation to sustainable agriculture is also evident in the achievements that have taken place in promoting and establishing urban agriculture in Havana. Enhancing food security in Havana and other Cuban cities became a particular focus with an emphasis on developing urban agriculture (Table 25).

Table 25
Urban and peri-urban cropping

Item	Number	Area (ha)
Organoponics	3 446	681
Intensive orchards	7 055	3 669
Plots and yards	471 863	13 707
Total	482 364	18 057

Chapter 4
Organic manures and biofertilizers

Table 26
Organic manures applied in urban agriculture in 2000

County	Organic manures ('000 m^3)	Average rate (t/ha)
Pinar del Río	181	168
La Habana	142	102
Ciudad Habana	69	58
Matanzas	87	143
Villa Clara	193	260
Cienfuegos	81	115
Sancti Spíritus	89	119
Ciego de Ávila	44	52
Camagüey	62	119
Las Tunas	106	149
Holguín	444	308
Granma	84	102
Stgo. De Cuba	84	69
Guantánamo	16	37
Isla de la Juventud	4	54
Total	1 686	135

Due to economic constraints, one of the measures taken by farmers to increase production is to apply organic manures. Table 26 shows the amounts applied in urban agriculture. The amounts of organic manures applied to sugar cane and those of two main products, worm humus and compost, are shown in Table 27.

There has been a consistent increase in the two main products, worm humus and compost. The trend to recycle nutrients and to use all available sources of organic material is expected to continue. There is a large-scale programme to this end, involving all the country's municipalities.

The search for alternative sources to replace the deficit of mineral fertilizers included the use of a number of products based on micro-organisms (Tables 28

and 29). Existing fermentors in sugar mills and other industrial plants were used for this purpose. Their use reached a high point during the crisis period of 1993 to 1995, since when there has been an appreciable reduction, except in the case of Rhizobium (Table 30).

Mycorrhizal fungi have been used on coffee with very good results.

Table 27
Organic materials applied to sugar cane ('000 tonnes)

Year	All	Worm humus	Compost
1997	1 163	26	454
1998	1 001	33	563
1999	2 020	43	754
2000	2 535	64	1 049
2001	4 101	145	1 340

Note: excludes urban agriculture.
Source: Department of Fertilizers, MINAG.

Tables 28
Use of Azotobacter on crops other than sugar cane

Years	Quantity ('000 litres)	Area ('000 ha)
1993	3 372	-
1994	1 667	66
1995	648	24
1996	712	29
1997	227	73
1998	266	11
1999	190	67
2000	45	25

Table 29
Use of Fosforin on crops other than sugar cane

Years	Quantity ('000 litres)	Area ('000 ha)
1993	-	-
1994	175.0	7.2
1995	72.5	2.9
1996	153.5	7.2
1997	68.3	2.6
1998	70.9	2.7
1999	48.1	1.6
2000	77.2	3.1

Table 30
Use of Rhizobium on crops other than sugar cane

Years	Quantity ('000 tonnes)	Area ('000 ha)
1993	8.3	10.7
1994	13.9	22.6
1995	9.8	16.3
1996	13.2	14.7
1997	14.7	19.1
1998	11.5	11.0
1999	9.6	8.6
2000	14.8	14.2

Chapter 5
Role of the agricultural universities

The Universities have played a very important role in the training of personnel currently working in the specialized crop institutes (sugar cane, rice, tobacco, citrus, vegetables, etc.). These institutes have established the critical levels of the main nutrients in the soil, the extraction coefficients and rates to be used under different soil and climactic conditions. They are responsible for the regional location of the crops and their varieties, as well as for the establishment and development of the standards of organic and inorganic fertilization, the application of soil amendments to correct acidic and basic soils and other technologies. The Universities themselves have contributed mainly to basic aspects such as dynamic nutrient processes (sorption, lixiviation and fixation), nutrition physiology and crop improvement.

These institutions give technical advice directly to the farmers and account for most of the agriculture extension.

The MINAG's Soil Institute has summarized the research and provides basic information on all crop nutrient requirements, apart from sugar cane. These general recommendations are modified as required taking into consideration the expected yield, soil analyses and the financial situation.

The Sugar Ministry (MINAZ) supervises the sugar cane crop. Among the main items of expenditure are fertilizers and herbicides, which are surpassed only by fuels and oil. In spite of the serious economic crisis due to the loss of preferential markets and to the low sugar prices on the world market, it was able to implement the Fertilizers and Amendments Recommendations Service (SERFE). It upgraded five soil and plant analysis laboratories, developed specialized decision-making software and participated in a programme of agricultural extension that has achieved important progress.

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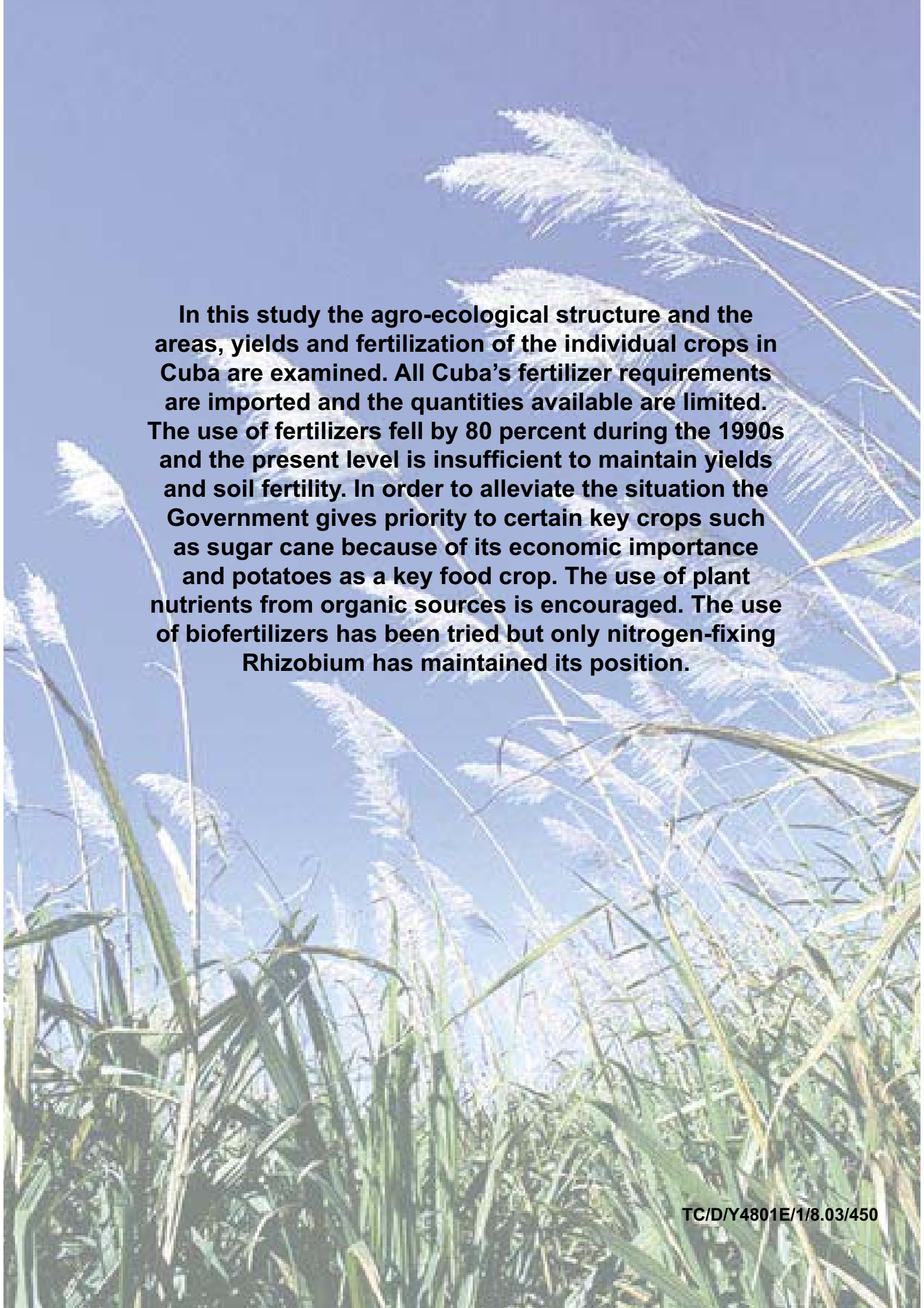
The main source of information on sugar cane was the Fertilizers and Amendments Recommendations Service (SERFE).

The main source for the other crops was the Department of Fertilizers of the Ministry of Agriculture (MINAG).



In this study the agro-ecological structure and the areas, yields and fertilization of the individual crops in Cuba are examined. All Cuba's fertilizer requirements are imported and the quantities available are limited. The use of fertilizers fell by 80 percent during the 1990s and the present level is insufficient to maintain yields and soil fertility. In order to alleviate the situation the Government gives priority to certain key crops such as sugar cane because of its economic importance and potatoes as a key food crop. The use of plant nutrients from organic sources is encouraged. The use of biofertilizers has been tried but only nitrogen-fixing Rhizobium has maintained its position.

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