Chapter 7: Preservation of agricultural soil

Recent sugar cane expansion in Brazil has happened mostly in poor soils (pasture land and strongly anthropized cerrados), contributing for their improvement with the addition of organic matter and fertilizers. Erosion losses are smaller than in many other important cultures; it is expected that the growing harvesting of cane without burning will further improve this condition, with the use of the remaining trash in the soil.

7.1 Introduction

Changes in the use of soil usually change the soil organic carbon content. Each type of occupation, soil and handling has a long-term "equilibrium" rate. For example, the equilibrium rate for forests with forestry activities is estimated at 45 t carbon / ha; for wood with fast rotation, 35 t / ha; and for grains,[1] 25 t / ha in the United States (the periods for equilibrium extending for dozens of years).

In the more general case of soil that used to be covered with forests (including *cerrado* vegetation) and were turned into pastures, there is a clear trend towards a decrease in the carbon content of the soil. There are studies involving direct planting practices for use with grains, showing that an appropriate handling allows the contents to be near those found in forests.[2]

In Brazil, 59 percent of the soil is latosol and clay soil, where 39 to 70 percent of the organic carbon is stored up to 30 cm deep, with great spacial variations. The growth of sugar cane crops is incorporating poorer areas (mostly extensive pastures) and shall contribute to the recovery of the soil through the addition of fertilizers and corrective substances, also including vinasse, filtercake and trash. This will lead to higher levels of carbon in the soil and decreased erosion.

Soil erosion loss is a serious problem, depending on the kind of crop, the agricultural practices, the soil type and the rainfall pattern. Pimentel[3] estimated the mean loss of soil due to erosion in the annual agricultural production in the United States at 18.1 t / ha. Corn (21.8 t / ha), soybean (40.9) and wheat (14.1) typically show high rates, whereas the rate for permanent crops and hay (upon establishment) is 0.2, and rotation forests 2 to 4 t / ha.

Today the sugar cane culture in Brazil is renowned for its relatively small soil erosion loss (compared with soybean and corn, for example). This situation keeps improving as harvesting without burning expands, thereby reducing losses to very low rates, comparable to those for direct planting in annual cultures.[4]

1 Ranney, J.W.; Mann, L.K.: "Environmental considerations in energy crop production", Biomass and Bioenergy, vol. 6, no. 3, 1994

2 Lima, M.A.: "Oportunidades: potencial de negócios em agropecuária, florestas, energia e resíduos", NT Solos e Pecuária, EMBRAPA, 2003

3 Pimentel, D.; Krummel, J.: "Biomass energy and soil erosion: assessment of resource costs"; Biomass, vol. 14, 1987, pp.15-38, cited in Ranney, J.W.: "Environmental considerations in energy crop production", Biomass and Bioenergy, vol. 6, no. 3, 1994

4 Rossetto, R.: "A cultura da cana, da degradação à conservação", Visão Agrícola, ESALQ-USP, Ano 1, Jan 2004

7.2 Soil used for sugar cane growing in Brazil; expansion tends

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Brazil covers a total area of 8.5 million km², and as a result, it has a wide variety of soil and climates (rainfall conditions). This makes any potential production study highly complex. In the total area, 84 percent of the soil has acidity problems (soil with high concentrations of aluminum and, on a smaller scale, iron and manganese), 16 percent lack oxygen certain times of the year, 7 percent is shallow soil, 2 percent is soil with high concentrations of salts, and 9 percent is soil with no relevant limitations on agricultural exploitation.[5] Leaving out of account the slopes where the soil is located, which can be a limiting factor to agricultural use, Brazil has a huge production/productivity potential when advanced agricultural handling practices are in place.

As a matter of fact, the successful agricultural occupation of the soil in the Brazilian *cerrado* over the past fifteen years has been supported by the application of advanced agricultural technology. The soils found in the large agricultural border formed by the *cerrados* in Brazil's Center-West region are listed in **Table 1**:

Table 1: Approximate distribution of the largest soil units in the *cerrados*

Soil types			Area (million ha)	Occupation (%)
Order	Sub-order	Group		
Latosol	Red yellow		77.4	38.0
	Red		20.6	10.1
	Ferric red		7.3	3.6
Plintosols			18.9	9.3
Neosol	Arenic		37.7	18.5
	Lithic		17.0	8.4
Clay soils	Red yellow	Dystrophic	1.9	0.9
		Eutrophic	7.3	3.6
Nitosol	Red		3.5	1.7
Cambisol	Haplite		6.1	3.0
Gleysol			4.1	2.0
Others			1.8	0.9
Total			203.8	100.0

Source: Notes 6, 7, 8

5 Amaral, F.C.S., Pereira N.R.; Carvalho Jr., W.: "Principais limitações dos solos do Brasil", embrapa Solos, site: www.cnps.embrapa.br/solosbr/ (2004), Rio de Janeiro, 1999

6 Lopes, A.S.: *Solos sob cerrado, características, propriedades e manejo*, Piracicaba, Instituto da Potassa & Fosfato - Instituto Internacional da Potassa, 1983

7 Malavolta, E.; Kliemann, H.J.: *Desordens nutricionais no cerrado*, Piracicaba, Potafós, 1985

8 Goedert, W.J.: "Solos dos cerrados: tecnologias e estratégias de manejo", *in*: Goedert, W.J. (Ed.): São Paulo – Nobel, embrapa, Centro de Pesquisa Agropecuária dos Cerrados, Brasília, 1986

On the other hand, a study conducted for the purpose of assessing the potential for agriculture in western São Paulo[9] using images provided by the Landsat 7 satellite and field work based on determinations of IAC,[10] has mapped the use and physicochemical properties of the soil covering approximately 583,200 hectares in two representative locations of the current sugar cane expansion areas within São Paulo State. It concluded that the vast majority of soil (or soil combinations) found in that region are the same as that found in the agricultural border formed by the *cerrados* in Brazil's Center-West region in terms of classification (unit, fertility and texture). The mean soil fertility in the sampled areas (V% = base saturation index) for soil covered by pastures and sugar cane and corn crops, decreases, as shown:

9 DONZELLI, J.L.; JOAQUIM, A.C.; SIMÕES, M.S.; SOUZA, S.A.V.: "Plano de expansão da Usina Catanduva", Piracicaba, Centro de Tecnologia Canavieira (Internal report), 2003a

10 IAC – Instituto Agronômico/Centro Nacional de Pesquisa de Solos: "Mapa pedológico do Estado de São Paulo", Campinas, 1999

Table 2: Mean soil fertility for different kinds of use

		Sugar cane	Corn	Pasture
Layer		A	A	A
P resin	mg / dm^3	2	2	2
M. O.	g / dm^3	9	11	8
pH		4,9	4,9	4,4
K	$mmol / dm^3$	1,6	1,1	0,7
Ca		11	12	6
Mg		5	5	3
Al		2	2	4
SB		17	18	10
CTC		34	35	27
V	%	50	50	36

8 see p. 140

The occupation of areas in the Brazilian *cerrado* have led to the following soil use distribution[11]:

Non-*cerrado*	49.11%
Non-anthropized	16.77%
Anthropized	17.45%
Highly anthropized	16.72%

At least two classes, "non-*cerrado*" and "highly anthropized *cerrado*", can be used for sustainable agriculture with no deforestation required, as they are areas that have already been occupied, probably with some kind of crop or pasture. The total area of the *cerrados*,[8-11] i.e. 2.0 million km^2, and

11 MACHADO, R.B.; RAMOS NETO, M.B.; PEREIRA, P.G.P.; CALDAS, E.F.; GONÇALVES, D.A.; SANTOS, N.S.; TABOR, K.; STEINIGER, M.: "Estimativas de perda de área do cerrado brasileiro", Technical report, site: www.conservation.org.br/arquivos/RelatDesmatamCerrado.pdf Brasília, Conservação Internacional, 2004

considering that a vast majority of the pastures probably fall into the "highly anthropized" class, reach 17 percent, or 34 million ha. If their soil has a base saturation index similar to that found in the studies of western São Paulo (around 36%), soil fertility can be expected to increase at a mean rate of 39 percent just by adjusting the base saturation index to V% = 50%, through the addition of corrective substances and fertilizers. This would be possible with the introduction of advanced, sustainable agricultural handling practices in these soils, which could then be effectively incorporated into Brazil's agricultural area.

Chemical correction (limestone and gypsum) and fertilizers are required, but the sustainability of the production entails the addition of organic matter (OM) to the soil. The use of this soils for growing crops that add OM and/or chemical-organic fertilization, as in the case of sugar cane, will contribute to improving their physicochemical conditions.

There is an increase in the OM contents of soil used for growing sugar cane and corn compared to those of pastures (**Table 2**). Studies[12] of the accumulation of OM in a soil where sugar cane is grown (eutroferric red latosol), conducted in the Ribeirão Preto region, found an addition of 13.5 t (MS) / ha. This data is consistent with other results obtained in São Paulo, and lower than those achieved for Brazil's Northeast region.[12] Experiments[13] have shown the great potential for sugar cane growing without trash burning of increasing the concentration of organic matter in the soil, especially arenic (AQ), which is known to have very low carbon content.

Evaluations of these results, and of studies conducted with the use of vinasse (**Chapter 9**) point to the potential for improvement of the soil through sugar cane planting in both physical (due to the addition of organic matter by the trash and roots), and nutritional aspects (through addition of wastes from the sugar and ethanol production processes, vinasse and filtercake).

12 Luca, E.F. *et. al*: "Efeitos da colheita sem queima da cana-de-açúcar sobre a matéria orgânica e a biomassa microbiana de um latossolo roxo", presented in: XXVII Congresso Brasileiro de Ciência do Solo, Brasília, June 1999

13 Feller, C.L.: "Efeitos da colheita sem queima da cana-de-açúcar sob a dinâmica de carbono e propriedades do solo", Report by FAPESP/USP/CENA (98/12648-3), Piracicaba, Universidade de São Paulo, Centro de Energia Nuclear na Agricultura, 2001

7.3 Erosion in sugar cane crops: situation and prospects

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The erosion process is the leading cause of agricultural soil degradation. The application of soil conservation techniques aim at mitigating soil loss. Any project for the use of land in agriculture should consider the soil type (texture, diagnostic horizon types, water infiltration rate), slope, rainfall pattern, and the crop to be grown. For centuries, sugar cane has been grown in Brazil, often in the same areas, and enough knowledge has been gained for determining the measures to be taken for soil preservation.

Sugar cane in Brazil is renowned for being a preservationist culture. Bertoni *et al.*[14] have demonstrated that the loss of soil under soybean is around 62 percent higher than under sugar cane, and with castor oil plant the loss is around 235 percent higher (**Table 3**).

Table 3: Soil and water losses in annual and semi-permanent crops

Annual crop	Losses	
	Soil	Water
	t / ha·year	% rain
Castor	41.5	12.0
Beans	38.1	11.2
Manioc	33.9	11.4
Peanut	26.7	9.2
Rice	25.1	11.2
Cotton	24.8	9.7
Soybean	20.1	6.9
English potato	18.4	6.6
Sugar cane	12.4	4.2
Corn	12.0	5.2
Corn + beans	10.1	4.6
Sweet potato	6.6	4.2

As an overall average for the handling practices applied, sugar cane crops in Brazil can be counted on to prevent annual erosion of around 74.8 million tons of soil compared to grain production in the same area (grains: mean loss rate of 24.5 t / ha·year).

Soil erosion loss assessments conducted for a period of eleven years (ending in 2004),[15] comparing in the same sugar cane crop area in the Catanduva region, São Paulo State, on a clay red yellow, eutrophic, sandy/medium-textured soil (PVA-25), showed that between the initial survey[15] and that which concluded in 2004, there were no significant

14 Bertoni, J.; Pastana, F.I.; Lombardi Neto, F.; Benatti Junior, R.: "Conclusões gerais das pesquisas sobre conservação de solo no Instituto Agronômico", Campinas, Instituto Agronômico, 2nd print, Jan 1982, Circular 20, 57 p., *in*: Lombardi Neto, F.; Bellinazi Jr, R.: *Simpósio sobre terraceamento agrícola*, Campinas, SP, Fundação Cargill, 1998

15 CTC, "Relatório final de projeto Carta de Solos", Piracicaba, Centro de Tecnologia Canavieira, Technical report 604 – Volumes I and II, 1993

changes in profile horizon thickness or in the physicochemical composition of the soil in the area (**Tables 4** and **5**).

Table 4: Physicochemical analyses of the 4 trenches (2004)

Trench	Compartment	Depth	Diagnostic horizon	Clay	Org. Mat.	Base Sum	CEC	V
		cm		g / kg	g / dm^3	mmol / dm^3	mmol / dm^3	%
1	22	0-25	Ap	102	11	35	48	73.1
		25-50	Ap/B1	183	6	30	43	70.0
		90-110	B2	324	4	22	37	60.6
2	27	0-25	Ap	101	9	27	40	67.4
		25-50	Ap/B1	268	6	23	38	61.6
		90-110	B2	325	4	28	43	64.8
3	22	0-25	Ap	110	11	27	45	60.0
		25-50	Ap/B1	198	6	25	43	57.4
		90-110	B2	250	2	21	37	56.3
4	27	0-25	Ap	118	9	46	59	78.0
		25-50	Ap/B1	160	4	30	44	67.4
		90-110	B2	381	2	36	52	69.4

For the clay content (g / kg) of the Ap horizon, the variations fall within the "very sandy" textural class; the thickness of the soil allows it to classified as clayey with Ap horizon variation of 30 cm to 60 cm. Such thickness was never lower than 35 cm, which indicates that the erosion processes in sugar cane crops were efficiently minimized, preserving the physical part of the soil.

The base sum (Ca + Mg + K) indicates the adequacy of the conservation technique applied to the area: it was maintained or, in some cases, increased, showing that there was no chemical degradation of the area. Reaffirming this trend, the *cation exchange capacity* (CEC) of the soil today is clearly higher than that found in historic data.

The base saturation (V%) of a soil shows how its cation exchange capacity (CEC) is saturated by cations (Ca + Mg + K = base sum) important to the development and growing of plants. The V% values were maintained, which demonstrates that the soil conservation technique has minimized the environmental impacts.

Table 5: Initial physicochemical analysis (1993)

Spot no.	Depth	Dia-gnostic horizon	Clay	Org. Mat.	Base Sum	CEC	V
	cm		g / kg	g / dm^3	mmol / dm^3	mmol / dm^3	%
148	0-25	Ap	140	13.1	28.1	38.8	72.0
	25-50	Ap/B1	140	11.6	28.4	41.1	69.0
	90-110	B2	290	9.3	26.4	43.7	60.0
150	0-25	Ap	120	13.4	24.2	36.6	66.0
	25-50	Ap/B1	160	11.6	22.7	34.2	66.0
	90-110	B2	330	9.3	30.6	41.0	75.0
155	0-25	Ap	150	10.2	19.3	32.3	60.0
	25-50	Ap/B1	140	10.5	24.0	39.4	61.0
	90-110	B2	330	7.8	34.5	43.5	79.0
156	0-25	Ap	120	12.8	18.4	38.4	48.0
	25-50	Ap/B1	180	7.4	13.8	31.6	44.0
	90-110	B2	320	7.9	30.0	42.1	71.0

The technological evolution in sugar cane growing has enabled sugar cane harvesting without trash burning in some areas. Using this technique, considerable amounts of trash (around 10-15 tons of dry matter ha·year) are left on the soil, which allows the introduction of reduced soil preparation practices[16, 17] on the re-planting of the sugar cane crop. The growing use of the two technologies (harvesting without burning and reduced preparation) may raise the soil conservation level for sugar cane crops over the next few years, since the trash protects the soil (Table 6)[14, 17] from the direct impact of rain drops, while reduced preparation contributes to smaller soil disruption, as in the case of direct planting of cereals.

16 Gandini, M.O.; Gazon, A.L.; Conde A.J.; Donzelli, J.L.: “Conservação de solos e planejamento da sulcação em áreas de colheita mecânica de cana crua”, Congresso Nacional STAB, Recife, 1996

14 see p. 143

17 Conde, A.J.; Donzelli, J.L.: “Manejo conservacionista do solo para áreas de colheita mecanizada de cana queimada e sem queimar”, VII Seminário de Tecnologia Agronômica, Centro de Tecnologia Canavieira, Piracicaba, 1997

Table 6: Effect of the use of crop waste on soil erosion loss

Handling systems	Losses	
	Soil (t / ha)	Water (% rain)
Burnt straw	20.2	8.0
Buried straw	13.8	5.8
Straw on the surface	6.5	2.5

Average rainfall: 1,300 mm; slopes ranging from 8.5 to 12 percent

7.4 Summary and conclusions

• Sugar cane crops have been expanding in areas having poorer soil (especially "highly anthropized *cerrados*", mostly extensive pastures). They contribute to the recovery of the soil by adding organic matter and chemical-organic fertilizers, which also contributes to improving the physicochemical conditions of the soil, thereby incorporating them into Brazil's agricultural area.

• Today, the sugar cane culture in Brazil is renowned for its relatively small soil erosion loss (compared to soybean, for example). This situation is improving as harvesting without burning expands and reduced preparation techniques are introduced, thereby reducing losses to very low rates that are comparable to those of direct planting in annual cultures.

Chapter 8:
Use of agrochemicals

Among the main sugar cane pests, the sugar cane beetle and spittlebug are currently biologically controlled. Plant diseases are fought with the selection of disease-resistant varieties in genetic improvement programs. No transgenic variety is used today, but the developments in course may help reducing the use of chemicals in the future. In Brazil, sugar cane crops still use more herbicides than coffee and corn crops, less herbicides than citric crops and the same amount as soybeans.

8.1 Introduction

Several principles of the Rio Declaration and, more specifically, Chapters 14 and 19 of Agenda 21, refer to the cautions to be taken in using chemicals (including pesticides). The principle concerned with precaution requires control measures for cases in which there still isn't a fully established scientific certainty about environmental degradation. The precaution principle would have us avoid some of the major problems facing us today worldwide, such as water contamination with pesticides, and very expensive cleaning actions. The inter-generation equity principle needs to be followed in order to prevent the repetition of problems for future generations, such as contaminated agricultural and aquatic ecosystems through the use of DDT, PCBs and dioxins. Another principle refers to the restriction on commercial movement of hazardous products and the people's access to information on their use and movement.

In Agenda 21, Chapter 14 includes "Integrated pest control and management in agriculture", which recommends, among other things, promoting the "use of biological control agents and organic pesticides". Chapter 19 establishes a program for control over toxic chemicals. The concerns are justified by the problems that were established during the relatively short period of intensified "modern" agriculture. For example, the use of pesticides (insecticides, herbicides and fungicides) doubled in the United States (from 400 to 800 million lb / year) between 1965 and 1985,[1] while the use of non-agricultural pesticides dropped 33 percent between 1970 and 1990.

1 GOLDMAN, L.R.: "Toxic chemicals and pesticides", *in*: DERNBACH, J.C. (Ed.): *Stumbling toward sustainability*, Washington DC, Environmental Law Institute, 2002

In several situations, there is now a growing interest in new technologies (PIPs) based on genetic modifications of plants designed to add resistance to pests or pesticide characteristics. Agenda 21 highlights some of the promises of these technologies (more specific, and cleaner in production), but also mentions the potential problems, such as the scattering of genes, adverse impacts on non-targeted organisms, potential food contamination, etc. In the United States, the EPA approved nine PIPs between 1992 and 2002 (most of which with genes for Bt toxin production) and rejected two.

There are differences between countries in legislations on PIPs. For example, in the United States there are no specific labeling procedures for GMO foods, but there are in the European Union. Brazil is gradually defining its position, especially in regard to soybean. The sugar cane industry has not yet started to make efforts to get authorizations to commercial planting of transgenic varieties, but it may do so shortly (see **item 10.3**).

Other ways to reduce the use of pesticides include the application of biological control. Brazil's major programs in this field are already in use in sugar cane crops. This has been done in a more (commercially) limited but very important way, given the results and orientation for the future, "organic" production.

Organic production is much more than reducing the use of pesticides. Organic production of brown sugar and spirits[2] has been used in relatively small areas for ten years now. Large-scale production was developed in Brazil by the São Francisco mill, based in São Paulo, where 13,500 ha of sugar cane plantations have been certified for organic production since 1997. Other mills are certified; there are a few certifying agencies for the production of sugar and spirits. The requirements vary, but they usually include the utilization of areas having not used pesticides and trash burning for a few years, and the preservation of ecosystems (forest corridors, diversity islands). The conservation of soil and water resources is checked, and the use of pesticides under predetermined amounts and other conditions may be allowed in some cases. Biological controls (pests and diseases) and soil coverage with straw (in substitution of herbicides) are given priority. One other resource is manual harrowing. Vinasse and filtercake recycling is an essential part of fertilization, for which low-solubility organic or mineral fertilizers can be used. The cautions extend to industrial production. On such an important scale, and having its production certified for seven years now, the S. Francisco mill reports rises of 10 percent in productivity and 50 to 60 percent in costs.[2]

2 Rossetto, R.: "O sistema de cultivo orgânico", Visão Agrícola, ESALQ-USP, Ano 1, Jan 2004

That work is considered very important for testing the limits of the process of reducing impacts for sugar cane crops, and should be watched very closely over the coming years.

8.2 Agrochemicals (pesticides and others)

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8.2.1 Legislation and controls in Brazil

The Brazilian legislation on pesticides was updated by Law no. 7,802, in July 11, 1989, as regulated by Decree no. 98,816 of January 11, 1990. Agrochemicals include herbicides, insecticides, fungicides, maturators, adhesive spreading agents, and defoliants, among others. "Related" products include all biological and microbial products, vegetable extracts and pheromones that are used to control pests and diseases, yet have no toxicological characteristics and risks. The legislation is complemented by Ordinances by the Crops and Livestock Protection Department, IBAMA – Brazilian Institute of the Environment and ANVISA – Brazilian Sanitary Authority.

The recommendation to use pesticides and related products is made by professionals in the agricultural, cattle-breeding and forestry industries by way of specific Agronomical Prescriptions for each place and problem, among listed products. It is incumbent upon the State Departments of Agriculture and the CREAs (Regional Councils of Engineering, Architecture and Agronomy) to inspect and notify. Pesticides are listed upon evaluation by agronomical efficiency, residue tests, and toxicological and environmental studies. The Ministries of Agriculture, Environment and Health are responsible for these evaluations.

8.2.2 Use of pesticides (insecticides, fungicides and others) in sugar cane crops

The level of consumption of insecticides, fungicides, acaricides and other pesticides in Brazil's sugar cane crops is lower than in citric, corn, coffee and soybean crops. Herbicides, which are the group most widely used as commercially available products or active ingredients, are addressed in **item 8.3**. The fungicide consumption is virtually nil, while insecticide consumption is relatively low (**Tables 1** and **2**).

Table 1: Consumption of fungicides, 1999-2003

		Coffee	Sugar cane	Citric	Corn[1]	Soybean[1]
Commercial product (kg / ha)	1999	6.98	0.00	4.54	0.02	0.34
	2000	5.22	0.00	4.98	0.02	0.40
	2001	1.62	0.00	4.71	0.03	0.37
	2002	1.32	0.00	5.02	0.03	0.42
	2003	1.76	0.00	5.51	0.03	0.56
Active ingredient (kg / ha)	1999	1.38	0.00	2.38	0.01	0.16
	2000	1.61	0.00	2.49	0.01	0.18
	2001	0.75	0.00	2.89	0.01	0.16
	2002	0.55	0.00	3.00	0.01	0.16
	2003	0.66	0.00	3.56	0.01	0.16

1 The use of agrochemicals for seed treatment was considered

Source: Table prepared from data provided by SINDAG and IBGE/CONAB

Table 2: Consumption of insecticides, 1999-2003

		Coffee	Sugar cane	Citric	Corn[1]	Soybean[1]
Commercial product (kg / ha)	1999	4.72	0.44	2.71	0.39	0.91
	2000	4.47	0.41	2.32	0.51	0.99
	2001	2.35	0.51	2.71	0.47	1.07
	2002	0.97	0.48	2.62	0.42	1.02
	2003	2.22	0.54	2.43	0.53	1.03
Active ingredient (kg / ha)	1999	0.91	0.06	1.06	0.12	0.39
	2000	0.65	0.11	0.96	0.17	0.41
	2001	0.36	0.13	0.88	0.16	0.45
	2002	0.14	0.14	0.66	0.14	0.43
	2003	0.26	0.12	0.72	0.18	0.46

1 The use of agrochemicals for seed treatment was considered

Source: Table prepared from data provided by SINDAG and IBGE/CONAB

Table 3: Consumption of acaricides, 1999-2003

		Coffee	Sugar cane	Citric	Corn[1]	Soybean[1]
Commercial product (kg / ha)	1999	0.02	0.00	12.45	0.00	0.00
	2000	0.02	0.00	13.77	0.00	0.00
	2001	0.11	0.00	14.82	0.00	0.01
	2002	0.08	0.00	16.98	0.00	0.01
	2003	0.00	0.05	16.00	0.00	0.01
Active ingredient (kg / ha)	1999	0.00	0.00	8.94	0.00	0.00
	2000	0.00	0.00	9.94	0.00	0.00
	2001	0.08	0.00	10.77	0.00	0.01
	2002	0.06	0.00	12.23	0.00	0.01
	2003	0.07	0.00	10.78	0.00	0.01

1 The use of agrochemicals for seed treatment was considered

Source: Table prepared from data provided by SINDAG and IBGE/CONAB

Table 4: Consumption of other agricultural defensives, 1999-2003

		Coffee	Sugar cane	Citric	Corn[1]	Soybean[1]
Commercial product (kg / ha)	1999	0.15	0.12	0.37	0.08	0.74
	2000	0.34	0.13	2.07	0.08	0.71
	2001	0.64	0.09	2.88	0.08	0.65
	2002	0.28	0.10	3.21	0.14	0.60
	2003	0.26	0.08	2.41	0.12	0.80
Active ingredient (kg / ha)	1999	0.06	0.03	0.28	0.05	0.52
	2000	0.15	0.04	1.83	0.04	0.45
	2001	0.32	0.04	2.34	0.06	0.43
	2002	0.17	0.04	2.70	0.09	0.38
	2003	0.14	0.04	1.97	0.09	0.51

1 The use of agrochemicals for seed treatment was considered

Source: Table prepared from data provided by SINDAG and IBGE/CONAB

For reference, the use of insecticides (active ingredients) in the U.S. was 0.38 kg / ha for corn, and 0.26 kg / ha for soybean in 1991. The use of fungicides in that country was 0.0008 kg / ha for corn, and 0.001 kg / ha for soybean.[3]

3 RANNEY, J.W.; MANN, L.K.: "Environmental considerations in energy crop production", Biomass and Bioenergy vol. 6, no. 3, 1994, pp. 211-228

The SINDAG (National Syndicate for the Agricultural Defensives Industry) shows that the importation of agricultural defensives (active ingredient) decrease from 111 thousand ton in 2004 to 89 thousand t in 2005.[4]

4 NEVES, E.M.; RODRIGUES, L.; SAKAMOTO, R.L. Defensivos: demanda em queda. Agroanalysis. Fundação Getulio Vargas/São Paulo. Outubro. 2006.

The reduction occurred in fungicides (32.7%), acaricides (29.1%), herbicides (22.1%) and insecticides (11.1%). Total imports decreased 22.0%. Total sales to the internal market also decreased 5.6%, but the sales of insecticides increased. For sugar cane, the large increases in production led to larger defensive sales (from 292 M US$ to 362 M US$); defensives for sugar cane corresponded (2004) to 6.5% of total agricultural defensive sales in Brazil.

8.2.3 Main sugar cane pests and controls

Sugar cane beetle (Diatraea saccharalis)

The sugar cane is a moth species that occurs throughout the Brazilian territory and in several countries in South, Central and North America. It has been determined that for each 1-percent infestation, the mean losses in sugar cane production amount to 0.77 percent, plus 0.25 percent in sugar production and 0.20 percent in ethanol production.

Dealing with the sugar cane beetle involves mainly the biological control method, which consists of getting parasitoids and releasing beneficial insects in the most severely infected sugar cane plantations. The most commonly used parasitoid today is the *Cotesia flavipes* wasp. **Figure 1** shows the release of parasitoids and their effect on CTC associated mills between 1980 and 2005. In 2005, 39.2 million masses of *C. flavipes* were released in those units, corresponding to 1.96 billion adult wasps, which resulted in a mean Infestation Intensity of 2.6 percent of internodes damaged by the beetle.

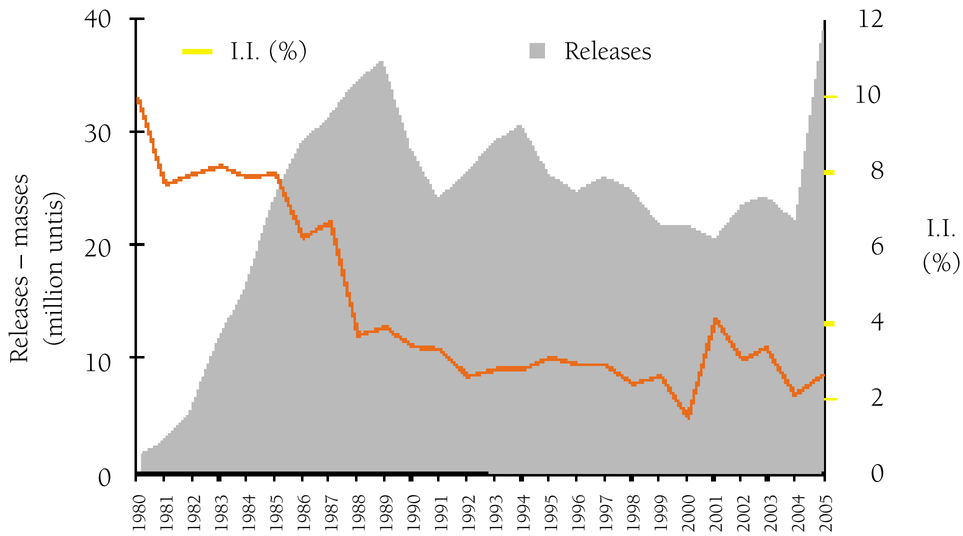
The alternative to biological control is chemical control, which has a lot of drawbacks.[5] Sugar cane crop areas with mechanical harvesting and no burning can use biological control as well.

5 ARRIGONI, E.D.B.: "Uso de defensivos agrícolas na cultura da cana-de-açúcar", Report to UNICA, Piracicaba, CTC, 2005

Defoliating caterpillars

There is no efficient control for the five species of sugar cane defoliating caterpillars because they are only detected when the most damage has already taken place, and only one defoliation brings no significant loss. The control

Figure 1: Number of parasitoids released (adult Tachinid flies and masses of *Cotesia flavipes*) and Infestation Intensity (I.I.%) in CTC associated mills in the period from 1980 to 2005.



by natural parasitoids and natural predators is very high. These pests occur in virtually all of Brazil's sugar cane producing regions, and there is no trend towards an increase in occurrence of this pest in areas where harvesting is performed without straw burning.

Spittlebugs

The *Mahanarva fimbriolata* occurs in São Paulo and neighboring states. Depending on the population levels, it can cause significant losses of 15 tons of sugar cane/ha·year on average, while reducing the sugar content by 1.5 percentage points. With the growth of mechanical harvesting, there will be a significant increase in areas infested by spittlebugs. The areas where the population will reach levels needing control are estimated at 20 percent.

Microbial control by application of the *Metarhizium anisopliae* fungus is the most recommended, most efficient biological method nowadays. Today, when properly implemented, it is the best, most cost-effective option. In the 2004/05 crop, 26 tons of this fungus were used in 25,600 ha of infested areas.

Monitoring spittlebug populations is essential to define the strategy for its biological control; the preservation of the control agents for the spittlebug and also for other insects (like the sugar cane beetle) must be considered. This biological control shows economic advantages over the use of insecticides. Legal limitations in cane burning practices are increasing the need for spittlebug control.

Leaf-cutting ants

Leaf-cutting ants are important; in São Paulo State, the main species are *Atta bisphaerica* and *A. capiguara.*

Each adult leaf-cutting ant causes mean losses of three tons of sugar cane per harvesting season, and the raw material loses quality because of the decreased sucrose content. The mean infestation is currently estimated at 0.5 to 0.7 adult leaf-cutting ant nests per hectare of sugar cane crop in the Center-South region, which corresponds to losses of 1.5 to 2.1 tons of sugar cane / ha·year.

Leaf-cutting ants are controlled by specialized teams that search all of the sugar cane crops at the mills, using thermofogging with motorized equipment to apply the insecticide mixture. Mechanical harvesting of sugar cane without straw burning favors occurrence of this pest for making it harder to locate and control the nests.

Migdolus fryanus (Migdolus beetle)

Migdolus fryanus is a beetle of the Vesperidae family whose larval stage causes damage to the sugar cane root system, which begins to show drought symptoms. A mean reduction of 30 tons / ha·year occurs in infested areas compared to areas treated with soil insecticides. In São Paulo State, the sugar cane crops affected by the pest (that occurs in the Center-South region) cover an area estimated at 100,000 ha.

Mostly, it is controlled by application of insecticides on the distributed sugar cane seedling at the planting furrow, in a joint mechanical operation. This is done in order to protect rural workers from contact with the insecticide. It is indispensable to thoroughly define the infested area and the infestation level in order to reduce the use of pesticides. The harvesting method, either raw or through burning, does not interfere with the population and spread of this pest.

Sphenophorus levis (sphenophorus or sugar cane weevil)

The sugar cane weevil, of the Curculionidae family, that causes damage to the sprouts and the base of developing stalks. It causes losses of 20 to 23 tons / ha·year in infested areas.

The infested area expands rapidly, probably because of the movement of seedlings. The most recommended method to control this pest is the cultural method, consisting of the early destruction of rootstocks in the infested areas to be reformed. The control methods that include insecticide application or toxic bait distribution have the drawbacks of being more costly and requiring constant re-applications.

Mechanical harvesting of sugar cane without trash burning significantly favors the populations of this pest and infestations.

Termites and other pests

Losses in infested areas are estimated at 10 tons of sugar cane / ha•year. Control is based on identification of areas where sugar cane stumps are damaged or areas to be reformed and, using this information, a recommendation of chemical control only where there is potential for damage. The soil pest monitoring method in reform areas enabled an 70-percent reduction of chemical control (data provided by CTC), thereby reducing costs and risks to operators and the environment.

No significant difference in soil pest populations and damages caused thereby occurs in different harvesting systems.

8.2.4 Sugar cane diseases and variety improvement programs

Sugar cane, as semi-permanent culture of annual cycle and vegetative propagation, forms a crop planted with a certain variety that is reformed only after 4 to 5 years of commercial use. These characteristics determine that the only economically feasible disease control option is to use varieties genetically resistant to the main crop diseases. Diseases constitute one of the main reasons for the replacement of a commercially grown variety.

Nine bacteria, 159 fungi, 8 viruses and 1 mycoplasma are known to the 109 sugar cane producing countries and regions, totaling 177 pathogens that cause the crop diseases. Of these, only 40 of them have been reported in Brazil.

The main disease occurrences that have prompted Brazil to replace varieties and caused production losses are as follows:

- The Mosaic virus epidemic in the 1920's, which caused serious losses and led to a quick replacement of the varieties known as "noble sugar canes" with hybrid varieties imported form Java.
- A major sugar cane smut epidemic in the 1980's, associated with the occurrence of rust (1996), affected the NA56-79 variety. Thies variety, which represented 50 percent of the crop area in São Paulo State, was quickly replaced with the SP71-6163 variety.
- A new disease called "Sugar Cane Yellow Leaf Syndrome" (SCYLV), affecting the SP6163 variety in 1990, which overtook this variety in all sugar cane plantations in 3 years and caused production losses of up to 40 percent, forcing its fast replacement.

The phytopathology work performed in accordance with the variety improvement program (at CTC) has been designed to prevent the coming of new pathogens, as well as avoid or minimize losses caused by existing pathogens. There are quarantine safeguard works for foreign varieties that use pathogen testing and provision of information on progenitor responses, as well as new clones for the main diseases occurring in Brazil. These procedures contribute to the efforts of those who work to improve the selection of disease-resistant varieties, and allow the producer to choose the best variety without worrying about the damages caused by diseases.

Notwithstanding the widespread of disease-resistant progenitors in the crossings that have been made, diseases like the sugar cane smut and the Mosaic virus, which limit the use of a new variety, account for the elimination of almost 50 percent of all selected plants (at CTC), thereby reducing selection opportunities for other desirable characteristics.

Recent advances in molecular biology and genetic engineering have an enormous potential for assisting sugar cane improvement experts in producing commercial varieties featuring high productivity and improved adaptation to biotic and abiotic stresses. The first transgenic sugar cane plants produced in Brazil were obtained in 1994 at CTC. Since then, sugar cane plants resistant to the glufosinate ammonium[6] and glyphosate[7] herbicides, the Mosaic virus (SCMV), the sugar cane yellow leaf virus (SCYLV) and the main sugar cane pest,[8] the beetle *Diatraea saccharalis*, have been produced.

The efforts to obtain transgenic sugar cane varieties resistant to the damaging pests that cause agricultural productivity losses and decreased sugar and ethanol production, have been numerous. Among the relevant strategies, it is worth pointing out the use of proteinase inhibitors,[9] lectin[10] production and the *Bacillus thuringiensis* (Bt) protein.

The most commonly used strategy to induce insect-resistance in plants by genetic engineering, is the insertion of genes that encode the *Cry* proteins produced by the Bt. These proteins are toxic to insects and are activated by the alkaline pH of the digestive system of the insect and by proteinases. Upon activation, they cause the insect to die within a few hours by breaking its osmotic balance. Genetically modified sugar cane containing the Cry1Ab Bt virus was evaluated by CTC in a field experiment and displayed an excellent level of sugar cane beetle resistance.[11]

6 Falco, M.C.; Neto, A.T.; Ulian, E.C.: "Transformation and expression of a gene for herbicide resistance in a Brazilian sugarcane plant cell", Rep 19 (12) 2000, pp. 1188-1194

7 Ulian, E.C.; Braga, D.P.V.; Lavrik, P.B.; Baerson, S.R.: "Transgenic sugar cane plants for roundup tolerance obtained through microprojectile bombardment", *in*: Plant and Animal Genome VIII San Diego, Abstracts San Diego: NCGR, 2000, p. 205

8 Braga, D.P.V.; Arrigoni, E.D.B.; Burnquist, W.L.; Silva-Filho, M.C.; Ulian, E.C.: "A new approach for control of *Diatraea saccharalis* (Lepidoptera: Crambidae) through the expression of an insecticidal CryIa(b) protein in transgenic sugarcane", Proc. Int. Soc. Sugar Cane Technol, vol. 24, 2001, pp.331-336

9 Shepherd, K.M.; Smith, G.R.; Joyce, P.A., Nutt, K.A.; McQualter, R.B.; McGhie, T.K.; Allsopp, P.G.: "Engineering cane-grub-tolerant transgenic sugarcane", *in*: Pathology and Molecular Biology Workshop, Kwazulu-Natal, Abstracts, 1997, Kwazulu-Natal: SASAExS, p 16

10 Irvine, J.E.; Mirkov, T.E.: "The development of genetic transformation of sugar cane in Texas", Sugar Journal vol. 6,1997, pp. 25-29

11 Braga, D.P.V.; Arrigoni, E.D.B.; Silva-Filho, M.C.; Ulian, E.C.: "Expression of the Cry1Ab protein in genetically modified sugar cane for the control of *Diatraea saccharalis* (Lepidoptara: Crambidae)", Journal of New Seeds 5(2/3), 2003, pp. 209-222

8.3 Pesticides: herbicides

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8.3.1 Weeds and the decrease in sugar cane productivity

Weeds lead to substantial losses in sugar cane crops. The American Weed Science Society[12] estimated losses caused by infesting plants in the US at 20 percent. In Brazil (1980), production losses of 24 percent occurred,[13] and much higher losses have been reported.[14, 15] The competition between weeds and sugar cane in Brazil has been the subject of extensive studies. The interference, and interference prevention periods, may vary even with the sugar cane cycle. Productivity losses may range from 10 to more than 80 percent.[16] The interference intensity of sugar cane weeds depends on factors related to the crop (type, species or variety, planting furrow spacing, and sowing density), the weed community (specific composition, density and distribution), and environmental factors.[17]

8.3.2 Main weeds in Brazil's sugar cane crops

A total of 566 plant species found in Brazil (Lorenzi, 2000) have been described, and can be considered undesirable plants or weeds. These

Table 5: The main weeds in sugar cane crops

Scientific name	Common name
Cyperus rotundus L.	Nutgrass
Cynodon dactylon (L.) Pers.	Bermuda grass
Digitaria sanguinalis (L.) Scop.	Hairy crabgrass; large crabgrass
Portulaca oleracea L.	Little hogweed
Eleusine indica (L.) Gaertn.	Goosegrass; Indian goosegrass
Echinochloa colonum (L.) Link.	Junglegrass; junglerice
Sorghum halepense (L.) Pers.	Johnsongrass
Panicum maximum Jacq.	Guinea grass
Rottboelia exaltata L. f.	Itchgrass
Amaranthus spinosus L.	Spiny amaranth
Ageratum conyzoides L.	Whiteweed; billygoat weed
Cyperus esculentus L.	Yellow nutsedge

12 Kissman, H.: "Controle de plantas infestantes: passado em futuro", *in*: Semana do Controle de Plantas Daninhas, 10, 1990, Bandeirantes, Anais Bandeirantes: Fundação Faculdade de Agronomia "Luiz Meneghel", 1990, pp.01-02

13 Colleti, J.T.; Rodrigues, J.C.S.; Giacomini, G.M.: "Influência da época de controle da matocompetição na produtividade da cana-de-açúcar, ciclo de 12 meses", *in*: Congresso Brasileiro de Herbicidas e Ervas Daninhas, 13º, Ilhéus/Itabuna, 1980, Resumos, Itabuna, Bahia, SBHED, CEPLAC, 1980, p. 35

14 Blanco, H.G.: "Ecologia das plantas daninhas: competição das plantas daninhas com culturas brasileiras", *in*: Marcondes, D.A.S. *et al.*: *Controle integrado de plantas daninhas*, São Paulo, crea, 1982, pp. 42-75

15 Lorenzi, H.: "Plantas daninhas e seu controle na cultura da cana-de-açúcar", *in*: Copersucar – Reunião Técnica Agronômica, 1983, pp. 59-73

16 Gravena, R.; Kuva, M.A.; Mattos, E.D.; Pitelli, R.A.; Alves, P.L.C.A.: "Períodos de convivência e controle das plantas daninhas em cana-planta (*Saccharum spp*)", *in*: XXIII Congresso Brasileiro da Ciência das Plantas Daninhas, Gramado, RS, 2002, Resumos: Gramado, RS, SBCPD, 2002, p. 95

17 Pitelli, R.A.; Kuva, M.A.: "Bases para manejo integrado de plantas daninhas em cana-de-açúcar", *in*: Semana da Cana-de-Açúcar de Piracicaba, 2, Piracicaba, Abril 22-25, 1997, anais

18 see p. 158

species are distributed among several Families and Orders of the Monocotyledone and Dichotyledone classes, Agiospermae division. Approximately 150 species of these occur in sugar cane crops most often. The 12 species that account for the most damage to the crops (1970) are listed in **Table 5**.[18]

Today, the following should be added: Signalgrass (*Brachiaria decumbens* Stapf.); Alexandergrass (*Brachiaria plantaginea*); Mexican fireplant or Wild poinsettia (*Euphorbia heterophilla* L..); Tropical spiderwort (*Commelina benghalensis* L.); and the weeds known as *Ipomea violacea* (Ipomoeas), which are comprised of several species and have become very important in crops mechanically harvested without trash burning.

8.3.3 Main control methods

The control or management of weeds encompasses specific methods or combinations of mechanical, cultural, chemical and biological methods, making up an extremely dynamic process that is often reviewed. The use of pesticides is regulated by the legislation referred to in **item 8.2.1**.

Preventive measures seek to prevent weeds from being introduced, developing and disseminating in a certain area where they don't exist. For example, using seedlings from areas that are free of pests, while maintaining and controlling weeds in vinasse channels, constitute preventive control methods.[19] And so is the cleaning of agricultural machines when shifting working places.[20]

Cultural measures are practices like crop rotation, crop plant spacing variation, and the use of green covers.

Mechanical or Physical measures include soil preparation for planting, uprooting, harrowing, ground preparation, flooding, burning, dead cover and mechanical growing.

Biological measures entail the use of natural enemies (pests and diseases) to control weeds, including the possible allelopathic inhibition of one plant by another. The control of nutgrass (*Cyperus rotundus* L) using jack bean (*Canavalia ensiformis*) is an example of this possibility.[21] In Brazil, natural enemies have not been used in weed control.

Chemical measures include the use of herbicides, many of which having a selective ability to eliminate some plant types or species, while preserving others. They are currently the main weed controlling tool, and their proper utilization can be efficient and safe.

18 Holm, L.G.; Plucknett, D.L.; Pancho, J.V.; Herberger, J.P.: *The world's worst weeds. Distribution and Biology*, Honolulu, The East-West Center, University Press of Hawaii, 1977, 609 p.

19 Lorenzi, H.: "Tiririca – Uma séria ameaça aos canaviais", Boletim Técnico Copersucar n. 36, Cooperativa Central dos Produtores de Açúcar e Álcool do Estado de São Paulo, 1986, pp. 3-10

20 Pitelli, R.A.: "Manejo Integrado de plantas daninhas", *in: Controle integrado de plantas daninhas*, São Paulo, CREA – Conselho Regional de Engenharia Arquitetura e Agronomia – SP, 1982, pp. 28-41

21 Deuber, R.: *Ciência das plantas daninhas: fundamentos*, Jaboticabal, FUNEP, vol. 1, 1992

Integrated weed management consists of simultaneously using control measures, generally of preventive nature, as well as mechanical and chemical methods. Using seedlings produced in nutgrass-free areas and leguminosae on rotation, and preparing the soil (mechanical control) help limit the necessary chemical control of pre-emerging herbicides, in order to prevent germination of weed seeds. Drastically reducing their emergence and population, these four measures make up a management technique that is widely used in weed control. The need to control several weed species (mono and dicotyledones) before the sugar cane grows and for as long a period as possible during the crop cycle makes broad-spectrum, long-residual power herbicides the most commonly used.

The use of herbicides in sugar cane crops (kg of active ingredient / ha) remained stable from 2000 to 2003. The decreased use in 1999 was due to the producers' difficult financial situation at the time (**Table 6**). Compared to other crops, sugar cane uses more herbicides that coffee and corn in Brazil, a little less than citric crops do, and the same amount as soybean crops do. However, the values are close.

Table 6: Use of herbicides in the main commercial crops[22]

Relative herbicide consumption	Destination	Coffee	Sugar cane	Citric	Corn[1]	Soybean[1]
Commercial product (kg / ha)	1999	3.38	2.78	3.23	2.51	4.44
	2000	3.10	3.91	3.28	3.21	5.24
	2001	3.99	5.24	5.80	2.84	4.57
	2002	2.57	4.23	5.53	2.58	4.45
	2003	2.42	4.14	6.69	3.31	4.92
	Mean	3.09	4.06	4.90	2.89	4.73
Active ingredient (kg / ha)	1999	1.84	1.52	1.75	1.21	2.01
	2000	1.56	2.17	1.69	1.54	2.33
	2001	2.01	2.77	2.46	1.38	2.09
	2002	1.35	2.22	2.63	1.24	2.05
	2003	1.27	2.29	3.40	1.70	2.50
	Mean	1.61	2.20	2.39	1.41	2.20

1 The use of agrochemicals for seed treatment was considered

Source: Table prepared from data provided by SINDAG and IBGE/CONAB

22 Marzabal Neves, E.; Gastadi, H.L.G. "Demanda relativa por defensivos agrícolas pelas principais culturas comerciais, pós-desvalorização do Real", ESALQ-USP, Aug 2004

In the United States, the use of active ingredient was 3.06 kg/ha, for corn, and 1.83 for soybean.[23]

8.3.4 Herbicide resistance of weeds

The rise of herbicide-resistant weeds is recent,[24] dating back to the 1960's, but have increased in number very fast. There are now 286 herbicide-resistant biotypes around the world,[25] spread over 171 species (102 monocotyledones and 69 dicotyledones). The countries having the highest numbers of herbicide-resistant weed biotypes are the United States (107), Canada (43), Australia (41), France (30), and Spain (26). Several cases of herbicide resistance have been reported in Brazil's rice and soybean crops since 1993. Soybean crops have the largest number of herbicide-resistant biotypes, perhaps because they are the leading herbicide users (more than 50%).[24] Even though the size of crop areas currently having herbicide-resistant weed biotypes is relatively small, their expansion has been fast and requires preventive and management measures in order to preserve the efficiency of herbicides. Strategies to prevent or retard the rise or evolution of herbicide-resistant weeds include crop rotation, mechanical control, planning on and use of different herbicides, and integrated control (cultural, mechanical and chemical).

8.3.5 Trends

The sugar cane culture in Brazil, especially in São Paulo State, will use two technologies for harvesting over the next few years: with and without trash burning for harvesting.

In the first case (raw sugar cane), the straw remaining on the soil was initially believed to be sufficient for controlling weeds throughout the crop cycle.[26, 27, 28] However, it is known today that the straw causes physical, chemical and biological change[29, 30] that favors the development of species that used to be rare or unusual in sugar cane plantations on uncovered soil. In addition, careless bush control during formation of the sugar cane crop may lead to severe infestations on the rootstocks. Therefore, herbicides are expected to continue in use, mostly in the pre-emerging mode, and integrated with mechanical control of soil preparation. An efficient sugar cane plant control will reduce the potential for infestation on the first rootstocks, thereby diminishing the need for modern herbicides. These herbicides need rain in order to reach the soil surface when used, thereby showing limited efficiency in drought times. Some mills have opted to remove the straw from

23 RANNEY, J.W.; MANN, L.K.: "Environmental considerations in energy crop production", Biomass and Bioenergy, vol. 6, no. 3, 1994, pp. 211-228

24 CHISTOFOLLETI, P.J.; OVEJERO, R.F.L.; CARVALHO, J.C.: *Aspectos de resistência de plantas daninhas a herbicidas*, Campinas, SP, Associação Brasileira de Ação a Resistência de Plantas aos Herbicidas (HRAC-BR), 2nd ed.; 2004, 100 p.

25 Weed Science, "International survey of herbicide resistant weeds" (2004), site: www.weedscience.org/in.asp (01/05/2003)

26 PHILLIPS, M.: "Trash blanketing on the increase in Bundaberg", *in*: BSES Bulletin, no. 55, 1996, pp. 14-15

27 MANECHINI, C.: "Manejo agronômico da cana crua", *in*: Anais do VII Seminário de Tecnologia Agronômica Copersucar, 1997, pp. 309-327

28 AREVALO, R.A.; BERTONCINI, E.I.: "Manejo químico de plantas daninhas nos resíduos de colheita de cana crua", STAB vol. 17. no. 4, 1999, pp. 36-38

29 see p. 161

30 see p. 161

the sugar cane line in order to control the spittlebugs and reduce the herbicide application area.

In burned sugar cane areas no change is expected in weed control techniques.

28 PITELLI, R.A.: "Plantas daninhas no sistema de plantio direto de culturas anuais", *in*: Congresso Latinoamericano de Malezas, 12, Montevidéu, 1995, Resumos Montevidéu: INIA (INIA. Technical Series, 56), 1995, pp. 37-42

29 VELINI, E.D.; NEGRISOLI, E.: "Controle de plantas daninhas em cana crua", *in*: Anais do XXII Congresso Brasileiro da Ciência das Plantas Daninhas, Foz do Iguaçu, PR, 2000, pp. 148-163

8.4 Summary and conclusions

• The concern about the impacts of pesticides is present in many sections of Agenda 21, which provides for specific control actions. The use of new technologies based on genetically modified plants is promising (reduction of pesticide utilization), but requires additional caution. Ideally, biological controls and, to the extent possible, "organic" agriculture techniques should be used.

• The Brazilian legislation, including rules and controls from production to use and disposal of materials, covers all important aspects.

• Pesticide consumption in sugar cane crops is lower than in citric, corn, coffee and soybean crops; the use of insecticides is low, and that of fungicides is virtually nil.

• Among the main sugar cane pests, the sugar cane beetle (the most important pest) and spittlebug are currently biologically controlled. The sugar cane beetle is the subject of the country's largest biological control program. Ants, beetles and termites are chemically controlled, and it has been possible to substantially reduce the use of pesticides through selective application.

• Sugar cane diseases are fought with the selection of disease-resistant varieties in major genetic improvement programs. This procedure has been sufficient to address the occurrences in large proportions, such as the Mosaic virus (1920), the sugar cane smut and rust (1980's), and the SCYLV (1990's), through replacement of varieties.

• Genetic modifications (at field test stage) have produced plants resistant to herbicides, smut, the Mosaic virus, the SCYLV and the sugar cane beetle.

• Weed control methods have been frequently changed because of advances in technology (cultural and mechanical or chemical). In Brazil, sugar cane crops still use more herbicides than coffee and corn crops, less herbicides than citric crops, and the same amounts as soybean crops. There is a strong trend towards an increase in the areas where raw sugar cane is harvested with the trash remaining on the soil. Today it seems impossible to use this to totally eliminate herbicides, as expected, especially because of the rise of unusual of pests.