Chapter 9:
Use of fertilizers

Among Brazil's large crops (area larger than 1 Mha), sugar cane uses smaller amounts of fertilizers than cotton, coffee and oranges, and is equivalent to soybean crops in this respect. The amount of fertilizers used is also small compared to sugar cane crops in other countries: Australia uses 48 percent more. The most significant factor is nutrient recycling through the application of industrial wastes, as vinasse and filtercake.

9.1 Introduction

Although Brazilian agriculture has been going through a great expansion period over the past few decades, and has reached a high level of competitiveness in export markets, it is not characterized by an intensive use of fertilizers in general. In 1998, the mean use intensity (kg / ha N-P_2O_5-K_2O) was equivalent to that of the United States and Venezuela, around 40 percent of the intensity in France or China, and 22 percent of that of the Netherlands. In terms of total consumption, Brazil had[1] an annual consumption of 7.68 Mt in 2002, representing around 5.4 percent of the total world consumption. At the same time, the United States used 13.7 percent, France used 2.8 percent, China 28.1 percent, India 11.4 percent, and Europe 15.5 percent.

1 FAO: Faostat Database 2004, http://faostat.fao.org/faostat , Feb 2005

The impact of fertilizers on water quality depends on many use conditions. Fertilization with nitrogen, sandy soil, irrigated soil, and soil with shallow water tables, are more vulnerable to nitrate contamination. The potential of nitrogen for reaching and contaminating water also depends on the quantity used, the use by the plant, the level of nutrients and organic matter in the soil, and the weather.

In the case of sugar cane crops in Brazil, an important characteristic is the full recycling of waste to the field. The rise in ethanol production required the vinasse to be taken care of. The solution was to recycle it for the crop. The benefits provided by this ferti-irrigation have become evident, and an optimization of potassium utilization was sought and yielded very favorable results. The infrastructure created has enabled the development to use the water from the industrial process and the ashes from boilers. Filtercake recycling processes were also developed, thereby increasing the supply of nutrients to the field. Recycling is addressed in this chapter because of its ability to reduce the need for external mineral fertilizers, and also from an environmental standpoint, i.e. water quality protection. The evolution of the applicable legislation has been very important and appropriate in this respect to the leading producing areas, such as São Paulo.

Another interesting aspect of the sugar cane culture in Brazil is that the mean nitrogen extraction by the crops is much higher than the fertilizer dose used in the first harvesting season. For example, besides the N mineralized in the crop and organic matter remainders on the soil, an explanation that has been investigated is the fixation of several bacteria in the rhizosphere and roots. The advanced uses of this possibility are the subject of studies.[2]

2 DEMATTÊ, J.L.I.: "Recuperação e manutenção da fertilidade dos solos", Visão Agrícola, ESALQ-USP, Ano 1, Jan 2004

9.2 The use of fertilizers in Brazil's sugar cane production

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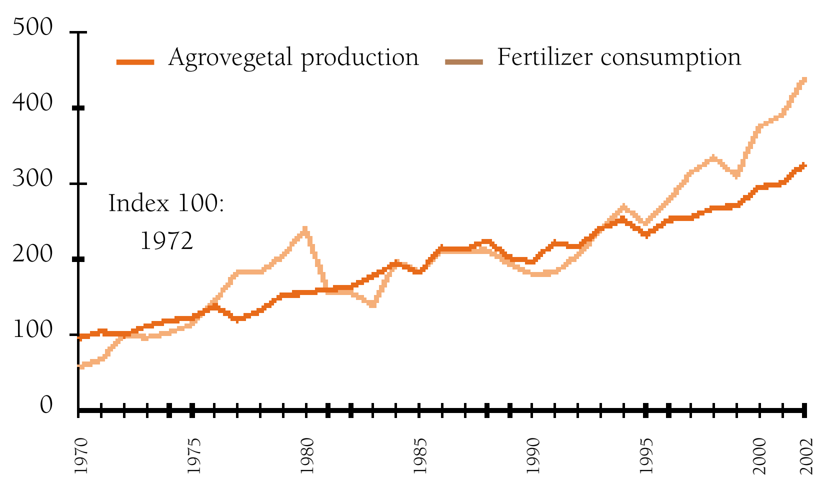
For the most part, the nutrient balance in Brazilian agriculture (taken as a whole) is unsatisfactory. In other words, the amount of nutrients taken is larger than the amount applied. The soil is progressively impoverished in terms of nutrients. Persisting in the long term, this would become a threat to the sustainability of agriculture.[3] On the other hand, both productivity and fertilizer consumption have increased[4] in Brazil over the past three decades (**Figure 1**).

3 FAO – Food and Agriculture Organization of the United Nations: "Use of fertilizer by crops in Brazil. based on Alfredo Scheid Lopes", Land and Plant Nutrition Management Service – Land and Water Development Division, Rome, 2004

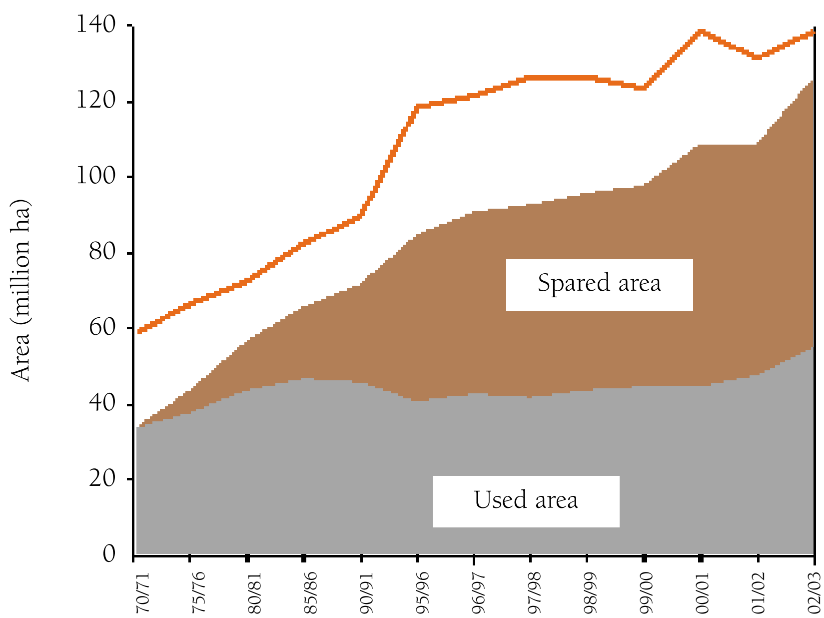
4 LOPES, A.S.; GUILHERME, L.R.G.; SILVA, C.A.P.: *A vocação da terra*, São Paulo, ANDA, 2nd ed., 2003, 23 p.

Figure 1: Agricultural production and fertilizer consumption in Brazil[4]



The use of fertilizers and the technological developments in agriculture have reduced the need to open new areas. Obtaining the 2002/03 agricultural production with the same productivity as in 1970/71 would require an additional area of around 71 million hectares (**Figure 2**).

Figure 2: Agricultural production and productivity in Brazil and spared additional area



Of all crops in Brazil that cover an area in excess of 1 million hectares, sugar cane crops rank fourth on a list of 10 users fertilizer use intensity (**Table 1**), with 460 kg of a mean formula of N-P_2O_5-K_2O per hectare.[5]

5 ANDA – Associação Nacional para Difusão de Adubos: *Anuário estatístico do setor de fertilizantes: 1987-2003*, São Paulo, 2003, p. 34

Sugar cane crops in Brazil use a low level of fertilizers compared to other countries. In Australia, the ratoon and plant sugar cane fertilization levels are 30 and 54 percent higher than in Brazil, respectively, especially in nitrogen application, with doses of up to 200 kg / ha (**Table 2**).

Table 1: Intensity of fertilizer use in crops in Brazil

Crops	Area[1] (1,000 ha)	Consumption (1,000 t)	Consumption / area
Year	2003	2003	(t / ha)
Herbaceous cotton	1,012	950	0.94
Coffee[3]	2,551	1,375	0.54
Orange[3]	823	406	0.49
Sugar cane[3]	5,592	2,600	0.46
Soybean	21,069	8,428	0.40
Corn[2]	13,043	4,082	0.31
Wheat[3]	2,489	742	0.30
Rice	3,575	872	0.24
Beans[2]	4,223	650	0.15
Reforestation	1,150	129	0.11

1 Data from the Systematic Survey of Agricultural Production – LSPA-IBGE and CONAB

2 These cultures total all of the harvested crops

3 Crops planted and harvested in the same year

Table 2: Fertilizer use level in sugar cane: Australia and Brazil, k / ha

		Cane stage	Plant	Ratoon
Country	Australia	N	200	200
		P_2O_5	58	57
		K_2O	120	145
		Total 1	378	402
	Brazil	N	50	100
		P_2O_5	120	30
		K_2O	120	130
		Total 2	290	260
Total 1/ Total 2 ratio (%)			1.30	1.54

Source: Adapted from: CaneGrowers', 1995 (Note 6); CTC, 1988 (Note 7);Manechini & Penatti, 2000 (Note 8).

6 Canegrowers: *Cane Growers' Information Handbook 1994-95*, Brisbane, Australian Canegrower, 1995

7 CTC: "Recomendação de adubação para a cultura de cana-de-açúcar", Cadernos Copersucar Série Agronômica n.º 17, Piracicaba, Centro de Tecnologia Canavieira, 1988

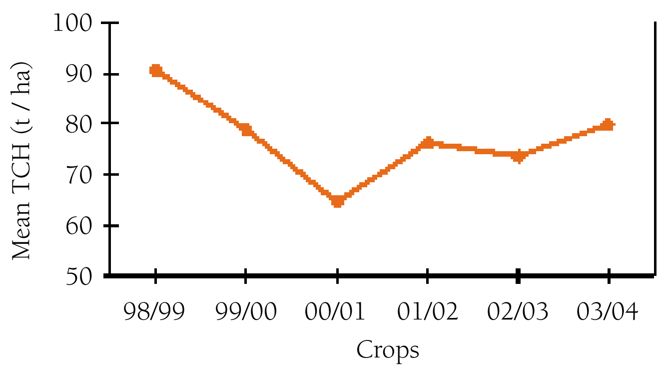
8 MANECHINI, C; PENATTI, C.P.: "Nutrição mineral de cana-de-açúcar – novos parâmetros", Agrícola Informa no. 112, Piracicaba, Centro de Tecnologia Canavieira, 2000

Such relatively low fertilization levels, as adjusted by the agricultural research in Brazil (especially at the Sugar Cane Technology Center), has not limited the agricultural productivity. However, applications below the recommended levels may result in decreased production. For example, when there was oversupply of sugar cane for the 1998/99 crop, the crop renewals and application of consumables (including fertilizers, by around 10%) were reduced in the 1999/2000 crop in several mills.[9] Consequently, this caused a fall in cane production for the 2000/01 crop (**Figure 3**).[10] In this crop, there was an increased application of fertilizers, among other management and climate-related actions, resulting in increasing production for the 2001/02 crop.

9 CTC: "Controle mútuo agroindustrial safra 2002/03", Internal report, Piracicaba, Centro de Tecnologia Canavieira, 2004

10 PAES, L.A.D.; OLIVEIRA, D.T.; DONZELLI, J.L.; ELIA NETO, A.: "Copersucar Benchmarking Program", Proceedings of XXV ISSCT Congress, Guatemala, 2005

Figure 3: Mean productivity in Copersucar units[10]



An important, specific factor in Brazil's sugar cane crops is the recycling of nutrients by the application of two items of industrial waste, namely, vinasse and filtercake. Vinasse is now treated as a nutrient source (rather than residue), and its application has been optimized within the topographic, soil and environmental control limits. Many of these results are well known. For example, vinasse applications conducted for seven consecutive years on a dystrophic alic, sandy red yellow latosol[11] have shown a significant increase in the amount of nutrients available to the plant after four consecutive applications divided into four years (**Figure 4**, p. 169).

11 PENATTI, C.P.; ARAUJO, J.V.; DONZELLI, J.L.; SOUZA, S.A.V.; FORTI, J.A.; RIBEIRO, R.: "Vinasse: a liquid fertilizer", *in*: Proceedings of XXV ISS-CT Congress, vol.1, Guatemala, 2005, pp. 403-411

Figure 4 shows that the potassium concentration significantly rose up to a depth of 100 cm, according to the increase in applied vinasse doses. **Figure 5** shows the sugar cane productivity increasing as soil fertility and water supply rise. The maximum vinasse dose produced an additional 73 t / ha in six years, which is equivalent to one more harvesting season, compared to standard mineral fertilization (57-28-115 kg / ha of N-P_2O_5-K_2O).

The sugar cane crops in Brazil now have a potential for nutrient recycling with vinasse, filtercake and straw of 1,195.1 million t of N-P_2O_5-K_2O (**Table 3**). Of that potential, only the portion corresponding to the trash is not significantly used (and maybe only a part of it will, even in the future). The use of both vinasse and filtercake can still be further optimized.

Even when leaving out of account the use of boiler ashes (which partially exists already), an increased and optimized use of residues can lead to higher productivity, thereby reducing costs and the need for additional areas. The nutrient recycling ability will be important especially in Brazil's Center-West region, contributing to soil fertility improvements.

Table 3: Potential for annual nutrient recycling in sugar cane crops

Subproduct		Filtercake[1]	Vinasse[2]	Straw[3]	Total
Nutrients (kg / t)	N	12.5	0.36	3.71	
	P_2O_5	21.8	0.14	0.7	
	K_2O	3.2	2.45	6.18	
Production (1,000 t / year)		4,682	148,940	54,779	
Total available (1,000 t)		175.6	439.4	580.1	1,195.1

1 12 kg / sugar cane ton

2 Production of 10 to15 liters per liter of ethanol

3 Future: for 4 Mha harvested without burning

Source: VII e VIII Seminários de Tecnologia Agronômica Copersucar, BTC 36/87; Note **14**

14 see p. 171

Figure 4: Potassium concentration at four soil depths after six months (04/1996) and four applications of vinasse doses

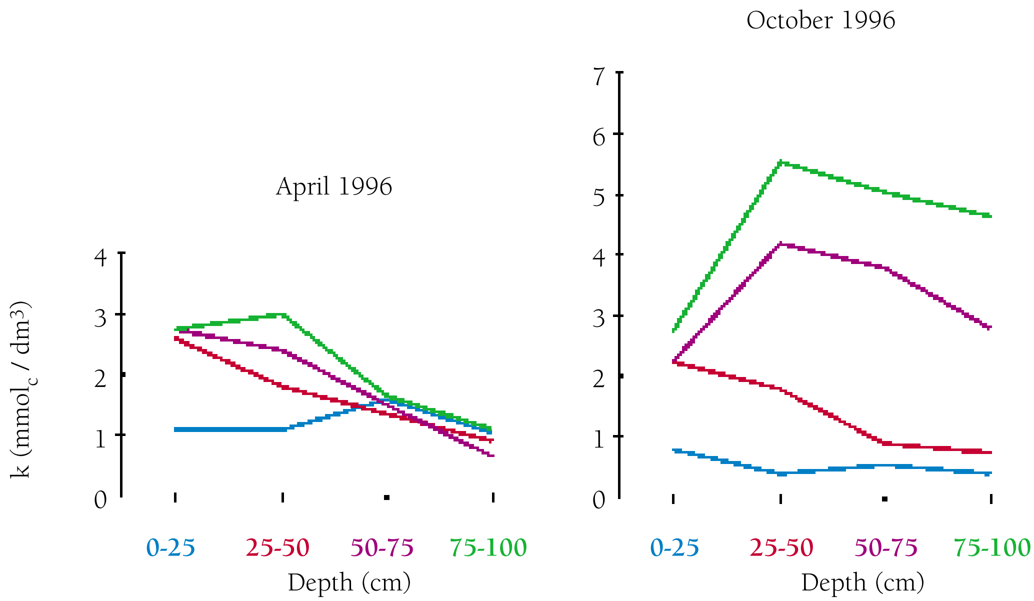
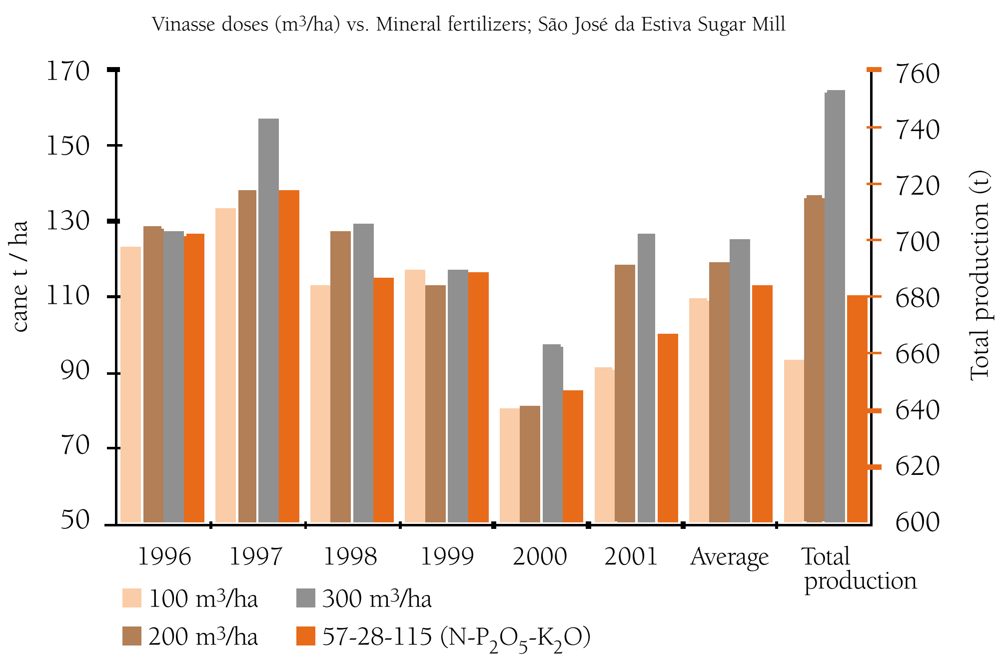


Figure 5: Sugar cane productivity/production; four vinasse dosages compared to standard mineral fertilization



9.3 Advances in the utilization of vinasse

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9.3.1 Vinasse characterization

Vinasse is the residue from the distillation of the sugar cane juice, molasses and honey alcoholic fermentation process. Its characteristics depend on the must composition (juice and molasses). For each liter of alcohol, 10 to 15 liters of vinasse are produced, depending on the sugar cane characteristics and processing. Vinasse used to be released to water streams 30 years ago (at that time, the volumes were much lower than today). It began to be recycled to the fields in 1978. The doses per area unit were gradually decreased, and new technologies were introduced with a view to expanding the ferti-irrigation area (for improved utilization of its potential) and eliminating underground water contamination risks. The current practice is full recycling, which has shown great benefits.

Generally the vinasse has a high organic matter and potassium content, and relatively poor nitrogen, calcium, phosphorus and magnesium contents. The composition depends on the origin (must), as shown in **Table 4** (data for 1984).[12, 13]

12 Ferreira, E.S.; Monteiro, A.O.: "Efeitos da aplicação da vinhaça nas propriedades químicas, físicas e biológicas do solo", Boletim Técnico Copersucar, vol. 36, São Paulo, 1987, pp.3-7

13 Orlando Filho, J.; Leme, E.J.: "Utilização agrícola dos resíduos da agroindústria canavieira", *in*: Simpósio sobre Fertilizantes na Agricultura Brasileira, Brasília, DF, 1984, Anais, pp. 451-475

Table 4: Chemical composition of vinasse from different kinds of must, 1984

Elements	Must		
	Molasses	Mixed	Juice
N (kg / m^3 vinasse)	0.75 - 0.79	0.33 - 0.48	0.26 - 0.35
P_2O_5 (kg / m^3 vinasse)	0.10 - 0.35	0.09 - 0.61	0.09 - 0.50
K_2O (kg / m^3 vinasse)	3.50 - 7.60	2.10 - 3.40	1.01 - 2.00
CaO (kg / m^3 vinasse)	1.80 - 2.40	0.57 - 1.46	0.13 - 0.76
MgO (kg / m^3 vinasse)	0.84 - 1.40	0.33 - 0.58	0.21 - 0.41
SO_4 (kg / m^3 vinasse)	1.50	1.60	2.03
O.M. (kg / m^3 vinasse)	37 - 57	19 - 45	15 - 35
Mn (mg / dm^3)	6 - 11	5 - 6	5 - 10
Fe (mg / dm^3)	52 -120	47 -130	45 -110
Cu (mg / dm^3)	3 - 9	2 - 57	1 - 18
Zn (mg / dm^3)	3 - 4	3 - 50	2 - 3
pH	4.0 - 4.5	3.5 - 4.5	3.5 - 4.0

Up-to-date information[14] (corresponding to current variations in must composition) on 28 mills in 1995 are summed up in **Table 5**. The collections were conducted in straight vinasse, i.e. with no flegmass mixture, just off the distillery. The mean vinasse flow rate was 10.85 l /ethanol l, with a standard deviation of 2.40. The potassium content is highlighted.

14 ELIA NETO, A.; NAKAHODO, T.: "Caracterização físico-química da vinhaça – Projeto n.º 9500278", Relatório Técnico da Seção de Tecnologia de Tratamento de Águas do Centro de Tecnologia Canavieira, Piracicaba, 1995

Table 5: Analytical characterization of vinasse, 1995

Vinasse characterization	Units	Minimum	Mean	Maximum	Standard deviation
pH		3.50	4.15	4.90	0.32
Temperature	ºC	65	89	111	9.78
DBO_5	mg / l	6,680	16,950	75,330	9,953.
Chemical Oxygen Demand (COD)	mg / l	9,200	28,450	97,400	13,943.
Total Solids (TS)	mg / l	10,780	25,155	38,680	6,792.
Total Suspended Solids (TSS)	mg / l	260	3.967	9.500	1.940.
Total Dissolved Solids (TDS)	mg / l	1,509	18,420	33,680	6,488.
Nitrogen	mg / l	90	357	885	177.
Total Phosphorus	mg / l	18	60	188	36.
Total Potassium	mg / l	814	**2,035**	3,852	804.
Calcium	mg / l	71	515	1,096	213.
Magnesium	mg / l	97	226	456	71.
Chloride	mg / l	480	1,219	2,300	417.
Sulphate	mg / l	790	1,538	2,800	514.
Sulphite	mg / l	5	36	153	32.

9.3.2 Vinasse distribution systems for ferti-irrigation; evolution and prospects

Vinasse is now fully recycled to the field for ferti-irrigation. The rate at which the areas are covered by ferti-irrigation at the mills is highly variable, depending on the topography and distribution of the mill's land. There are mills that have applied vinasse to 70 percent of their crop areas, whereas others do it at much lower fractions. For the most part, the mills' ferti-irrigation areas increase from crop to crop seeking a rational use of vinasse, with a view to greater agricultural productivity and decreased use of chemical fertilizers. This has been leading to smaller and smaller doses (m^3 / ha), drifting away from levels that could cause damage (salinization, water table contamination).

The systems currently used for ferti-irrigation with liquid residue (vinasse and wastewaters) are standard tanker trucks and application by sprinkling. For sprinkling, the direct-mounting system (pump and engine set and cannon sprinkler on a wheelbase) and the self-propelled, winding-reel system (currently the most disseminated) are used. The latter can be fed directly by channels or trucks. This is a semi-mechanical system, using less manual labor than direct mounting, but its fuel consumption is higher. **Table 6** shows the current use percentages for those systems in São Paulo.

Table 6: Vinasse application systems in São Paulo State

Application Method	Share (%)
Standard tanker truck	6
Sprinkling (channel + direct mounting)	10
Sprinkling (channel + reel)	53
Sprinkling (truck + reel)	31

Two systems that were disseminated at the beginning of the PNA (sacrifice area and infiltration furrows) have been eliminated for failing to promote full use of the vinasse and involving underground water contamination risks. Direct ferti-irrigation with tanker trucks has been widely disseminated, but its limitations (greater soil compacting, impossibility to apply in plant sugar cane areas, difficulties on rainy days, low distribution uniformity, costs) have boosted the development into the current systems.

Studies aiming at the development of vinasse application procedures have included center pivot and subsurface dripping systems.

Center pivot systems provide a more uniform distribution, but the costs are still high, including the need for vinasse corrosion-resistant materials. The pivot systems should be of the wheeled type, as the fixed system is unfeasible due to the small amounts of water corresponding to ferti-irrigation.

Experiments conducted by CTC – Sugar Cane Technology Center show that it is technically feasible to apply vinasse by dripping, but economic feasibility would allow this only if dripping irrigation was (independently) feasible. Alternatives are being studied.

15 Ferreira, E.S.; Monteiro, A.O.: "Efeitos da aplicação da vinhaça nas propriedades químicas, físicas e biológicas do solo", Boletim Técnico Copersucar, vol. 36, São Paulo, 1987, pp. 3-7

16 Orlando Filho, J.; Leme, E.J.: "Utilização agrícola dos resíduos da agroindústria canavieira", *in*: Simpósio sobre Fertilizantes na Agricultura Brasileira, Brasília, DF, Anais, 1984, pp. 451-475

17 Orlando Filho, J.; Zambello J.R.; Agujaro, R.; Rosseto, A.J.: "Efeito da aplicação prolongada da vinhaça nas propriedades químicas dos solos com cana-de-açúcar", Estudo Exploratório, STAB - Açúcar, Álcool e Subprodutos, Piracicaba, 1(6), Jul-Aug 1983, pp. 28-33

9.3.3 Ferti-irrigation; effects of vinasse on the soil

Analyses of the effects of vinasse on soil properties[15] indicate that the addition of *in natura* vinasse to the soil is a good option for taking advantage of this byproduct. It is an excellent fertilizer and provides several benefits in terms of the physical, chemical and biological properties of the soil. Advantages to using vinasse include a rise in pH, increased cation exchange capacity, availability of some nutrients, improved soil structure, increased water retention, and development of the soil's microflora and microfauna.

Not only does the vinasse provide water and nutrients, it also recovers the soil fertility, to some depth. The depth used by the sugar cane root system reaches 160 cm in some countries, but the mean depth in Brazil is 60 cm (given the low fertility of the soil). The vinasse introduces nutrients in depth, such as Ca^{++}, Mg^{++} and K^+, and enriches the soil.[16, 17, 18, 19] There are many experiments that demonstrate the good agricultural productivity results (sugar cane t / ha), regardless of the savings attained by buying smaller amounts of mineral fertilizers.[19, 20] Depending on the dose used and the potassium concentration, a nitrogen complementation is required in ratoon growing.[19, 20]

Several works have shown the effects of vinasse on the soil and environment over years of application. One example is the increase of potassium-content to the a sandy dark red latosol.[21]

Salinization evaluations of three soil types[22] (alluvial, 51% clay; red yellow podzolic, 38% clay; and hydromorphic, 5.5% clay) indicate that there are no saline indeces for doses lower than 400 m^3 / ha, and that applications should be made based on the salt contents and soil characteristics.

The leaching of the elements would represent a waste of fertilizer and could lead to pollution risks. In the case of vinasse, there are heavy elements at very low levels that do not represent any danger to the environment. The mineral macro- and micro-elements present at higher concentrations in leached elements would be K^+, Ca^{2+}, SO_4^{2-} and Cl^-, respectively. Risk assessments of the metals present in the vinasse[23] conducted over a period of five years concluded that the amounts of NO^-_3, NH_4^+ and soluble phosphor were not significantly changed. There were also no significant changes in the contents of soluble zinc, copper, iron and manganese. Only SO_4^{2-} showed leaching of up to 80 cm.

Many other studies have been conducted involving specific aspects pertaining to leaching and underground water contamination possibilities at

18 Camargo, O.A.; Valadares, J.M.A.S.; Geraldi, R.N.: "Características químicas e físicas de solo que recebeu vinhaça por longo tempo", Boletim Técnico IAC, vol. 76, Campinas, SP, Instituto de Agronomia de Campinas, 1983

19 Penatti, C.P.; Forti, J.A.: "Doses de vinhaça versus doses de nitrogênio em cana-soca", *in*: VII Seminário de Tecnologia Agronômica, Piracicaba, Anais Copersucar, Nov 1997, pp. 328-39

20 Penatti, C.P.; Cambria, S.; Boni, P.S.; Arruda, F.C. de O.; Manoel, L.A.: "Efeitos da aplicação de vinhaça e nitrogênio na soqueira da cana-de-açúcar", Boletim Técnico Copersucar, vol. 44, São Paulo, 1988, pp. 32-38

21 Penatti, C.P.: "Doses de vinhaça versus doses de nitrogênio em cana-soca durante quatro safras", Copersucar internal report, Usina São Luiz S.A., Clay soil (LR-2), 1999a

22 Ferreira, W.A.: *Efeito da vinhaça em solos de diferentes texturas*, Piracicaba, 1980, 67 p. Dissertação (Mestrado) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo

23 Camargo, O.A. de.; Valadares, J.M.A.S; Berton, R.S.; Sobrinho T.J.: "Aplicação de vinhaça no solo e efeito no teor de nitrogênio, fósforo e enxofre inorgânicos e no de alguns metais pesados", Boletim Técnico IAC, vol. 8, Campinas, SP, Instituto de Agronomia de Campinas, 1987

19 see p. 173

24 RODELLA, A.A.; FERRARI, S.E.: "A composição da vinhaça e efeitos de sua aplicação como fertilizante na cana-de-açúcar", Rio de Janeiro, Brasil Açucareiro, 90 (1), 1977, pp. 6-13

25 PEIXOTO, M.J.C.; COELHO, M.B.: "Aplicação de vinhaça diluída em cana-de-açúcar por sistema de aspersão", Congresso Nacional da Sociedade de Técnicos Açucareiros e Alcooleiros do Brasil, 2, Rio de Janeiro, Aug 16-21, 1981, Anais, STAB, 1981, pp. 177-194

variable vinasse doses over periods of up to 15 years. On the other hand, there is a consensus among some researchers that doses in excess of 400 m^3 / ha are harmful to sugar cane (inhibiting quality and productivity).[19, 24, 25]

Today vinasse is considered an organic fertilizer, and is also released for "organic" sugar production (where no chemicals can be used: herbicides, insecticides and mineral fertilizers). Respecting the characteristics of the soil to which it is applied, as well as the location of water springs and the volumes defined as suitable to each situation, vinasse does not have any negative effects. The results obtained from tests so far indicate that there are no damaging impacts on the soil at doses lower than 300 m^3/ha, while higher doses may damage the sugar cane or, in specific cases (sandy or shallow soil), contaminate underground waters.

9.3.4 Legislation on vinasse application

The evolution of the legislation on the disposal (currently the use) of vinasse dates back to 1978.

MINTER (National Integration Ministry) Ordinance no. 323 (1978) prohibited release of vinasse in surface fountainheads.

CONAMA (National Environment Council) Resolutions no. 0002 (1984) and 0001 (1986) required studies and determination of rules on the control of effluents from ethanol distilleries, and subsequently rendered the EIA and RIMA mandatory for new units or extensions, respectively.

Law no. 6,134 (1988), article 5^{th}, of São Paulo State provided that waste from industrial and other activities shall not contaminate underground waters.

Until the late 1970's, when ethanol production was still relatively small, there was no legislation on the matter. The practice consisted of disposing of the vinasse in surface fountainheads, thereby increasing their organic load. That changed as of 1978, when the vinasse was totally redirected to ferti-irrigation.

Recently, the São Paulo State's Office of the Secretary of Environment and the production sector developed a technical standard in order to regulate the application of vinasse in São Paulo State. The technical standard seeks a safe way to apply the vinasse by specifying permitted places, doses, protection of master channels and storage, etc. It also considered the results of years of studies seeking safe processes in respect to the various aspects of environmental protection.[26] The efficient use of vinasse is something in

26 Technical Standard P4.231: Vinasse: Criteria and procedures for application in agricultural soils, 2005

which producers are very interested given the economic return. The technologies are expected to keep on evolving in this respect, specifically involving the interaction between vinasse and the waste trash left in the field.

9.4 Summary and conclusions

• The use of fertilizers in Brazilian agriculture is relatively small, although it has increased over the past thirty years, thereby substantially reducing the need for new areas.
• Among Brazil's large crops (area larger than 1 Mha), sugar cane uses smaller amounts of fertilizers than cotton, coffee and oranges, and is equivalent to soybean crops in this respect. The amount of fertilizers used is also small compared to sugar cane crops in other countries (Australia uses 48% more).
• The most important factor is nutrient recycling through the application of industrial waste (vinasse and filtercake), considering the limiting topographic, soil and environmental control conditions. Substantial rises in the potassium content of the soil and productivity have been observed. Nutrient recycling is being optimized, although the use of trash has yet to be implemented. It will be very important in expansion areas.
• A large number of studies in respect to leaching and possibilities of underground water contamination with vinasse, indicate that there are generally no damaging impacts for applications of less than 300 m3 / ha. A technical standard by the Office of the Secretary of Environment (São Paulo) regulates all relevant aspects: risk areas (prohibition); permitted doses; and technologies.