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EFFECT OF SPREADING DISTILLERY WASTE IN OPEN FIELD[1]

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INTRODUCTION

A substantial amount of effluent is obtained from the rum and sugar factories in the French West Indies. Their discharge in river or the sea lead to significant pollution which becomes worse during dry years, due to the low flow of the rivers. Chemical and biological oxygen requirement of the distillery wastes are high and their degradation and their transformation upset the environment by removing an important part of dissolved oxygen. The low pH. high temperature, and high organic matter content are sources of nuisances.

For many years these effluents have been spread in the field in various geographical regions: particularly in Brasil, they are rationally applied as fertilizers providing to the plant useful nutrients.

In particular case of insular ecosystems as Martinique and Guadeloupe, experiments has been conducted to control the effect of field application of distillery wastes at different doses. This study does not consider only the fertilization aspect of waste application but aims at evaluating eventual modifications that may take place at the organic level. The experiments are here briefly presented and thė results about the dynamics of major elements are discussed.

MATERIAL AND METHODS

Soils

The experiment, was carried out by the Technical Centre for Sugar Cane in two different environments.

In Martinique, the experimental plots were established on intergrade ferrallitic/fersialitic soils, down slope; soil compaction is important, with a clay content of about 60% mixture of kaolinite and montmorillonite. Cation exchange capacity is high (35-45 me) and exchangeable cations content is 25 to 35 me., with a high saturation level. In the low lying plots some hydromorphy was observed.

In Guadeloupe, the experimental plots were established on vertisols: the clay content is about 60-70% mainly montmorillonite with a Cation exchange capacity also high (50 me). The absorption complex is saturated with Calcium (presence of calcareous sands), the pH is of about 7.5 to 7.8, locally 6.3 at surface, and 8 in deep horizons. The difference between water-pH and KCl-pH is 1 unit. These soils are more or less deep, 60 to 120 cm. All the plots are planted with sugar-cane.

1. Work done in contract with Centre Techniques de la Canne et de Sucre de Martinique et Guadeloupe, with financial participation of Ministére de la Culture et de l'Environnement, service de l'environnement industriel.

Experimental design

The experimental design is adapted to each situation: the common disposition being the storage of the distillery waste in a pond, digged in the soil. This induces the rapid neutralization of the effluent in Guadeloupe.

The spreading is realized by sprinkler (Guadeloupe), the topography not permitting an irrigation system by running water, and during the night, on a plot of about 8 ha.

The principal experiment in Martinique is done on 9 plots of 100 m2 with irrigation by flooding in the furrow.

The distillery waste is spread with 2 variables, crude or neutralized, at different levels.

The distillery waste (vinasse)

The composition of the distillery waste is variable, following the nature and the management of treatments in the factory (Vasseur et. al. 1977, Robert et. al. 1978): the quality is different according to the origin, from molasses or from cane juice.

One notices the high content in K, in N, and in organic matter. The distillery wastes have also an appreciable content in iron, copper, manganese, coming from the corrosion of pipes: these elements could be used as marks for evidence of water sheet pollution.

The mixture which is spread after storage in the ground is somewhat different from the factory waste: (table 1b). There is an important lowering of chemical requirement in oxygen,

Table 1. Composition of effluents

		Suspension (mg/l)	DCO	DB05	pH	N (mg/l)	P (mg/l)	K (g/l)	Ca (g/l)	Dry matter (g/l)
Martinique										
Effluents of Molasses	1a	2,200	50.000	26.000	3.2	227	13.9	3.8	1.5	53
Effluents of Cane	1a	5,700	18.000	8.000	3.5	100	22.5	1.2	0.2	11
Spread Mixture	1b	1,700	13.500	8.200	3.4	371	137	1.42	–	6.63
Effluent after Aeration			200		8.7	23	217	3.81		
Guadeloupe										
Effluents of Molasses	1a		45.000		3.27	315				36
Effluents of Cane	1a		14.000		3.22	164	67	0.438	0.2	13.9
Spread Mixture (pond)	1b		992	288	7.1	66	36	0.598	0.364	6

Source: Centre Techniques de la Canne et du Sucre Martinique et Guadeloupe.

an increase in N-NH4 content, a decrease in total N, a relative concentration in K. Vasseur and Montreau (1977) advise a passing through a "lit bactcerien" (lagunage) (aeration on columm), before storage and spreading, when natural neutralization as in Guadeloupe cannot be obtained (table 1, Effluent after aeration).

Application modes

The irrigation in Martinique is managed in order to satisfy the water requirement of the sugar-cane in correlation to water deficit and with the distillery waste coming out of the pond, crude (pH 3,5) or neutralized (pH 7). The doses were 12, 5 mm each 15 days from 7-04-76 to 30-05-76, 25 mm each 15 days from 30-05-76 to 30-06-76 and 50 mm/15 days from 30-06-76 to 30-09-76. 3000 cubic meters were spread at all, and 3 plots received double dose (5500 m^3). Neutralization required 4 kg of lime/m^3 of effluent, and must be added just before spreading, the pH going back to 3,5, if stored 24 hours after neutralization (F. Montreau, in Vasseur, op. cit.). The fertilizer (1 ton of 12-8-24) was normally added.

In Guadeloupe, irrigation tends to supply the fertilizer necessary to the plant (P_2O_5, 60 to 80 kg; K_2O 160 to 180 kg or 25 to 34 kg of P, 130-150 kg of K for 1 hectare.

The mixture is spread by sprinkler, during the night, with the naturally neutralized effluent during its storage in a pond digged in the soil. It represents 22 mm during 6 months (220 cubic meters/ha). The experiments then are situated between the mean of experiments in other regions (200 to 500 cubic meters) or are superior in quantity to the doses proposed by brasilian authors (1000 m^3/ha/year) (Da Gloria, 1975).

Sampling

Sampling is done at different periods (1) 0 time, before spreading, (2) 3 months, (3) 6 months, and (4) at the end of harvesting (12 months). In Guadeloupe, sampling is effectuated at (a) 0, (b) 6, (c) 12 months (table 2)

Results represent a mean of 15 samples in Martinique, 6 samples in Guadeloupe. In this island, a folliar analysis is done at 6 months.

RESULTS

If the irrigation by sprinkler, during the day, with non neutralized effluent induces burns on the leaves, the same operation, during the night, with neutralized effluents, does not induce any damage (table 2).

Physical properties

Due to their heavy texture, and presence of montmorillonite, the physical properties of the soils in experiment are naturally bad. No significant variation in stable agregates ratio is observed after treatment with the effluent: this ratio remain constant or increase slightly, in the first time of spreading. The decrease of stability noticed at the end of harvesting is less pronounced on the plots with effluent: the high level in effluent quantity (5500 m^3/ha) (an), does not affect the stability, in respect to a cultivation cycle of one year. The water retention capacity remains constant.

Table 2. Agricultural Results

	pH water	pH KCl	C $^{o}/oo$	N $^{o}/oo$	C/N	AF C($^{o}/oo$)	AH C($^{o}/oo$)	AF MHT	K^+ me%g	CEC me%g	SAT %	N&A N($^{o}/oo$)	Ag (%)
						FURROW IRRIGATION							
CRUDE EFFLUENT													
1	6.0	4.9	21.93	1.90	11.5	6.65	2.47	72.9	0.39	33.8	77.1	.182	38.73
2	5.7	4.9	19.77	1.91	10.3	5.93	2.29	72.1	0.56	35.0	79.6	.280	38.51
3	5.9	5.0	21.01	1.93	10.8	6.38	2.33	73.2	0.49	34.2	75.8	.322	40.22
4	6.2	4.9	19.51	2.18	8.9	5.72	1.87	74.7	1.12			.364	37.80
EFFLUENT pH 7													
1	6.1	4.9	21.69	1.84	11.7	6.45	2.19	74.6	0.44	32.3	77.7	.224	40.87
2	5.7	4.9	18.96	1.81	10.5	5.90	1.92	75.4	0.48	33.0	73.0	.182	40.67
3	5.9	5.1	21.44	2.10	10.2	6.45	2.53	71.2	0.60	34.6	79.0	.280	40.51
4	6.1	4.9	19.87	2.05	9.7	6.07	1.98	75.4	0.83			.392	36.88
EFFLUENT pH 7 (x 2)													
1	6.2	5.0	21.62	1.94	11.1	6.51	2.53	71.9	0.44	32.6	87.0	.252	40.30
2	6.0	5.0	21.55	1.98	10.9	6.34	2.23	74.0	0.58	35.5	78.0	.182	42.30
3	6.0	5.2	20.81	1.94	10.7	54.5	2.19	74.6	0.89	35.6	74.6	.224	42.63
4	6.1	4.8	18.65	2.04	9.2	6.04	1.71	78.0	0.77			.364	37.11
WATER													
1	5.9	5.0	18.07	1.71	10.5	3.33	1.65	67.0	0.42	30.0	79.4	.294	35.76
2	5.8	4.9	18.15	1.70	10.7	3.87	1.59	70.0	0.44	30.0	80.2		33.73
3	5.8	5.1	19.37	1.75	11.1	4.02	1.50	73.0	0.37	31.5	80.2	.252	33.22
4	5.8	4.6	18.79	2.17	8.7	5.71	1.77	75.5	0.70			.252	31.4
CONTROL													
1	5.6	4.7	22.25	1.96	11.3	3.78	1.62	68.5	0.39	34.0	71.7	.224	39.76
2	5.9	4.7	20.23	1.85	11.0	4.38	1.56	73.7	0.34	33.5	77.6	.210	39.55
3	5.6	4.8	20.23	1.75	11.5	3.81	1.89	66.8	0.18	34.0	70.0	.196	36.12
4	5.9	4.5	21.09	2.20	9.6	6.37	2.43	72.4	0.42			.252	38.7
						SPRINKLER IRRIGATION							
EFFLUENT pH 7													
a	7.8	6.9	21.3	2.30	9.3	3.2	5.7	35.9	0.35	50.6	Sat		47.1
b	7.6	6.9	24.0	2.70	8.8	4.0	4.8	45.5	1.18	49.7	Sat		44.1
c	7.6	6.9	23.4	2.60	9.0				1.13	51.3	Sat		
CONTROL													
a	8.0	7.2	23.4	2.50	9.3	3.5	6.0	36.8	0.54	45.2	Sat		37.2
b	8.0	7.2	21.7	2.40	9.0	4.3	5.9	42.0	0.55	47.1	Sat		41.2
c	7.9	7.1							0.57	47.6	Sat		

1 — Before spreading 07/04/76
2 — After spreading 09/07/76
3 — After spreading 10/10/76
4 — End of harvest

a — before spreading
b — at 6 months
c — at 12 months
(x2) — double dose

AF — Fulvic acids
AH — Humic acids
N & A — Aminated nitrogen
AG — Stable aggregates

The pH

In plots irrigated by the effluent, one can notice the light but systematic decrease, in the difference water-pH, KCl - pH. Although non significant, this difference would indicate a salt effect already mentioned: there is a slight but apparent increase of KCl-pH.

Adsorbing complex

The Cation exchange capacity remains constant in both cases. During the irrigation by flooding (Martinique), one can observe the increase of Potassium in surface horizon (0,35 to 0,45 me) the higher increase corresponding to the plot with double dose of neutralized effluent at pH 7 (0,44 to 0,89 me) (fig. 1). The control plots irrigated by water, or not, do not show any significant differences.

On the contrary, there in a clear increase at the end of spreading in the sub-surface horizons (40-60 cm) and a lowering at the end of harvest, after rainy season: it appears that in irrigation by flooding in the furrow, a great part of Potassium, and of elements supplied by the effluent, is susceptible to migrate deeply.

After irrigation by sprinkler (Guadeloupe), at low doses, the level of exchangeable K is multiplied by 3.

Magnesium does not show any variation in a complex saturated by Calcium. There are no variations deeply.

Organic matter and phoshorus

NITROGEN

In the experiments, there is an increase of total nitrogen. The lowering of C/N ratio in the effluent irrigated plots (11.5 towards 10.5) can be due, for a great part, to this increase. However, Robert and Gautheyrou (1978) point out that the balance determined by foliar analysis reveals a non complete utilization of nitrogen (low foliar diagnostic index).

The analysis of nitrogen forms shows a clear increase of hydrolizable aminated forms in the effluent irrigated plots.

This is of a particular evidence in the plot receiving crude effluent. The aminated N/total N ratio is changing from 11.2, 11.4%in the control to 17.8, 19.1, 16.7% in treated plots.

(fig. 2.) The spreading of the effluent contributes to a transformation of nitrogen products in α - aminated forms.

CARBON

The organic carbon remains constant or slightly increase in sprinkler irrigation.

In the case of irrigation by flooding, there is a general increase of extraction rate for fulvic and humic acids, increase correlated to the high level of humidity maintained by the irrigation followed by the rainy season: the extraction rate is the higher for plots receiving double dose of neutralized effluent (pH 7); in these plots too, ones notices the higher ratio of fulvic acids in extracted fraction (78%).

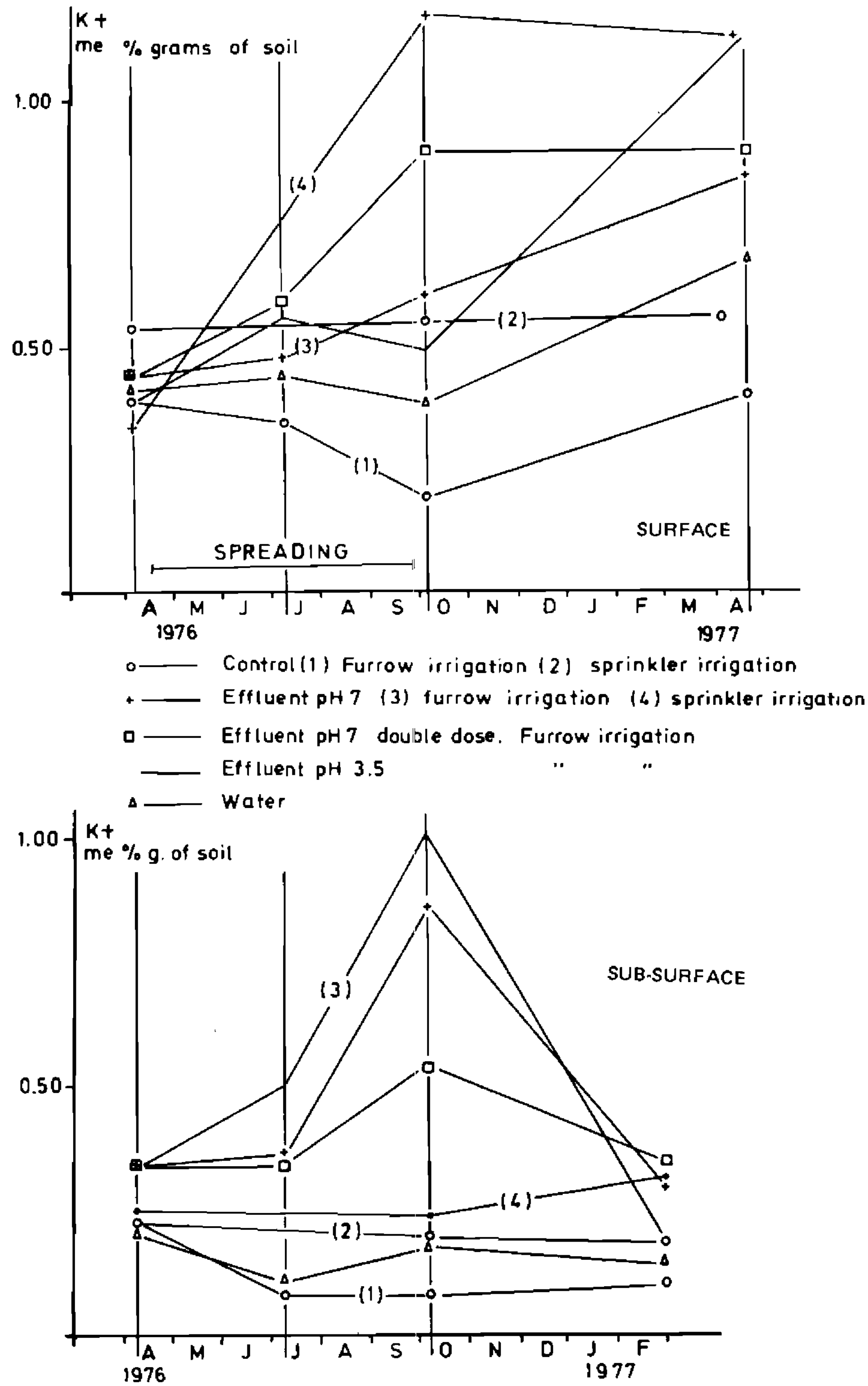

Fig. 1. Variation of potassium content at surface (0 - 20 cm) and at sub - surface (40 - 60 cm)

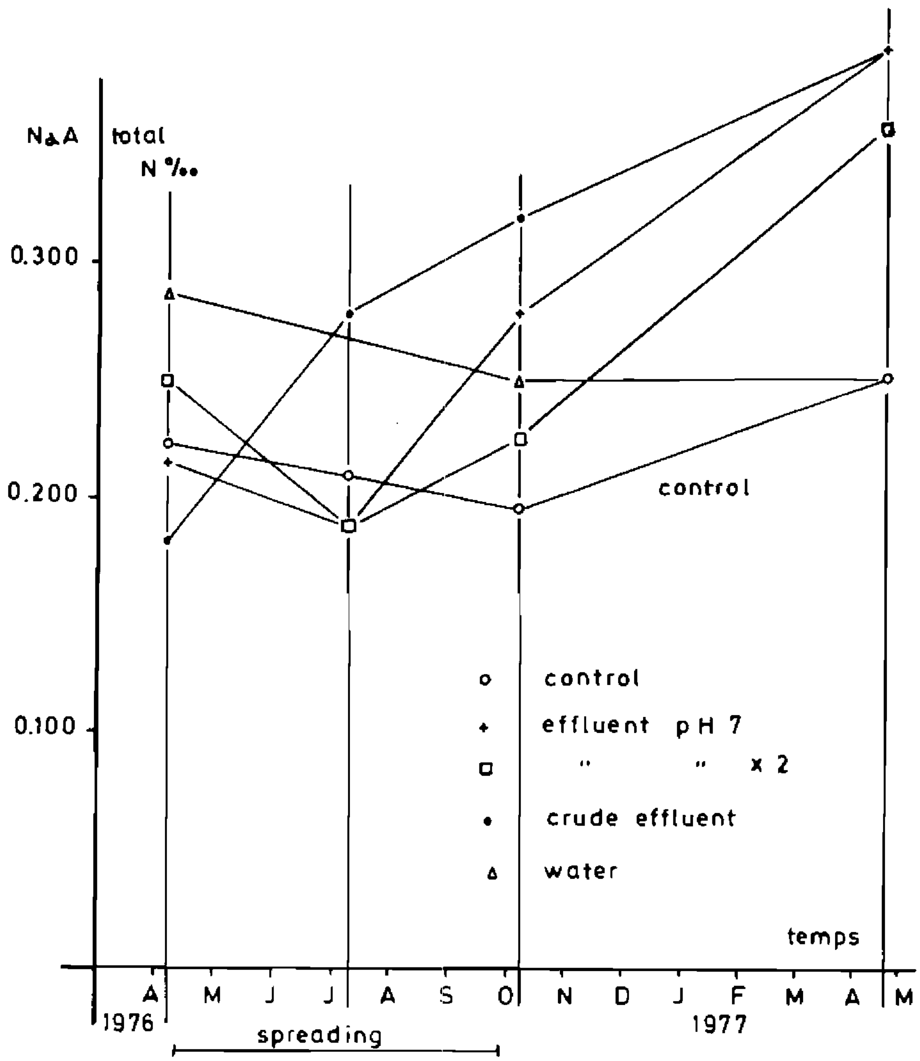

Fig. 2. Course of aminated nitrogen content

During sprinkler irrigation, the fulvic acid ratio in total organic matter does not vary.
The optical density analysis of the humic extracts (alcalin extract), and the comparison of extinction ratio at 400, 500, 600 nm (EQ 400/500 EQ 500/600, Salfeld J. Chr. H. Sochtig, 1974), emphasize the existence of two families of products, and reveals a lowering of the condensation of humic substances, in the following order (fig. 3): irrigated plots by pH 7 effluent, irrigated plots by pH 3.5 effluent.

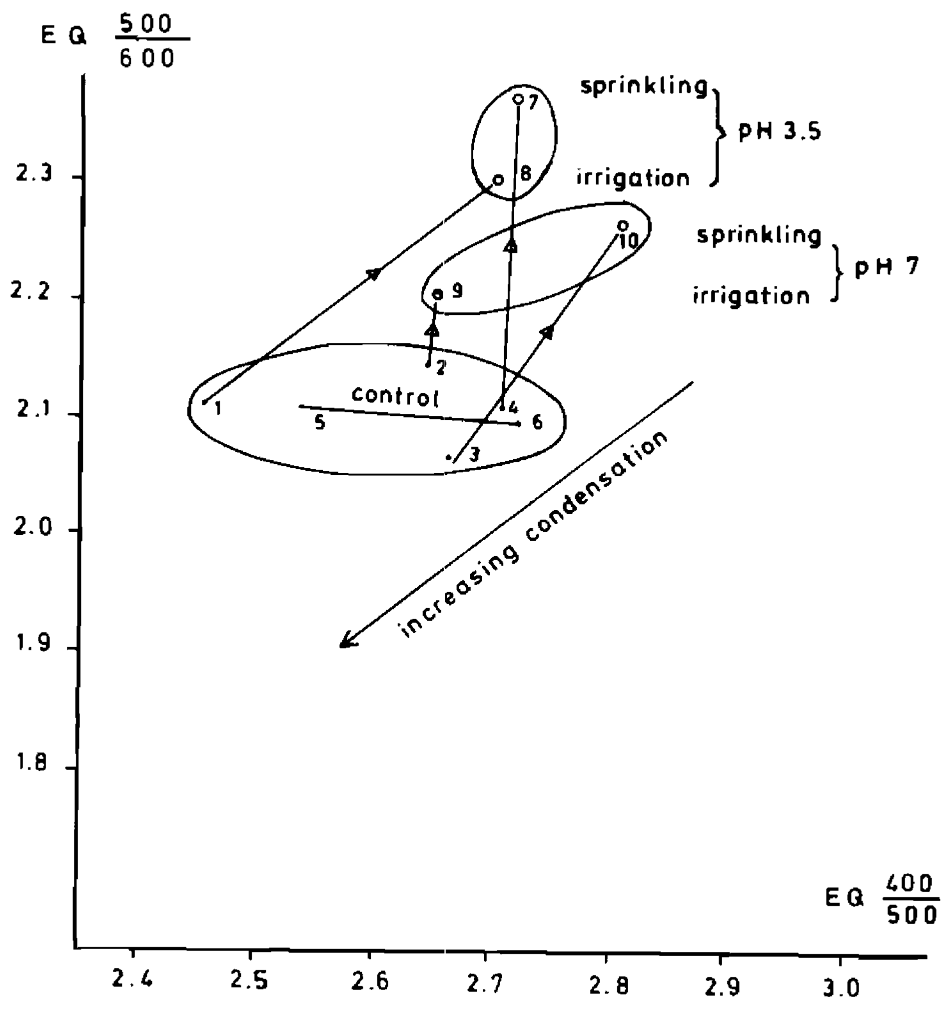

fig. 3. Optical characteristics of humic extracts.

The decrease of condensation is the higher with pH 3.5 effluent.

The persistent humidity all during the year participates to the increase of fulvic acid, and lowering of humic fractor condensation. The persistence of a high level of fulvic acids in the soil is susceptible in the long run to alterate the structural stability and to induce a leaching in the depth of complexed elements. The better use of the effluent seems to be in a neutralized form, at fertilizer doses, spread by sprinkler.

PHOSPHORUS

There is an increase of total P_2O_5 in the soil, exceeding the response level necessary for the sugar cane in these soils (before spreading control: 73.3 mg/100 g; 80.3 mg/100 g after spreading, at 12 months control, 70.3, irrigated plots 118.4) (Robert et al, 1978).

DISCUSSION

The observations done at harvest show in the irrigated plots a higher yield with an increase of 20t/ha (effluent irrigated plots 96t/ha, control 76t/ha), without a lowering in sugar content. The foliar analysis, at 6 months, in irrigated plots, give the following results:

	N	P	K
Sugar cane (mean)	1.879	0.225	1.411
Standard (Technical Centers)	1.9-2.1	0.18-0.20	1.12-1.22

The standard adopted for well balanced nutrient status is exceeded, considering Phosphorus and Potassium, inducing extra consumption.

The excess of Potassium does not affect fermentation in distillery but may be an inconvenience for sugar production.

Nitrogen content does not reach the minimum standard, and this has to be followed in case of repeated irrigation.

The important contribution in K and P is emphasized, as well as the need of a nitrogen complementation within a short time. This complementation can be balanced through an increase of nitrogen in biodegradable aminated forms.

The analysis of qualitative variations of organic matter shows however some modifications: they are useful index of possible unfavourable changes in soil system in case of repeated spreading, particularly with crude effluent; the lowering of condensation of humic substances can in fact act on structural stability and elements complexation.

REFERENCES

Nadir A. Da Gloria, 1975. Utilizacao agricola da vinhaça. Brasil Açucareiro, n°5 pp. 397-403.

Planal Sucar, Rapport annuel, 1976. Programa nacional de melhoramento da cana de açucar.

Robert G., Chofardet, D., Gautherou J.M., 1978. Etude d'épandage a la Distillerie Damoiseau Bellevue – Grande-terre (Guadeloupe) Année 1977. Orstom Antilles. 31 p. multigr. annexes.

Salfed J. and Chr. and H. Sochtig, 1974. Proposals for the characterization of soil organic matter as an approach to understand its dynamic. FAO. ROME.

Vasseur J.G. and Montreau, F.R., 1977. Les effluents des industries sucrieres et rhumieres aux Antilles. Centre Technique de la canne et du sucre, Martinique. 30 p. annexes, multigr.