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VINASSE (ALCOHOL INDUSTRY WASTE) RECYCLING IN COTTON CROP

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ABSTRACT

A three year experiment was carried out in Central Greece to assess the feasibility to apply vinasse, an alcohol industry waste, in cotton crop as a substitute of chemical fertilisers and a soil amendment. The effect of varying rates and times of vinasse application on crop emergence, growth and yield as well as the effect on the chemical properties of the soil were measured. The results showed that in general vinasse did not affect significantly the crop compared to chemical fertilisation. Soil salinity and sodicity were increased but not at hazardous levels. The research proved the feasibility to recycle vinasse in local crops and provided that when an once every four years application is used any soil adverse affect can be eliminated.

ΑΝΑΚΥΚΛΩΣΗ ΤΗΣ ΒΙΝΑΣΣΑΣ (ΑΠΟΒΛΗΤΟ ΤΗΣ ΒΙΟΜΗΧΑΝΙΑΣ ΟΙΝΟΠΝΕΥΜΑΤΟΣ) ΣΤΟ ΒΑΜΒΑΚΙ

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Περίληψη

Παρουσιάζονται τα αποτελέσματα ενός τριετούς πειράματος που διεξήχθη στην Κεντρική Ελλάδα για να μελετηθεί η δυνατότητα ανακύκλωσης βινάσσας (αποβλήτου της βιομηχανίας οινοπνεύματος) στην καλλιέργεια βαμβακιού ως υποκατάστατο χημικών λιπασμάτων και εδαφοβελτιωτικό. Μελετήθηκε η επίδραση διαφόρων δόσεων και χρόνων εφαρμογής βινάσσας στο φυτόμα, στην ανάπτυξη της καλλιέργειας και την παραγωγή καθώς και στις χημικές ιδιότητες του εδάφους. Τα αποτελέσματα έδειξαν ότι η εφαρμογή βινάσσας δεν είχε στατιστικά σημαντική επίδραση σχετικά με τη χημική λίπανση. Η αλατότητα και η Νατρίωση του εδάφους αυξήθηκαν αλλά όχι σε επικίνδυνο επίπεδο. Η έρευνα απέδειξε την δυνατότητα ανακύκλωσης της βινάσσας σε καλλιέργειες και κάνοντας εφαρμογές ανά τέσσερα έτη ώστε να διατηρηθούμε στην ασφαλή πλευρά δεν δημιουργούμε κινδύνους για το έδαφος.

1. INTRODUCTION

Vinasse is a by-product of the alcohol industry using molasses from the sugar industry or other material like raisins as a raw material. This material is fermented to produce alcohol and the remaining by-product is vinasse. Vinasse is produced in many countries of the world as a by-product of the alcohol industry. As the raw material is different, vinasse has also different properties. The sodium concentration in sugar beet vinasse can cause hazardous conditions for the soil and the plants. Casarini et al., [1] studied the effect of vinasse application to the soil and observed an initial reduction of pH, but later it increased. In a previous laboratory experiment (incubation with soil in vitro), vinasse increased salinity, sodicity and alkalinity of soil [2] but soil samples mixed with large amounts of vinasse, were not submitted to water cleaning as in natural conditions. In an other field experiment for 5 years, where vinasse was applied in a durum wheat crop [3], N, exchangeable Na, K and available Mn were increased, without causing hazardous conditions for soil and plants. Vinasse application significantly increased yields and the work proved the beneficial effects of vinasse recycling as substitute for chemical fertilizers.

TABLE 1. Chemical analysis of vinasse (wet basis) applied in 1995

parameters	values
Organic material	29 %
pH	4.5 %
N	3.2 %
P	0.05 %
K	6.1 %
Na	2.6 %
Fe	260 mg/kg
Zn	60 mg/kg
Mn	60 mg/kg
Cu	40 mg/kg

In a factory in Central Greece this vinasse is condensed to a dry matter content of 60% (wet basis) with the properties shown in Table1. The material has very high biological oxygen demand (BOD₅) values and it is difficult to be cleaned economically. A suggested solution is to use vinasse in agriculture as a substitute for chemical fertilizers and as an organic fertilizer for soil improvement, reducing the problem of the very low organic matter content of Greek soils. In this factory, more than 10000 t of vinasse is produced every year. Gemtos et al. [3] have studied vinasse application in durum wheat crop. They found that it could be applied in the fields the summer with immediate incorporation in the soil or during autumn before wheat drilling without any significant problem. The application period covers about five months of the year. Applications in spring-sown crops like cotton could increase application period by about four months (December – March or April). This would reduce the storage capacity requirements of the industry and the relative costs. Almost complete storage elimination can be achieved if the period of April to June can be covered. This is possible if vinasse could be applied in spring-sown crops not only as basic dressing but also after crop emergence between the plant rows. This would help the industry to minimize vinasse-handling costs. A crop, which can be used, is cotton. It is the most important arable crop in Greece and covers a high percentage of the fields in the factory area. It is sown in April in rows 1 m apart. Machinery movement between rows is possible till June.

The objective of the present work is to study the feasibility of vinasse applications in cotton crop either as basic dressing or as after emergence application as well as the effects of this application on the crop and the soil.

2. MATERIALS AND METHODS

A three-year (1993 - 1995) field experiment of vinasse application was carried out in cotton under continuous rotation (which is the usual rotation in Thessaly, Central Greece). The recommended fertilizer rate by the Hellenic Cotton Board was 150-kg/ha N, 100 kg/ha P₂O₅ without K application. Given the hypothesis that vinasse should substitute chemical fertilizers and the most important element is nitrogen, rates should be based on N-requirements. The rates should be up to 5000 kg/ha (giving 175 kg/ha of N). This rate would add 25 kg/ha of P, 300 kg/ha of K and 125 kg/ha of Na. Undoubtedly K is in surplus, especially for the used soils, which are considered to be sufficiently supplied (see also Table 2). At the rate of 5000 kg/ha the yearly production of vinasse has to be distributed on an area of 3,000 ha or a circular area of 3.2 km around the factory. Even with application once every four years, to remain at the safe side, the distribution area is not large and the transportation distance remain short to keep the application cost low. The experiments were designed in randomized complete blocks with four replications. Vinasse was applied at 5,000 kg/ha. Three t/ha were applied as basic dressing. In one half of the plots in autumn, after ploughing and in the other half in spring before crop planting. A tank-sprayer was used for vinasse applications. Its specifications were reported by Gemtos et al. [3]. In part of the plots 2 t/ha were applied in May while in the rest 300 kg/ha of 26-0-0 or 21-0-0 were applied to cover N requirements. Control plots were fertilized with chemical fertilizers at 500 kg/ha 11-15-15, 200 kg/ha 24-10-0 and 20 kg/ha 34-0-0. The first year one more treatment was used to apply the May dressing by a drip irrigation system. This proved to cause plugging problems to the system and it was abandoned in the following years. Vinasse was applied in May by pots and incorporated by hand hoeing. The experiment was installed in one site. The soil was classified according to the USDA classification system as clay loam (clay 40%, silt 32% sand 28%, o.m. 1.8%, shrinkage limit 8.5%, lower plastic limit 12.9%, upper plastic limit 25%). Soil chemical properties are shown in Table 2.

TABLE 2. Properties of soil used (0-25 cm)

Texture	CL
Organic matter %	1.8
CaCO ₃ %	6.6
pH (1:5) suspension in H ₂ O	8.7
CEC, cmol/kg	30
Saturation by bases, %	100
Electrical conductivity (1:5) extract, dS/m	0.273

Conventional tillage was applied. Soil was ploughed at a depth of 0.25 m in the autumn just after the first rains, which turned the soil to a friable condition. Each plot had a width of 8-m (two passes of a four-row planting machine) and was 10 m in length. Ten meters wide corridors were left at the end of the plots, to allow for machinery maneuvers and there was a 2-m separation between the blocks. All machinery traffic for fertilization or spraying in Spring, was done through these 2 m corridors. The trailed sprayer distributed vinasse in the field. The tractor (having tire width of 43 cm) and the tanker compacted about 1 m of soil, in the middle of each plot, during each pass. In order to investigate the effect of soil compaction induced by the machinery movement, a strip of 3 m width was compacted by two additional passes of the tractor-tanker system, besides the tracks of the first passage (one on the left and the other on the right side of the first track). This resulted in a compacted, 3 m wide, central strip through the plot. At the end, each plot had two un-compacted strips of 2 m each and one compacted strip of 3 m width. Plant parameters and yield were measured

in the second row from each side of the plot for the uncompacted treatments and in the middle row for the compacted. During the experiment the following parameters were measured:

- (1) Number of emerged plants
- (2) Plant growth during the season by measuring plant height;
- (3) Chemical properties of the soil; and
- (4) Final yield.

Soil samples taken in autumn of 1995, the end of the third year of the experiment and were analyzed for the following properties:

- a) Organic matter content measured by chemical oxidation with $K_2Cr_2O_7$ and titration by 0.5M $FeSO_4 \cdot 7H_2O$
- b) pH in soil:H₂O (1:5);
- c) Electrical conductivity of water extract (soil:H₂O=1:5);
- d) Exchangeable Na⁺ and K⁺ extractable by 1N NH_4OAc ;
- e) Total N, after soil digestion and NH_4^+ distillation;
- f) Available P extractable by 0.5 M $NaHCO_3$, pH:8.5 (Olsen);
- g) Available Fe, Mn, Cu and Zn extractable by Diethylene Triamine Penta Acetic Acid (DTPA) (0.005 M DTPA + 0.01 M $CaCl_2$ +0.1 M triethanalamine).

All the procedures for the measurements are referred by Page et al. [4].

Soil samples were taken from depths of 0-0.25 m. Three samples were taken from each plot diagonally and mixed thoroughly to produce a composite sample which was analyzed in duplicates. Samples from compacted and uncompacted plots were not analysed separately. The meaning of the symbols used in the soil properties tables are given in Table 3.

TABLE 3. Symbols used for the presentation of data.

Control	Chemical fertilizers
B1A	<ul style="list-style-type: none"> • Basic dressing of vinasse in autumn • May application of vinasse
B1B	<ul style="list-style-type: none"> • Basic dressing of vinasse in spring before crop planting • May application of vinasse
B2A	<ul style="list-style-type: none"> • Basic dressing of vinasse in autumn • May application of chemical fertilizers
B2B	<ul style="list-style-type: none"> • Basic dressing of vinasse in spring before crop planting • May application of chemical fertilizers

3. RESULTS AND DISCUSSION

Table 4 shows the emergence rates of plants. No significant effects were observed indicating that vinasse did not have adverse effects on cotton seed and the seedlings. Table 5 presents the plant height for two dates during the season. Again no significant effects were observed although some trends can be seen like the higher plants in non-compacted plots. It appears that vinasse did not have any adverse effect on plant emergence and growth and from that point of view it can substitute chemical fertilizers without problems from the Na content.

TABLE 4. Plants emerged for the treatment studied

Treatment	1993	1994	1995
Basic dressing			
Application time			
Autum	15,6	16,1	17,0
Spring	15.0	16.7	15,1
Control	15.5	15.9	13,7
Significance	NS	NS	NS
Vinasse Rate			
5000 kg/ha	14.9	17.1	15.3
3000 kg/ha	15.6	15.3	16.6
Control	15.3	14.8	13.7
Significance	NS	NS	NS
Compacted	14.5	15.5	16,4
Non compacted	16.1	17.2	14,2
	NS	NS	NS

TABLE 5. Plant height for two dates during the growing season

Treatment	1993		1994		1995	
	July	Sept	June	Sept	June	Sept
Basic dressing						
Application time						
Autumn	60.3	73.0	28,4	72.1	24.9	71.4
Spring	66.4	71.1	26.3	71.5	21,7	71.0
Control	60.1	71.5	25.6	70	23.7	68.4
Significance	NS	NS	NS	NS	NS	NS
Vinasse Rate						
5000 kg/ha	61.6	73.0	27.4	72,1	24.1	71.9
3000 kg/ha	65.1	71.5	24.7	71.6	23.6	69.5
Control	60.9	71.1	26.5	72.3	21.7	68.4
Significance	NS	NS	NS	NS	NS	NS
Compacted	64.0	70.8	26.4	70.4	21.3	67.8
Non compacted	61.1	70.8	28.2	72.6	25.1	72.1
	NS	NS	NS	NS	NS	NS

Table 6 shows the effect of the parameters studied on the crop yield. Generally speaking no significant effects were observed. Compaction had a varying effect on yields and in 1994 the effect was significant. The results indicate that time of application effects were not significant while compaction effect was not systematic. This shows the feasibility to apply vinasse all over the year and permits the factory to recycle the waste solving a problem threatening its viability and minimize storage cost.

Vinasse is an acid material but sodium salts content and their hydrolytic effect into soil, could increase soil alkalinity [2]. Tables 7 and 8 show the effects of vinasse on the chemical properties of the soil. The results do not show any hazardous effect of vinasse application on pH and salinity despite the significant sodium content of vinasse.

TABLE 6. Plots yield for the studied treatment.

Treatment	1993	1994	1995
Basic dressing			
Application time			
Autumn	298.3	198.9	195.7
Spring	355.9	204.1	194.8
Control	307.8	204.8	192.3
Significance	NS	NS	NS
Vinasse Rate			
5000 kg/ha	319.8	196.2	185.3
3000 kg/ha	334.4	206.8	203.3
Control	307.8	204.7	192.3
Significance	NS	NS	NS
Compacted	307.7	186.0	208.2
Non compacted	333.7	219.1	179.2
	NS	S	NS

TABLE 7. The effect of vinasse on the chemical properties of the soil

Treatment	Organic matter %	pH suspension (1:5)	Electrical Conductivity extract (1:5) dS/m	Exchangeable Na ⁺ , mg/kg
Control	1.8 a	8.70 b	0.273 a	356 a
B1A	1.9 ab	8.64 ab	0.287 a	353 a
B1B	2.0 ab	8.73 b	0.275 a	359 a
B2A	1.9 ab	8.44 a	0.350 b	368 b
B2B	2.1 b	8.78 b	0.263 a	393 c

Same letters in the column blocks indicate statistically non-significant differences at a probability p=0.05 level, while different letters indicate statistically significant differences (LSD test).

Assuming a yearly decomposition rate of 40% of the vinasse organic matter, it is rather difficult to detect the organic matter added with vinasse given the method used and the variability of the soil [3]. Despite that assumption the organic matter content in treatments with vinasse was increased significantly.

All vinasse treatments increased significantly nitrogen content, exchangeable forms of K⁺ in most cases and that confirms vinasse value to the soil fertility. In another experiment for five years in durum wheat [3] an important increase of available K forms, has been observed. The results do not show any systematic effect of vinasse application on the available forms of P, Fe, Zn, Mn and Cu.

Table 9 shows the significant positive correlation between N content with values of organic matter content, salinity and Na. These results confirm the effects of vinasse to the soil, related to its chemical composition (N content).

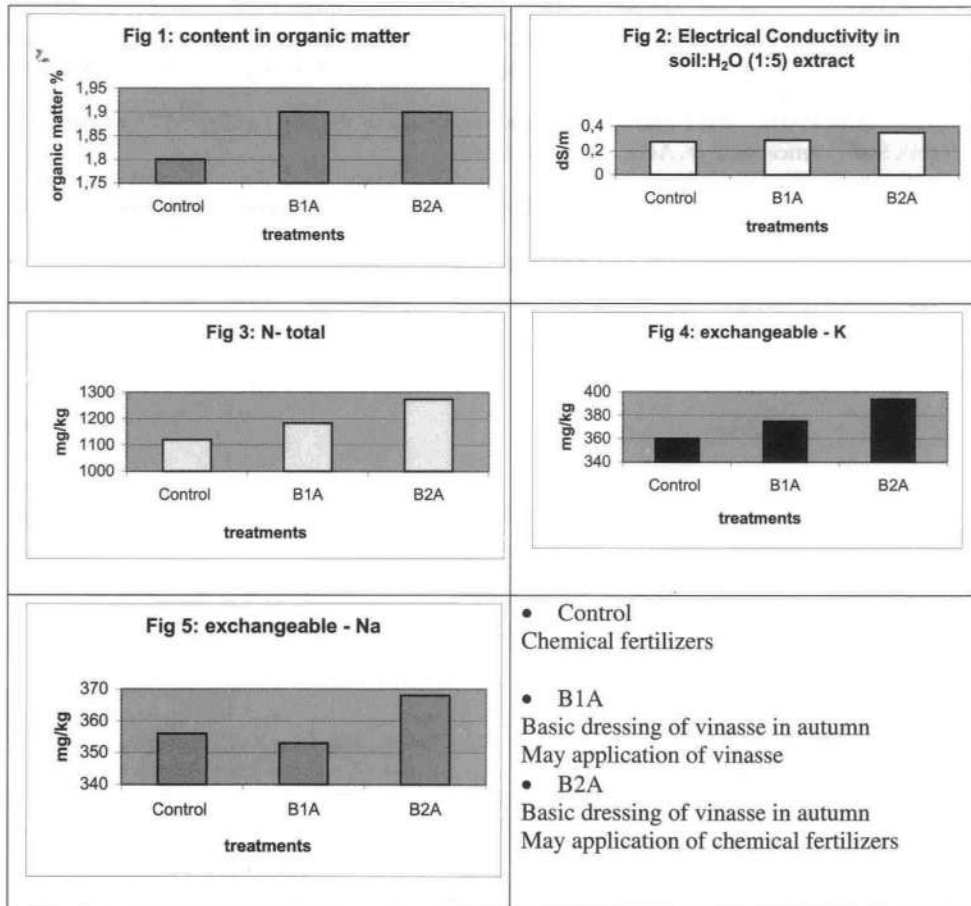
TABLE 8. The effect of vinasse on nutritive elements of the soil

Treatment	Total-N, mg/kg	K ⁺ exchangeable mg/kg	P-Olsen, mg/kg	DTPA forms, mg/kg			
				Fe	Zn	Mn	Cu
Control	1120 a	360 ab	38 ab	5.4 a	0.6 b	7.6 a	0.8 ab
B1A	1183 b	374 ab	30 a	5.1 a	0.6 b	8.0 a	0.8 ab
B1B	11225 c	342 a	47 b	4.8 a	0.5 a	7.8 a	0.7 a
B2A	1274 d	394 ab	45 b	5.0 a	0.5 a	8.5 a	0.8 ab
B2B	1316 e	449 b	38 ab	5.0 a	0.8 c	7.1 a	0.8 ab

Same letters in the column blocks indicate statistically non-significant differences at a probability p=0.05 level, while different letters indicate statistically significant differences (LSD test).

TABLE 9. Correlation coefficients between soil properties after vinasse application

	Electrical Conductivity	N total	Na exchangeable
Organic matter	ns	+0.619 p=0.003	ns
pH	-0.896 p=0.0001	ns	ns
Electrical Conductivity	-	+0.518 p=0,020	ns
K exchangeable	ns	ns	+0.461 p=0.04
Na exchangeable	ns	+0.664 p=0.001	-



Figures 1-5 show the significant effect of several treatments related to vinasse addition on organic matter content, salinity, Nitrogen, sodium and potassium contents, without causing a hazardous effect.

4. CONCLUSIONS

From the presented results it can be concluded that:

- Vinasse application may successfully substitute chemical fertilizer in cotton crop.
- Time of application does not cause significant effects permitting applications all over the year.
- Compaction can have some adverse effects on yield
- Vinasse causes an increase of salinity and Na content but at levels which do not cause toxicity concerns. The observed increase of K is beneficial to the crop.
- The application method used can solve a huge problem for the industry

REFERENCES

1. Casarini D. C. P., Cuhna R. C. de A., Maset Fihlo B. (1987) 'Effects of irrigation with vinasse and the dynamics of its constituents in the soil. II Microbial aspects' **Water Science Technology**, 19, 167-176.
2. Chouliaras N. (1994) 'The Effect of the Organic materials on the Soil fertility', **5th Congress of Greek Soil Science Society, Acta**, vol:A, 383-399.
3. Gemtos T. A., Chouliaras N. and Marakis St. (1999) 'Vinasse Rate, Time of Application and Compaction Effect on soil Properties and Durum Wheat Crop.' **J. Agric.Engng Res.** 73, 283-296.
4. Page A. L. (1992) '**Methods for Soil Analysis. Part 2**', ASA publications, No:9, 1153 pp.