COMPARISON OF THE EFFECT OF COMPOST, SOLID AND LIQUID MANURE ON SUGARCANE YIELDS AND ON PHYSICO-CHEMICAL PROPERTIES OF THE SOILS

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INTRODUCTION

A number of investigators\textsuperscript{1–11} reported improved yields due to a combined application of farmyard manure or composts and mineral fertilizer. Increased humus content, higher absorption capacity and more efficient utilization of mineral NPK are considered to be the main reasons.

Continuous manuring resulted in higher humus contents, better structural stability and a marked increase in water-stable aggregates\textsuperscript{12–14}. Robinson\textsuperscript{15} reported that air space of 9.2–12.2% of the soil volume allowed normal root development in sugarcane in a low humic latosol. Tymieniecka\textsuperscript{17} reported that application of 60 t/ha farmyard manure to 45–60 cm depth increased moisture-storage capacity in loose sands lacking a loamy layer in the profile\textsuperscript{17}.

Recent studies (1966, 1967) showed that pore volume of the soils was increased by an average of 1–2% by long-term manuring and annual application of 20–60 t/ha dung during a period of 43 years increased organic matter in the 5–20 cm layer of soils by an average of 1.5–0.7% over that from mineral fertilizing, thus, improved moisture conditions, resistance against erosion, permeability and porosity, soil aggregate stability, etc.\textsuperscript{18–21}.

The object of the research reported herein was to compare the effects of compost, solid and liquid manure on sugarcane yields, and to study their effects on some physico-chemical properties of the soils in the hope to prove whether the increase of sugarcane yields is mainly due to continuous dressing of composts and manure can raise the sugarcane yield.

EXPERIMENTAL

Ten crops 1955–1967 of sugarcane variety N: Co. 310 on loam of plain land have been cultivated with 7 different treatments and six replications.

The amounts of composts, solid and liquid manure dressing for each treatment were on the basis of equal amounts of available nutrients (NPK).

After harvesting the nineth crop, the soils of each plot were sampled for chemical analyses and the measurements of some physical properties.

The Upland soil sampling cylinder was used for core samples\textsuperscript{22}. The pipet method was applied to soil mechanical analyses, while the Upland method was applied for measurement of soil bulk density.
The measurement of soil moisture

The pressure cooker method was applied for under one atmosphere while the pressure membrane method was applied for 1-15 atmosphere\(^2\). The measurements of volume percentages of soil macro pores and micro pores have been conducted by Baver's method\(^3\). The measurement of water-stable aggregates has been carried out by Yoder's method\(^4\). Chemical analyses of the soils: Kjeldahl method for total nitrogen, Walkey's method for organic matter, Bray No. 1 method for dilute acid-soluble phosphorus, ammonium acetate method for exchangeable potassium\(^2\).

Plant analyses were applied for total nitrogen, phosphorus and potassium contents of cane stalks, cane leaves, cane tops and roots\(^2\).

A lysimeter experiment was carried out with chemical analyses and some measurements of physical properties for soils to investigate whether composts and manure dressing can elevate the NPK absorption rate of mineral fertilizers.

RESULTS AND DISCUSSION

Average data of chemical analyses of composts, solid and liquid manure dressed to the fields during 10 crops cultivation and the results of field trials are shown in Tables 1 and 2 respectively.

Application of composts 30-40 tons, solid manure 20 tons or liquid manure 100 tons/ha besides mineral fertilizer N 200, P\(_2\)O\(_5\) 100 and K\(_2\)O 100 kg/ha dressing increased the length of cane stalks (10 cm higher), number of millable canes 2400-6000 (an increase of 2-5\%) per ha and sugar yields 1.3-1.9 tons/ha (an increase of 12-18\%) per ha as compared to mineral fertilizer alone (statistically significant at \(P < 0.05\) or \(P < 0.01\)).

Application of composts, solid or liquid manure in lieu of reducing its equivalent amount of mineral fertilizers dressing increased sugar yields as compared to mineral fertilizers dressing alone, but the difference was not statistically significant.

Some measurements of physical properties and chemical analyses of the soils were shown in Table 3.

Continuous application of composts and solid manure to each crop, after harvesting of 9 crops, slightly increased the total pores and macro pores of soils while the soil bulk density was decreased (statistically significant at \(P < 0.05\) or \(P < 0.01\)). The water-stable aggregates were also increased by continuous dressing of composts or solid manure. Manure increased the organic matter content from 0.5 to 0.9\% (sta-

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVERAGE DATA OF CHEMICAL ANALYSES OF COMPOSTS, SOLID AND LIQUID MANURE</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Composts</td>
</tr>
<tr>
<td>Solid manure</td>
</tr>
<tr>
<td>Liquid manure</td>
</tr>
</tbody>
</table>
TABLE 2
AVERAGE TILLER, STALK LENGTH, MILLABLE CANE STALKS, CANE AND SUGAR YIELDS OF THE 10 CROPS CULTIVATED ON LOAM

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Length of cane stalks (cm)</th>
<th>Tillering</th>
<th>No. of millable cane/ha</th>
<th>Tons cane/ha</th>
<th>Tons sugar/ha</th>
<th>Index (sugar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. F</td>
<td>244.3</td>
<td>8.1</td>
<td>102,160</td>
<td>83.8</td>
<td>10.1</td>
<td>100</td>
</tr>
<tr>
<td>2. FC</td>
<td>255.3*</td>
<td>8.8</td>
<td>105,530*</td>
<td>94.3**</td>
<td>11.4**</td>
<td>112.87</td>
</tr>
<tr>
<td>3. FM</td>
<td>257.9*</td>
<td>8.9</td>
<td>108,231*</td>
<td>97.5**</td>
<td>12.0**</td>
<td>118.87</td>
</tr>
<tr>
<td>4. FU</td>
<td>255.1*</td>
<td>8.7</td>
<td>106,645*</td>
<td>93.9**</td>
<td>11.28</td>
<td>118.87</td>
</tr>
<tr>
<td>5. RFC</td>
<td>244.1</td>
<td>8.6</td>
<td>100,864</td>
<td>86.9</td>
<td>10.7</td>
<td>105.94</td>
</tr>
<tr>
<td>6. RFM</td>
<td>245.4</td>
<td>8.5</td>
<td>101,591*</td>
<td>86.7</td>
<td>10.8</td>
<td>105.94</td>
</tr>
<tr>
<td>7. RFU</td>
<td>239.5</td>
<td>8.1</td>
<td>100,650</td>
<td>86.2</td>
<td>10.7</td>
<td>105.94</td>
</tr>
</tbody>
</table>

Note: F = 200 kg N, 100 kg P₂O₅ and 100 kg K₂O/ha/crop.
C = 30–40 tons compost/ha/crop.
M = 20± tons solid manure/ha/crop.
U = 100± tons liquid manure/ha/crop.
R = Amount of mineral fertilizer adjusted according to the NPK-content of the organic fertilizer (C, M, U) applied so that the total quantity of NPK would correspond to treatment “F”.

* P < 0.05 (significant as compared to treatment No. 1).
** P < 0.01 (very significant as compared to treatment No. 1).

TABLE 3
AVERAGE DATA OF SOME PHYSICAL PROPERTIES AND CHEMICAL ANALYSES OF THE SOILS USED FOR EXPERIMENT

<table>
<thead>
<tr>
<th>Items</th>
<th>Treatments</th>
<th>Total porosity %</th>
<th>Micro pores %</th>
<th>Macro pores %</th>
<th>Soil available water %</th>
<th>Water stable aggregates 0.25 mm</th>
<th>Total acid-soluble phosphorus (p.p.m.)</th>
<th>Exchangeable potassium %</th>
<th>Organic matter %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. F</td>
<td>1.52</td>
<td>41.86</td>
<td>23.40</td>
<td>18.46</td>
<td>6.60</td>
<td>26.14</td>
<td>0.095</td>
<td>59</td>
<td>7.8</td>
</tr>
<tr>
<td>2. FC</td>
<td>1.38*</td>
<td>47.99**</td>
<td>24.41</td>
<td>23.58</td>
<td>9.89</td>
<td>38.27</td>
<td>0.122**</td>
<td>118*</td>
<td>15.0</td>
</tr>
<tr>
<td>3. FM</td>
<td>1.37**</td>
<td>47.77**</td>
<td>23.30</td>
<td>24.48</td>
<td>6.88</td>
<td>33.26</td>
<td>0.113*</td>
<td>156*</td>
<td>15.5*</td>
</tr>
<tr>
<td>4. FU</td>
<td>1.37**</td>
<td>47.76**</td>
<td>23.28</td>
<td>24.48</td>
<td>6.93</td>
<td>27.90</td>
<td>0.107</td>
<td>78</td>
<td>18.0</td>
</tr>
<tr>
<td>5. RFC</td>
<td>1.40*</td>
<td>46.44**</td>
<td>22.95</td>
<td>23.48</td>
<td>7.41</td>
<td>38.26</td>
<td>0.107</td>
<td>71</td>
<td>10.4</td>
</tr>
<tr>
<td>6. RFM</td>
<td>1.37**</td>
<td>47.75**</td>
<td>22.41</td>
<td>26.30</td>
<td>7.17</td>
<td>34.29</td>
<td>0.109</td>
<td>73</td>
<td>13.1</td>
</tr>
<tr>
<td>7. RFU</td>
<td>1.46</td>
<td>44.94</td>
<td>23.19</td>
<td>20.90</td>
<td>7.78</td>
<td>21.58</td>
<td>0.104</td>
<td>79</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Note: * P < 0.05 (significant as compared to treatment No. 1).
** P < 0.01 (very significant as compared to treatment No. 1).

A lysimeter experiment was carried out with some measurements of chemical and physical properties to investigate whether solid manure or composts can elevate the absorption rate of mineral fertilizers.

The plots dressed with solid manure (20 tons/ha) or composts (40 tons/ha) besides mineral fertilizers increased the unit area of cane production 18–25% as compared to that of dressing mineral fertilizers alone even if the amounts of available NPK dressing were same.

This fact proved that: (a) solid manure or composts made sugarcane roots develop more vigorously resulting in increasing root weight, (b) some physical prop-
erties of the soils were improved, that is to say, soil bulk density was decreased, increasing soil macro pores made the three phase distribution (solid, micro and macro pores) of the soils more even, thus the permeability and drainage of soils were improved and the water-stable aggregates were also increased.

Solid manure or composts dressing increased soil organic matter content from 0.99% up to 1.66-1.88%, total nitrogen contents from 0.08 up to 0.15-0.17%, and acid-soluble phosphorus from 21-24 to 74-98 p.p.m.

Solid manure or composts increased the absorption rate of mineral fertilizers by sugarcane while leaching of soil and fertilizer nutrients was decreased (see Table 4).

**TABLE 4**

<table>
<thead>
<tr>
<th>Items</th>
<th>Treatments</th>
<th>Amounts of water leaching ml/m³</th>
<th>Amounts of potassium leaching g/m³</th>
<th>Absorption rate by sugarcane (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No fertilizers</td>
<td>976155</td>
<td>22.836</td>
<td>52.48</td>
<td>94.54</td>
</tr>
<tr>
<td>2. Chemical fertilizer N 200, P₂O₅ 100, K₂O 100 kg/ha</td>
<td>958800</td>
<td>38.423</td>
<td>49.57</td>
<td>104.66</td>
</tr>
<tr>
<td>3. Chemical fertilizers + solid manure 20 t/ha</td>
<td>923180</td>
<td>32.611</td>
<td>59.57</td>
<td>115.57</td>
</tr>
<tr>
<td>4. Chemical fertilizers + compost 40 t/ha</td>
<td>880015</td>
<td>30.148</td>
<td>60.20</td>
<td>115.57</td>
</tr>
</tbody>
</table>

Note: The amounts of available NPK applied were the same in the treatments No. 2, 3 and 4.

According to the chemical analyses, almost no loss of nitrogen and phosphorus by leaching was found, while leaching of potassium decreased.

**CONCLUSION**

Summarizing the experiments of ten crops 1955-1967 of sugarcane variety N: Co. 310 on loam of plain land and a lysimeter experiment with chemical analyses and some measurements of physical properties of soils, the following results were obtained;

1. Application of 30-40 tons of composts, 20 tons of solid manure or 100 tons of liquid manure per ha besides mineral fertilizers (N 200, P₂O₅ 100 and K₂O 100 kg/ha) increased the length of cane stalks by 10 cm, the number of millable cane stalks by 2400-6000 (an increase of 2-5%) and the sugar yield by 1.3-1.9 tons/ha (an increase of 12-18%) as compared to mineral fertilizers alone. The difference was statistically significant at P < 0.05 or P < 0.01.

2. Continuous application of composts or solid manure to each crop for a period of nine crop years slightly increased the total pores and macro pores of soils while the soil bulk density was decreased.

The water-stable aggregates were also increased. The organic matter, total nitrogen, acid-soluble phosphorus and exchangeable potassium contents of the soils were also increased by continuous dressing of composts, solid or liquid manure. The differences were statistically significant at P < 0.05 or P < 0.01.

3. On the basis of approximately equal amounts of nutrients supply (available NPK) by composts, solid or liquid manure dressing in long term field trials, the
effects of composts, solid or liquid manure on sugarcane production were almost equal as compared among the treatments No. 5, 6 and 7, but as compared with no organic matter dressing an increase of around 6% sugar yield was observed. Thus, it is considered that dressing of composts, solid or liquid manure may elevate the NPK absorption rate by improving some physicochemical properties of the soils. This fact has been also proved by a lysimeter experiment.

4. According to the lysimeter experiment, solid manure or composts decreased the amount of water percolation and also decreased the loss of potassium by leaching accordingly.

The chemical analyses showed that almost no loss of nitrogen and phosphorus by leaching was found.

ACKNOWLEDGEMENTS

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REFERENCES

Discussion

Y. C. PAN: In Table 2, although you added high levels of N in treatment No. 5 (300 kg/ha) the yield you got is low; will you explain why your yield decreased when the 300 kg/ha was added?

T. P. YEH: 200–250 kg N/ha is the optimum amount of N and the low yield with the 300 kg N/ha may be due to inaccuracy in collecting the data.

D. J. I. ODANGA: Has any work been done to find out whether the use of hog manure is economical?

(Editor's note: Both long-term and short-term field experiments have been conducted on the economics of hog manure. On nutritional basis, hog manure NPK are more expensive compared with chemicals. But, as explained by the author, the plant material in the manure is employed as a carrier of the animal droppings.)

T. P. YEH: Our way of thinking is to prevent loss of NPK through application of hog manure. We mix hog manure with bagasse and we get active humus that improves the physical properties of the soil.

Y. C. PAN: The yield of standard treatment of the field experiment was only 13.5 tons/ha, which seems too low. In that kind of land we usually don't use for cane growing.

T. P. YEH: Yes, the yield of this field is too low, and there happened to be a very dry period during the experiment. The plot having 13.5 tons/ha of cane yield was the one treated with no fertilizer application.

Y. C. PAN: Did you make mechanical analysis of the soil?

T. P. YEH: There was a high % of sand.