compounds could affect protein synthesis as reported earlier that a 45 kDa protein produced by *Acinetobacter radioresistens* is highly effective in the solubilization of hydrocarbons including polycyclic aromatic hydrocarbons[17].

The presence of TBTCl-induced periplasmic proteins in *Alcaligenes* sp. indicates their possible involvement in resistance/degradation of TBTCl. The genes encoding TBTCl-induced periplasmic polypeptides can be used to construct a microbial TBTCl sensor to directly monitor TBTCl levels in the aquatic environment. Further work is in progress on the gene(s) encoding TBTCl-induced proteins.

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VIDYA RAMACHANDRAN
SANTOSH KUMAR DUBEY*

Department of Microbiology,
Goa University,
Taleigao Plateau,
Goa 403 206, India
**For correspondence.*
e-mail: dubey_santosh1@rediffmail.com

Toxicity due to salinity caused by the addition of excess compost in potted plants

Addition of organic matter as compost or manure (green manure, farmyard manure (FYM), poultry manure, etc.) is a common practice for growing plants in pot culture studies and for potted plants. In addition to supplying plant nutrients, organic matter application provides a favourable physical and biological environment for plant roots in the growth medium[1].

Harmful effects to the young plants leading to retarded growth or death have been observed when organic matter in the form of compost or FYM is added at high rates in pot experiments under greenhouse conditions. We have observed such toxic or harmful effects on plant growth for some of the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) mandate crops such as sorghum (*Sorghum bicolor* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R.Br.), and pigeonpea (*Cajanus cajan* (L.) Millsp). Toxic effects observed in growing plants varied from stunted growth to complete death of the plants at 2–4 weeks after germination of the seeds, depending on the proportion of the compost added relative to the soil mass or the composition of the soil mixture used for growing of the plants in pots.

It is important to diagnose the cause(s) of the harmful effects in plants resulting from the application of high rates of well-decomposed compost or FYM because varying rates of FYM are used, especially for growing plants in pot experiments. Several hypotheses were put forward to account for the toxic or harmful effects associated with the addition of FYM at high rates, including the immobilization of nutrients, especially of nitrogen (N) and the occurrence of plant diseases. Our preliminary investigations however showed that they indeed were not the causes for the poor plant growth or death of the plants. Also based on the initial symptoms on the plant leaves, we suspected that the mobilization of high concentration of soluble salts in the soil solution following the addition of FYM at high rates to the potted mixture could be the cause of the harmful effect on plant growth.

To test the hypothesis that the harmful effects of FYM were associated with the high salt concentration, we measured the electrical conductivity (EC) of FYM samples and the FYM–soil mixture used as medium for growing plants in pots under greenhouse conditions at the ICRISAT, Patancheru, Andhra Pradesh. An attempt was made to relate the salt concentration in the growing medium, as measured by EC, with plant growth.

To evaluate salt content in manure samples, we used nine additional FYM samples (in addition to the FYM sample used in the pot experiment for growing pigeonpea plants) obtained from various sources in the neighbourhood of Patancheru. The FYM samples selected for testing had organic matter contents varying from 26.4% to 35.5%. The EC of the FYM samples, as a measure of their soluble salt contents, was determined with an EC meter using a FYM (by wt) to water (by volume) ratio of 1 : 5.

In a greenhouse experiment, pigeonpea plants were grown in pots filled with potting mixture (10 kg per pot) containing soil : FYM : sand in the ratio of 6 : 3 : 1. The soil used in the pots was an Alfisol with neutral pH and non-saline in nature. Decomposed FYM was used. Before use in the potting mixture, the sand was soaked overnight in dilute hydrochloric acid and then thoroughly washed with water to remove any extraneous calcareous material from the sand. The washed sand did not contain any significant amount of salts as indicated by the EC.

Measurement of salt content revealed that the EC, measured using a FYM (by wt) to water (v) ratio of 1 : 5, of the nine FYM samples tested varied from 8.2 to 10.9 dS m^{-1}, clearly demonstrating high content of salts in the FYM samples evaluated. The FYM samples had similar pH values, which varied from 8.1 to 8.2 (Table 1).

In the pot experiment, all the pigeonpea plants were killed as a result of the toxic effect in the growth medium when the plants were 2–3 weeks old after germination of the seeds. The toxicity symptoms were similar to the injury caused by excess salts (drying of leaves, starting from the tip of the older leaves, spreading to younger leaves and the whole plant dried and gave a burnt appearance).

We measured the EC of soil, FYM, and soil plus sand and FYM mixture using soil, FYM or mixture of soil, FYM plus sand to water ratio of 1 : 5. Results showed that FYM had the highest EC

Table 1. Electrical conductivity (EC) and pH of nine FYM samples. EC and pH were determined using a FYM to water ratio of 1 : 5

FYM sample no.	EC (dS m^{-1})	pH
1	8.2	8.2
2	9.9	8.1
3	10.1	8.1
4	10.9	8.1
5	9.6	8.2
6	10.5	8.2
7	9.5	8.2
8	10.1	8.2
9	10.1	8.2
Mean	9.9	8.2

Table 2. pH and EC of soil, FYM, soil plus FYM plus sand mixture used for growing pigeonpea plants in greenhouse pots. Soil, FYM or FYM plus soil mixture to water ratio of 1 : 5 was used for measuring EC and pH

Sample	pH	EC (dS m^{-1})
FYM	8.7	4.6
Soil plus FYM plus sand	7.8	0.83
Soil	7.1	0.16

(4.6 dS m^{-1}), followed by the soil, FYM plus sand mixture (0.83 dS m^{-1}) and soil alone (0.16 dS m^{-1}). The results indicated a relatively high salt content in the soil–FYM mixture used for growing pigeonpea plants (Table 2). While the soil itself did not contain any significant concentration of salts (EC 0.16 dS m^{-1}), mixing of FYM increased the salt content of the mixture (EC 0.83 dS m^{-1}), which proved toxic to the young pigeonpea plants. Although as compared to the EC of the FYM alone, the EC of the soil–FYM–sand mixture decreased, the EC was high enough to cause toxicity to the young pigeonpea plant[2].

Grain legumes such as pigeonpea are particularly sensitive to salinity and an EC of 0.83 dS m^{-1} in the plant-growth medium because the EC determined using a wide potted mixture to water ratio of 1 : 5 was still high enough to cause toxicity to the young growing plants[2]. High salt concentration in the soil–FYM mixture was responsible for killing the pigeonpea plants. The results also show that the FYM samples differ in their capacity to mobilize salts in solution (see Tables 1 and 2). Salt content of manure depends on its chemical composition and nutrient element contents. From these results along with our earlier observations with sorghum and pearl millet plants grown in soil plus FYM mixtures, it can be concluded that the addition of FYM at high rates builds up a high and at times a lethal concentration of salts leading to the death of crops such as pigeonpea, sorghum and pearl millet. It is suggested that when using organic manure such as FYM, care should be taken while deciding their rates of addition in soil mixtures for growing plants in pots.

We have observed that salt contents of the FYM samples differ depending on the source of the organic materials or crop residues used for preparing the manure. The FYM sample used in the pot experiment was lower in EC than the nine FYM samples evaluated; additional nine FYM were evaluated to ascertain the range in EC.

Obviously, there is need to study the effects of various manures (FYM, poultry manure, etc.) at different rates on plant growth in the dry areas on soils of varying depths (shallow, medium and deep soils) in the field. Earlier observations for growing plants in pots using soil plus FYM mixtures also suggested that FYM addition at rates such that the FYM formed 0.5% to 1% (by wt.) of the mixture, was suitable and was without any negative or toxic effects on plant growth (K. L. Sahrawat, unpublished observations).

It is however, important to note that crops and cultivars within a crop differ in their sensitivity to salts and plants of various crops or cultivars within a crop may show variable response to salt concentration in the growing medium[2–6]. It is therefore recommended that EC of the potting mixture or the growing medium should be measured to avoid harmful effects to plants grown in pots. More importantly, the measurement of EC of compost or FYM samples provides a simple and rapid measure of the salt concentration, and is a useful index for their use in various potting mixtures or in the field. The measurement of EC as a guide for potential salt injury to plants can also be used for the potted mixtures amended with mineral fertilizers (especially in the case of chemical fertilizers where nutrients ionize).

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K. L. SAHRAWAT*
T. J. REGO
K. V. S. MURTHY
S. P. WANI

Global Theme-Agroecosystems,
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),
Patancheru 502 324, India
**For correspondence.*
e-mail: k.sahrawat@cgiar.org