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Valuation of Municipal Solid Waste Compost of Tunis (Tunisia) – Agronomic Aspect

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I. Introduction

In Tunisia, the relative urban population growth (61% in 1994) and then the amount of municipal solid waste (MSW) per capita day^{-1} (0.5 - 1Kg) composed in 65% by compostable materials (organic matter) represents a favorable potential for composting which has gained wide acceptance as a key component of integrated solid waste management. In fact, this process has two goals: Recycling the compostable materials to reduce rejects volume to be disposed of at a landfill, and to provide an hygienic, odor-free finished product (MSW compost) which could be used as an organic matter supply in croplands since the Tunisian farming system is in shortage of farm yard manure and soil organic matter content is less than 1%. However, the use of MSW composts as a soil fertilizer is of concern in Tunisia because of its high concentration in heavy metals. Latter appear in the municipal solid waste stream from a variety of sources : batteries, consumer electronics, ceramics, light bulbs, house dust and paint chips, lead foils such as wine bottle closures, used motor oils, plastics, and some inks and glass can all introduce metal contaminant into the solid waste stream. Even though many of these trace elements (e.g. Boron, Zinc, Copper and Nickel) are essential for plant growth in small amounts, excessive MSW compost amendment is likely to affect plant physiology. Other trace elements (e.g. Arsenic, Cadmium Lead and Mercury) are of concern primarily because of their potential to harm soil organisms, animals and humans who may eat contaminated plants or soil. The impact of heavy metals on plant growth in MSW compost amended soils depends not only on their concentration but also upon climatic conditions, soil physical and chemical properties. In addition, vegetable species are likely to react differently to croplands metallic concentration. In Tunisia, researchers have been working on MSW compost valorization since 1984. Even though composting techniques are likely to be mastered, MSW compost quality is of concern since solid waste source-separation is not well popularized. For the agricultural valuation purpose, stringent physical and chemical analyses are needed to follow the MSW compost evolution after application and to assess contamination risk in different kind of soils. Now that increasing crop yield with MSW composts amendment seems to be confirmed, little is known concerning heavy metals fate in soil-plant system, soil biomass growth and finally critical heavy metals concentration thresholds that preserve consumer's health.

II. Material and Methods

To encircle the declension of MSW compost effects in relation with soil structure and crop species, the Water and Environment Laboratory (Tunisia National Institute for Technical and Scientific Research) has been conducting some field-scale experiment in the framework of the research project entitled "Composting and municipal solid waste valuation".

Our field-scale experiment has two purposes:

1- To investigate the long-term effectiveness of using MSW composts as an organic matter supply in enhancing yield in some crops mainly irrigated wheat and greenhouse grown tomato.

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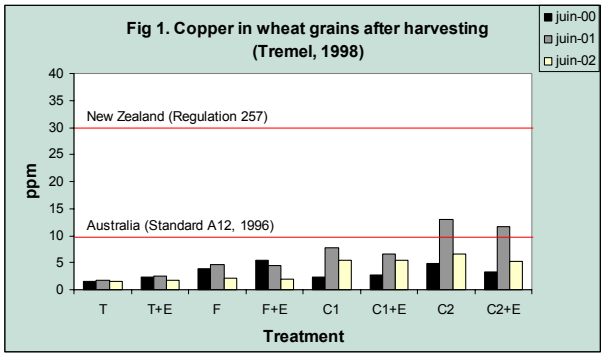
Irrigated wheat "cv Karim" (Loamy-clayey soil).

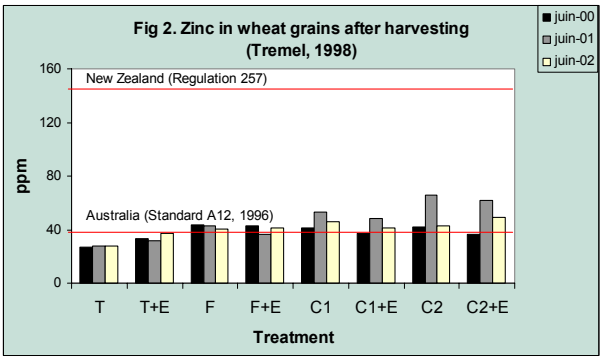
Different amounts of MSW compost and farmyard manure are used yearly as autumnal amendment (1999-2000-2001-2002) combined or not with the mineral fertilization (Normally performed by Tunisian farmers) in 8 m² plots (Loamy-clayey soil) distributed as follows:

T : Non-treated soil (Control)
T+E : Soil + Conventional mineral fertilization
F: Soil + Farmyard manure (40t ha^{-1})
F+E: Soil + Farmyard manure (40t ha^{-1}) + Conventional mineral fertilization
C1 : Soil + MSW compost (40t ha^{-1})
C1+E : Soil + MSW compost (40t ha^{-1}) + Conventional mineral fertilization
C2 : Soil + MSW compost (80t ha^{-1})
C2+E : Soil + MSW compost (80t ha^{-1}) + Conventional mineral fertilization

After harvesting (June) and determining the yield per treatment, soil samples (0-40 cm) and plant samples are collected from each plot to be analyzed for some physical and chemical parameters to investigate especially the concentration and the fate of heavy metals. As an irrigated crop, a special interest will be given by the end of the project, to the metallic and mineral concentration (mainly N) below the root zone especially in the 60 to 100 cm depth because of leachate. The latter may provoke groundwater contamination. The LSD test at 5% reveals that difference in yield starts to be statistically significant in June 2001 and more obvious in 2002 . Control shows a drastic decrease in yield testifying a continuous impoverishment of the initial mineral stock of the soil. For three years consecutively, treatments C1+E and C2+E led to the more stable productivity and the best yield exceeding 64 quintals ha^{-1} (1 quintal of wheat = 100 Kg). Thus, Improving yield with MSW compost amendment is likely to be proved.

The quality of wheat produced was put into evidence through the measurement of the concentration of 6 heavy metals : Cd, Pb, Cr, Ni, Cu and Zn by Atomic Absorption Spectrometry (AAS). Only Cu and Zn were found in wheat seeds and the rest of heavy metals were blocked either in the soil or in the rooting system. An evident increase in the concentration of Copper and Zinc in relation with MSW compost amount was observed, but both of them were under New Zealander standard (Regulation 257) for Cu and Australian standard (A12, 1996) for Zn (Figs. 1 and 2).





Greenhouse grown tomato (Sandy soil).

Different amounts of MSW compost and farmyard manure were used as autumnal amendment (October 1999) with or without mineral fertilization. Treatments are distributed as follows:

T : Non-treated soil (Control)
T+E : Soil + Conventional mineral fertilization
F: Soil + Farmyard manure (40t ha^{-1})
F+E: Soil + Farmyard manure (40t ha^{-1}) + Conventional mineral fertilization

C : Soil + MSW compost (40t ha^{-1})
C+E : Soil + MSW compost (40t ha^{-1}) + Conventional mineral fertilization
As the MSW compost's effect on yield was proved, we wanted to investigate heavy metals fate in market gardening crops known to concentrate heavy metals through their high potential uptake.

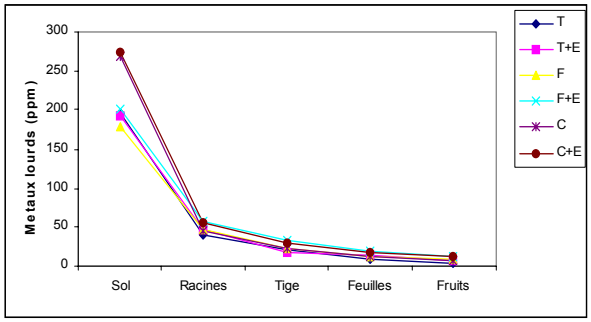


Figure 3. Heavy metals concentration in different parts of the plant.

We concluded that heavy metals concentration had decreased from roots to fruit for all the treatments. Cd, Pb, Ni and Cr were blocked in the underground part of the plant. Only Cu and Zn diffused through stem with a decreasing gradient (Fig. 3). Although, the concentrations of Cu and Zn were not high in tomato fruit, this experience was abandoned because of a high bacteriological contamination..

2- To investigate the long-term (4 years) accumulation and concentration gradient of heavy metals, the organic matter (C), N, P and K from soil surface down to 1m depth in non-planted compost or farmyard manure amended plots. Besides, cationic exchange capacity (CEC) and soil stability to water parameters are determined to assess the risk of contaminant availability and leachate into groundwater under Tunisian climatic conditions. Plots of 2,25 m² were treated as follows:

T : Untreated soil control
F40: Soil + Farmyard manure (40t ha^{-1})
F120: Soil + Farmyard manure (120t ha^{-1})
C40 : Soil + MSW compost (40t ha^{-1})
C80 : Soil + MSW compost (80t ha^{-1})
C120 : Soil + MSW compost (120t ha^{-1})
The results of this experience will be divulged late 2003

III. Conclusions

- Combining MSW compost to mineral fertilization improves both wheat and tomato yield under the Tunisian farming system.
- There was no significant difference in yield between MSW compost at 40t ha^{-1} and 80t ha^{-1}. Decision in favour of 40t ha^{-1} seems to be a convenient solution in order to minimize metallic contamination risks.
- Now, we are tending to establish heavy metals concentration thresholds in the edible parts of the plant and we are likely to set up some Tunisian standards related to the maximum amount of MSW compost that could be amended to landcrops without affecting human health and environment, either. This would be a useful database for Tunisia since the government strategy is to implement a composting facility in each Governorate (25).
- Besides the metallic contamination, We are focusing on the organic pollution that may provide such composts especially when the source-separation policy is not wide spread in Tunisia.

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