GEROLD RAHMANN, VICTOR OLOWE, TIMOTHY OLABIYI, KHALID AZIM, OLUGBENGA ADEOLUWA (Eds.) (2018) Scientific Track Proceedings of the 4TH African Organic Conference. "*Ecological and Organic Agriculture Strategies for Viable Continental and National Development in the Context of the African Union's Agenda 2063*". November 5-8, 2018. Saly Portudal, Senegal

Developing a Strategy for Sustainable Improved Soil Productivity in the Tropics – Efficient Management of Crop Residue/Farm Waste

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Keywords:
Harvest index, crop residue, soil mining, residue burning and pollution, composting

Abstract

If soil productivity must be improved in the tropics, returning nutrients from crop residues back to the soil is a practice farmers must undertake to maintain the soil's fertility without resort to chemicals that can have negative impacts on the soil and the environment. Many smallholder farmers do not own livestock that can be used to process residues, and so they resort to burning of the residues so that the ash will be available to apply as a form of fertilizer. Burning residues result in the loss of most nutrients through volatilization; and the pollution of the environment through production of green house gases, contributing to global warming. If fed to livestock in-situ, they may not reap the full benefit of the crop residue as animals will leave the field after feeding and thus the excrement produced subsequently is not available as manure. To overcome this bottleneck, a method of composting is advocated where crop residues can be chopped in smaller bits, mixed with contents from the rumen of ruminants obtained from abattoir and some water and ensilaged in a pit or containers for some days to decompose. The same process can also be used for non-consumable parts of products taken to the market or home, so that the decomposed product (compost) is then returned to the farm to improve the soil's fertility. Application of compost will build up the soil's organic N, the loss of which is implicated in the loss of the soil's productivity.

Introduction

In many tropical and subtropical regions, land productivity among small-scale farmers has stagnated for years. The soils contain heavily weathered clay minerals with poor ion exchange capacity and their potential to absorb nutrients is low; resulting in the washing of mineral fertilizers applied. In addition, most crop production practices result in soil mining and if no attempt is made to return such nutrients to the soil it will lose its productive capacity; and such a soil is said to be degraded. For example, 8 t/ha of wheat harvested in Germany takes 180 kg of nitrogen, 37 kg of phosphorus and 124 kg of potassium from the soil (LFL, 2006). If however, only grains are harvested and the straw left on the land to be worked in or spread in stables and returned to the fields as manure, the volume of nutrients taken from the system will be reduced to 64 % of the original crop withdrawal in the case of nitrogen, 41 % of the phosphorus and 18 % of the potassium, showing that farming withdraws enormous amounts of nutrients from the soil; and the more intensively the land is farmed, the higher the yields and the greater the withdrawal. Mulvaney *et al*, (2009) showed that loss of organic N decreases soil productivity and the agronomic efficiency of fertilizer N and that this has been implicated in the widespread reports of yield stagnation or even decline for grain production in Asia.

Preserving and sustaining the soil's productive capacity is very important in the tropics due to the vagaries in the production climate of the region. Sunshine and temperatures are high and sometimes for very long periods during the dry season; rainfalls are sometimes scanty, resulting in poor crop establishment, growth and development. The application of chemicals can exacerbate the harsh conditions impoverishing the production environment for crops still further.

The global share of land farmed by smallholders is not known. In the 1980s, it was estimated to be 60% (Francis, 1986); and currently assumed to be at least 40%. Small-scale agriculture is vital for the livelihood of a vast majority of rural people, most of whom have no alternative sources of income. These farmers produce the majority of grains, almost all root, tubers and plantain crops, and the majority of the legumes. If they are therefore to improve productivity of these soils, management practices that will sustain the soil's production capacity must be maintained. These include - that the soil's chemical nutrients removed by crops must be replenished, and the physical condition of the soil must be maintained; that is the humus level must be constant or increasing; no build up of weeds, pests and diseases; no increase in soil acidity or of toxic elements and soil erosion must be controlled to be equal to less than the rate of soil genesis (Greenland, 1975).

Zingore *et al* 2011, reported a village analysis indicating that only a third of the village cropland could be covered with manure produced with its own livestock population in equilibrium with the carrying capacity of local grasslands. Thus, hunger, food insecurity and environmental harms will continue if current trends in population growth, food and energy consumption, and food waste are not curtailed (Tilman *et al.* 2011; Tomlinson, 2013); but to maintain the soil's capacity to produce food, it is imperative that we adopt sustainable and resilient agricultural practices as soon as possible. Currently the shifting cultivation, the bush fallow, the improved fallow, conservation agriculture are employed, but they can be improved by practicing the clipping/thinning management of legume crops for green manure (Odion *et al.* 2007). This will improve the fertility of the soil as well as detoxify acid soils (Woomer and Muchena, 1993; Hue et al 1986; Bell and Besho, 1993). The processes alone may not sufficiently feed the soil to ensure for intensification of production among smallholders, and thus, could necessitate composting; the biological and chemical decomposition and conversion of animal and plant waste into high quality humus. Thus crop/farm residues will be made available for use on the farm instead of either being burned or used for land filling as it is currently being done. But how can they be digested through composting? The process can be modified to involve ensiling crop/farm residues mixed with rumen contents or *Trichoderma* species - where available (Doni *et al.* 2017). If this is possible, it could be enlarged by involving or teaching smallholders to process their crop residues and other wastes from markets. Such wastes turned into compost, can be used to improve and sustain productivity, such that farms and perhaps grazing lands are improved. Cisse (1986), reported by Myers *et al*. (1994), demonstrated the effect of organic inputs on root development and crop yields in Senegal; also improved root production, assessed by the root-pulling resistance, is implicated in improved rice yield in early transplanted SRI rice production, Barison and Uphoff, 2011.

Materials and Method

Crop residues gotten from the farm or market were chopped into smaller sizes that can be managed easily and mixed with the rumen contents from the abattoir together with some water. The mixture was then put in a polythene container and tied to reduce draught and improve the temperature so that decomposition of the residues can take place. It was then put in a bucket, covered up and allowed to ferment for some weeks. The chopping into bits was to mimic chewing of the crop residue by animals; while reducing air draught was to mimic the condition in the rumen. The mixing with the contents of the rumen gotten from the abattoir was done using rubber gloves.

Results

This initial trial to demonstrate the feasibility of digesting crop residues shows that the process of digesting crop/farm residues to return to the farms is possible. However, observations made are that very dry materials are difficult to digest properly and so freshly harvested materials should be ensilaged as soon as possible instead of keeping them to dry. Chopped materials digest better than whole material as they seem to produce more surfaces for the rumen content to interact with the residue. Pictures of the compost made from maize stalk, rice straw and cowpea haulms are shown below.

Analysis of the rumen content used and the compost derived from the mixture will be beneficial to explain what happened to the crop residue and what is being added to the soil.

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