Chapter 9

Producing Fortified Compost from Crop Residues

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Many African countries continue to require increasing amount of food aid (World Bank, 1996) because their agricultural production does not match population growth. This is most evident in countries where population growth is very high and yet soils tend to be highly weathered and have low inherent fertility (Smaling *et al.,* 1997). In Kenya, farmers realize the need for soil amendments by using available resources such as farmyard manure, poultry wastes and piggery effluent (Woomer and Swift, 1994), however, the quantity and quality of these materials limit their use (Delve, 1998). In addition, farmers appreciate the use of mineral fertilizers but their ever-increasing costs often prohibit their application at recommended rates (Heisey and Mwangi 1996). In some areas, crop residues such as wheat straw and maize stovers are left on the land but their decomposition rate is very low because of the high C:N ratio. These materials accumulate in very large amounts and are difficult to dispose. For example, in Uasin Gishu and Trans Nzoia districts of Kenya, yields of maize stover and wheat straw range from 4 to 15 t ha^{-1} (Muasya, 1996). Management of these residues includes incorporation back into the soil, feeding residues to livestock or burning (Lwayo *et al*., 2001). The Faculty of Agriculture at Moi University has developed a technology to recycle plant nutrients from wheat straw and maize stover. This technology involves fortification of these residues with nitrogen (N) and phosphorus (P) fertilizers to reduce losses from the composting process.

Procedure for Fortification of Organic Residues

Low quality organic materials such as maize stover or wheat straw with a wide C/N ratio are suitable for preparing fortified compost. The procedure for fortifying such organic materials is:

1. Chop crop residues into 30-45 cm lengths in order to increase their surface area.
2. Spread the chopped material in five successive layers of 30 cm high by 2.0 m wide into windrows 25 m long (» 500 kg in each layer).
3. At every 30 cm layer, evenly broadcast 3.75 kg DAP (or any other nitrogen-bearing fertilizer) for fortification lowering the C:N ratio from 80 to about 12.
4. Apply 1.0 kg of organic soil uniformly as a "starter inoculant". Farmyard manure, sugarcane mill filter mud or pond sediments are suitable materials for this purpose.
5. Apply 20 litres of water at the same height to enhance dissolution of fertilizers and to moisten the stover for microbial activity.
6. Repeat steps 1 to 5 until the 25 m windrows are 1.5 m in height (Figure1).

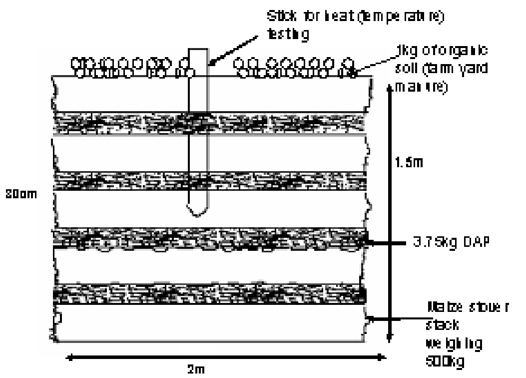

Figure 1. Fortified compost heap set up using the Moi University fortification method

Turning the Compost

Turning compost is important as it ensures proper mixing, wetting, aeration and decomposition. The compost heap is allowed to settle for one month, and then turned using pitch forks. Material on the top of the heap and along the edges is laid on the ground first, followed by the materials in the middle of the heap. Materials at the bottom are then placed at the top of the heap. It is recommended to sprinkle 20 liters of water on the heap during turning particularly when conditions are dry. Compost turning is continued until the heaped materials turn dark gray. Biological activity is monitored by pushing a stick into the middle and sides of the stack. The stick is pulled periodically and felt by hand for any temperature changes. For example, eight days after compost piling, much heat is generated from the center of the heap and the stick driven in the compost should indicate the same. This is an indication of biological activity in the compost (e.g. the thermophilic stage). Composting requires 4 to 6 months and at maturity and about 1900 kg of fortified compost is produced. Mature compost is odourless and has a fine texture. When the stick for testing temperature is driven into the heap, it should be cool (at ambient temperature) indicating that all the potentially harmful organisms and by-products have been eliminated.

Table 1. Sources and characteristics of commonly available crop residues, compost and manure among smallhold farmers in western Kenya

Material	Nutrient content			
	Organic matter	N	P	K
	---------------------%--------------------			
Maize stover	-	0.89	0.08	2.78
Bean trash	-	1.20	0.13	2.06
Banana trash	-	0.83	0.06	4.54
Compost (Ben Mutambo, Kanduyi)	39.6	1.17	0.24	0.53
Slaughter house manure (Bungoma)	44.7	1.65	0.59	0.56
FYM[1] (Protus Opicho, Bungoma)	21.3	0.89	0.19	0.82
FYM (Mary Wangila, Webuye)	42.8	1.61	0.54	2.52
FYM (Boniface Wamalwa)	13.1	0.39	0.11	0.40
Compost (Peter Simiyu, Siritanyi)	19.6	1.22	0.26	0.86
Fortified compost (Moi University)	52.0	2.20	0.42	1.40

[1]FYM = farmyard manure

Chemical Properties and Use

A comparison between fortified compost and a number of crop residues and organic manures appears in Table 1. Fortified compost is consistently among the highest organic resources in terms of nitrogen (2.2%), phosphorus (0.42%), potassium (1.42%) and organic matter (52%).

Significant maize grain yields from fortified compost applied at 2 t ha^{-1} were observed as compared to the control (Figure 2). Fortified compost provided 4 t ha^{-1} of grain yield, which was comparable to DAP at 20 kg P per ha, probably due to the increased N and P release from the compost. Non-fortified compost applied in conjunction with DAP at 20 kg P ha^{-1} resulted in reduced yields, demonstrating better agronomic effectiveness of fortified compost compared to an alternative allocation of the same inputs. In areas with large quantities of maize stover, fortifying these residues is an alternative to burning.

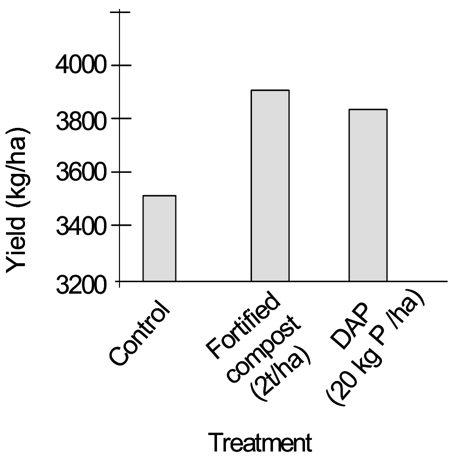

Figure 2. Effect of fortified compost, conventional compost and DAP fertilizer on maize yield in Uasin Gishu, 1998.

Conclusion

There is potentially a large number of farmers in western Kenya who could benefit from the use of fortified compost to improve their overall crop yields and better utilize post harvest residues. The technology offers potential to smallhold sugar outgrowers in western Kenya as well as large-scale and wheat producers in the Rift Valley. The mound and windrow composting technique described in this chapter is appropriate for materials other than maize stover and wheat straw and when higher quality materials such as manure, tree prunings and grass cuttings are being composted, there is little or no need to fortify them with mineral fertilizer. However, lack of technical know-how to make and use compost is lacking. Farmers should be trained on how to prepare fortified compost. On-farm trials should be conducted at multiple locations to enable as many farmers as possible to learn how to make and use fortified compost. Socio-economic factors, such as labor availability or lack of space, that hamper the adoption of this technology should also be identified and solutions to these problems offered.

References

Delve, R.J. 1998. Implications of Livestock Feeding Management on Soil Fertility in Smallholder Farming Systems. Ph.D Thesis, University of London.

Heisey, P.W. and Mwangi, W. 1996. Fertilizer Use and Maize Production in Sub- Saharan Africa. CIMMYT Economics Working Paper 96-01, CIMMYT, Mexico.

Lwayo-Kisaka, M., Okalebo, J.R., Muasya, R.M. and Mongare, P.O. 2001. a diagnostic survey on the utilization of phosphate fortified wheat straw and maize stover compost for increasing cereal production in Uasin Gishu District, Kenya. A KARI-ARF-Moi University Report, Eldoret, Kenya. 106 pp.

Muasya, R.M. 1996. Wheat Responses to Fortified Wheat Straw Compost, M.Ph. Thesis, Moi University, Eldoret, Kenya.

Smaling, E.M.A., Nandwa, S.M. and Janssen, B.H. 1997. Soil Fertility in Africa is at Stake pp. 47-61. In: R.J. Buresh, P.A. Sanchez and F. Calhoun (Eds.), Replenishing Soil Fertility in Africa. SSSA Special Soil Publication No. 51, SSSA, Madison Wisconsin, USA.

Woomer, P.L. and Swift, M.J. (Eds.). 1994. Biological Management of Tropical Soil Fertility. John Wiley and Sons, Chichester, UK.

World Bank. 1996. Natural Resource Degradation in Sub-Saharan Africa: Restoring of Soil Fertility in Africa. The World Bank, Washington D.C.

Fortified Compost Network

Compost-making is a very important topic among FORMAT members and they have taken the lead in processing organic resources as nutrient inputs to soil. Fortified composting was undertaken in seven locations across Kenya, including Busia, Embu, Kiambu, Kisumu, Kitale, Mombasa and Nairobi. Composting organic materials with low nutrient contents and undesirable physical properties into organic fertilizers poses a particularly difficult challenge to the composting network.


A fortified composting field day held in Busia.

Nine "under-utilized" organic materials were identified for composting at different locations by several cooperators: maize stover and sugarcane waste (ARDAP, Busia and Manor House Agricultural Centre, Kitale); tea dust, rice straw and husk (Organic Africa, Embu); coarse crop-dairy farming residues (Kenyan Smallholders Advancement Group, Kiambu); water hyacinth (COLIDEF, Kisumu); seaweed, coconut husks and *makuti* waste (Jamii Humanist Centre, Mombasa); and domestic and market wastes (City Park Environmental Group, Nairobi). A protocol for fortified composting was prepared and used to train participating cooperators on the composting process. Field days were organized at all the sites to facilitate sharing and transfer of knowledge among farmers, extension and NGO workers on fortified compost preparation skills, the importance of compost quality and to further emphasize the processing of locally-available organic materials into soil amendments. An exhibit and a presentation on fortified composting were given at all the eight countrywide events to educate participants on this technology. A television documentary on fortified composting was co-produced by FORMAT and broadcast on Kenyan television.

A simple procedure for fortifying organic residues. Low quality organic materials such as maize stover or wheat straw require fortification with nutrient rich additives and biological catalysts before they can be readily composted. A procedure for fortifying such organic materials follows:

1. Chop the residues into 30-45 cm pieces in order to increase their surface area where necessary.
2. Spread the chopped material in five successive layers 30 cm high by 2.0 m wide into windrows 5-25 m long (» 100-500 kg in each layer respectively).
3. At every 30 cm layer, evenly broadcast 0.75-3.75 kg DAP in respect to the length of the windrow (or any other nitrogen-bearing fertilizer) for fortification to lower the C:N ratio.
4. Apply 1.0 kg of organic soil uniformly as a "starter inoculant". Farmyard manure, sugarcane mill filter mud or pond sediments are suitable materials for this purpose.
5. Apply 20 litres of water at the same height to enhance dissolution of fertilizers and to moisten the stover for microbial activity.
6. Repeat steps 1 to 5 until the 25 m windrows are 1.5 m in height

Compost characteristics. Compost quality relies mostly on the nature of the organic materials used for production and the management practice during the composting process. The important physical properties of materials intended for composting are particle size and moisture content. Particle size affects oxygen movement into and within the pile, as well as microbial and enzymatic access to the substrate. Proper balance in the particle size should be maintained. If too large, the organic materials should be chopped into smaller pieces. On the other hand if too small, the organic materials should be mixed with a bulking agent (e.g. wood chips or tree bark). The optimum moisture content for composting is 40 to 60%. Too much water interferes with oxygen accessibility slowing down the rate of composting, while too little hinders diffusion of soluble molecules and microbial activity.


Harvesting compost from coconut wastes and seaweed in Mombasa.

The appearance of the harvested fortified compost is related to the organic resources used in its preparation. Farmers can easily tell the difference in colours and texture. Several discernible characteristics could be used to judge maturity and quality of these composts including texture, colours, smell and biological activity. Biological activity is a useful indicator of compost maturity.

The presence of macrofauna in maturing compost, particularly earthworms and grubs, serves as an indication of the stage of compost maturity because time is required for these invertebrates to re-colonize the substrate after it cools down. When compost texture is considered, coarse materials become finer over time until a fine, loamy material is produced. Changes in the colour of the compost can also tell its quality and maturity. The chemical composition of fortified and conventional composts prepared by the project appears below.

Initial material	fortification	nitrogen	phosphorus	potassium
		--------- kg per ton ----------		
maize stover	none	13	2	13
	DAP	21	3	19
sugarcane tops & leaves	MPR	23	5	7
	DAP	27	8	10
rice straws	none	19	6	28
	DAP	22	9	25
highland farm wastes	EM	27	15	20
	DAP	30	21	34
coastal farm waste	none	13	3	9
	DAP	18	4	11
market waste	none	27	16	46
	DAP	35	19	50

MPR: Minjingu Rock Phosphate; EM: Effective Micro-organisms