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Case Report

Assessment of Nutrient Contents of Farmers' Used Composts for Crop Production in the North Shewa, South West Shewa, and West Shewa Zones, Oromia

Dejene Getahun*, Abera Donis, Dereje Girma, Ajema Lema

Oromia Agricultural Research Institute, Fitche Agricultural Research Center, Oromia, Ethiopia

Email address:
dejenegetahun2009@gmail.com (D. Getahun)
*Corresponding author

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Abstract: Composting is one of the most effective mulches and soil additives available in nature. The usefulness of this rich, dark, earthy material in enhancing the soil and producing a healthy environment for plants is well known among gardeners. The public's interest in learning how to manufacture and use compost is growing as the waste disposal situation worsens. In the years 2012-2013, the nutrient content and quality of currently used composts for agricultural purposes were assessed in various districts of North Shewa (Kuyu and G/Jarso), South West Shewa (Woliso and Becho), and Special zone of Oromia around Finfine (Akaki and Welmera) Zones, Oromia region to assess the nutrient contents of currently used composts prepared from diversified material sources for agricultural purposes, composting practices, and composting The majority of farmers see collected FYM or home garbage as compost. The compost samples were taken without regard for the material used to make them. Compost was made by some farmers from cow manure and household garbage. Even if some farmers make compost from ash, cow dung, and green leaf, they do not adequately combine and wet it. The information on the compost samples was gathered via questionnaires. Following consultation with the agricultural development office, Fitche Soil Research Center collected 116 compost samples from eight districts and analyzed them for EC, pH, N, P, K, Ca, Mg, organic matter, C:N ratio, micronutrients, and CEC using the laboratory protocol described for each parameter. Compost generated from varied materials has a different nutritious value. 6.04-10.20, 0.25-9.07, percent TN 0.19-178, percent OC 9.36-29.12, P 180-7175, and k 2.8 to 70.97 are the pH of compost collected from various districts. Accordingly, based on all parameters required for quality and nutrient content analysis, the nutrient content and quality of farmers' used composts for crop production did not meet the standard. This could be due to the raw materials used and their proportions, the standard composting process, and storage conditions that did not adhere to the guidelines provided. To determine the appropriate compost maturity time, a scientific method of compost application should be followed, and it is better to train farmers on how to prepare compost so as to improve land productivity and crop yield.

Keywords: Compost, Special Zone, FYM, Nutrient, Agricultural Purposes

1. Introduction

Agriculture is Ethiopia's most important economic sector, providing employment to 85 percent of the population, 48 percent of GDP, and 90 percent of foreign exchange profits [14]. Continuous exploitation of natural resources by agricultural activities has put enormous strain on natural resources, particularly soil. Farmers who are trained to maintain soil fertility and productivity rely on a restricted number of chemical fertilizers while overlooking the role of organic fertilizer. However, growing concerns relating to land degradation, the inappropriate use of inorganic fertilizers, atmospheric pollution, soil health, soil biodiversity and sanitation have rekindling global interest in organic cycling practices such as composting [7].

The cost of chemical fertilizer that becomes beyond affordable capacity of small farmers of developing countries is another cause for the rekindling interest in organic recycling. In addition, the potential of composting to turn on-farm waste materials into a farm resource makes it an attractive proposition.

Composting is the biological decomposition and stabilization of organic materials by microorganisms under aerobic conditions. Composting is rich, humus like material valued for its soil-conditioning qualities. It is formed when a mixture of organic material, such as manure, bedding, food processing wastes, decomposes in the presence of oxygen.

Composting is a practice of creating humus like organic materials outside the soil by mixing, pilling, or other means under condition conducive to aerobic decomposition and nutrient conservation [2].

Determining the appropriate plant material composition in compost, composting time and inorganic fertilizer equivalency of compost are useful for scientific way of compost application so as to improve land productivity and crop yield. During composting process, the C/N ratio of organic materials in the piles decreases until a fairly stable ratio in the range of 14:1 to 20:1 is achieved. Achieving this ratio is possible by selecting appropriate combination of cereal and legume plant materials and identifying the appropriate composting period. Compost maturity can be determined by monitoring C/N dynamics since compost must have a C/N ratio of less than or equal to 25 before its application to the soil [12].

Composting is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrition, it improves the physico-chemical and biological properties of the soil [1].

As a result of these improvements, the soil becomes more resistant to stresses such as drought, disease and toxicity; helps the crop in improved uptake of plant nutrients; and possesses an active nutrient cycling capacity because of vigorous microbial activity, and allowing root growth [4].

Generally, compositing offers benefits such as improves soil physical properties such as structure, water infiltration rate and water holding capacity, soil porosity, water percolation, soil aggregation, aggregate stability, decreased soil crusting and bulk density, as well as chemical properties like cation exchange capacity, buffering capacity, supply of nutrient, improved soil biodiversity, and a better environment. The organic matter in compost improves soil nutrient holding and water retaining capabilities which, in turn, reduces fertilizer requirements and erosion while enhancing soil tilth [7].

These advantages manifest themselves in reduced cropping risks, higher yields, and lower outlays on inorganic fertilizers for farmers. Despite all these benefits rendered by organic recycling, many farmers, especially those in developing countries, find themselves at a disadvantage as they fail to make the best use of organic recycling opportunities. This may be because of a lack of knowledge of efficient, speedy technology, long time spans, intense labor, land and investment, resources (raw materials) and economic factors.

Composting may be divided into two categories by the nature of the decomposition process (Aerobic and anaerobic) while it is grouped into two based on extent/rate of decomposition, traditional and rapid composting practices. Traditional methods generally adopt an approach based on anaerobic decomposition or one based on aerobic decomposition using passive aeration through measures such as little and in frequent turnings or static aeration provisions such as perforated poles/pipes. These processes take several months (Traditional methods based on passive composting involve stacking the material in piles or pits to decompose over a long period with little agitation and management). On the other hand, using the recently developed techniques rapid methods expedite the aerobic decomposition process and reduce the composting about four to five weeks.

The stability of given compost is important in determining the potential impact of the material on nitrogen availability in soil. Maturity is the degree or level of completeness of composting. Maturity is influenced in part by the material's relative stability, but it also refers to the impact of other compost chemical qualities on plant development. Some immature composts may include significant levels of free ammonia, organic acids, or other water-soluble chemicals, all of which can inhibit seed germination and root development. All compost applications necessitate a mature product that is free of these potentially hazardous components. Mature compost will have features that suggest that the composting process is complete and that there is little risk of detrimental effects on plant development. The organic carbon content dropped as the composting duration increased due to CO_2 loss and N conservation throughout the mineralization process [10].

Knowing the nutrient composition and quality of any material utilized is essential for improving soil fertility. As a result, most developed countries (for example, Austria, Australia, Belgium, Canada, Denmark, and others) have established compost-specific standards and promoted quality criteria in order to support the compost industry and aid the growth of new markets over nearly two decades throughout the Western world [5]. The following parameters are standardized in compost: amount of heavy metals such as Lead, Copper, Zinc, Chromium, Nickel, Mercury, and Cadmium; special metals (in industrial/municipal waste such as Molybdenum, Selenium, Florin, Arsenic); pathogens; physical composition (stones); salt content; compost maturity, and others [1].

Despite the reality of developing countries, including Ethiopia, failing to make the best use of organic recycling, there are unorganized beginnings of organic recycling activities in various zones of the Oromia region, aiming to replace the use of inorganic fertilizer. Proper soil fertility management is the only way to increase crop production and productivity. Farmers utilize various composting materials to boost soil fertility and raise soil productivity in order to address our country's major agricultural soil restrictions [9].

However, the types of composting material sources, compost preparation procedures, the volume of compost applied, and, most importantly, the amount of nutrients in the compost used are the foundation for using compost to boost crop yield. However, there is no information accessible on compost's level or quality. As a result, this research was to bridge the gap by evaluating the quality of present utilized in Oromia.

The major goals of this study were to look at the nutritional value of currently used composts made from a variety of materials for agricultural use, to evaluate the most common raw materials used as compost sources in different agro-ecologies, and to establish a composting database.

2. Materials and Methods

2.1. Location of Study Area

In several districts of North Shewa (Kuyu and G/Jarso), South West Shewa (Woliso and Becho), and the special zone of Oromia around Finfine (Akaki and Welmera) Zones, Oromia region, the nutrient content and quality of currently employed composts for agricultural purposes were assessed.

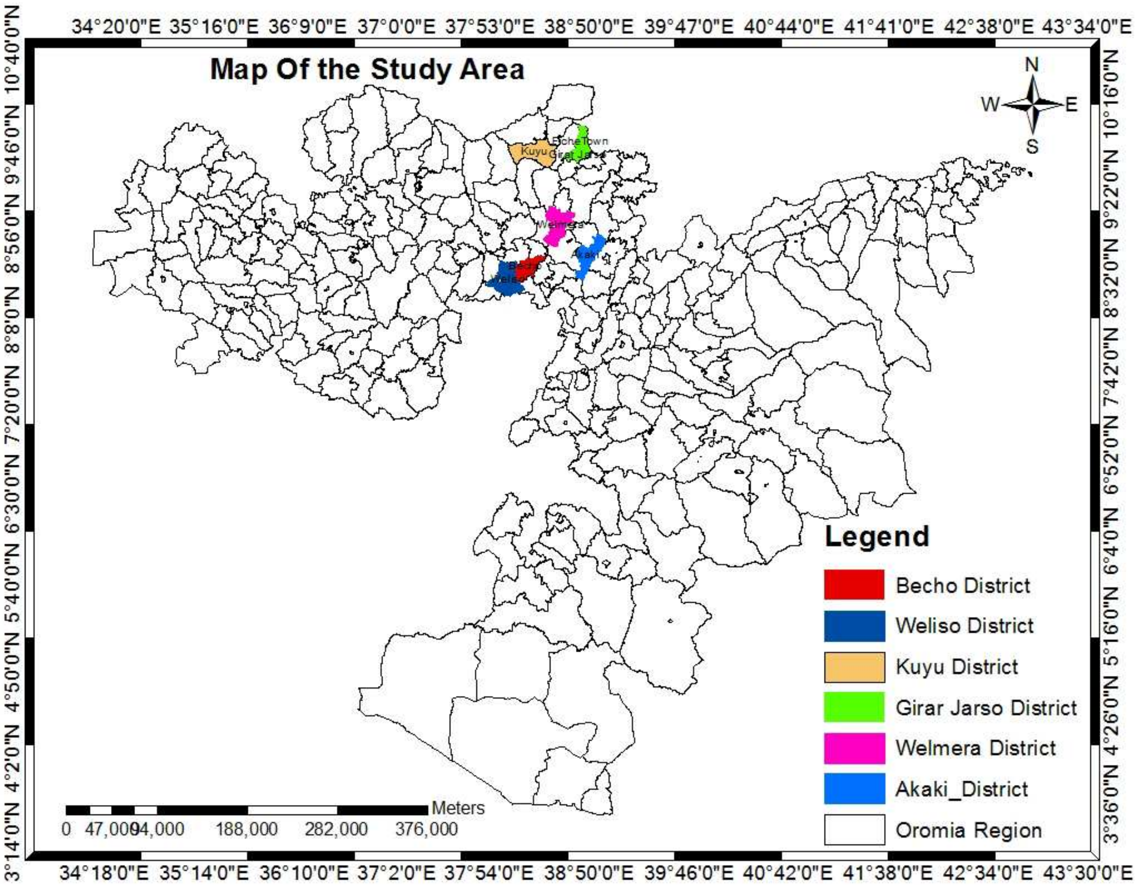

Figure 1. *Location of the study area.*

2.2. Site Selection and Sampling

A total of 320 matured compost samples planned 116 were taken from eight districts for laboratory analysis. Before sample collection Questionnaires were developed and researchers moved to those selected zones and districts and discuss with each zones and districts agricultural development office and concerned experts to make awareness in order to prepare representative sample farmers. Then, the researchers moved to the village of each farmer and collected information on (how to prepare compost, how much they prepare, limitations to prepare more compost, raw material used, time taken to complete decomposition types and age of raw materials used, rate of application, how much inorganic fertilizer used, if they use with a combination of inorganic fertilizer, for which crops they use, problems encountered during preparation and application, performance of crop because of the use of compost, awareness level of farm community to use compost and their limitation, etc). And then, a kilo of compost samples was collected from each representative farmers' compost preparation site. The compost samples were labeled and taken to laboratory for further analysis for the required parameters.

2.3. Compost Sample Analysis

Compost samples submitted to the laboratory were air dried, and prepared for analysis by grinding and sieving through 2mm sieve. Based on laboratory analysis capacity and standard methods the collected compost samples were analyzed for EC, pH, N, P, K, Ca, Mg, S, organic matter, C: N ratio, micro nutrients and CEC according to outlined laboratory procedure for each parameter [1].

Compost pH was determined potentiometrically using pH meter in 1:5 compost water ratios. Salinity was also measured from compost sample with water (1:5 water: water ratio) by electrical conductivity (EC) using a conductivity bridge.

Finally, the analyzed composts for required parameters were compared with existing established standard compost quality parameters by different authors.

3. Result and Discussion

Inorganic chemical fertilizers that carry a label by law must declare their N-P-K (Nitrogen-phosphorus potassium) content according to rules established more than half a century ago. However, compost, a product that contains nutrients and organic matter, is not subject to any systematic rules for reporting its content, its quality or risks. Therefore, this paper tried to give selected nutrient contents of currently used composts with some comparison using variety of established and published standards.

The composition of compost determines the suitability of the material for a particular task and the maximum amount that can be applied. About half of most forms of commercial composts consist of carbon and much of the remaining half is O_2 and H_2. There are also lower amount of N, P, and a large variety of other constituents. The composition of lower constituents depends on the source materials used for preparing compost (Table 1). Carbon containing materials should always be more than those containing high nitrogen i.e., a ratio of 2:1-3:1 are the best [6].

Table 1. *Raw materials used by farmers for compost making.*

N o	Districts	Composting materials used	Method
1	Welmera	FYM, cow dung, Ash, straw &green leaf	Pit method
2	Akaki	FYM, Ash, cow dung, straw, &green leaf	Pit Method
3	Woliso	FYM, Ash, green leaf& straw	Pit Method
4	Becho	FYM, Ash, straw& weeds	Pit Method
5	Kuyu	FYM, ash, straw, green leaf & top soil	Pit Method
6	Girar jarso	FYM, Ash, top soil,& green leaf	Pit Method

3.1. Compost pH

pH is a numerical measure of the acidity or alkalinity of the soil. The pH of collected sample differs from sample to sample. The result of the collected compost sample from Welmera, Akaki, Waliso, Becho, Kuyu and Girar Jarso district showed that pH range from 6.04-10.20. According to [6] and The Pennsylvania state University (2009) most compost has pH between 6 and 8. The composting pH depends on the source materials and varies in each phase of the process (from 4.5 to 8.5). In the early phases of the process, the pH was acidified by the formation of organic acids. In the thermophilic phase, due to the conversion of ammonium into ammonia, the pH rises, the medium is alkalized to finally stabilize at values close to neutral. The pH determines the survival of microorganisms and each group has optimal pH for growth and multiplication.

Most decomposition takes place between pH 5.5 and 9 [6]. During the start of the composting process, organic acids typically are formed and the composting materials usually become acidic with a pH of about 5. At this point, the acid tolerating fungi play a significant role in decomposition. Microorganisms soon break down the acids, however, and the pH levels gradually rise to a more neutral range, or even as high as 8.5. The role of bacteria in composting increases in predominance again as pH levels rise. If the pH does not rise, this could be an indication that the compost product is not fully matured or cured.

So when compare assessment sample result with these standards most of investigated samples have high pH value above neutral (pH 7). Since high pH enhance ammonia volatilization, lowering the pH value of compost help to reduce the problem of ammonia volatilization and reduce odours [6].

3.2. Electrical Conductivity

Conductivity is the measure of a solutions ability to carry electrical charge, that is, a measure of the soluble salt content of compost. The salt content of compost is due to the presence of sodium, chloride, potassium, nitrate, sulphate and ammonia salts [3]. Some soluble salts may be detrimental to plants whereas, other plant nutrients supplied to plants exist in salt form and are essential for plant growth. Though excessive amounts of soluble salts in compost used in growing media or applied to the land may inhibit crop growth and affect crop yield [3].

Electrical conductivity result analyzed from collected compost sample ranges between 0.25 to 9.07 which disagree with [6] report that the recommended range for conductivity in compost is between 2-6 mS/cm. Similarly, electrical conductivity of matured compost should only range from 1-3 mmho/cm [1]. Generally, out of the collected compost sample only 50% (17 samples) found in the range given by [4].

3.3. Nutrient Content of Compost

Nitrogen, phosphorous and potassium are the nutrients, which are utilized, in the greatest quantities by plants. Knowledge of the nutrient content of compost is important because the nutrient content of compost can vary widely and also because it allows facility operators to determine an appropriate end use for the compost. In general, nutrients are organically bound within compost and are slowly released over a period of time as a result of microbial activity. This ensures a continuous supply of nutrients to the [13]. Total nutrient content is usually expressed as a percentage on a dry weight basis.

3.4. Organic Carbon

Organic carbon is an important ingredient in all soils and has an important role to play in maintaining soil structure, nutrient availability and water holding capacity. It also serves as a vital role in maintaining a healthy soil ecology (Paul, 2007). The collected compost sample from Welmera, Akaki, Waliso, Becho, Kuyu and Girar Jarso district contain organic carbon ranged from 9.36 to 26.14 and average 17.75% (Table 2). When these results correlated with standards sated by Australian [15] which is above 19.4% organic carbon content most of compost representative sample were far below the standard. Out of 34 representative sample analyzed 74.07% (27 sample) were found below the standard sated by Australian [15] and only 25.93% (7 sample) were meet the standard.

Low percent Organic carbon could be due to absence or low proportion of carbon rich material like crop residue.

3.5. Carbon to Nitrogen Ratio

The C: N ratio is not a test within itself, it is rather a test for organically bound carbon and for total nitrogen. The ratio of these two can be used to provide an indication of the rate of decomposition of the feedstock and to determine when ripeness has been reached. Therefore, C: N ratios should be used in conjunction with some other relevant parameter for testing compost maturity (Wood End Research Laboratory, 1998). The EPA acknowledges this and specifies within a waste license that the C: N ratio of compost must be below 25.

The C: N ratio changes according to the parent material and the numeric ratio is obtained by dividing total C content (total C%) over the total N content (total N%), of the material to compost. This ratio also varies throughout the process, with a continuous reduction from 35:1 to 15:1 which is the ideal range. At this range higher amount of nitrogen-rich material is found in the mixture Farmer's compost handbook, [5].

The result of assessment shows that C: N ratio which ranges from 12:1 to 47:1 were obtained. Most of representative compost sample meet the quality standard given by EPA parameter which specifies within a waste license that the C: N ratio of compost must be below 25. The only 8.8% (3 samples) disagree the quality standard given by EPA Parameter.

3.6. Total Nitrogen

The collected compost from different areas differs in TN which was found between 0.17 to 3.81%. Most of the representative sample collected analyzed for TN found below 1% (64.71% of sample) that contradict [3] reported that compost as having fertilizing capabilities and for it to be used in agriculture the TN content must be over 1%, dry weight.

If compost contains TN of less than 1%, supplemental nitrogen fertilizer will be required if the compost is to be used as a soil improver or in potting media. If the TN in compost is approximately 0.6% or less there is a chance that nitrogen immobilization will occur. Thus, compost with low TN levels is better used as mulch [1]. The typical range of TN in compost is 1.0-3.0%, dry wt. Compost over 3% TN is usually found to be immature and ammoniacal [3].

3.7. Available Phosphorous

Phosphorous is also an important nutrient for plant growth. Phosphorus is essential for cell reproduction and metabolism. Total phosphorous (TP) is usually expressed in terms of percentage concentration per dry weight.

Most of the result obtained from assessment of compost nutrient content collected from Welmera, Akaki, Woliso, Becho, North Showa (Kuyu and Girar Jarso) shows 0.1 to 10.76% range in total phosphorous disagree [4] the range of TP is usually between 0.4 - 1.1%, dry wt for bio-waste and green waste compost. Similarly, according to [9] it ranges from% P 0.5 to 1 (5000-10,000 ppm). Even though available phosphorus contained in most sampled representative composts samples from all district s were above total nitrogen it was far below the range. This might because of raw material used for compost making and level of compost management during and after preparation.

3.8. Potassium

Potassium is a very abundant nutrient in plants. Potassium in its available form in compost exists as K_2O. The amount of potassium in compost depends on the feedstock but also on the composting process [3]. Compost usually does not contain a great concentration of potassium because due to its high water solubility it can be easily leached from the feedstock during the composting process.

The result of soil analysis range between 0.03% to 0.73% that disagree with Bord na Mona (2003) state that as cited in Herity, (2003), the typical range of total potassium (TK) in bio-waste and green waste compost is between 0.6-1.7%, dry weight. Most of the representative sample taken from Welmera, Akaki, Woliso, Becho, North Showa (Kuyu and Girar Jarso) result found below the range.

The optimum range of K is between 0.5 - 1.5 meq/100g. Levels less than 0.5 will need K added to support plant growth. Levels greater than 1.5 may contribute to a soluble salt condition that can restrict root growth and cause plant injury [1].

3.9. Magnesium and Calcium Content

Calcium is act as bases when they exist as oxides, hydroxide and carbonate. Compost containing these bases when applied to soil, may counteract soil acidification varying pH levels and making soil nutrients more available to plants [10].

Similar to Calcium compost containing these bases, when applied to soil, may counteract soil acidification varying pH levels and making soil nutrients more available to plants. The average of Calcium in compost for six district were 18.34, 9.44, 17.77, 20.82, 21.20 and 23.20 cmol/kg for Welmera, Akaki, Woliso, Becho, Kuyu and Girar Jarso districts respectively.

Most of the result of representative compost sample analyzed disagree the standard range of exchangeable calcium is 8-13 cmol/kg (Canada laboratory, http//www.al.labs.can.com accessed on September 24, 2018).

Averages of Magnesium in compost for six districts were 13.09, 5.69, 7.77, 13.78, 12.84 and 16.68 respectively.

The standard range for exchangeable magnesium in compost is 1.2-8 cmol/kg (Canada laboratory, http//www.al.labs.can.com). According to this standard the exchangeable magnesium of most of the district disagree with the standard except Akaki and Woliso (Canada laboratory, http//www.al.labs.can.com accessed on September 24, 2018).

Mg to K should be 7:1 for optimum availability of each nutrient. The relationship of Ca to Mg should be 5:1.

Table 2. *Summary of Nutrient content of composts analyzed for different parameters.*

SN	Districts	Composting materials used	Nutrient content of Compost											
			PH		EC mm/cm at 25°C		%TN		%OC		Avail. P (ppm)		Avail. K (ppm)	
			min	max	min	max	Min	max	min	Max	min	Max	min	Max
1	Welmera	FYM, cow dung, Ash, straw &green leaf	6.6	8.77	1.71	4.79	0.79	1.25	15.18	24.94	180	600	11.19	42.20
2	Akaki	FYM, Ash, cow dung, straw, &green leaf	7.01	8.84	0.97	6.47	0.58	1.59	12.10	26.14	265.5	717.5	15.98	64.58
3	Woliso	FYM, Ash, green leaf& straw	6.04	10.20	0.25	8.87	0.19	0.85	9.36	19.95	9.94	1076	2.80	72.89
4	Becho	FYM, Ash, straw& weeds	8.26	8.90	1.37	8.07	0.47	1.04	11.66	17.56	397	616	23.34	62.02
5	Kuyu	FYM, ash, straw, green leaf & top soil	6.79	9.01	3.16	7.75	0.79	1.28	16.40	25.46	250	752	12.92	46.99
6	Girar jarso	FYM, Ash, top soil,& green leaf	7.22	8.89	2.32	9.07	0.67	1.78	15.27	29.12	382	660	20.14	70.97

4. Conclusion and Recommendation

Compost enhances both physical and chemical qualities of soil, such as structure, water infiltration rate, and water holding capacity, as well as cation exchange capacity, buffering capacity, and nutrient availability. Soil aggregation, aggregate stability, decreased soil crusting, and bulk density are all improved by compost. Compost's organic matter improves soil nutrient and water retention, reducing fertilizer use and erosion while also improving soil tilth.

Various districts of North Shewa (Kuyu and G/Jarso), South West Shewa (Woliso and Becho), and the Special zone of Oromia around Finfine (Akaki and Welmera) Zones, Oromia region, were analyzed for nutritional content and quality of currently used composts for agricultural purposes in the years 2012-2013. The PH, EC, C: N, TN, OC, av.P, K, Mg, and Ca of collected typical compost samples were evaluated and compared to current standards. 116 farmers' compost samples were obtained from six districts from 320 selected representative compost samples, and 34 were tested for critical criteria. The majority of the investigated parameter values, such as calcium, TN, carbon to nitrogen ratio (C: N), organic carbon, availability of P, K, Mg, and calcium, do not fall within the conventional ranges established by various literatures. This could be due to a lack of strict oversight and guidance by local developmental agents, as well as the raw materials used and their proportions, composting procedures, and storage conditions that did not follow the guidelines supplied.

As a result, the following recommendations were made based on the results of the compost sample analysis conducted in six districts.

Appropriate compost maturity time should be observed, and it is preferable to teach farmers on how to prepare compost, including compost preparation techniques, materials and processes selection, and compost material composition, in order to increase land productivity and crop production.

Finally Perform a soil test to control nutrient levels and modify fertilization depending on the release mechanism and crop needs before applying compost or organic matter (knowing its chemical makeup) or mineral fertilizers.

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