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Techniques of Sampling Organic Manure for Nutrient Analysis in Crop Production

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Manure is a rich nutrient source in crop production. It contains essential nutrients needed by crop for growth and development. One of the challenges of manure nutrient contents determination is obtaining representative samples of manure for nutrient analysis. This is attributed to the differences in the manure handling method, type of storage structures, application method, and physical state of the manure and livestock management system. A representative manure sample is needed to provide an accurate reflection of the nutrient content. This paper examined the physical classifications of organic manure, highlighting the solid, liquid, and semi solid state of manure, when to sample organic manure for nutrient analysis in crop production especially during land application and also elucidate on sample preparations for nutrient analysis.

Keywords: Organic manure; sample preparation; nutrient content; liquid; semi solid and solid manure.

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1. INTRODUCTION

One of the challenges of manure nutrient content determination in crop production is the difficulty in getting a representative sample of manure for nutrient analysis. This is attributed to the differences in the manure handling method, type of storage structures, application method, and physical state of the manure and livestock management system. [1] observed that the two key factors affecting the nutrient content of manure are the type of storage structure and manure handling method. [2] reported that about 20-40% of phosphorous and 30-50% of potassium can be lost by run-off and leaching in open lots respectively. Other means of nutrient loss from manure is through volatilization and erosion. [2] also noted a 15-30%, 10-30%, 20-40% and 70-85% nitrogen loss during handling and storage in anaerobic pit, above-ground storage, earth storage and lagoon respectively. There is much less nitrogen loss from compost pits, liquid storage systems or roofed feeding areas.

However, the best way to assess manure nutrients is by sampling and analyzing the manure in the laboratory. A representative manure sample is needed to provide an accurate reflection of the nutrient content. Furthermore, manure quality is also determined by the type of animal. [3] found sheep and cattle manure and urine to affect millet production differently; this effect was attributed to the fact that application of sheep urine caused a much greater increase in the pH of the soil than did cattle urine. The effect of manure on the soil quality for agronomic purpose is another determinant factor of manure use efficiency. [4,5] reported that animal manure is an important soil fertility replenishment component in the mixed crop-livestock farming systems through the cause of increase in soil pH, water holding capacity, hydraulic conductivity and infiltration rate and decrease in bulk density of soil. Similarly, [6] observed that in the sub-humid zone of Burkina Faso surface application of compost at 5 t ha $^{-1}$ led to grain and straw yield increase of 46-69% and 16-20% in sorghum (*Sorghum bicolor* L.) above the unamended control. [7] also reported yield increase of 13 and 54% above the control in soya bean (*Glycine max* L.) and maize *(Zea mays* L.) grain respectively when applying 1.5-2 t ha^{-1} of compost manure. [8] observed that the application of different rates od swine waste sinificantly altered the chemical properties of the soil. The concentration of exchanagble bases (calcium, magnesuim, potassuim and sodium) was increased while there was a significant difference in soil pH, cation exchange capacity, base saturation, bulk density and moisture content among the treatments. The mean plant height at harvest of maize and grain yield increased relative to the control treatment (plot without swine waste application). Also, [9] noted that the highest application rate of 15 t ha^{-1} of composted rice husks + poultry manure (75%:25%, volume to volume; v/v) gave significantly the highest values of total nitrogen (1.36%), available phosphorus (80.36 ppm), organic carbon (4.10%), organic matter content (7.07%), exchangeable potassium (0.38 meq/100 g), exchangeable calcium (5.80 meq/100 g) and exchangeable magnesium (4.30 meq/100 g) compared with the control (plot without amendment). There was highest correlation coefficient (r = .995**) between soil organic carbon and exchangeable calcium and the least between exchangeable potassium and magnesium (r = .473). The 15 t ha^{-1} of compost manure significantly (P = .05) gave the highest values of plant height, stem girth, leaf area, number of leaves and yield in the three varieties of cucumber (*Poinsett, Marketer and Supermarketer*).

The main objective of this paper is to expound on the physical classifications of organic manure, highlighting the solid, liquid, and semi solid state of manure, when to sample organic manure for nutrient analysis in crop production especially during land application, elucidate on sample preparations for nutrient analysis and how to sample organic manure during land application tailoring it down to techniques of sampling liquid manure and dry or solid manure.

2. PHYSICAL CLASSIFICATIONS OF ORGANIC MANURE

Manure may be viewed as a mixture of water and solid materials. The dry matter or solid content of manure represents the proportion on a mass basis of the dissolved and suspended materials in the manure [10]. There is variability in the level of moisture content and solid portion of manure from different sources and livestock system. [11] noted that fresh manure of swine feaces, chicken feaces and cattle feaces contain 76.8%, 65.4% and 81.9% moisture respectively. Classifying manure based on the proportion of solid or dry matter content aid in developing a good sampling technique for accurate nutrient analysis in crop production. The concentrations of nutrients in the dry matter of manure are uneven as shown in Table 1.

Table 1. Minimum and maximum dry matter concentration (mg/kg) of total boron in different organic manure sources [12]

Source	No of samples	Mean	mg/kg dry matter	
			Minimum	Maximum
Sewage sludge	48	61	2	390
Pig slurry	4	84	65	91
Pig FYM	4	28	16	38
Cattle slurry	4	52	25	88

According to [1] manure is classified based on their physical characteristics as stated below:

2.1 Liquid Manure

This is manure with less than 10 percent dry matter content. It flows easily when poured. It can be applied to the soil with pumps, pipes, tank wagons and irrigation equipments. It is normally stored in tanks, pit or ponds usually called lagoons in a large intensive livestock production farm.

2.2 Semi-solid Manure

This is manure that contains 10 to 20 percent dry matter content and can be handled as liquid manure but it is more viscose than liquid manure.

2.3 Solid Manure

This type of manure is sometimes regarded as dry manure. It contains more than 20 percent dry matter it can be stored in an open lot or pen in a livestock production farm.

3. WHEN TO SAMPLE ORGANIC MANURE FOR NUTRIENT ANALYSIS IN CROP PRODUCTION

Manure is a valuable input in crop production that contains the essential nutrients needed by crop for its growth and development. The level of available nutrients in manure depends on many factors such as type, age, species, body weight, gender of the animal, type of feeding materials, bedding materials, type of manure storage system, application method and biological break down as stated by [13]. Table 2 show the percentage nitrogen applied that is lost within 4 days as influenced by application method.

From the point of view of crop production, the best time to sample manure for nutrient analysis is during the time of land application as noted by [1] Sampling during land application will help to ensure that samples are well mixed and representative of the manure being applied. Nutrients in manure are lost most especially during handling, storage and application through volatilization, leaching, runoff and erosion. [2] reported that about 20-40% of the phosphorous and 30-50% of the potassium can be lost by run-off and leaching in open lots. Nutrient loss can be reduced in the field by incorporating the manure immediately into the soil. [2] also observed that most losses occur in the first 24 hours after application. So injecting or chiseling of liquid manure into the soil minimizes nutrient losses to the air and to runoff.

However, a representative manure sample is needed to provide an accurate reflection of the nutrient content. Unfortunately, manure nutrient content is not uniform within storage structure as earlier noted. So obtaining a representative sample can be challenging. Mixing and sampling strategies should therefore insure that samples simulate as closely as possible the type of manure that will be applied. Therefore, the best time of collecting manure sample for nutrient analysis in crop production should be the time that ensures that the time of sample collection, manure incorporation into the soil and nutrient analysis in the laboratory is close as possible to provide a true estimate of the nutrient in the manure incorporated into the soil at that particular time.

Table 2. Percentage of nitrogen applied that is lost within 4 days of application [2]

Application method	Types of waste	Nitrogen lost (%)
Broadcast	Solid	15-30
	Liquid	10-25
Broadcast with immediate cultivation	Solid	1-5
	Liquid	1-5
Injection into soil	Liquid	0-2
Sprinkler irrigation	Liquid	15-40

4. SAMPLE PREPARATION FOR NUTRIENT ANALYSIS

Sample preparation involves the procedures and precautions taken during handling and conveying manure samples to the laboratory for nutrient analysis. It ensures that the representative samples from different lots and piles are mixed together to form a composite sample. The accuracy of manure analysis is only as good as the sample taken to the laboratory for analysis. Vital precautions for proper manure sample preparations are as follows:

- Manure samples should be collected using a transparent plastic bottle that can be sealed tightly. Glass bottles should not be used because the motions of gas molecules especially ammonia (NH_3) volatilization can break or crack the glass container.
- The plastic bottles should not be filled to the brim. A space of at least 0-1 inch from the brim should be left to ensure allowance for expansion of molecules in the manure during preservation and also provide a void for gas molecules to react. The plastic bottle container should be labeled for easy identification. Date, name of the collector, type of manure, sample identification number, site (farm) and the analysis to be done should be written on the label.
- The plastic bottle should be sealed tightly and refrigerated if not sent to the laboratory within few hours of sampling.

5. HOW TO SAMPLE ORGANIC MANURE DURING LAND APPLICATION

Manure exists in the form of liquid, semi-solid, and solid often referred to as dry manure. The techniques of collecting manure samples vary due to the differences in the physical state of the manure. An appropriate sampling technique is the one that put into account the differences in the physical state of manure, the storage method, method and time of application and the livestock production system that produced the manure being sampled. How to sample organic manure for nutrient analysis in crop production shall be discussed as follows:

5.1 Techniques of Sampling Liquid Manure

Liquid manure is manure that contains more moisture than the solid matter component of manure. In the livestock farm it is stored in pits, concrete tanks or evacuated from the animal pen to man-made pond called lagoon. The best time to sample manure is during the time of land application. Liquid manure can be applied in the field using irrigation system or tank wagon.

5.1.1 Sampling liquid manure applied by irrigation systems

- Place catch pans or small buckets randomly in the field to collect liquid manure that is applied by an irrigation system. For instance in the case of sprinkler irrigation use several pans at different distances from the sprinkler tractor.
- Immediately after the manure has been applied, collect manure from each catch pans or buckets and combine the manure in one bigger bucket to make one composite sample.
- Always stir the liquid manure in the bucket to ensure that the liquid portion and solid fraction mixes well uniformly and pour into a sample plastic bottle and always leave a space at the top of the sample plastic bottle.
- Seal tightly all the sample plastic bottle and take to the laboratory for nutrient analysis.
- Refrigerate the sample if not taken to the laboratory for nutrient analysis within few hours after sampling.

5.1.2 Sampling liquid manure applied with tank wagons

Tank wagons are motorized means of applying liquid manure to land. For an accurate representative sample collection, the tank should always be agitated or stirred to ensure uniform mixture of the liquid and solid portion of the manure, since settling begins as soon as agitation stops.

1. Collect samples as soon as possible after the manure tank wagon is filled or loaded
2. Immediately after filling the tank wagon, use a clean plastic pail to collect manure from the loading or unloading port or the opening near the bottom of the tank, be sure the part or opening does not have solid accumulation from prior loads.
3. Collect another representative sample when the tank has dispense half of its content and the another sample at the final discharge level.

4. Mix samples collected from the 3 sample levels in a plastic bucket to form a composite sample.
5. Pour samples into the plastic bottle and send to the laboratory for nutrient analysis and always ensure that the plastic bottle is not filled to the brim.
6. Refrigerate the sample if not taken to the laboratory for nutrient Analysis.

5.2 Techniques of Sampling Dry Manure

Dry manure is manure that contains more solid matter content than the liquid part. The Techniques of sampling dry manure should put into account the method of application and the storage facility of the manure, thus whether the manure is stored in the open lot or confine structure. The following method describes the procedures for collecting dry manure samples from the field during land application for crop production.

5.2.1 Sampling dry manure in the open lot during land application

Open lot manure heap can be formed by hauling feed lots manure collected from different sources. Feed lots manures are collected from the farm using shovel to gather manures near the building, fences, floors, gutters and litter, of the animal pen and mixing together to ensure a homogeneous mixture. Once an open lot manure heap is formed, samples should be taken from different sides of the heap including the center and at various depths of the heap to form a representative sample. The representative sample is poured into a plastic bucket and mix thoroughly to get a composite sample. The samples are then scoop into a plastic bottle and seal tightly. The plastic bottle is refrigerated if not taken immediately to the laboratory for nutrient analysis.

5.2.2 Sampling dry manure applied with a manure spreader during land application

Manure spreader is a tank mounted on a tractor that contains manure which is spread evenly on the crop field. The nozzles of the spreader are adjusted to permit the oozing out of the required particle size during spreading. Samples are collected as follows:

- Place catch pans randomly in the field to collect representative solid manure samples that have been spread by the manure spreader.
- Another representative sample should be collected when the tank has dispensed half of its content and the last representative sample at the final discharge level.
- Bulk manure from each catch pan and at the various levels of representative sample collection to form one composite sample.
- Pour samples into the plastic bottle and send to the laboratory for nutrient analysis and always ensure that the plastic bottle is not filled to the brim.
- Refrigerate the sample if not taken to the laboratory for nutrient Analysis.

6. CONCLUSION

From the point of view of crop production, the appropriate time to sample manure for nutrient analysis is during the time of land application, this ensures that samples are well mixed and representative of the manure being collected. How to sample organic manure for nutrient analysis in crop production differs depending on the differences in the physical state of the manure, the storage method, method and time of application and the livestock production system that produced the manure being sampled.

Finally, the determination of the nutrient content of manure in the farm is very pertinent and this can be achieved through an appropriate sampling technique that aims at getting a uniform fraction or subset of the manure being applied for analysis. The result from such analysis will assist a farm manager in making decisions on nutrient budget and recommendations that may be applied in the crop farm for improved yield and quality of produce.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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