Review Article
Soil Sampling and Sample Preparation

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Abstract

Soil sampling is a fundamental practice in soil science, essential for assessing soil fertility, nutrient availability, and overall soil health. This paper provides an in-depth overview of soil sampling techniques, their significance, and the processes involved in sample collection and laboratory preparation. It highlights the role of soil in supporting plant growth by providing essential nutrients and water, as well as its critical functions in ecosystems. Understanding the methods of soil sampling is key for accurate soil testing, which in turn aids in efficient soil management, crop nutrition, and environmental sustainability. The paper discusses various types of soil sampling, including pedological sampling, which focuses on soil formation and profile analysis, and fertility assessment sampling, which examines the nutrient status within the root zone. Different approaches to sampling are outlined, such as shallow surface sampling, deep subsurface sampling, and stratified sampling, all of which are tailored to specific soil characteristics and management needs. A key focus is placed on the importance of selecting representative sample areas within a field to avoid errors caused by non-homogeneous soil conditions, such as varying soil types, management practices, and crop growth patterns. The manuscript further explains the procedures involved in collecting and preparing soil samples, emphasizing the need for proper tools, techniques, and sample handling to ensure accurate laboratory results. The preparation process includes drying, grinding, sieving, and storing samples, with careful attention to maintaining sample integrity. Special attention is also given to the sampling of salt-affected soils, highlighting unique challenges and methods for evaluating gypsum requirements and soil reclamation. Soil testing, followed by precise analysis, enables accurate fertilizer recommendations, helping farmers optimize nutrient use, reduce costs, and minimize environmental impacts. This paper underscores the necessity of consistent, accurate soil sampling as part of a sustainable agricultural practice that supports crop productivity and environmental stewardship.

Key Words: Soil sampling; Soil fertility; Nutrient availability; Soil testing; Sampling methods; Soil preparation; Environmental sustainability; Agricultural practices.

Introduction:

Soil

Sampling

Objectives

• To familiarize with types of soil sampling techniques.

• To provides information when, where, and how to take soil sample for different purposes of soil sample.

• To understand the procedures of soil sampling in different problematic soil.

• To understand methods of soil sample preparation in the laboratory.

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Soil consists of a blend of organic materials, minerals, gases, liquids, and both microscopic and larger organisms that nutrients for plants. Soil provides more than 16 essential plant nutrients for the plant [1]. The nutrients essential for plant growth consist of Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe), Sulphur (S), Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), Molybdenum (Mo), and Chlorine (Cl). These elements need to be available to crops in sufficient quantities to achieve targeted yields. However, when these nutrients are limited or deficient, crop growth is adversely affected. In every ecosystem—whether it's a home garden, agricultural fields, wooded areas, or a watershed—soils serve five key functions [2].

These are:

1) It serves as a medium for the growth of plants.
2) It provides a habitat for various soil organisms.
3) It functions as an engineering medium.
4) It recycles raw materials.
5) It helps regulate water resources.

Why Soil Testing?

- Soil testing evaluates how much nutrients are present and their condition in the soil.
- It reveals the nutrients that crops can easily utilize.
- Guiding the appropriate fertilizer application for optimal growth.
- This method assesses the nutrient status and physicochemical properties of the soil, evaluating its fertility to identify any nutrient deficiencies.
- Accurate soil testing, along with reliable analysis data, provides insight into the chemical, physical, and biological conditions of the soil, which collectively sustain life. It serves as a fundamental source of water and

  is essential for various management decisions on the farm.
- The essential nutrients for crops can be sourced from various places such as the atmosphere, soil, irrigation water, mineral fertilizers, animal manures, and biofertilizers.
- Conducting soil tests allows for effective planning of cultivation and soil management practices, supporting a sustainable crop nutrition program that is accurate, timely, and increasingly focused on environmental responsibility.
- Soil testing provides crucial insights to ensure that crop nutrition choices are precise, efficient, cost-effective, and environmentally sound.
- Soil analysis enables the evaluation of fertility and gives specific fertilizer recommendations for crop growth.
- It also focuses on maintaining environmental quality to mitigate community hazards.

Literature Review:

<u>Definitions:</u>

Soil sampling is the process of obtaining small amount of soil from sampling point to represent the total sampling area. Soil testing employs physical (without chemical tests but some calculation) and chemical methods to estimate the nutrient supply capacity of the soil, which is known as soil fertility assessment. Soil fertility refers to the soil's natural ability to provide plants
with the necessary nutrients in sufficient quantities and appropriate ratios. In contrast,soil

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productivity measures the soil's ability to grow crops under particular management practices, typically reflected in yield [3].

Generally, Procedures for Soil Testing Follow the Following Phases:

1. Gathering soil samples and preparing them for analysis.
2. Performing laboratory analyses to determine the physicochemical properties of the soil.
3. Interpretation of the analytical results.
4. Fertilizer or other management recommendations
5. Finally, follow up the result and evaluation of recommendation.

<u>Soil Sampling Methods</u>

The methods used to collect soil samples depend on the specific objectives of the sampling. Soil sample analysis may be required for both engineering and agricultural applications. Based on the purpose of soil sampling, methods of soil sampling can be:

1. Pedological Purpose Soil Sampling: Pedological soil sampling conducted to study soil formation and soil development (soil profile and soil horizon). The procedures of pedological purpose sampling are:

a. The profile is 1st divided into horizons.
b. The sampling and compositing of the samples is therefore, done for each horizon.
c. The soil profile excavated >150 cm depth is often used.
d. The analysis of this sampling is used to categorize the soil in their parent materials.

2. Soil Fertility Assessment Soil Sampling: It is important to study the presence of organic, inorganic and other soil nutrients around the root zone (up 20 cm) of soil. Soil sampling for soil fertility assessment purpose conducted either shallow or deep subsurface soil sampling.

3. Shallow Surface Soil Sampling: The soil surface excavated up to 30 cm deep. These types of soil sampling conducted if there is full information about soil type and management history from the previous soil sampling [4].

4. Deep Subsurface Soil Sampling: Deep subsurface soil samplings allow us how deep the concentration of salt minerals within the soil in comparison with other soil nutrients. The soil sample taken up to 100 cm depth based on concentration of salt in the soil.

Sampling Guideline

Soil sampling protocols provide insights on the appropriate timing, locations, and depths for sampling, along with the recommended number of samples to collect in a particular area [5].

Guidelines for Selecting Sampling Locations

To perform a comprehensive assessment of soil quality, choose sample sites in a field that accurately represent the entire area. Refer to soil survey maps to pinpoint variations in soil types within the mapped units (*Figure 1*).

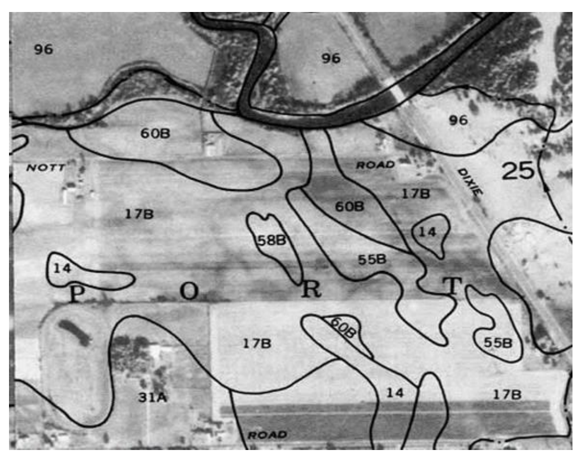

Figure 1) *Soil Maps with Different Soil Types* When assessing trouble spots in a field, choose

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sampling locations that reflect the characteristics of those problematic areas

Figure 2) *Trouble Spot Areas*

When comparing management systems, ensure that the sites chosen for comparison share the same soil type and are situated on similar topographical features in both fields. For instance, if measurements are taken in wheel tracks in one field, corresponding wheel track sites should be selected in the comparison field. To monitor changes in soil quality over time, consistently measure the same sites within the field during each sampling period. Additionally, aim to take measurements under similar soil moisture conditions at each sampling to minimize variability. In some instances, it may be beneficial to compare sampling points across gradients of soil type, moisture, slope, or other variables rather than relying solely on fixed points [6].

Time of soil sampling: The preferred time to sample is fall. Soil samples can be taken from agricultural fields after the harvest and prior to planting the next crop. Typically, the following instances are important for sampling:

- For the most accurate assessment of nitrogen availability, collect samples as near to planting time as possible.
- Differences in management practices (crops, manure history, fertilizer use
- Areas with wheel tracks versus those without.
- Variations in crop growth.
- Salt-affected areas compared to non-

(*Figure 2*).

- An annual soil sampling is suggested for evaluating soil quality.
- For non-legume crops, nitrate and nitrogen levels should be measured each year.
- Phosphorus and potassium levels should be analyzed every three to four years.
- Sampling for phosphorus and nitrate/nitrogen is essential before manure application.
- Post-harvest samples should consider nutrient removal by crops and the impact of fertilizers on soil acidity.
- Choose a sampling timeframe and maintain consistency from year to year, ideally aligning it with the crop rotation schedule.

Disscusion:

Where to Sample:

A key factor in deciding where to sample within a field is the variability of the area. Fields exhibiting significant landscape or other variations should be divided into separate sampling sections. Variations might include differences in soil types (differences in soil textures, structure, color, parent materials and other characteristics), slope, erosion severity, drainage, cropping practices, manure history, and other elements that can influence soil nutrient content. Subsequently, soil samples should then be collected from each individual, similar area [7].

When sampling soil, consider the following field characteristics:

- Row areas compared with inter-row spaces.
- Variations in soil type.

- , lime application, irrigation, etc.).

salt- affected regions.

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- Eroded versus non-eroded land.
- Differences in slope.
- Wet areas versus those that is well- drained.

Amount of Soil Sample

The number of samples or measurements required will vary according to the field's variability. It is advisable to collect at least three samples for each unique combination of soil type and management practices. To ensure accurate results, individual soil cores from at least 20 different locations within the sampling area should be collected and then mixed thoroughly in a clean plastic container. Generally, higher variability in the field necessitates a greater number of measurements to obtain a representative field-scale value. For assessing electrical conductivity (EC), pH, phosphates, and nitrates on a field scale, it is suggested to bulk and mix eight or nine core samples taken from various parts of the field, followed by analyzing two subsamples from the mixture [8].

Error in Soil Sampling

Soil sampling error refers to statistical inaccuracies that happen when a sample is chosen that does not accurately reflect the entire data population. As a result, the outcomes derived from the sample may not correspond to those that would be obtained from the total population.

How Error is occurred in Soil Sampling?

Errors can occur when the sample does not adequately represent the field and is improperly collected from the designated sampling area.

Avoiding Non-Representative Samples:

Make an effort to steer clear of locations that may lead to sample misrepresentation, or consider sampling them separately:

- Regions that have experienced erosion.
- Locations with inadequate drainage.
- Areas exhibiting variedcropping practices.
- Areas with differing applications of lime, manure, or fertilizers.
- Edges of fields and boundary lines.
- Recent applications of fertilizer in bands.
- Furrows that are dead and reveal subsoil.
- Spaces near roads, as well as piles of lime, manure, or crop residues.
- **Incorrectly Taken:** When sampling points are randomly chosen without equal interval in the uniform field and also taking soil sample without fulfilling all the required material leads to error in soil sampling. It's crucial to conduct careful soil sampling and proper handling to ensure that fertility recommendations are reliable. Samples should genuinely represent the soil's fertility to ensure that analyses, interpretations, and recommendations reflect the nutrient conditions of the entire field. A precise assessment can lead to more efficient fertilizer application, lower expenses, and minimized environmental impact.
- **Techniques for Collecting Soil Samples** Based on the variability observed within a field, three primary methods are typically used for soil sampling in designated areas.
- **Composite Sampling**
- A composite soil sample should accurately reflect a uniform section of the field. Each sampled area should share similar crop and fertility backgrounds. The soil attributes, such as color, slope, texture, and drainage, should also be consistent. The most prevalent method is to gather random samples from the field without considering topographical features or other characteristics. This approach is effective in fields that exhibit uniformity in soil

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- type,agricultural practices, and management history (*Figures 3 and* 4)

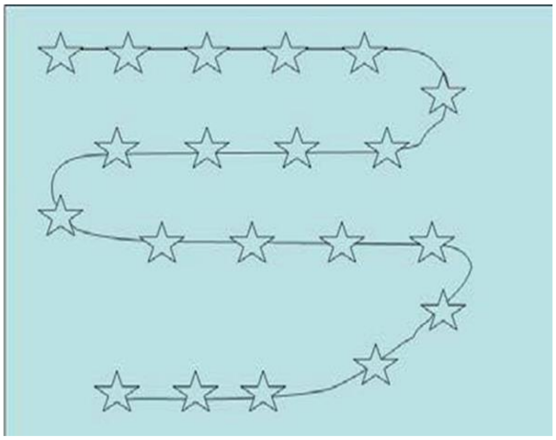


Figure 3) One composite soil sample

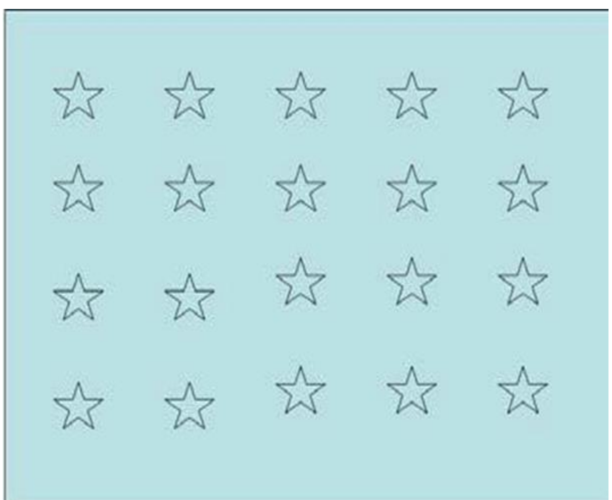
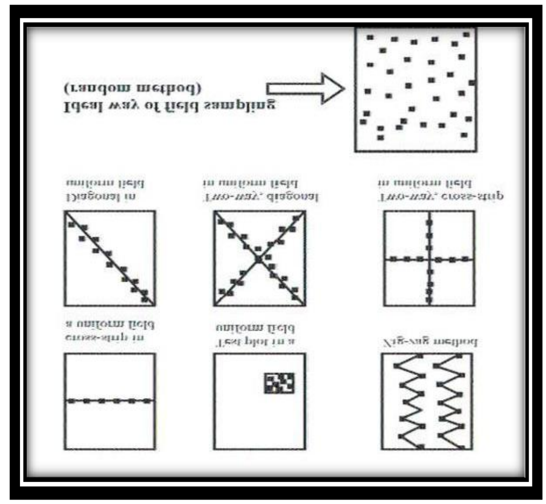


Figure 5) *Three composite soil samples, each*

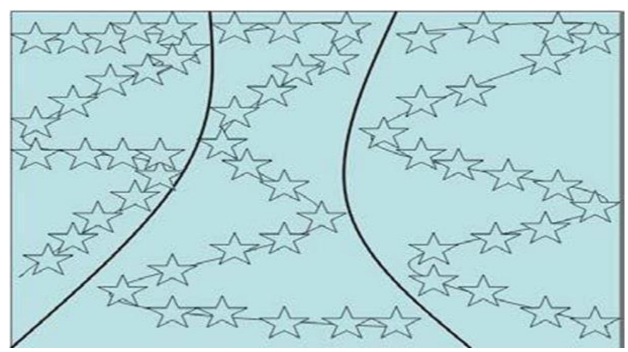
Systematic or Grid Sampling

Sampling points are established at regular intervals throughout a field, such as one point per hectare. Near each predetermined with comparable nutrient levels. This method is especially useful for high-value crops or those that are sensitive to specific nutrient concentrations or pH levels. However, in soils that already show high nutrient levels, the advantages of this sampling approach may be limited. This

disruption to the surrounding soil, allowing for easy division into different



technique often utilizes GPS technology for precision (*Figure 6*).



made up of 20+ sub-samples

point, four to five subsamples are collected. Each point produces its own soil sample and analysis. This data can be used to create a fertility map for the field, indicating areas

Figure 6) *20 composite soil samples, each made up of 4 or 5 sub-samples*

Soil Sampling Tools and Equipment

A stainless steel soil sampling auger (or probe) is the primary tool utilized for collecting soil samples in typical conditions. This soil probe captures a continuous core while causing minimal sampling depths. Essential tools include:

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- A meter stick or tape for measuring the distance between sampling points.
- One or two plastic containers for collecting samples.
- A shovel or spade for digging.
- Sample bags for transporting the collected soil.
- Rope: used to connect sample point.
- Page: used to mark sample point.
- Trowel: used to mix sample.
- Newspaper: used to dry soil sample.
- Balance: used to measure sample weight.
- Sampling card used to write information about sample.
- Markers to write necessary information on sampling card.

✍ **Note that:** Tools must be kept clean, free from rust, and stored separately from any fertilizer materials. Avoid using galvanized or brass equipment, as these can contaminate the soil samples.

Soil Sampling Procedures

Sampling procedure for shallow surface soil:

1) *Assess whether the field is uniform or varied, and classify the area based on similar topographical features, management practices, or crop yield.*
2) *Selecting appropriate sample collection methods.*
3) *Preparing all soil sampling tools and equipment.*
4) *Dividing the total uniform or heterogeneous field in to equal distance to make the sampling point representative of the whole field. Then starting from the border of the farm land measure 3-5 m distance based on the size of the study area and mark by page and then continuo in to the center farm land.*
5) *Select sub sampling points which have equal distance from each other.*
6) *Based on the sample collection method 20+ sub-sampling points can be identified.*
7) *Removing ash, animal manure, plant* leaves, grass and other residues from selected soil sampling points to increase the accuracy of soil sampling.
Digging 900 (vertically) up to 20-30 cm depth and 10 cm thickness on selected soil sampling point by spade if we take soil sample by soil auger. Sampling of saline soil depend on the nature of salt concentration in sub soil surface and the excavation reaches up to 90 cm down in to the soil surface. If soil sample taken by soil probe there is no excavation because it is adjusted in different depth, so it is simply inserted down into the soil surface with its graduate distance.
8) Taking soil sample from 20+ sub sample and put in to large clean plastic or paper if sampling field is uniform. If sample collected in heterogeneous field, sample collected from each sampling area collected separately.
9) Mixing the collected soil sample. Appropriately mixing the whole collected soil sample and dividing in to 4 equal parts. The required soil sample is
¼ or quarter of the whole mixed soil sample. Composite soil sample 1 kg may take from 4-5 ha area of land. Composite soil sample of 0.5 kg may take for area less than 1 ha.
10) Drying the soil (quarter of soil selected) in clean paper or plastic for one day (24 hr) if it is very wet. But little moisture required determining pore pace, microorganism and other prosperity of soil.
11) Grinding and Sieving: Aggregates larger than 2 mm should be processed using a mechanical

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12) *grinder and then passed through a 2 mm* sieve. Repeat this process until
13) to pass through the sieve.
14) Store the soil fractions in a plastic bag, ensuring no contact with other soil or hands. Contaminated soil can lead to incorrect analysis, interpretation, and conclusions.
15) Finally write all information about sampling area on soil sampling card and insert in to the plastic bag and packing the bag.
16) Send sampled soil to the laboratory for further analysis (*Figure 7*).

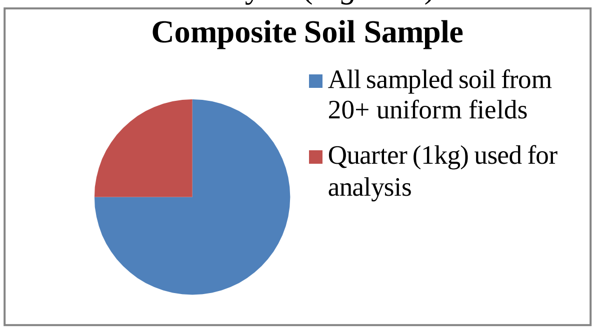

Figure 7) *Quarter (1 kg) of soil sample taken for lab analysis in Red color and Blue color shows that all sampled soil from 20+ uniform fields.*

Sampling Salt-Affected Soils: There are two methods for sampling salt-affected soils:

Soil Sampling for Gypsum Requirement: Surface samples at a depth of 20-30 cm should be collected in the same manner as for soil fertility assessments. These samples are utilized to assess the gypsum needs of the soil.

Soil Sampling for Reclamation (Subsurface Soil Sampling): To effectively reclaim soils, it's important to understand the characteristics of deeper soil layers. Therefore, samples should be collected down to a depth of 1 meter.

1. Soil should be sampled separately from specific depths (approximately 0.5 kg per depth) at intervals of 0-15, 15-30, 30-60, and 60-100 cm, based on the

Include:

all fractions are able

concentration of salts in the soil.

2. If a stony layer is encountered during sampling, it should be sampled separately, and its depth must be recorded. This detail is crucial and should not be overlooked.
3. Soil samples can be extracted using a spade, or if an auger is employed, it's essential to note the depth of any "concretion" (stones) or other impermeable layers (such as hardpan).
4. If the soil displays signs of profile development or clear stratification, samples should be collected by horizon.
5. In cases where a pit is excavated and horizons are not visible, mark the vertical wall of the pit at depths of 15, 30, 60, and 100 cm from the surface, and gather approximately 0.5 kg of soil from each layer by cutting uniform slices.
6. Additionally, one surface soil sample should be collected following the standard procedure for fertilizer recommendation. Because salt minerals leached down in to the subsurface of soil so, it is difficult to study their concentration in the soil by taking shallow surface soil sampling (Supplementary data).

Soil Sample Preparation

Laboratory Handling: Upon arrival at the soil testing laboratory, samples should be verified against the provided information list. Proper field notes must be maintained. Any samples that cannot be identified should be discarded. Details about each sampleshouldbedocumentedin a registration book, and every sample should receive a unique laboratory number or code. **Drying Samples: Procedures For Drying Samples**

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- Use wooden or enameled trays for drying.
- During the drying process, trays can be numbered or labeled with a plastic tag.
- Allow the samples to air dry at room temperature.
- Alternatively, trays can be placed on racks in a hot-air cabinet, ensuring the temperature does not exceed 35°C and the relative humidity remains between 30-60 percent

Figure 8) *Soil Sample Drying Up*

Figure 9) Soil Sample Preparation

Post-Drying Care: Procedures for post- drying care include:

- Once dried, the samples should be moved to the preparation room.
- Air-dried samples are crushed using a wooden pestle and mortar, ensuring that soil aggregates break down without fragmenting the soil particles.
- For heavy clay soils, an end-runner grinding mill with a hardwood pestle and rubber-lined mortar may be necessary.
- Care must be taken not to crush pebbles, concretions, or stones during the grinding process.
- After grinding, the soil is passed through a 2 mm sieve.
- It is incorrect to only sieve a portion of the ground sample and discard the rest, as this can introduce a positive bias; the rejected material may contain soil components with varying fertility. Therefore, the entire sample should be sieved, excluding only pebbles and concretions larger than 2 mm.
- The coarse material remaining on the sieve should be returned to the mortar for additional grinding. Continue sieving and grinding until all aggregate particles are sufficiently fine to pass through the sieve, leaving only pebbles, organic matter, and larger concretions.

Conclusion:

Soil sampling is a critical component of soil management and agricultural practices, providing essential data for evaluating sofertility and nutrient availability. Accurate soiltesting,whic begins with representative and methodical soil sampling, isfundamentalforoptimizingcrop productivity and ensuring sustainable land use. This paper underscores the importance of understanding different soil samplingtechniques, including pedological and fertility assessment sampling, as well as specialized

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methods for saltaffected soils. Proper sampling enables reliable soil analysis, which in turn informs decision- making related to fertilizer application, soil amendments, and overall crop management. One of the key factors in successful soil sampling is selecting appropriate sites within a field. Variability in soil properties, management history, and topography must be considered when choosing sample locations to ensure that the collected sample accurately reflects the conditions of the entire field. This is crucial for minimizing sampling errors and ensuring that the data obtained will lead to accurate soil fertility evaluations. Sampling procedures must be standardized and precise, with careful attention to the tools and techniques used to collect, handle, and prepare soil samples. As noted in the paper, maintaining sample integrity during collection, storage, and transport is essential for obtaining reliable results. The laboratory preparation of soil samples—entailing drying, grinding, sieving, and proper storage is equally important for accurate nutrient analysis. Special consideration is needed when handling salt-affected soils, where deeper and more precise sampling is necessary for effective reclamation or gypsum requirement assessments. Ultimately, soil sampling and subsequent testing are indispensable for informed soil management decisions. By ensuring that soil nutrient levels are accurately measured and analyzed, farmers can make more efficient and environmentally responsible fertilizer and irrigation choices. This contributes not only to improved crop yields but also to the long- term sustainability of agricultural systems. Soil sampling thus plays a vital role in enhancing agricultural productivity while protecting natural resources and promoting ecological balance.

Conflicts of Interest: The author asserts that there are no conflicts of interest.

Data Availability: The data supporting this review are freely accessible from the corresponding author upon request.

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