Soil Analysis for Fertility Management in Rainfed Agriculture

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Soil fertility is one of the important factors that determines the productivity and profitability of crops and crops systems in rainfed agriculture. In simple terms soil fertility is the ability of the soil to provide all essential nutrients required for plant growth in a proper proportion. In order to achieve higher productivity and profitability, every farmer should realize that fertility levels must be measured as these measurements can then be used to manage soil fertility. Currently the tools available for measuring the fertility levels of the fields are: a) Indigenous knowledge, b) Plant/Tissue analysis c) Visual diagnosis, d) remote sensing and e) soil analysis. f) greenhouse pot experiments g) biological tests. Of all these tools, soil analysis is widely used for measuring the fertility status of the soils as this technique is simple, rapid, cost-effective, accurate, universal, and works for all kinds of soils.

Soil analysis and soil testing are two different terms. The former refers any chemical, physical or biological measurement made on a soil, whereas the latter refers to the measurement, interpretation and fertilizer and other recommendations based the result of the analysis and other considerations. However, in this paper the two terms soil analysis and testing will be used as synonymous. The basic objective of soil testing are to : a) accurately determine the available nutrient status of the soils, b) clearly indicate to the farmer the seriousness of any deficiency or excess that may exist in terms of various crops c) forms the basis on which fertilizer needs are determined, and d) express the results in such way that they permit an economic evaluation of the suggested fertilizer recommendations.

A sound soil-testing program requires an enormous amount of background research. This background research should determine, the significant chemical forms of the available nutrients in the soils of the area, the extractants most suitable for extracting all or part of the available nutrient forms, the relative productive capacity of the soils of various crops, the differential response of the various rates and methods of fertilizer applications for different crops, field sampling techniques, test procedures and methodologies. The soundness of the required interpretive judgments will depend almost entirely on the thoroughness and quality of these background studies and it is aptly said that the success of soil testing is directly proportional to its research backing. The various steps involved in soil analysis/ testing are:

1) Collection of the representative soil sample: The first basic principle of the soil testing program is that the field should be sample in a such way that chemical analysis of the collected samples should accurately reflect the field's true nutrient status. Some of the methods reported in the literature for collecting the representative soil samples are a) random sampling, b) stratified random sampling c)grid or systematic sampling and d) composite sampling. Each of these methods has their own advantages and disadvantages. Which

method of these to be followed depends upon the purpose and resource availability.

2) Extraction and chemical analysis: Once the soil sample has been collected and prepared, the status of plant-available nutrients must be determined. By plant available nutrient, one usually means the chemical form of forms of an essential plant nutrient in the soil whose variation in amount is reflected in variations in plant growth and yield. It is a basic principle of soil testing that the simple rapid chemical analytical procedures can be designed to accurately measure, or be a measure of, the level of plant available soil nutrients. In majority of the soil testing laboratories of India, the commonly employed soil test methods for determining the available nutrients are presented in Table 1.

3) Interpretation of analytical results: Analytical results obtained from chemical analysis of soils must be interpreted meaningfully. This is usually done through some type of previously determined correlation between soil tests and known field crop responses. In majority of the soil testing laboratories of rainfed areas, the interpretation of the soil test results are done based on the critical nutrient concept proposed by Cate and Nelson (1969). The critical fertility ratings and critical limits being adopted by different soil testing laboratories for differentiating the soil test results into deficient and adequate for many of the crops are furnished in Table 2a and Table 2b.

4) Fertilizer recommendations: Ideally for sound fertilizer recommendation it is very essential to have information with respect to 1) the soil test level of the field 2) crop to be grown 3) yield potential 4) soil and fertilizer efficiency of each nutrient 5) the response of the crop to the added nutrient 6) addition of any organic manure 7) the degree of mineralization. In addition to these, economic considerations are important to determine the upper level of fertilization. To make economic evaluations, an estimate is needed of the forthcoming yield of the particular crop and its probable value in the absolute terms. The final fertilizer recommendations depend on the accurate soil test analysis and on interpretations of the test results based on the sound research and judgment. An ideal method would be to recommend fertilizers for different yield levels and prices and allow farmers to choose the yield level and price combination they desire.

In rainfed areas, the commonly followed nutrient (inorganic) management strategies employed are:

a) Indigenous knowledge / Farmer practice
b) General fertilizer recommendations
c) Site specific nutrient recommendations
    i) Soil test crop response
    ii) Balanced nutrient recommendation
    iii) Mid-season corrections by using leaf colour charts, cholorphyll meter readings, tissue testing,
d) Customized fertilizer recommendations

Table 1: Soil test methods employed for determination of available nutrients in majority of soil testing laboratories

Nutrient	Extractant used	Method of determination
Organic carbon (as s a measure of available N)	-	Wet oxidation of Walkely and Black (1939)
Avaialble phoshorus	Olsen's extractant for alkaline soils, Brays extractant for acid soils	Spectrophotometer
Available potassium	Neutral normal ammomium acetate	Flame photometer
Available sulphur	Calcium chloride	Colorimeter/ Spectrophotometer
Available calcium and magnesium	Neutral normal ammomium acetate	Titration/ Flame photometer/ Atomic absorption spectrophotometer
Available Zn, Cu, Mn, and Fe	DTPA extractant	Atomic absorption spectrophotometer
Available boron	Hot water soluble	Spectrophotometer / Atomic absorption spectrophotometer

Table 2 a: Soil fertility ratings employed by different soil testing laboratories for organic carbon, available phosphours and available potassium

Nutrient	Fertility status ratings		
	Low	Medium	High
Organic carbon	< 0.5 %	0.5 – 0.75 %	>0.75 %
Available phosphorus	<11 kg P/ha	11 – 25 kg P/ha	> 25 kg P/ha
Available potassium	< 120 kg K /ha	120 – 280 kg/ha	> 280 kg K/ha

Table 2b: Critical limits for different micronutrients for majority of the crops (DTPA-extractable micronutrients)

Nutrient	Critical limit (ppm)	
	Deficient	Adequate
Zinc	< 0.6	> 0.6
Iron	< 4.5	> 4.5
Copper	< 0.2	> 0.2
Manganese	< 2.0	> 2.0