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Soil testing:

a valuable tool for efficient and economic crop production

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Soil testing commonly refers to the analysis of a soil sample to determine nutrient content, composition, and other characteristics such as the acidity or pH level. A soil test can determine fertility, or the expected growth potential of the soil which indicates nutrient deficiencies, potential toxicities from excessive fertility and inhibitions from the presence of non-essential trace elements in the soil systems. Objective(s) of the soil testing are to determine the available nutrient status and soil reaction; to appraise the soil fertility status of a country or a state or a district and prepare soil fertility map which will be useful for various on aspects (delineating, sufficiency and deficiency areas of nutrients; soil fertility pattern over the periods etc); to prepare a basis for fertilizer and soil amendments recommendation; and to prepare soil health card (SHCs) for farmers.

Key words: *Azolla*, Crop, Production, Soil, Testing

THE soil testing service was initiated in India during 1955-56 with the establishment of 16 soil testing labs under the Indo-US operational agreement for determination of soil fertility and fertilizer uses. The programme is being expanded and at present, there are ~ 600 district/regional soil testing lab and mobile labs in the country. In Uttarakhand, at present, 26 soils testing labs are working for soil testing. These soil testing laboratories play a significant role in diagnosing the physical, chemical and biological properties of the soils by providing the conditions of available nutrients which indicates the fertility and productivity of the soils. The primary goal of soil testing is to answer efficient and effective resource management. Soil testing is the most accurate way to determine lime and nutrient needs. Soil testing is also useful for identifying contaminated sites. Soil tests measure the relative nutrient status of soils and are used as profitable and environmentally responsible fertilizer application.

Efficient utilization of agricultural inputs is a major factor in soil testing to bring sustainable production system in agriculture. The farmers involved in such a programme like soil testing will have to application of Se balanced fertilization to achieve the desired yield levels. However, the amounts and kinds of fertilizers required for the same crop vary from soil to soil, even field to field on the same soil.

The use of fertilizers without prior soil testing is like taking medicine without first consulting a physician to find out what is needed. It is observed that the fertilizers increase yields and the farmers are aware of this. But are they applying right quantities of the right kind of fertilizers at the right time at the right place to ensure maximum profit?. Without the fertilizer recommendation based upon a soil test, a farmer may be applying too much of a little needed plant food element and too little of another element which is actually the

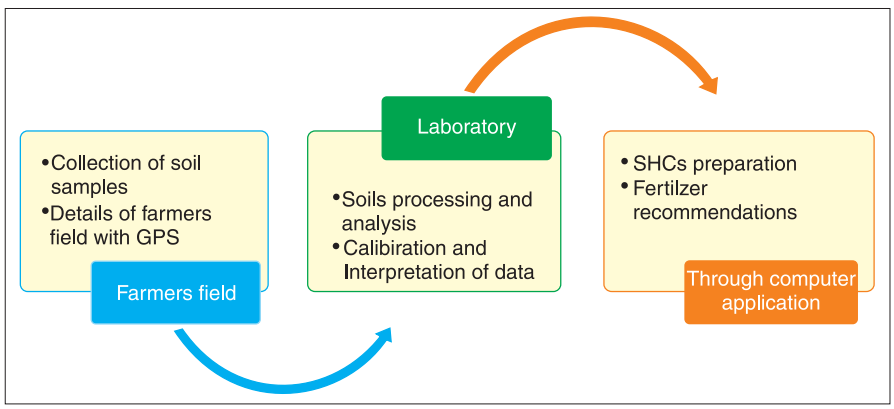


Fig. 1. An overview of soil testing process from farmer field to laboratory and *vice-versa*



Fig. 2a Different equipment useful for the collection of soil samples

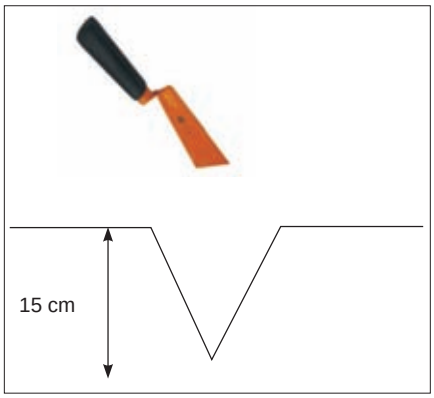


Fig. 2b. Draw samples from field in "V" shaped cut

principal factor limiting plant growth. This not only means an uneconomical use of fertilizers, but in some cases crop yields actually may be reduced because of use of the wrong kinds or amounts, or improper use of fertilizers.

Why soil testing is important?

Sustaining the agricultural production system often requires the application of agricultural inputs. The soil testing enables to find out the make up, soil fertility status and soil amendments quantities for mitigation of the problematic soils.

Different components of soil testing are illustrated in Fig. 1.

Soil sampling

The soil sampling is perhaps the most vital step for analysis. A useful soil testing service starts with the collection of representative soil samples. A fertilizer recommendation is made after analyzing the soils. The importance of taking a representative composite soil sample is, therefore, self-evident. One field can be treated as a single sampling unit only if it is relatively uniform and does not exceed ~ 1 ha area. Variations in slope, colour, texture, management, and cropping pattern should be taken into account and separate composite soil sample adequately representing the field, small portions of surface soil should be collected ~ 15 cm soil depth from at least ten well-distributed spots in the field, mixed well, and ~ 500 g of representative sample sent to laboratory. Proper sampling tools are essential for collection of good soil samples. Spade or *khurpi* is an appropriate tool for sampling of soft and moist soil. However, a screw type auger is more suitable on hard and dry soil although post hole auger is useful in the excessively wet area.

Collection of soil samples from field

Different types of equipments are required (Figs. 2a and 2b) for soil sampling, (viz. spade, *khurpi*, auger, sampling bag, tray, scale, marker, pencil, a sheet of thick paper and polythene sheet).

Procedure of soil sampling

Decide the soil unit (or plot) and make a traverse over the soil unit (Fig. 3).

Clean the site (with spade) from where soil sample is to be collected.

Standing on opposite side, a lump of soil is removed.

A pit of vee (V) shape is formed. Its depth should be 0-15 or 0-30 cm. (*i.e.* depth of soil).

Take out the soil-slice (like bread-slice) of 1.25 cm thick from both the exposed surface of the pit from top to bottom. This slice is also termed as furrow-slice. To collect the soil-slice spade may be used.

Collect furrow-slices from 8 to 10 or sometimes 20 to 30 sites. Select the sites at random in a zigzag (or criss-cross) manner. Distribute the sites throughout the entire soil unit (plot).

Reduce the collected bulk soil up to ~ 500 g by quartering process (Fig. 4)

Require information in two sheets of thick paper with the sample. One sheet is folded and kept inside the bag, another sheet is folded and attached with the bag.

- Information
- Name, address and contact number of the farmer (or farm owner)
- GPS coordinates with plot number
- Availability of irrigation facilities and drainage system
- Upland/Medium land/Lowland
- Depth of soil sample (0-15/15-30/30-45 cm)
- Information of the previous crop-name and variety of the crops
- Dose of organic manure and dose of fertilizers, if applied and yield
- Information of the crop that will be grown-name, season (pre *kharif*/*kharif*/*rabi*)
- Problem, if any
- Date of sample collection
- Signature of the farmer (or farm owner)
- Chemical analysis

Soil analysis is a set of various chemical processes that not only determine the amount of available plant nutrients in the soil, but also the chemical, physical and biological soil properties important for plant

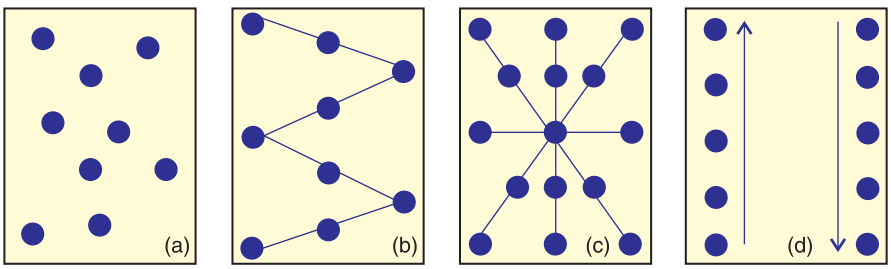


Fig. 3. Several ways of taking samples: (a) network (b) Z-scheme (c) diagonally in (d) permanent crops or standing crops



Fig. 4. An overview of soil processing, showing (a) collecton of soil sample; (b) spread soil sample like a thick layer; (c-e) the quartering process (make four quarters, discard the opposite ones); (f-g) remixing the remaining two quarters and repeated the process to reduce the quantity ~ 500 g; (h-j) attach one label inside or outside the bag indicating above mentioning information and transfer the remaining (~ 500 g) soil in bag and send to soil testing laboratory; (k) soil processing with 2 mm stainless steel sieve for analysis

nutrition, or 'soil health'. Chemical soil analysis determines soil reaction (pH), soil salinity (EC), total $CaCO_3$, lime requirement, gypsum requirement, organic matter, and the content of basic plant nutrients; nitrogen (N), phosphorus (P_2O_5), potassium (K_2O), humus content, total sulphur (S), trace elements, and other physical characteristics (capacity, permeability, density).

Interpretation

Definitely, the greatest challenge in soil testing is calibration of the tests. It is essential that the results of soil tests be calibrated against crop responses from applications of the plant nutrients (Fig. 5). The yield responses from rates of applied nutrients can then be related to the quantity of available nutrients in the soil. On the basis of long-term field experiments (LTFEs), soil test calibration studies on different soil types are then utilized to establish recommended amounts of plant nutrients to apply to a particular crop at a given soil test level.

Crop-wise fertilizer recommendation

An upward revision in fertilizers recommendation is needed in the light of lessons learnt from LTFEs. The crop-wise fertilizer recommendations equations developed on the basis of LTFEs for different crops under different agro-ecological situations are given in Table 1. These recommendations of fertilizer were developed for different soils, different varieties etc.

On the basis of soil test results, the soils are grouped into different categories with rvespect to organic carbon, vailable macronutrients and micronutrients (Tables 2 and 3).

Soil test reports will generally provide appropriate dose of fertilizer recommendations for applications of nitrogen, phosphorous, potassium, gypsum and limestone. Soil testing also provides details about micronutrient requirements of crop. If you apply too little fertilizer, your crop yields and returns will be lower. Supply of higher dose of fertilizer will waste time and money, and risks environmental damage due to nutrient runoff. Consequently, soil testing is a tool which gives to farmers accurate soil fertility status of their farm, so that farmers do better effort to efficiently utilize inputs such as fertilizers and get benefit as economically as manageable and increasing agricultural production of their farm.

Table 1. Crop-wise fertilizer recommendations

Crops	Fertility class	Quantity (NPK kg ha^{-1})			Time of application
		N	P_2O_5	K_2O	
Rice, *kharif,* transplanted	H	20	15	15	Basal ½ N, full P and K; top dressing of ½ N at 30-35 DAT
	M	40	20	20	
	L	50	25	25	
Rice, *kharif*, short duration	H	40	20	20	Basal ¼ N, full P and K; top dressing of ½ N at 15 DAT and ¼ N at 30-35 DAT
	M	50	25	25	
	L	60	30	30	
Rice, *kharif*, medium and long duration	H	50	25	25	Basal ¼ N, full P and K; top dressing of ½ at N at 15 DAT and ¼ N at 40-45 DAT
	M	60	30	30	
	L	80	40	40	
Rainfed wheat	H	40	20	15	Basal ½ N, full P and K; top dressing of ¼ N at 21 DAS and ¼ N at 40-45 DAS
	M	60	30	20	
	L	70	40	30	
Irrigated wheat	H	100	40	30	Basal ½ N, full P and K; top dressing of ¼ N at 21 DAS and ¼ N at 40-45 DAS
	M	120	50	40	
	L	130	60	60	
Maize	H	60	45	20	Basal ¼ N, P and K; ½ N at knee-high stage, ¼ N at tussling stage
	M	80	60	30	
	L	100	75	40	
Soybean	H	15	45	15	Basal full N, P and K
	M	20	60	20	
	L	25	75	30	
Millets (finger and barnyard)	H	35	15	15	Basal ½ N, P and K; ½ N after firstweeding
	M	40	20	20	
	L	50	30	30	
Vegetables	H	80	40	40	Basal ½ N, full P and K; top dressing of ¼ N at 25-30 DAT and ¼ N at 45-55 DAT
	M	100	50	50	
	L	120	60	60	

DAT, Days after transplanting; DAS, Days after sowing; H, High; M, Medium; H, High rating of soil test results

Table 2. Categories of soils with respect to soil pH and electrical conductivity (EC)

Soil pH	Categories	EC (dS m^{-1})	Categories
< 5.5	Acid	< 1.0	Normal
5.5-6.5	Slightly acid	1.0-2.0	Not suitable for germination
6.5-7.5	Neutral	2.0-3.0	Critical for growth of salt-sensitive crops
7.5-8.5	Slightly alkali/saline	> 3.0	Injurious to most crops
> 8.5	Alkali		

Table 3. Soil test values for fertility status

Categories	Organic Carbon	Available N	Available P	Available K_2O	Available S	Available extractable DTPA				B Hot water soluble	Mo Ammonium oxalate extractable (pH 3.3)
						Fe	Mn	Zn	Cu		
	g kg^{-1}		kg ha^{-1}						mg kg^{-1}		
High	> 7.5	> 550	> 25	> 335	> 35	> 9	> 7	> 1.0	> 0.4	> 2.0	> 0.4
Medium	5.0-7.5	280-550	12.5-25	135-335	22.4-35	4.5-9	3.5-7	0.6-1.0	0.2-0.4	0.5-2.0	0.2-0.4
Low	< 5.0	< 280	< 12.5	< 135	< 22.4	< 4.5	< 3.5	< 0.6	< 0.2	< 0.2	< 0.2

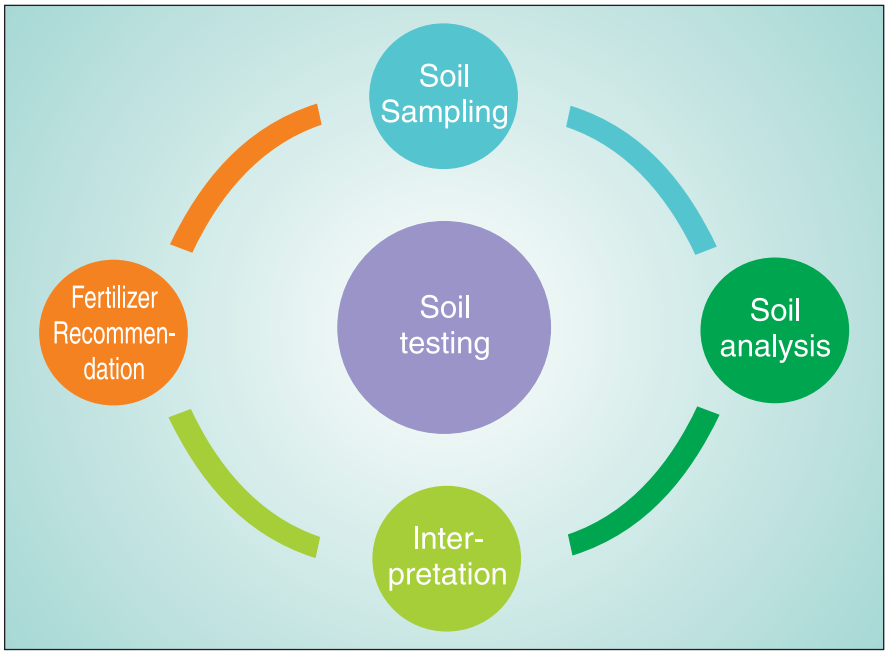


Fig. 5. Soil testing is central of soil sampling, analysis, interpretation and fertilizer recommendation

SUMMARY

Soil testing is playing an important role in recommending dose of fertilizer inputs required in farm of farmers. From the soil testing, farmers know status of nutrients available in soil, so that they are able to decide future crop patterns as per their suitability without indiscriminate use of chemical fertilizers. With the help of soil testing, soil-health card is also issued to every farmer in every three years for efficient utilization of available nutrients and fertilizer inputs for sustaining agriculture production.

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Impact of Research of ICAR-DOGR

Brainstorming on challenges in export of onion and garlic in India

Pune, the Directorate of Onion and Garlic Research, Rajgurunagar, organized a one-day brainstorming session on "Challenges in Export of Onion and Garlic in India" in collaboration with Indian Society of Alliums (ISE), Pune, National Horticultural Research and Development Foundation (NHRDF), New Delhi and Agricultural and Processed Food Products Export Development Authority (APEDA), New Delhi on September 16, 2017 at this Directorate to address various issues related to onion and garlic export oriented production, market research, packaging, forwarding and policy framing among different stakeholders.



Dr A. K. Singh (DDG, Horticultural Science) urged the participants to use modern information tools for timely application of advance technologies in production and export of onion and garlic. He emphasized on involvement of researchers in every step of crop production.

Dr K. E. Lawande (Ex-Vice Chancellor, Dr. BSKKV, Dapoli) mentioned difficulties in production and export of onion and garlic. He stressed on development of high-yielding varieties and emphasized on improvement of trading system, pure seed production, IPM technology and market intelligence.

The deliberations were on :

- inclusion of onion in horticultural export basket;
- firm export policies and proper maintenance of demand-supply chain, processing and e-marketing to solve price fluctuation problem of onion and garlic;
- change from exporting in traditional gulf countries to the European countries; and
- need of stress management in onion and garlic production.

Researchers, farmers, traders, exporter, authorities from APEDA, BARC, State Agriculture Department and Marketing Board participated in the programme and exchanged their views and experiences.

(Courtsey: Directorate of Onion and Garlic Research, Pune)