

Sustainable agriculture: Need for Soil testing

K.S.Karthika^{1*}, S.Neenu² and B.Hemalatha³

¹ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore 560 024

² ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala

³Dept.of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore

*Corresponding Author: kskavukattu@gmail.com

Dwindling natural resources and burgeoning population have resulted in building up a pressure on our ecosystem. To feed the estimated population, our production has to be increased significantly. The limited availability of land for crop production, along with declining yield growth of major food crops has raised concerns about agriculture's ability to feed the population. Stagnation in crop yields, increased cost of fertilizers and imbalanced nutrition and decline in soil fertility has pushed Indian agriculture to be at cross roads.

The year 2025 could be foreseen as a "Watershed year" by when Indian population would overtake the population of China and the availability of land to every child born will be negative. The solution to this lies in increasing the food production per unit area per unit time. India is using about 17.5 million tonnes of plant nutrients (NPK) and is likely to need about 45 million tonnes by 2025. For this the soil health needs to be cared. Mismanagement and neglect of the soil can ruin the fragile resource and become a threat to human survival.

SUSTAINABLE AGRICULTURE

Gordon Lee (Bill) McClymont, an Australian scientist coined the term sustainable agriculture in his book *New Roots for Agriculture* during 1980. But the importance of sustainable agriculture came in picture since the publication of the Brundtland Report in 1987. According to MacRae *et al.* 1989, *Sustainable Agriculture* comprises "management procedures that work with natural processes to conserve all resources, minimize waste and environmental impact, prevent problems and promote agroecosystem resilience, self-regulation, evolution and sustained production for the nourishment and fulfillment of all." Hence, we have to put more emphasis on methods and processes that improve soil

productivity at the same time as minimizing harmful effects on climate, soil, water, air, biodiversity and human health.

Ecosystem would be adversely affected as agriculture may be forced to end up in stagnation as indicated by many long term projections. Imbalanced nutrition, adverse soil reaction due to use of fertilizers, build up of phosphorus antagonizing zinc uptake, deleterious effect on microorganisms, soil degradation and affecting the soil quality are the reasons for decrease in the growth rate of crops. To overcome these problems, we have to increase soil productivity. This is linked to soil health and soil quality. Maintenance of soil health and soil quality is essential to sustainable agriculture. Hence, in recent years a concept of sustainable agriculture is developed in order to ensure that the agro-eco-systems are stabilized and sustained crop yields are assured on long term basis.

As the term suggests, sustainability is maintenance in such a way that the human needs are satisfied by successful management of available natural resources without creating any damage to the ecosystem and environment while conserving the natural resources. Many of our agricultural practices like natural and biological control of pests, organic farming, watershed approach for soil and water conservation emphasize the sustainable agriculture practices. In this practice of agriculture, nutrient supply is guaranteed on a self sustaining basis while stabilizing the crop yields. It is sustainable agriculture - which ensures pollution free food production and which ensures continuation of agriculture with least damage to eco-system.

Why soil testing?

To achieve sustainable crop production levels for feeding the ever increasing population, soil fertility should be maintained through the application of a balanced mix of different nutrient elements to soil during the crop cycles. Here comes the importance of soil testing. To maintain the soil health as well as quality, protecting the degradation of soil due to excess use of fertilizers and saving our soils from residual contamination. Soil testing is done to understand the quantity of plant available nutrients present in the soil and to determine the fertilizer recommendation based on it. It is a powerful scientific tool to determine the nutrient supplying capacity of the soil. Hence, soil testing and fertility management programmes have been given sufficient importance for getting sustainable crop yield and follow balanced fertilization in Indian agriculture.

There are 17 essential nutrients recognized for growth of plants. These are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni). Carbon (C), hydrogen (H) and oxygen (O) are obtained primarily from water and carbon-di-oxide; hence these are not considered mineral nutrients (Taiz and Zeiger 2002). Other nutrients are mainly taken up from the soil. Hence, soil testing is essential in assessing their status in soil. Soil organic carbon

status is one of the indicators of soil quality. The determination of soil organic carbon content thus would provide an idea as any reduction in the content of soil organic carbon indicates a change in land use which is not favourable towards the ecosystem.

Those nutrients that are required by plants in large quantities are classified under major or macro nutrients. Macro nutrients are C, H, O, N, P, K, Ca, Mg and S. Among these N, P and K are called primary nutrients as they are required in larger quantities by plants and Ca, Mg, S form the secondary nutrients due to their moderate requirements by plants and localized deficiencies (Rattan 2015). Those nutrients that are required by plants in relatively lesser quantities, but as essential as macronutrients are classified as micronutrients. These include Fe, Mn, Zn, Cu, Ni, B, Mo and Cl. There are certain elements that promote plant growth and essential for some but not for all higher plant species. These are classified as *beneficial elements*. These include silicon (Si), sodium (Na), cobalt (Co) and selenium (Se).

Before analysis, it becomes important to understand the available forms of nutrients and their movement in the soil leading to their uptake. Major nutrients are taken up in cationic forms except P and S which are taken up in anionic forms of PO_4^{3-} and SO_4^{2-} respectively. Nitrogen is absorbed either as nitrate (NO_3^-) ion, the prevalent form of uptake or as ammonium (NH_4^+) ion. Ionic forms of potassium, calcium and magnesium are K^+ , Ca^{2+} and Mg^{2+} . Micronutrients can be cationic (Fe, Mn, Zn, Cu, Ni) and anionic (B, Mo and Cl) in nature. Cationic micronutrients are absorbed as the divalent cations and anionic micronutrients are absorbed in anionic forms by the crops. Boron could also be taken up as neutral H_3BO_3 molecule by the plants. We have to analyze and determine the status of available nutrients in the soil through soil testing in order to proceed towards fertilizer recommendation.

Table 1: Essential Nutrients for plant growth and forms in which it is absorbed by plant

Nutrient	Chemical symbol	Form taken up by plant
Primary Nutrients		
Carbon	C	CO_2 , HCO_3
Hydrogen	H	H_2O
Oxygen	O	H_2O , O_2
Nitrogen	N	NH_4^+ , NO_3^-
Phosphorus	P	H_2PO_4^- , HPO_4^{2-}
Potassium	K	K^+
Secondary Nutrients		
Calcium	Ca	Ca^{2+}
Magnesium	Mg	Mg^{2+}
Sulphur	S	SO_4^{2-}

Micro Nutrients		
Iron	Fe	Fe ²⁺ , Fe ³⁺ , chelate
Zinc	Zn	Zn ²⁺ , Zn(OH) ₂ , chelate
Manganese	Mn	Mn ²⁺ , chelate
Copper	Cu	Cu ²⁺ , chelate
Boron	B	B(OH) ₃
Molybdenum	Mo	MoO ₄ ²⁻
Chlorine	Cl	Cl ⁻

Soil pH has a direct relationship with the availability of nutrients. Adjusting soil pH to the recommended level can increase the availability of different nutrients. The optimum pH for nutrient availability ranges from 6.0-7.0. As pH changes some elements become more available while others become less available to plants. Hence soil pH measurement is very important for ensuring proper maintenance of fertility of soil. The routine soil test also helps to find out the pH of the soil and helps to correct the acidity or alkalinity of the soil for better nutrient availability.

It is well known that the soil's nutrient requirement vary from site to site and crop to crop. So the amount of nutrients required depends on the nutrient deficiency of the soil and the crop requirement. This type of fertilizer recommendation is named as Site Specific Nutrient Management (SSNM). Here the most important requirement is soil testing and through soil testing farmers may be benefited to adopt SSNM for their crops. Soil Test Fertilizer Recommendation (STCR) is the method in which recommendations are made based on conclusions on the status of soil nutrients as per the soil test. It should not be misunderstood that soil testing and fertilizer recommendation are one and the same. The soil test results in a realistic picture of plant available nutrients in the soil, whereas fertilizer recommendation depends on the interpretation of the results, to determine the fertilizer /nutrient needed by the crop.

CONCLUSION

Different soil test laboratories, agricultural department staff, farm supply dealers *etc.* use different soil test fertilizer recommendation approaches. This may result in contrasting fertilizer recommendations leaving our farmers confused what these differences mean in a farming operation. In this context, it becomes important to follow the most suited approach in soil test based fertilizer recommendation. This soil test based fertilizer recommendation considers the status of nutrients in soil and avoids non-judicious application of fertilizers which would otherwise produce negative impacts on soil health and soil quality. Maintenance of soil health is the key towards a sustainable ecosystem.

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