NUTRIENT MINING AND ITS IMPACT ON SOIL PRODUCTIVITY

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Soil fertility is one of the factors of soil productivity and it is the inherent capacity of the soil to supply plant nutrients in quantity, forms and proportions required for the growth and development of plants. A soil with good quality can sustain the productivity in terms of crop yields. But inadequate nutrient status often limits the soil's capacity to perform or function to sustain the productivity. One of the prerequisites for preserving and enhancing crop yields in intensively cultivated areas is preservation of native soil fertility. During year-round agricultural production, intensive cropping methods extract a significant amount of plant nutrients from the soil. The fundamental idea behind maintaining a soil's fertility under intensive crop production systems is to restock the nutrients that are taken out of the field each year. In fact, this becomes even more important if steps are not taken to sufficiently restore the depleted nutrient pools by clearing crop leftovers from agricultural areas (Sanyal, 2014). When a crop extracts more soil nutrients from an agricultural field than are recycled back and/or restored in the field, this phenomenon is referred to as "nutrient mining." The native soil fertility is reduced by nutrient mining, which might put the nation's future food security in grave danger. Unfortunately, the scientific community is primarily unaware of the problem of nutrient mining in Indian soils, and agricultural production strategies have not sufficiently considered this risk.

India has a huge population of 1.44 billion people with a land area of only 29 lakh sq.km. According to the Ministry of Agriculture & Farmers Welfare, Government of India, the national target for total food grain production for the year 2023-24 was estimated to be 309 million tonnes (MT). Over the past few decades, the overall area under cultivation has stayed relatively stable at 140–142 M ha, however, there are signs that the agricultural areas are gradually being redirected to accommodate growing urbanization and industrialization. It is improbable that a significant amount of new land will be brought in for cultivation anytime soon. Therefore, the only practical way to achieve the production targets for the future is to raise crop productivity per unit area (Sanyal et al., 2014). To meet the future production goals and ensure accepting challenges of food security, nutrient mining issues in the soil must be addressed properly.

NUTRIENT MINING

Nutrient mining refers to the situation when the amount of nutrients removed by the crops exceed the amount of the nutrients retained in the soil and are not replenished/

recycled to the soil. This results in a decline in soil fertility and crop productivity. This poses a threat to the food security overall. Nutrient mining is a serious concern mainly with the less mobile nutrients in the soil. The chances of losses of mobile nutrients are relatively higher when compared to the less mobile nutrients bringing out the importance of replenishing those losses by means of fertilizer additions. Due to this, the input-output balance shows a positive result in the cases of more mobile nutrients. However, the lesser mobile nutrients are expected to have negligible chances of being lost other than by erosion or by leaching. Nutrient mining takes place by different mechanisms such as plant removal, growing environment induced losses. skewed nutrient addition, improper nutrient ratios, poor organic matter, inappropriate cultivation practices, which are explained hereunder.

MECHANISMS OF NUTRIENT MINING

1. **Plant Removal:** This refers to the removal of nutrients from soil by plants and the removal exceeds that of nutrient inputs through combined indigenous sources and external addition of fertilizers. This will result in a negative nutrient balance in soil. This is a typical scenario in farmers' fields where nutrient mining in intensive cropping systems is encouraged by inadequate nutrient application.

2. **Growing Environment Induced Losses:** In addition to the crop removal there are different environment induced nutrient losses from the soil. Leaching, volatilization, run off, erosion etc. are examples for such losses. In specific crop growing conditions, these losses could add considerably to the negative side of the nutrient balance equation. The leaching loss of K from a coarse textured soil and the volatilization loss of nitrogen from applied urea in a calcareous soil are examples of such growing environment induced nutrient losses.

3. **Skewed Nutrient Addition:** When a few nutrients are added in adequate amounts while neglecting the other nutrients, it arises the situation of the skewed addition of nutrients. Indian farmers focus mainly on the application of N and P, neglecting K resulting in a deficiency of K in Indian soils.

4. **Improper Nutrient Ratios:** The skewed nutrient addition can also lead to improper nutrient ratios. When there is an imbalance in nutrient ratios, it affects the nutrient availability to crops and thereby crop productivity.

5. **Inappropriate Cultivation Practices:** The crop production systems in India are mainly intensive. The heavy removal of nutrients by the crops and inadequate replenishment resulted in nutrient deficiencies and depletion of nutrient reserves in soil.

IMPACT ON SOIL PRODUCTIVITY

Soil fertility is usually measured by the quantity of nutrient elements or compounds required by the plants. In a cropping system, usually, the mining of nutrients limits the nutrient supply and lead to low productivity of the soil. Many experimental findings revealed that the underperformance or the low soil productivity occurs when the soil fertility is downgraded due to over extraction (crop removal) and under application of nutrients. Nutrient balance or the nutrient input-output ratio gives the indication of nutrient depletion and provides a measure of how much and what extent the nutrient exceeds the nutrient additions and the possible estimates of gross nutrient depletion.

At the highest productivity levels, crop removal leads to the greatest amount of nutrient mining. When high yield targets are set and a certain nutrient's application is skipped, this could also result in the nutrient's depletion from the native soil reserves. If soil mining continues for an extended period without any outside nutrient supply, the native soil contributions will decline. Crop residue removal from the field could make nutrient mining worse once more. Due to their higher nutritional demands than traditional varieties, high-yielding crops—including hybrid plants—also require a lot more soil to be mined for nutrients. If sufficient nutrients are not received from outside sources for these crops, the native nutrient reserves could run out at a worrying rate.

Due to pH-dependent mechanisms, applied P gets fixed and remained rather immobile, hence additional external application may cause P to accumulate in the soil. The P that has already been fixed in the soil can slowly release P to crops, but it will not meet the crop's peak P requirements. As a result, the crop may react strongly to the external P application even in cases where the P balance is positive. Compared to N, K losses are less from the soil since it is found in native minerals like feldspar, mica, and others and is adsorbed in soil clays. However, K is the most crucial mineral that has a big impact on crop yield in India when it comes to nutrient mining. Applying K to crops at a slower rate has frequently resulted in an excessive loss of native soil K stores (Sarkar *et al*., 2014). As a result of the ongoing extraction of K from native reserves, applied K responded more strongly, making this problem increasingly crucial to address to preserve the soil fertility status of the country.

Since there is insufficient application of secondary and micronutrients through fertilisers in India, native reserves are being depleted at an alarming rate in all agricultural systems. Unless there is an external supply, there will be a negative balance of these elements across the entire agricultural production system. An indication of nutrient mining from soil may be found in data on crop removal or crop nutrient balance of secondary and micronutrients. To maintain a favourable balance of these nutrients in the soil, it is also crucial to understand the native soil reserves of these nutrients and how much is needed to meet crop demand.

Balanced nutrient application is the key to prevent excessive nutrient mining from the agricultural fields. For that a desired balanced fertilizer application should be recommended for the state or agro-ecological zone level. Usually, farmers prefer to use N fertilizers as these are less costly and give quick response in plants. The low use of P and K fertilizers compared to N fertilizers often lead to high nutrient mining of these nutrients from the soil due to their high demand for crop production. Also, omission of the secondary and micro nutrients from the fertilizer schedule certainly led to depletion of the native reserve of these nutrients and increase the nutrient mining and create nutrient imbalance. Hence, proper application of all the nutrients in a balanced way is the key to maintain the soil more productive and sustain the native soil reserves of all the nutrients.

CONCLUSION

Nutrient mining is an unavoidable process in agriculture. The evaluation of nutrient mining produces valuable, useful information on whether the nutrient status of a soil (or area) is being maintained, built up, or depleted. Understanding the extent of nutrient mining in an area is essential to arrive at measures to tackle the issue. Suitable management practices help to withstand the stress on inherent native source of nutrients due to nutrient mining. Maintaining a positive nutrient balance is possible by strengthening the inherent nutrient reserve in a soil by application of external sources of nutrients. This would enhance the soil's capacity to provide nutrients to crops. Soil fertility thus is pivotal in enhancing crop productivity. Soil productivity must be improved by adopting suitable balanced fertilization plan with reduced nutrient mining of native reserves. Hence the extent of allowable range of nutrient mining under different agro-ecological crop management domains should be assessed and a suitable balanced fertilization plan needs to be prepared to sustain the soil quality and soil resources for future food security.

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