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Evaluation of Soil Macronutrients to Enhance Soil Fertility and The Yield of Mango (Mangifera Indica L.) in The Malihabad Area of Uttar Pradesh, India

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ABSTRACT

The evaluation of changes in soil organic carbon and the availability of inorganic nutrients (N, P, K, Ca, Mg) in a mango orchard soil was conducted over the period of 2023-24, specifically in the months of June, September, December, and March, at three-month intervals. This study took place in the subtropical region of Lucknow, India, and involved a comprehensive chemical analysis of soil samples collected from various sites within the Malihabad block of Lucknow District. The pH levels indicated a highly alkaline soil, ranging from 8.0 to 12.9. Monthly applications of organic matter, specifically Azolla pinnata, were made within the tree basin. The results demonstrated a significant increase in the concentrations of soil nutrients in both organic and inorganic amended soils when compared to the control group. The incorporation of organic matter and biofertilizers effectively enhanced the balance of soil organic carbon content and the concentrations of available inorganic nutrients (N, P, K, Ca, Mg).

Key Words: Soil Fertility, Soil Organic Carbon, Total Nitrogen, Bio-Fertilizers

Introduction

India holds the leading position in mango production, contributing nearly 50% to the global total. This fruit is extensively cultivated across nearly all states, benefiting from diverse soil and climatic conditions [1]. The Malihabad region in Uttar Pradesh is recognized as a significant mango cultivation area, particularly for the preservation of mango diversity, especially indigenous varieties. To ensure the conservation of these varieties for future generations, effective management of both macro and micronutrients is crucial [2], [3]. However, the use of inadequate production technologies has led to a decline in soil quality, resulting in the loss of soil organic matter and structural integrity, which adversely affects the flow of water, air, and nutrients, ultimately hindering plant growth and yield [4], [5]. To promote soil health and sustainability in intensive cropping systems, organic manure is typically utilized [6]. The incorporation of organic matter and biofertilizers not only increases nutrient levels but also enhances soil fertility and stimulates microbial activity within the soil [7].

Intense rainfall and uneven topography significantly diminish nutrient availability by accelerating the leaching of essential nutrients. Consequently, both the soils and mango trees experience deficiencies in several vital nutrients [8]. Additionally, inadequate nutrient management practices employed by growers have exacerbated this issue. While mango trees can thrive in a variety of soil types, they flourish best in fertile lands with a slightly acidic to slightly alkaline pH range of 6.5 to 7.5 [9]. The Malihabad mango belt in Lucknow, characterized by deep alluvial soils that are deemed ideal for mango cultivation, faces challenges such as mild to moderate alkalinity and calcareousness [10]. Therefore, this study was initiated to evaluate the macronutrient status in mango orchards by collecting 20 soil samples from various

locations within the subtropical climate of Uttar Pradesh, specifically the Malihabad region, to assess nutritional disorders present in the orchards.

Materials & Methods

Study Sites

The district of Lucknow formed the central part of the province of Avadh. The district lies between the parallels 26030' and 27010' north latitude and 80030' & 81013' east longitude. The 20 soil samples were collected from Malihabad block of Lucknow district in regular interval of 3 month from June 2023 to March 2024. Various sampling sites indicated in fig. 1. The Mango growing villages of Rasoolaabaad, Rasoolapur, Badaura, Sahilamau, Mandauli, Mahamoodanagar, Hariharapur, Purava, Ataura, Belva, Daulatpur, Dheremau, Habibpur, Kanar, Khadoha, Khalispur, Navi Nagar, Salihabad, Tilsua & Surgaula, respectively comes under the block Malihabad and selected as study area. The Soil samples were collected from the block Malihabad in every three months. Soil samples were obtained from a depth of 0–30 cm within the tree basin following the mango harvest during the months of June 2023, September 2023, December 2024, and March 2024. The samples were air-dried at ambient temperatures, then ground using a wooden pestle and mortar, and subsequently sieved through a 2 mm mesh sieve. This mesh size is recognized as the international standard, as the soil that passes through it retains nearly all the essential nutrients necessary for plant growth.

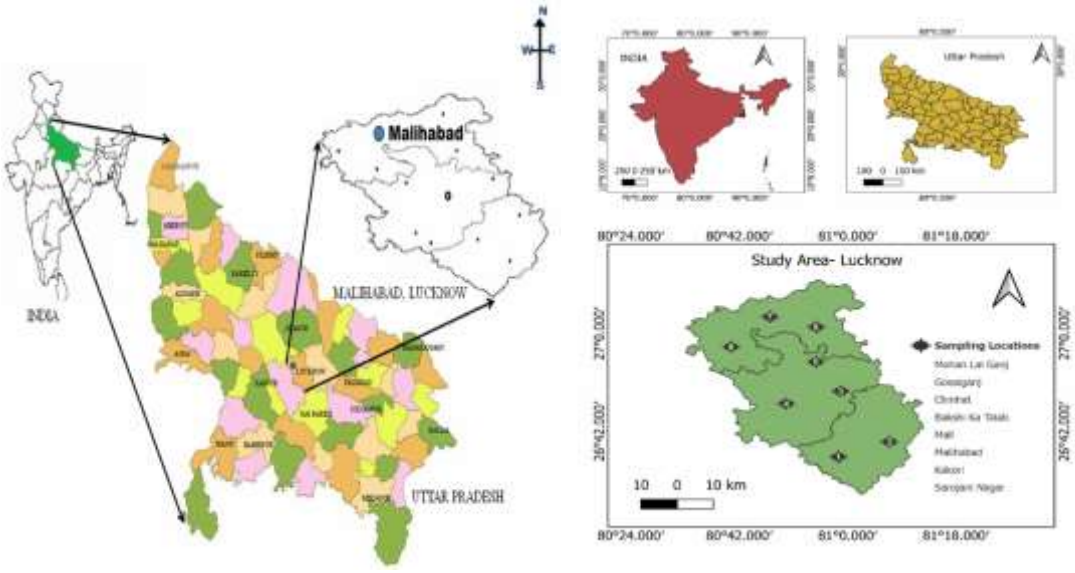


Fig 1: Various Sampling Sites of Lucknow District

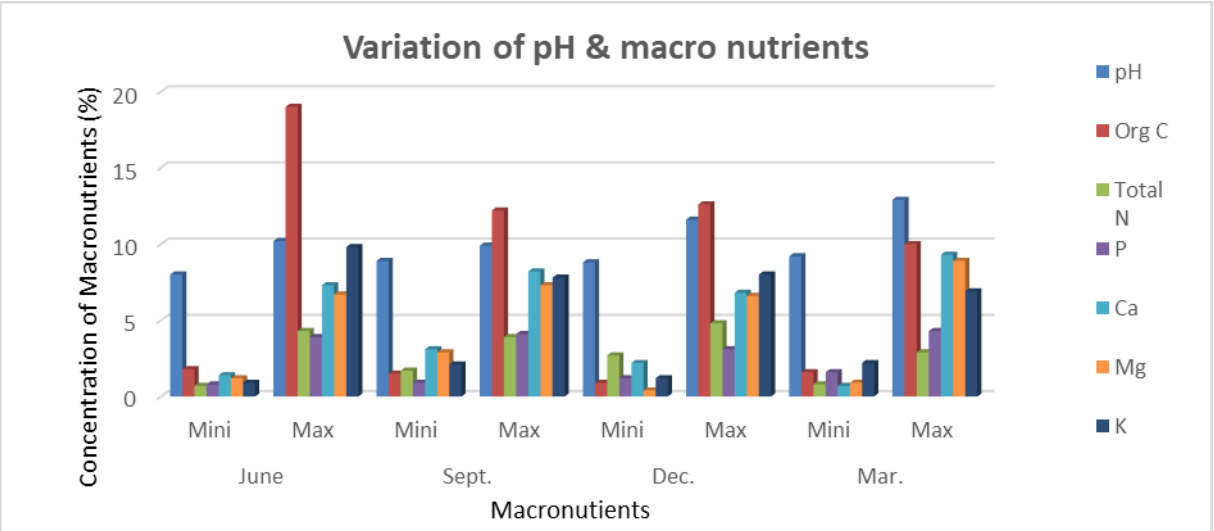
The pH of the soil was assessed utilizing a pH meter. The analysis of soil organic carbon, total nitrogen, phosphorus, potassium, calcium, and magnesium was conducted following established analytical protocols. Specifically, organic carbon was measured using the Walkley and Black method [11], total nitrogen was determined via the Kjeldahl method [11], phosphorus was assessed through the Olsen method [12], potassium was analyzed using the flame photometric method [11], and calcium and magnesium were quantified by the EDTA titration method [11].

Result & Discussion

In this study, the pH ranged from 8.0 to 12.9. Organic carbon fluctuated strongly, with a maximum in June (19%) and a minimum in Dec (0.9%). Total nitrogen varied between 0.7% and 4.8%, The range of phosphorus was identified as being between 0.8% and 4.3%. Potassium levels were found to be abundant throughout all seasons, varying from 0.9% to 9.8%. Furthermore, high concentrations of calcium and magnesium were consistently detected across all seasons. The recommended and ideal levels of macronutrients in healthy soils, which include organic carbon, total nitrogen, phosphorus, potassium, calcium, and magnesium, are established as follows: 0.2% to 10%, 2% to 5%, 0.01% to 0.2%, 0.02% to 2%, 0.1% to 2%, and 0.05% to 3%, respectively. [11]. Seasonal variation of pH & macro nutrients in soil samples mentioned in Table 1 & Fig 2.

Table 1: Variation of pH & Macro Nutrients at Selected Sampling Sites During June 2023 to March 2024

S.No	Parameters	Jun-23		Sept-23		Dec-24		Mar-24	
		Mini.	Max.	Mini.	Max.	Mini.	Max.	Mini.	Max.
1	pH	8.0	10.2	8.9	9.9	8.8	11.6	9.2	12.9
2	Org C	1.8	19.0	1.5	12.2	0.9	12.6	1.6	10.0
3	Total N	0.7	4.3	1.7	3.9	2.7	4.8	0.8	2.9
4	P	0.8	3.9	0.9	4.1	1.2	3.1	1.6	4.3
5	Ca	1.4	7.3	3.1	8.2	2.2	6.8	0.7	9.3
6	Mg	1.2	6.7	2.9	7.3	0.4	6.6	0.9	8.9
7	K	0.9	9.8	2.1	7.8	1.2	8.0	2.2	6.9



Soil of Malihabad is alkaline in nature, its pH varies from 8 to 12.9. Soil samples showed excess organic carbon level in June (19%) due to decomposition and fixation of organic matters at higher temperature. Higher pH leads to acid group dissociation, which increases organic carbon dissolution. Nitrogen deficiency reported in almost all seasons, its concentrations can increase using bio-fertilizer (Azolla pinnata), The water fern Azolla pinnata is known to have a symbiotic relationship with the cyanobacteria Anabaena azollae which can fix free N2 in the atmosphere [13], [14]. Biofertilizers improve soil nutrient quality. Azolla pinnata helps create healthy, organic-rich soil that is well-aerated and able to absorb and maintain water after rain [15] The phosphorous concentration increased with increasing pH. [16] High potassium content is due to the fixation of soluble salts at high temperatures. Alkaline soils had low

nitrogen and medium potassium. The potassium content varied from 0.9% to 9.8%. Excess calcium and magnesium were reported across seasons, with calcium from 0.7% to 9.3% and magnesium from 0.4% to 8.9%.

Conclusion

For the Lucknow district, the big picture showcased that the soil is of alkaline nature. High iron was reported all year since the fly ash contained high amounts of iron bearing fly ash. Copper was also high at all the sites; excess could be probably due to chemical fertilizers forming insoluble copper complexes. Predominantly high concentration of manganese and chromium were noted in all the seasons. Boron had the right amount of concentration all the months but had too much of it in October. Organic carbon was found to be positively correlated with total nitrogen content of the soil. Additional contributions of carbon included stabilized mineral carbon and excessive cropping have also contributed to carbon accumulation as organic matter. There was also a rich positive relationship revealed with phosphorus concentration rising as pH levels went up. Soluble salts fix at high temperatures and potassium was high in July. High levels of calcium and magnesium were noted all over the year from cement industry dust. Chemical fertilizers entail high levels of heavy metals which are poisonous to plants and humans, the level should be reduced by using microbial/bio- Azolla pinnata instead of chemical fertilizers. There is another saying in agriculture that best nutrient level and moisture enhance the production of crops. Macronutrients should be balanced properly by applying the right salts and avoiding leaching of these nutrients in to the ground water. It is proved that fly ash enhances many crop yields in fields by enhancing the physicochemical and biological characteristics of soil when amended properly.

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