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SUMMARY OF DOCTORAL THESIS

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Title: CHARACTERIZATION OF PADDY SOILS FOR FERTILITY BASED INTERVENTIONS IN KENYA

(ケニアにおける土壌肥沃度に基づく土壌管理のための水田土壌の特性づけ)

The demand for rice continues to increase owing to continued population growth and it is predicted that a 50-60% increase in rice production will be required to meet the demand from this growth by 2025. In the face of this and with the pressure on available land for cultivation, the increases in rice yields are likely to occur through enhancement of crop production systems. Successful management of crop production systems requires analysis and design of practices that enhance yield by ensuring that growth limiting factors are minimized or completely eliminated. High availability and efficient utilization of soil nutrients are major determinants of healthy plant growth and realization of optimum yield returns. Thus an assessment of nutrient availability, uptake and utilization by plants is vital for optimized crop productivity. In Kenya, rice production has stagnated while consumption has greatly escalated in the recent past. About 74% of the rice produced is from government established irrigation schemes namely; Mwea, Ahero, Bunyala and West Kano. In these irrigation schemes however, soil chemical and physical degradation among other factors has led to low productivity. The variability in soil properties in the rice growing irrigation schemes has not been exploited for appropriate targeting of soil fertility investment programs. The hypothesis is that there exists high variability in soil properties which requires fertility based soil management strategy for realization of enhanced productivity.

Three irrigation schemes namely Mwea (Central), Ahero and West Kano (Western Kenya) were identified for this study from where surface 0-15 cm soil samples were collected and prepared for laboratory analysis using standard set procedures. Rice plant samples (straw with rachis branch and grain) were collected at harvest from selected paddy fields in Mwea irrigation scheme and analyzed for total for nutrient. The results obtained for soil and plant were evaluated by comparing with nutrient management guidelines for rice issued by IRRI (2000).

Results showed that soil pH ranged from 6.2 to 8.0 and 5.4 to 7.5 in Ahero and West Kano irrigation schemes respectively, while in Mwea, values from 4.5 to 7.7 were recorded. As per the ratings by the Kenya soil survey, the soil pH was moderately high on average which is attributed to the basaltic parent material and the dry climate which favor the formation of Vertisols that largely cover the sites. In terms of soil salt concentration, the surface soils in all the three schemes are regarded as non-saline as low EC values (< 0.4 dS/m) were observed.

Soil total carbon was moderately high on average across the three sites as farmers usually do apply organic matter in their paddy fields especially in Mwea. Furthermore, although rice straw is removed from the fields at harvest, stubble remained and manure from animal was applied. In Ahero and West Kano, straw and stubble was rarely removed from the paddy fields. Soil total nitrogen contents were averagely low despite widespread use of nitrogen fertilizers probably because of inappropriate N-fertilizer management that leads to N losses.

Exchangeable Ca^{2+}dominated the cation complex followed by exchangeable Mg^{2+}which was in slightly higher concentration in Mwea as compared to Ahero and West Kano schemes. This relatively high level of exchangeable Ca^{2+} and Mg^{2+} is due to the basaltic parent materials. Exchangeable K^{+} occurred in higher concentration in Ahero and West Kano compared to exchangeable Na^{+}. Exchangeable Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} contents exceeded the deficiency criteria for rice in Ahero and West Kano schemes while 13% of the fields in Mwea showed deficiency in exchangeable K^{+}(<0.2 $cmol_c$/kg). In Mwea, disproportionate cation distribution with the Ca+Mg/K ratio higher than 100 in about 83% fields indicate high K deficiency risk; thus efforts to enhance soil K availability should be embraced. In Ahero and West Kano, there were no cases of disproportionate cation distribution.

The contents of available P_2O_5 was generally high above the critical deficiency criteria of IRRI with only 1% of the sampled fields in Mwea showing levels below the deficiency limit. The high levels of soil P_2O_5 observed could be because of the soil pH close to neutral and with continuous P fertilization. Soil available SiO_2 was high and exceeded the deficiency criteria for rice in all sites, although Ahero and West Kano values were higher than Mwea perhaps because of high siltation and straw retention. Mean soil available S was above the deficiency level for rice across all sites which could be because of fertilizer widely used in rice production.

Among the soil available micronutrients, soil Fe dominated in Mwea and West Kano while soil Mn dominated in Ahero and Zn was less than 2.0 mg/kg deficiency level, on average in Mwea therefore application of Zn fertilizer should be exploited.

Results of plant nutrient content from Mwea scheme indicated that on average, total Ca contents in straw was high (>0.30%) in Tebere, Wamumu and Karaba and below the deficiency level of 0.30% in Thiba and Mwea units which had slightly lower soil Ca content. In addition, high soil Fe could have contributed to the low Ca accumulation in the straw as they associated negatively. Straw total K was also below the deficiency level in the same two units, which was probably due to high soil (Ca+Mg)/K ratio in the two units. Straw total Mg, Cu, Fe, Mn, P_2O_5 and Zn exceeded the deficiency level on average while Mwea unit showed deficiency in straw total S. Soil and straw nutrient concentrations were positively correlated for most nutrients since the concentration of a particular nutrient in the plant is generally greater when the concentration in the soil is high except for straw total Zn that was high despite the soil concentration being below the critical deficiency level.

Grain samples on the other hand showed deficiency in total Ca, Fe, K, Mg and S in all units while grain total Cu, Mn, P_2O_5 and Zn exceeded deficiency limit. The deficiency in grain total Ca, Fe, K, Mg and S could be attributed to their low transfer coefficients from straw to grain. Furthermore, for the case of Fe, it is known that rice as a plant is inefficient at transporting Fe to grain. Ca is said to be immobile in the phloem and since the seed is mainly fed by the phloem, Ca loading into the seed is hampered.

Soil nutrient concentrations affected nutrient accumulation in the straw and grain at various levels thus there is need to apply nutrient at appropriate timing to ensure maximum use-efficiencies. Furthermore, proper soil fertility management practices should be considered to avoid depletion or excessive accumulation of nutrients for improved quality and quantity of rice yields.