EXPLORING IMPROVED NUTRIENT OPTIONS FOR INCREASED RAINFED LOWLAND RICE PRODUCTION IN EASTERN AND NORTHERN UGANDA

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DECLARATION

This thesis is my original work and has not been presented for any degree in any other University.

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GENERAL ABSTRACT

Although rice is increasingly becoming an important crop in Uganda, yields continue to decline due to poor soil fertility, weed problems and intermittent rainfall. Poor soil fertility has been ranked as the most important abiotic stress limiting rice production. The main objective of this study was to develop nutrient options for the improvement of rice production in eastern and northern Uganda. The specific objectives were: 1) to establish the current nutrient status, nutrient management practices and household characteristics that affect the use of fertilizer and other agro-inputs in lowland rice growing areas in eastern and northern Uganda; 2) to determine the effect of nursery management practices, age of seedlings at transplanting and split application of nitrogen fertilizer on the yield of four rice cultivars; 3) to determine the nutrient use efficiency and indigenous nutrient supply in lowland rice fields; 4) to assess yield responses of four rice cultivars to varying rates of inorganic fertilizers. Objective one was implemented through a survey to document soil fertility status and factors determining use of fertilizers and agro-inputs. Objective two was studied by applying di-ammonium phosphate (DAP) and fungicide in the nursery and transplanting seedlings at either 14 or 30 days after seeding using the following treatments: control (no chemical + 30-day old seedling), DAP+ 14 day old seedlings, DAP + 30 days old seedlings, fungicide + 30 day old seedlings, DAP + fungicide + 14 day old seedlings. Effect of split application of N on yield was determined by setting up an experiment using split plot design with five N-fertilizer treatments: 1) control (no fertilizer added); 2) 23 kg N ha^{-1} applied at planting; 3) 23 kg N ha^{-1} applied in two splits; 4) 46 kg N ha^{-1} applied at planting; 5) 46 kg N ha^{-1} applied in two splits. Objective three was studied using the omission plot technique with five treatments laid out in a randomised complete block design with four replicates: control (no fertilizer), NPK, PK (-N), NK (-P) and NP (-K). Agronomic efficiency (AE), recovery efficiency (RE), internal use efficiency

(IE) and gross return over fertilizer (GRF) were calculated. Appropriate N, P and K rates for site specific nutrient management (SSNM) were also calculated. For objective four, yield responses to different fertilizer options were determined using six fertilizer treatments: 20-20-0, 40-20-0, 60-30-0, 80-20-0, 80-40-0 and 120-40-0 kg ha^{-1} N- P_2O_5- K_2O. A split plot design was used with treatments as main effects and varieties as sub plots. All experiments were set up between 2013 and 2014. The omission experiments were set up using a local variety Bedinego while the other experiments were set up with four rice varieties; K 5, K 85, GSR 007 and WITA 9. Data was collected on plant height, number of tillers, number of panicles, grain yield and rice biomass dry weight at harvest. Profitability analysis of the different fertilizer treatments was also done. Determinants of use of agro-inputs were examined using a binary probit model. Analysis of variance (ANOVA) was performed for the different treatments and means separated using the least significant difference (LSD) at P=0.05. Results showed that male farmers dominated lowland rice production (90.7 %) and only 12 % of farmers used inorganic fertilizers at a rate of 10-50 kg ha^{-1}. Farmers' occupation and fertilizer prices were the main determinants for fertilizer use while age, household size, gender and training in agricultural production determined the use of agrochemicals on rice fields. Generally, the nutrient status at farmers' fields was low. All the sampled fields had medium levels of organic matter (2-4.2 %), over 80 % of farms had low levels of Olsen P (5-15 mg kg^{-1}) and all farms had medium to high levels of nitrogen and over 50 % of the farms had high levels of K (0.6-1.2 cmoles kg^{-1}). Common weeds in farmers' fields were *Cyperus difformis, Kyllinga erecta* Schum. and *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers., *Echinochloa colona* (L.) Link.). The parasitic weed *Ramphircarpa fistulosa* (Hochst.) Benth was found mainly in Butaleja and Bugiri districts. Applying DAP and transplanting 14 day old seedlings resulted in the highest yield (average yield= 3.4 t ha^{-1}). Generally, applying fertilizers and fungicide in the

nursery and transplanting 14 day old seedlings resulted in a yield increase of 0.6-0.8 t ha^{-1}. The interaction between split N applications and variety was significant for yield. When 23 kg of N was applied at once to all varieties, GSR 0057 yielded better than WITA 9 but its yield was similar to K 5 and K 85. Application of 46 and 23 kg of N ha^{-1} at once had significantly lower harvest indices (HI= 0.31 and 0.32 respectively) than the control and split application of 23 and 46 kg of N ha^{-1}. The full NPK treatment in omission trials had 73, 40, 23 and 25 % higher yield than control, PK (-N), NK (-P) and NP (-K) treatments respectively. The average AE, RE and IE of N were 9.4 kg kg^{-1}, 31% and 36.9% respectively. The average indigenous supplies for N, P and K were 52, 9.7 and 87.2 kg ha^{-1} respectively. The calculated appropriate nitrogen, phosphorus and potassium doses required to achieve 5 t ha^{-1} rice yield were 63, 12.6 and 24.5 kg ha^{-1} respectively. The gross return over fertilizer cost (GRF) for NPK, PK, NK and NP treatments were $1,275.3, 1039,1057 and 1008 ha^{-1} respectively. Yield in the different nutrient regimes generally increased with increase in amounts of fertilizer applied and variety K 85 out yielded all other varieties irrespective of treatment and season. The highest average yield (3.4 t ha^{-1}) was recorded in plots which received 120-40-0 (N, P and K respectively) while the lowest yield was recorded in 20-20-0 NPK (average yield= 1.3 t ha^{-1}). Generally, 120-40-0NPK recorded the highest net returns and profits of 29.0 % and 26.8 % in 2013A and B respectively. Improving nursery management has greater prospects for increasing rice yields in smallholder farms at minimal costs. The low nutrient use efficiency observed implies that maximum benefits from fertilizer use will only be realized if farmers can adopt good agricultural practices. Incentives to increase use of external inputs on rice production coupled with supportive policies for availability of affordable agro-inputs and improved technologies (including new varieties) can lead to increased rice production in Uganda.