ASSESSMENT OF SOIL PROPERTIES AND YIELD UNDER DIVERSE CROPPING SYSTEMS IN ALFISOLS FOR MAIZE (*Zea mays* L.) CROP

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INTRODUCTION

Farmers cultivate field crops requiring less water instead of paddy due to the lower amount of rainfall in the *Yala* season. Maize (*Zea mays* L.) is the most important coarse grain highland crop, which is second most largely cultivated crop after paddy in Sri Lanka. Maize is cultivated mainly in the Dry and Intermediate zones. Most farmers use synthetic inputs such as fertilizers, pesticides and herbicides to gain higher yields without considering their adverse effects. Regular application of chemical inputs into farming lands for long term may directly influence hazardously on soil structure as well as on the whole environment (Ranasinghe, 2017). Continuous and overuse of chemical inputs has become an alarming issue and demand for alternative agricultural practices such as, integrated agricultural practices and organic management has increased.

The broad objective of this research is to evaluate the soil fertility related parameters and their relationship to crop yield during the transition period from conventional input systems to alternative systems (integrated nutrient management system and organic input system) in the maize crop during the *Yala* season.

MATERIALS AND METHODS

A field experiment was conducted during the *Yala* season at the research farm, Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura. This is a low land paddy field under DL_{1b} agro ecological region between latitude 8° 57' 44N and longitude 80° 31' 16E with mean an annual rainfall between 1250mm to 1750mm. Reddish Brown Earth (RBE) Low Humic Gley (LHG) soil types are common within Dry zone (Sanjeevani *et al*., 2015).

Experimental layout and treatments

This study was initiated during the *Maha* season 2019. The experimental design was Randomized Complete Block Design together with six replicates for each treatment combination. Three treatments were based on three inputs systems as, T1-conventional, T2-reduced and T3-organic.

Crop establishment and management

Pacific (hybrid) seeds were planted at 7.4 plants/m^2 rate. Conventional fertilizer system was managed according to 100% DOA recommendations. Reduced input system was carried out by reducing the fertilizer usage by 50% and supplement with 50% organic fertilizer. The organic fertilizer system was managed using 100% organic manure (compost and cow dung).

Soil sampling and analysis

There were 18 plots per season. Soil samples were collected from initial stage, 50% tasselling stage and after harvesting. Each soil sample was analyzed for available phosphorous, nitrate nitrogen and ammonium nitrogen.

Yield parameters

The yield of each plot for maize were obtained using yield parameters i.e. - Barren plants per unit area, Number of plants per unit area (90 m^2), Number of cobs per plant, Number of kernels per cob, Number of kernel rows per cob, Number of kernels per rows, 1000 grain weight and final grain yield.

Data analysis

Data was analyzed using ANOVA procedure in SAS. Means were separated using LSD mean at P = 0.05.

RESULTS AND DISCUSSION

Available Phosphorous

Available P within Aluthwewa soil series referred as 5 mg kg^{-1} in surface soil (Mapa *et al*., 2010). Initially the field contained very low available P. It expressed significant difference at $P \leq 0.05$ for interaction effects of input system and time. Conventional and reduced systems reflected no significant difference to each but recorded highest available P at tasselling stage. Available P content changes with the time according to factors such as, fertilizer application, different soil reactions, microbial activity, soil aeration and temperature. Phosphorous directly affected by soil pH. Alkaline pH prompt calcium and magnesium to react quickly with phosphate ions to form less soluble compounds (Perera and Weerasinghe, 2014). Available P at both conventional and reduced systems showed significant increase from initial to tasselling stage. Available P in organic system has significantly increased from initial to harvest. Organic system may contain contrastingly higher value might be influenced with reduction of nutrient uptake and with the decomposition of nutrients.

Nitrate Nitrogen

Nitrate nitrogen is the easily accessible form of nitrogen to plant. NO_3^- nitrogen tends to be leached easily down through the soil profile (Krell, 2020). Nitrate nitrogen revealed significant difference at $P \leq 0.05$ with input system × time with the stage of plant development. Initially, there was no significant difference among three input systems. At tasselling stage conventional system recorded significantly higher rate than organic. At initial condition conventional system contained lower NO_3^- nitrogen but when it comes to tasselling and harvest stages it increased significantly. Continuous fertilizer application and rapid nitrification might be the reasons for higher amounts of NO_3^- at latter stage of maize growth. Reduced system does not show any significant difference, though it was incorporated with inorganic and organic fertilizers. It gains one half in a readily available form and next half it is inaccessible unless decomposition makes it available. In organic system there is no significant increase from the initial to tasselling stage. Low rate of nitrification due to more binding sites for NH_4^+ nitrogen might be triggered (Krell, 2020). Plant uptake also may cause lowering of the NO_3^- nitrogen content within soil. Harvest stage NO_3^- nitrogen has significantly increased. Decomposing organic manure, lowers negative binding sites may accelerate the nitrification. Compost or organic manure application can also cause increased nitrification (Yamamuro, 1983). Less plant uptake after silking stage to harvest stage might be cause for a higher amount of NO_3^- nitrogen at harvest stage. One of the major reasons for this increment might be good aeration within the maize soil (Bender *et al*., 2013).

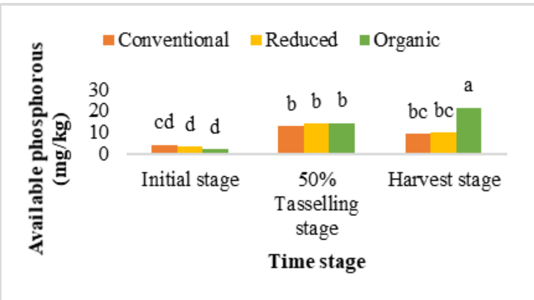

Figure 1: Distribution of input system × time stage interaction effect on soil available Phosphorous

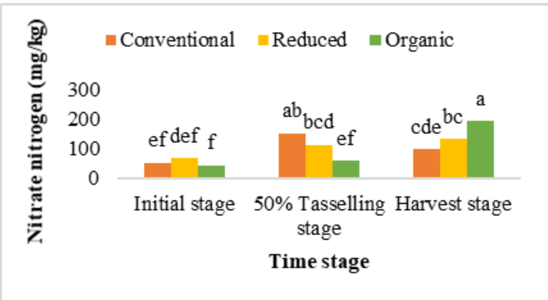

Figure 2: Distribution of input system × time stage interaction effect on soil nitrate Nitrogen

Ammonium Nitrogen

Ammonium nitrogen (NH_4^+ N) is one of the major forms of available N. It should go through nitrification to convert into NO_3^- nitrogen (Beegle, 2005). NH_4^+ nitrogen revealed significant difference at $P \leq 0.05$ with input system. Conventional input system recorded significantly higher amount of NH_4^+ nitrogen amount compared to organic system and there's no significant difference from a reduced system to others. Low content of NH_4^+ nitrogen compared to NO_3^- nitrogen occurred as a consequence of low organic matter and sandy soil texture (Hofman and Cleemput, 2004). Highest NH_4^+ nitrogen with conventional system might be happened with inoculation of chemical fertilizer. As, it easily releases into available forms, NH_4^+ nitrogen content may be significantly rise. As these reduced and organic systems were incorporated with organic manure, it takes time to decompose and release nutrient to soil (Perera and Weerasinghe, 2014). As a result of slower releasing rate and higher usage of available nitrogen in organic input system it has been given lower NH_4^+ nitrogen compared to conventional. Maize soil contained higher rate of NH_4^+ nitrogen might have occurred due to the amount of N mineralization being greater in well-drained soil than ill drained soil (Yamamuro, 1983).

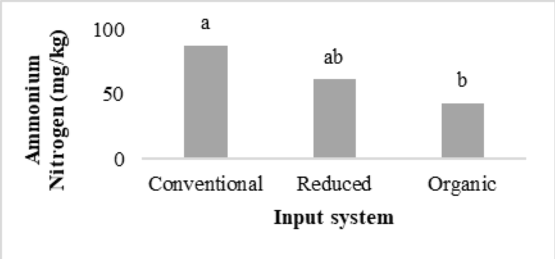

Figure 3: Distribution of time stage effect on ammonium Nitrogen

Maize yield parameters

Hybrid maize varieties such as Pacific 999 and Pacific 984 are common varieties among farmers in Sri Lanka due to the high yield potential. Number of kernels per cob, number of kernel rows per cob, number of filled kernels per row, barren plants per hectare and final grain yield at 14% moisture were significant at $P \leq 0.05$ with input systems. Although plant density of each input system was the same, there were greater difference of final grain yield. The final grain yield varied from 5.9 ton/ha, 3.2 ton/ha and 1.8 ton/ha for conventional, reduced and organic systems respectively. Organic system contained significantly higher barren plants. Researchers have found that plant density has a great influence on final grain yield. Different plant densities, 111111,88888 and 55555 plants ha^{-1} were given 7.96 ton ha^{-1}, 7.44 ton ha^{-1} and 6 ton ha^{-1} grain yield, respectively (Dawadi and Sah, 2012). Number of kernels per cob, number of kernel rows per cob and 100 seed weight have highly influenced the final grain yield (Damiyal *et al*., 2017).

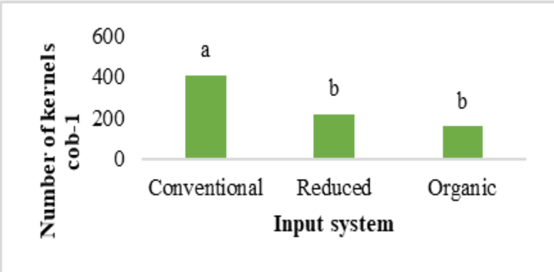

Figure 5: Variation of number of kernels per cob with input systems

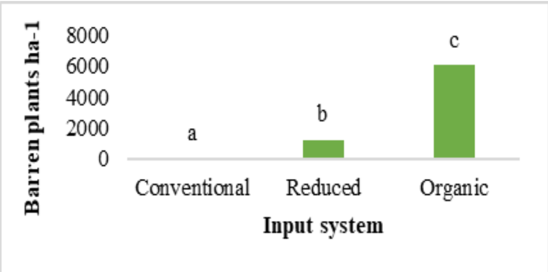

Figure 4: Variation of barren plants ha^{-1} with input systems

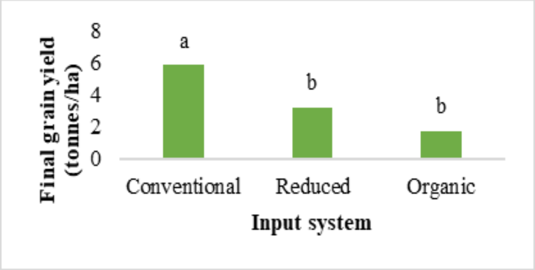

Figure 6: Variation of final yield (ton/ha) at 14% moisture with three input systems

Conventional system gave the highest maize yield. There was no significant difference ($P \leq 0.05$) within reduced and organic systems. Vegetative growth stage 5 to 10 are critical to maize crop, it determines the yield between these stages (Nleya *et al*., 2019). Though inorganic fertilizers are readily available while organic inputs take time to decompose and release nutrients. At tasselling stage, there was significant difference of available nitrogen contents with conventional and organic systems. An organic system is insufficient to provide required N need from first vegetative growth stage to silking stage may affect the higher number of barren plants and lower yield in reduced and organic systems. N stress at any time during the life time of corn plants deducts from the yield (Butzen, 2011). NH_4^+ N should be managed equal to NO_3^- N for the better performance of hybrid maize yield (Tsai *et al*., 1982). But in our systems NH_4^+ N levels were at a low level compared to NO_3^- N levels. Reduced system was given somewhat higher yield compared to organic system which may be due to the 50% of inorganic fertilizer. Both compost and cow dung were applied in 5 ton/ha and 2.8 ton/ha respectively. Though the N is critical nutrient requirement in maize, previous research has found that 5 ton/ha cattle manure gives higher number of seeds per cob (625), highest number of leaves, plant height and 5.65 ton/ha final yield (Damiyal *et al*., 2017). Furthermore, it has proven that rate of organic manure may affect the nutrient availability and finally on crop growth and yield in organic and reduced input systems.

CONCLUSIONS

Soil needs time to build up desirable soil properties with organic manure application. Nitrate nitrogen and available phosphorous were significantly increased at the organic management from its' first transition year. The highest Maize yield was obtained from using the conventional system. Maize crop did not produce optimum yield with both organic (100% organic manure) and reduced (50% DOA + 50% organic manure) input systems. We are unable to draw strong conclusions about maize yield for the first transition year and further research is needed to study the behaviour of soil fertility parameters with yield of maize in Alfisols.

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