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RESEARCH ARTICLE

Assessment of soil properties and yield under diverse input systems in Alfisols for rice (*Oryza sativa* L.) crop

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ABSTRACT

Today's agricultural system relies heavily on synthetic inputs for higher yields. Prolonged use of chemical inputs pollutes and degrades the farming lands and it should go through a transition period to achieve soil fertility. Sri Lanka needs research to identify the potential and challenges of organic or integrated plant nutrient management strategies, particularly during the transition phase. More information is lacking on the soil fertility dynamics and yield performance among these diverse input systems for rice (Oryza sativa L.) hybrids as they were bred under conventional management. Main objective of this study was to compare the final grain yield between conventional (100% Department of Agriculture, DOA recommendation) reduced (50% DOA + 50% organic manure) and organic systems with great attention to soil fertility dynamics within its first transition year. The experiment was carried out in Puliyankulama, Anuradhapura during Yala season 2019. Soil samples were analysed for different fertility parameters. The final grain yield and yield parameters were also determined. Data were subjected to analysis of varience (ANOVA) using SAS software to distinguish treatment effects. With time stages, ammonium nitrogen (N), nitrate N, available phosphorous (P), and microbial biomass carbon (MBC) fluctuation among different input systems were significant ($P<0.05$). Nitrate N and available P revealed a significant increment within the organic system from the first transition year. Initial 77.27 mg kg^{-1} nitrate N of organic system reached up to 144.16 mg kg^{-1} at the end of the first transition year while available P surged from 2.25 to 15.1 mg kg^{-1}. Conventional and reduced systems produced similar final yields for rice as 4.9 and 4.7 t ha^{-1}, correspondingly while 2.7 t ha^{-1} final yield produced by organic input system. The results suggest a potential to replace inorganic chemical fertilizers by 50% with organic manure without much impact on the yield while reducing the cost of production applied for commercial fertilizers. Overall, long-term investigations are needed to confirm soil fertility dynamics and final grain yield of rice within its transition period.

***Keywords**: Grain yield, input systems, rice, soil fertility parameters*

INTRODUCTION

Decades ago, Sri Lanka had an economy which was considered as “rural” and “subsistence agricultural-based” with the majority of the population cultivating rice (*Oryza sativa* L.) and other field crops (Jayasinghe-Mudalige, 2010). Today, our agricultural system, which is characterized by conventional traditional farming methods, is a descendant of the Green Revolution. Farmers here use external synthetic petroleum-based inputs such as fertilizers and pesticides to achieve high yields disregarding the adverse impact. Continued use of these chemical inputs in agriculture can have a detrimental effect not only on soil structure and soil properties but also on the whole environment (Ranasinghe, 2017). Therefore, at present continuous and overuse of chemical inputs in agriculture has become an alarming issue as the society is relentlessly developing resistance against consuming conventionally produced food.

Due to these reasons, the demand for alternative agriculture practices is increasing throughout the world as well as within the country. Integrated agricultural practices and organic farming can be one of sustainable alternatives for conventional agriculture. As most of the farmlands are under conventional farming by today, most of them are polluted and cannot be used as organic farming lands. The time, it takes for conversion from conventional to organic and achieves the corresponding soil fertility levels required is known as the transition period (Ranasinghe, 2017). Organic farming systems substitute all synthetic farm inputs with alternatives such as compost, bio pesticides, bio herbicides, farmyard manure, crop residues, animal manure, off farm organic wastes, etc. Integrated Plant Nutrient Management (IPNM) system is a system that partially accepts both synthetic fertilizer and organic fertilizer both (Du *et al.*, 2014). By converting into IPNM systems, it can reduce the use of synthetic chemical compounds and reduce the damage caused to the soil properties while maintaining soil fertility. The IPNM system may be the best alternative to farmers who are resistant to practice organic farming due to the fear of losing yields. Conversion from conventional farming to organic farming or integrated farming ensures that enhancement in biodiversity, biological cycles, agro-ecosystems and human health (Meena *et al.*, 2013). Sri Lanka is requiring research on identifying the potential and challenges of soil nutrient management using either organic or IPNM strategies, particularly during the transition phase in rice-based cropping systems. Further information is lacking on the soil fertility dynamics among these diverse input systems for rice hybrids as they were bred under conventional management. Thus, it is doubtful the yield performances under alternative systems; farmers refuse to adopt into above approaches.

The objective of this research was to evaluate the soil fertility related parameters and their relationship to crop yield during the transition period from conventional input systems to alternative systems (IPNS system and organic input system) in the rice crop during *Yala* season. Thus, our study was planned to carry out as a part of the main project established in the 2018/19 *Maha* season with three different input systems to compare soil properties and yield parameters of rice cultivation during *Yala* season in 2019. The experiment was conducted with three different input systems: (a) with 100% of fertilizer recommendation of the Department of Agriculture (DOA), (b) reduced input system (50% of fertilizer recommendation of DOA + 50% compost), and (c) organic system with 100% organic manure for obtaining the results for a sustainable cropping approach and raise awareness among farmers about these alternatives for conventional farming system.

MATERIALS AND METHODS

Experimental site

Research farm of Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura was used as the experimental site during the *Yala* season in 2019. A low land paddy field under DL_{1b} agro-ecological region between latitude 8° 57' 44 N and longitude 80° 31' 16 E was used (Sanjeevani *et al.*, 2015). *Yala* season receives 337.3 mm seasonal rainfall while mean and maximum season temperatures are 30.0 and 34.3 °C, respectively (Wickramasinghe *et al.*, 2021). A considerable extent of the land in the dry zone consists of Reddish Brown Earth (RBE) soil type whereas some other certain areas consist of Low Humic Gley (LHG) soil type (Vidyarathna *et al.*, 2008).

Experimental layout and treatments

The study was initiated during the *Maha* season 2018/19 and the experimental design was the Randomized Complete Block Design (RCBD) together with six replicates for each treatment combination. Bg300 rice variety was used to cultivate at a 120 kg ha^{-1} seeding rate. The treatments applied were: T1 - 100% DOA recommendation and synthetic inputs used to weed and pest management (conventional); T2 - 50% reduction of DOA recommendation + organic fertilizers by volume and weed and pest management were obtained by integrated manner (reduced); T3 - 100% organic fertilizers and commercially available organic botanicals used to pest control while water management used to weed suppression (organic). Compost (10 t ha^{-1}) and cow dung (5 t ha^{-1}) were added as organic fertilizers, twice within the season.

Soil sampling and analysis

There were 18 plots (3 treatments x 6 replicates). Four sub soil samples were collected to the depth of 0-30 cm to obtain a composite sample representing each plot. Samples were collected from the (i) initial stage, (ii) 50% heading stage and (iii) after harvesting. Each soil sample was analyzed for different chemical, biological and physical parameters. Soil pH (1:2.5 soil: water suspension) (Rowell, 1994) and electrical conductivity (EC) (1:5 soil: water suspension) (Black, 1965) were measured using multi parameter analyzer (HACH HQ40d). NH_4OAc method was used to measure cation exchange capacity (CEC) (Chapman, 1965). Organic matter (OM) content was measured using Walkey and Black method (Smith and Mullins, 1991). Kjedhal method was used to measure total nitrogen (N) (Bremner and Muloaney, 1982), while ammonium N and nitrate N were measured using colorimetric methods via spectrophotometer (Markus *et al.*, 1985). Ascorbic acid colorimetric method and spectrophotometer were used to determine available phosphorus (P) (Watanabe and Olsen, 1965). NH_4OAc extraction method and flame photometer were used to measure exchangeable potassium (K) (Jackson, 1958). Microbial biomass carbon (MBC) was measured using chloroform fumigated method (Anderson and Ingram, 1994) and simplified hydrometer method was used to determine soil texture (Sheldric and Wang, 1993).

Yield parameters

Number of plants per unit area (90 m^2), number of panicles per plant, number of grains per panicle, filled grain weight, unfilled grain weight, 1,000 grain weight and final grain yield were recorded as yield parameters.

Data analysis

Data were analyzed using the ANOVA procedure in SAS computer programme version 9.0. Means were separated using LSD at $P \leq 0.05$.

RESULTS AND DISCUSSION

Initial soil condition and soil parameters

We have tested basic soil fertility related parameters at the initial stage to get a clear understanding of the field. Table 1 provides average mean values of soil properties of initial soil condition at the beginning of the *Yala* season in 2019. The experimental field comes under loamy sand textural group with higher sand (86.12%) and low clay (8.32%) percentages, and contained neutral soil pH with low concentrations of available P, total N, CEC, and OM. However, the amount of MBC was considerable (Table 1). Although, we have analyzed many soil parameters, only the pH, MBC, ammonium N, nitrate N, and available P changed with input system (IS) × time stage (T) interaction (Table 2). Table 3 depicts details for the effect of input system on rice yield parameters.

Table 1: Average mean values of soil properties of initial soil condition at the beginning of the *Yala* season in 2019.

Soil property	Mean value
Sand (%)	86.12 (1.90)
Silt (%)	5.56 (3.98)
Clay (%)	8.32 (3.72)
Textural group	Loamy sand
pH (1: 2.5, soil: water)	7.39 (0.36)
EC (dS m^{-1})	0.07 (0.03)
Available P (mg kg^{-1})	3.31 (2.47)
Total N %	0.03 (0.02)
NH_4^+ N (mg kg^{-1})	40.24 (29.65)
NO_3^- N (mg kg^{-1})	66.20 (39.60)
Exchangeable K (mg kg^{-1})	69.98 (16.49)
OM %	1.66 (0.34)
CEC (cmol(+) kg^{-1})	6.07 (1.67)
MBC (mg kg^{-1})	1004.75 (513.72)

Table 2: ANOVA results of the effect of different input systems and time stage on soil pH, electrical conductivity (EC), cation exchange capacity (CEC), organic matter (OM) content, microbial biomass carbon (MBC), total nitrogen (TN), ammonium nitrogen (NH_4^+ N), nitrate nitrogen (NO_3^- N), available phosphorous (Av. P) and exchangeable potassium (Ex. K).

Source of variation	pH	EC	CEC	OM	MBC	TN	NH_4^+N	NO_3^-N	Av. P	Ex. K
Input system	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	0.01	*ns*	*ns*	*ns*
Time stage	*ns*	0.0005	<.0001	*ns*	0.0002	<.0001	0.01	<.0001	0.002	*ns*
IS × T	0.03	*ns*	*ns*	*ns*	0.012	*ns*	0.001	<.0001	0.039	*ns*

IS – Input system, T – Time stage
Means of 36 soil samples from each input system
ns Not significant at $P \leq 0.05$, ** significant at $P \leq 0.05$

Table 3: Effect of input system on rice yield parameters and results of analysis of variance (ANOVA) in mixed effect models.

System	PLD m^{-2}	NP m^{-2}	NG P^{-1}	FGW (g)	1000 GW (g)	GY (t ha^{-1})
Conventional	241^{a}	259^{a}	87^{a}	425.6^{a}	23.8^{a}	4.9^{a}
Reduced	239^{a}	344^{a}	61^{b}	409.3^{ab}	23.2^{a}	4.7^{ab}
Organic	154^{a}	307^{a}	42^{c}	240.3^{b}	21.5^{b}	2.7^{b}
Standard error	1.20	1.0	0.29	43.9	0.35	0.50
Source of variation			$P \leq 0.05$			
IS	*ns*	*ns*	**	*ns*	**	*ns*

PLD m^{-2} Plant density m^{-2}, NP m^{-2} Number of panicles m^{-2}, NG P^{-1} Number of grains per panicle, FGW Filled grain weight, 1,000 GW 1,000 grain weight, GY Grain yield at 14% moisture, IS Input system
Means of 24 quadrats (50 cm^2) samples from each input system
ns - not significant at $P \leq 0.05$, **significant at $P \leq 0.05$, means followed by the different letters in the same column are significantly different at $P \leq 0.05$

Soil pH

pH is the basic soil chemical parameter that indicates soil acidity and alkalinity. Within the cropping period, pH varies within 7.00-7.70 range from neutral to slightly alkaline pH range and it is a common value for Alfisols (Rosemary *et al.*, 2017). Initially, the reduced system shows a significantly ($P<0.05$) low pH level around 7.18 while conventional and organic systems recorded 7.51 and 7.48 soil pH, respectively. But all three input systems deny showing significance at 50% heading and harvesting stage. The pH of the field has fluctuated closer to a slightly alkaline state throughout the season (Figure 1).

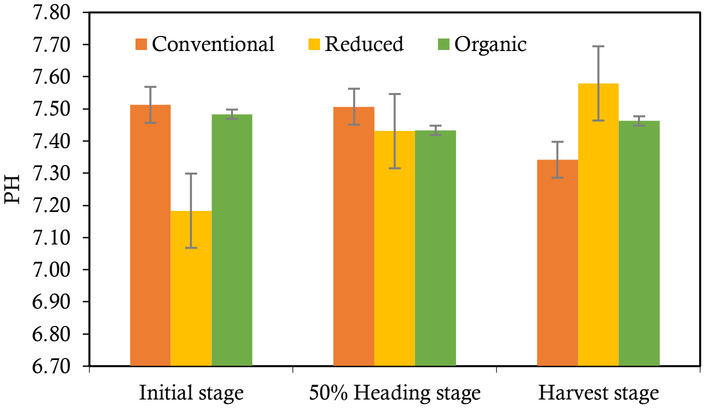

Figure 1: Distribution of input system × time stage interaction effect on soil pH.

pH in organic and reduced input systems might be influenced by the addition of organic manure. Because, it continuously complexes and reduces Al and Fe which initiate an increase of base saturation. The first transition year denied pH fluctuation but it was convincing lightly in *Yala* cropping period (Offord *et al.*, 2014). Some researchers found that slightly alkaline soil might be established in organic plots within this transition period (Maharjan *et al.*, 2017). Furthermore, soil pH changes may occur with different soil activities such as nutrient accumulation, N fixation, litter chemical compositions and simulation of mineral weathering etc. Soil type and weathering can predict the number of base cations such as Ca, Mg, K and Na which are able to cause soil alkalinity as well (Miller, 2016).

Microbial biomass carbon

MBC is one of the major biological properties which helps indicate microbial activity in the soil. MBC level of conventional input system decreased gradually with the time from 998.37 to 671.60 mg kg^{-1}. MBC level of organic system reached up to 799.76 mg kg^{-1} at its harvest stage from 525.72 mg kg^{-1} and at 50% heading stage, from 539.80 to 916.76 mg kg^{-1} (Figure 2).

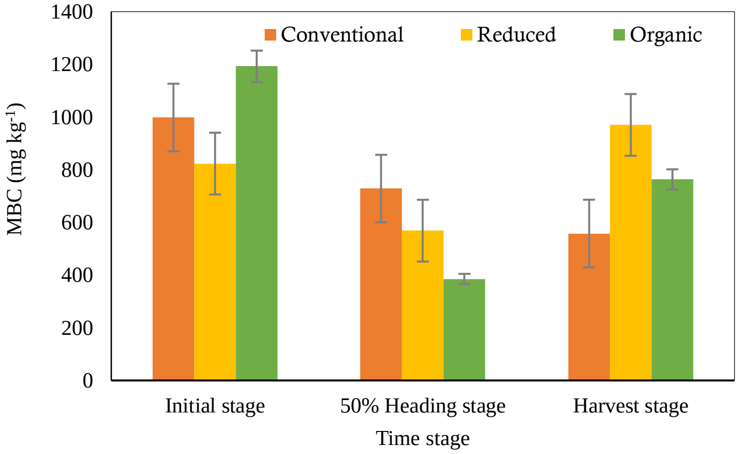

Figure 2: Distribution of input system × time stage interaction effect on MBC.

Many researchers found that MBC fluctuates significantly among soils with different fertilizer treatments, soil layers, and sampling seasons (Ge *et al.*, 2010; Nakhro and Dkhar, 2010). Also, they discovered the highest MBC values at seedling and ripening stages, but when it comes to heading stage MBC seem reducing (Ge *et al.*, 2010). An alternative pattern was obvious with our organic and reduced input systems. But, in conventional input system, MBC got significantly (P<0.05) decreased from the initial stage to the next stages. Higher MBC at the initial stage might be influenced by nutrient availability of soil due to previous applications of fertilizers, decomposed crop residues which stimulate nutrient absorption of microorganisms; consequently, it gives higher MBC. However, at the 50% heading stage, availability of nutrients for microbial activities get lower due to regular plant uptake within the cropping period. Furthermore, MBC may be lower with the influence of higher soil temperature and water content. Usually, MBC again gets higher at the harvest stage as a reflection of increased nutrient storage by microorganisms. It was coinciding with a high amount of plant residues and root secretions (Ge *et al.*, 2010).

Researchers have found that the treatment effect of inputs revealed significance. It reflects a higher MBC in organically treated plots (Nakhro and Dkhar, 2010). According to the outcome of some researchers, 10-26% increase in MBC occurred under organic management. There is a positive correlation between organic matter and MBC because organic materials are good substrates for microbial activity (Bargali *et al.*, 2018; Prommer *et al.*, 2020) as well as organic C stimulates microbial activity within the soil. Though organic input system should show drastically difference in MBC, with our findings, it is disputable. Still there is a plus point with organic management compared to the conventional system. A major influence for this situation is still the field at its first transition year. Researchers have optimized that there are very fewer changes in MBC in the first transition year and it may be affected by low OM and depletion of nutrients within the soil (Perera and Weerasinghe, 2014).

Dropdown of MBC at 50% heading stage of the reduced system is obvious because the plant takes most of the nutrients and microbial pool may lack nutrients at this time. End of the cropping season, plant uptake gets reduced and microbial pools get available nutrients through one-half of inorganic fertilizers in this system may have influenced increment of MBC at the harvest stage. MBC also differently fluctuate though it is not transparently evident within its first transition year.

Ammonium nitrogen

Organic forms of N are probably resistant to change and inaccessible to plant uptake. Ammonium N is also unavailable to plants unless it has gone through the nitrification process (Beegle, 2005). If the land was treated with any legume crop, manure application, or remained crop residual prior to the season perhaps the field may express greater ammonium N initially. Conventional system optimized the significantly (*P*<0.05) highest value of ammonium N about 108.07 mg kg^{-1} at 50% heading stage whilst other input systems remained in low levels of ammonium N (Figure 3).

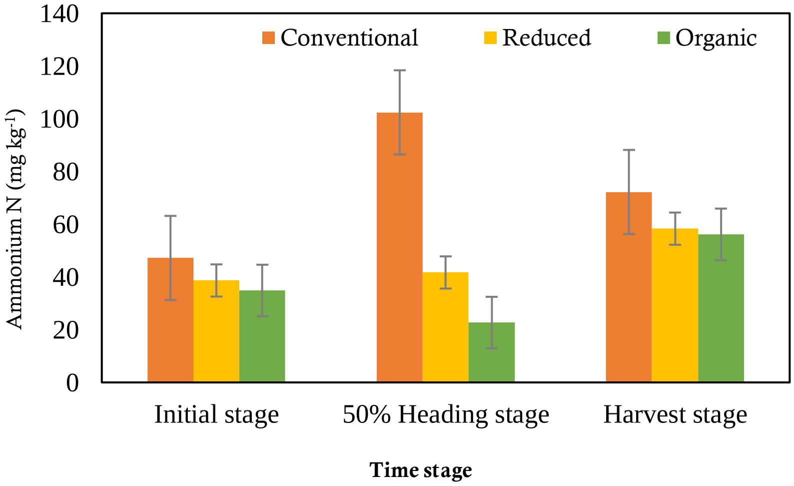

Figure 3: Distribution of input system × time stage interaction effect on ammonium N.

Low ammonium N compared to nitrate N may affect low OM in loamy sand texture (Hofman and Cleemput, 2004). As chemical fertilizers are easily released into available forms, conventional input system showed the highest value at 50% heading stage (Figure 3). Hence, incorporated OM takes time to decompose and release nutrients into the soil (Ayilara *et al.,* 2020); ammonium N levels of both reduced and organic input systems failed to fluctuate significantly. However, the conventional system showed the highest value while organic showed the lowest at the harvest stage (Figure 3) with the similar reason mentioned above (Perera and Weerasinghe, 2014). Another point is rice completes two-third of the N requirement after the heading stage; therefore, the conventional system may have excessed nutrients after plant uptake while all the available nutrient of the organic system released used by plants, weeds, and microbes (Yoshida, 1981; Bender *et al.*, 2013). Thus, OM application increases mineralization. There is a possibility to reduce mineralization if the OM decomposition rate was above the average (Yamamuro, 1983).

Nitrate nitrogen

Nitrate N occurs with the nitrification process and it is readily accessible to plants and easily leached through the soil profile (Krell, 2020). Altogether, nitrate N status in our field was quite higher than ammonium N (Table 1). Initially, all three input systems contained low levels of nitrate N around 50-70 mg kg^{-1}. However, at the 50% heading stage, the conventional system held a greater amount of nitrate N (125.71 mg kg^{-1}) than the reduced (91.33 mg kg^{-1}) and organic systems (72.56 mg kg^{-1}). It is contrasted that the organic input system recorded significantly ($P<0.05$) greater amount of nitrate N at the harvest stage around 144.16 mg kg^{-1} (Figure 4).

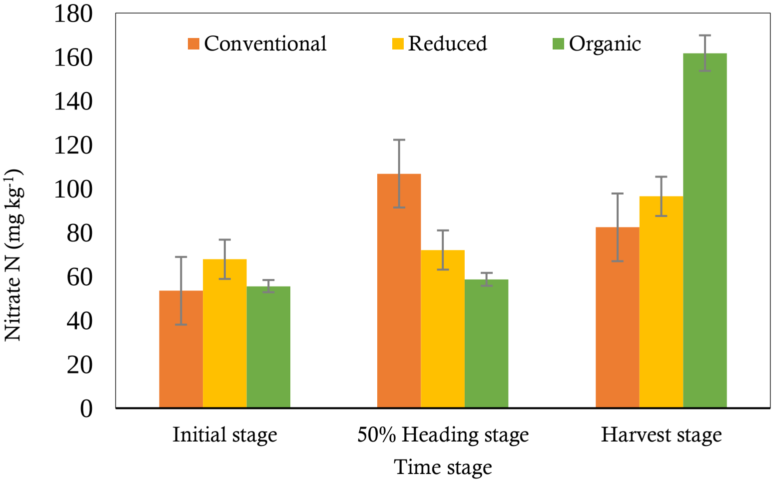

Figure 4: Distribution of input system × time stage interaction effect on nitrate N.

Continuous fertilizer application and nitrification might be the reasons for significant increment of nitrate N from the initial stage. The reduced system incorporated with both inorganic and organic fertilizers. It gained one half in readily available forms and the half in a form of inaccessible. However, the latter must be decomposed to make it available. With regard to the values, it may contain somewhat lower nitrate N compared to the conventional system. A low rate of nitrification due to more binding sites for ammonium N of the organic system may affect low nitrate N at the initial and heading stages (Krell, 2020).

In another point of view, plant uptake also may cause to lowering the nitrate N content. But at the harvest stage, this has significantly (P<0.05) increased. Decomposing organic manure lowers negative binding sites to ammonium N and it may accelerate the nitrification process. Some research findings proved that compost or organic manure application also causes to increment in nitrification (Yamamuro, 1983). Lesser plant uptake after heading to harvest stage might affect the higher nitrate N at the harvest stage.

Available phosphorous

Previous research conducted in the field area revealed 24 - 62 mg kg^{-1} available P (Vidyarathna *et al.*, 2008). Altogether available P varied in low range, initially it fluctuates around 2-4 mg kg^{-1} without any significant difference at $P \leq 0.05$ among input systems (Figure 5). However, organic input system exhibited significantly a highest available phosphorous, while conventional and reduced systems do not express any significant difference at $P \leq 0.05$. Available P shows gradual increase from 2.25, 11.6 and 15.1 mg kg-1 correspondingly for initial, 50% heading, and harvest stages (Figure 5).

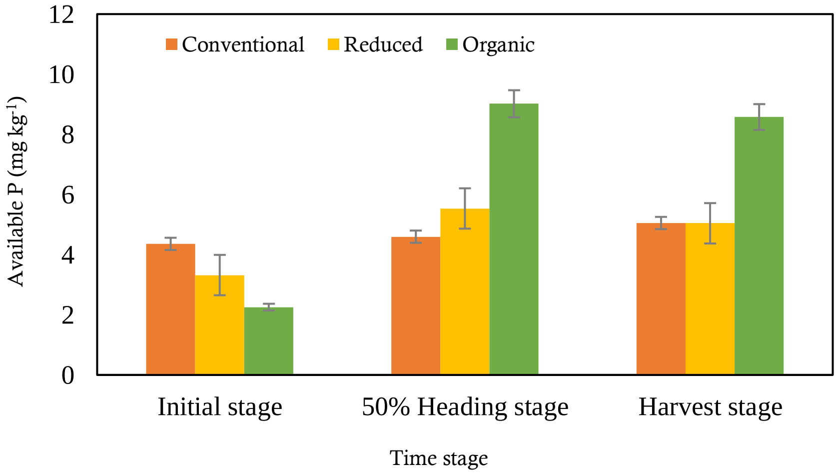

Figure 5: Distribution of input system × time stage interaction effect on available P.

With the factors such as fertilizer application, different soil reactions, microbial activity, soil aeration and temperature available P fluctuates differently among different input systems. The influence of soil pH on available P is another major point in soil fertility. Soil alkalinity may cause a quick reaction of calcium and magnesium with phosphate ions and the formation of less soluble compounds

(Nascimento *et al.*, 2018). Slightly alkaline soil pH at field may cause experiment of medium phosphate fixation rate. Significantly (P<0.05) higher values with organic input system might be influenced by less nutrient uptake after 50% heading stage and with the increasing decomposition rate of organic manure with the time.

Rice yield

We measured different rice yield parameters and final grain yield. But only the number of grains per panicle and 1,000 grain weight showed significant (P<0.05) differences among input systems. The conventional system expressed the highest values with both parameters. However, the final yield was not significantly (P≤0.05) different among the input systems tested (Table 3). However, conventional, and reduced systems produced more or less similar final yields as 4.9 and 4.7 ton ha^{-1} correspondingly, while 2.7 ton ha^{-1} final yield produced by organic input system (Figure 6).

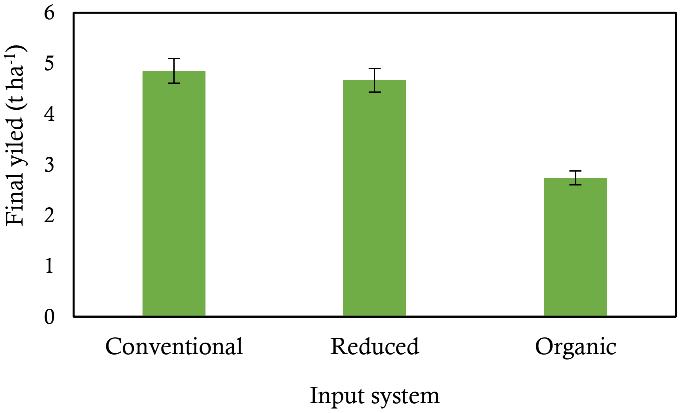

Figure 6: Variation of final yield (t ha^{-1}) at 14% moisture with three input systems.

Bg300 rice variety is a 3-month variety which has 6.5 t ha^{-1} yield potential. The expected rice yield in major irrigation, minor irrigation, and rainfed are 3.90, 3.03 and 2.55 t ha^{-1}, respectively, due to low rainfall in *Yala* season (Dhanapala, 2000). Productivity and final grain yield of the rice plant are greatly affected by number of productive tillers, panicles m^{-2}, number of grains per panicle, and weight of 1000 grains, also, the well-grown plants have a greater number of productive tillers and long panicles. Such plants can utilize sunlight for photosynthesis optimally and are able to absorb nutrients more efficiently. Both abilities increase plant growth and yield (Yoshida, 1981). As per the present findings, the highest number of grains per panicle was recorded from the conventional input system (Figure 7).

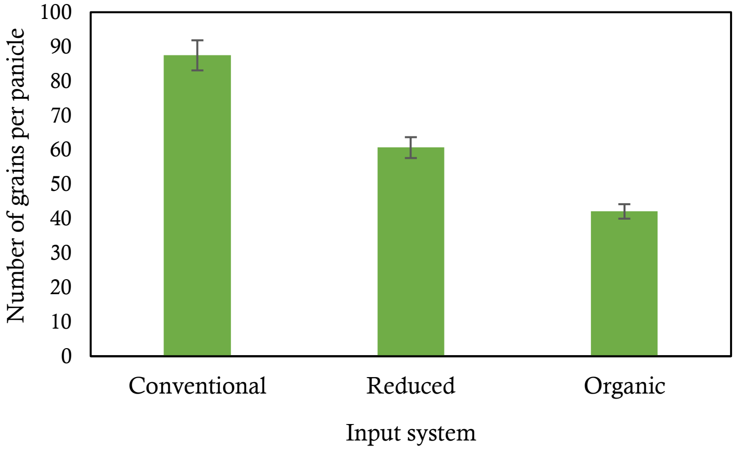

Figure 7: Variation of number of grains per panicle with input systems.

In general, nitrogen is the most critical nutrient to all crops and in rice, it helps to increase plant height, tillering, panicles, yield (Fageria, 2014), No. of spikelet per panicle, and percentage of filled spikelet (Dobermann and Fairhurst, 2000). Nitrogen requirement before heading is high, compared to the ripening stage (Yoshida, 1981). When it comes to the heading stage, the organic field lacked ammonium nitrogen and nitrate nitrogen. Though the availability of nutrients at early growth stages is critical, applied organic manure into the soil gets time to decompose and release the nutrients to plant uptake. Since this season is still under the first transition year, it causes a lower accumulation of decomposed organic materials within the soil. Conventional input system supplied with readily available forms of nutrients, so plants can get nutrients at the appropriate time. And the slightly alkaline pH also caused to low availability of soil phosphorous and medium availability of nitrogen to plants.

Organic input system records significantly low 1,000 grain weight compared to conventional and reduced systems (Figure 8). The significant ($P<0.05$) difference that occurred within the number of grains per panicle may influence grain yield because the organic input system carried a smaller number of grains per panicle compared to other input systems.

Final grain yield at 14% moisture did not vary with three input systems. Reduced input system and conventional input system produced no significantly ($P<0.05$) different final grain yields. Therefore, it is obvious that replacing 50% of the DOA recommendation with organic inputs may not harm the final yield. Previous economic calculations for rice crops also expressed that IPNM fertilization is more economical for farmers (Gaind, 2015). It has proven into other varieties of rice; even BG 352 produced similar yields in IPNM and 100% DOA fertilizers for lowland rice in Anuradhapura district. The study concluded as 50% of expenditure on imported inorganic fertilizers can be saved by adopting into IPNM (Dissanayake *et al.*, 2015). Some researchers have found 5-7.5 t ha^{-1} cow dung compost has had a better influence on the growth and production of rice. One ton ha^{-1} of cow dung application has potential to increase the grain yield by 0.097 t ha^{-1} with the equation $Y = 0.097x + 4.17$ ($r = 0.969$) (Atman *et al.*, 2018).

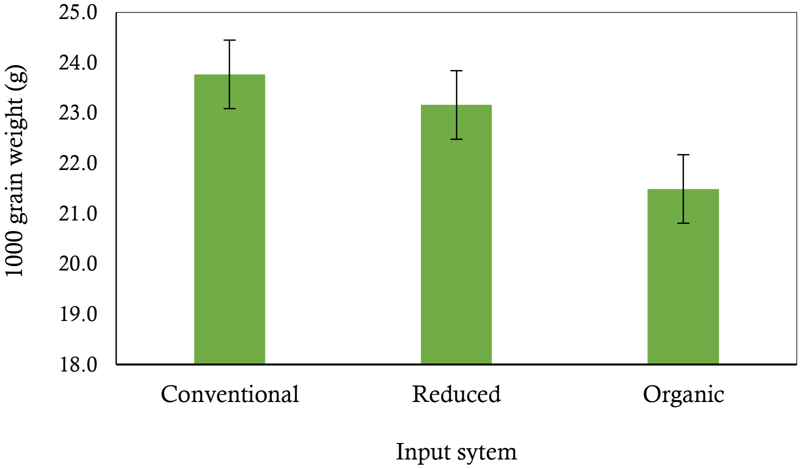

Figure 8: Variation of 1000 grain weight (g) with input systems.

Thus, in *Yala* season in 2019, the second season of the first transition year, observing lower grain yield in the organic input system was obvious (Table 3). Usually, the land needs two to three years to be recognized as an organic land. It takes more than two years of period to stabilize rice productivity within the organic input system. Further, it needs time to develop soil fertility once it has built after a while with continuous use of organic nutrient sources that release nutrients to the plant and accumulate nutrients in a balanced way for a longer period (Surekha *et al.*, 2013). Some researchers have found that 5 y of transition period is also not enough to give that optimal rice yield with conventional, organic, and environmentally friendly systems (Du *et al.*, 2014). Research results of a field experiment conducted in Japan from 2004 to 2008 observed 4.35, 4.43 and 3.37 t ha^{-1} final rice yields in conventional, environmentally friendly and organic, respectively (Hokazono and Hayashi, 2012).

First transition year may affect lower yield of rice in organic system while reduced system equally performs as does the conventional system. Therefore, it might be an alternative approach to the problems arose with inorganic fertilizers.

CONCLUSIONS

Paddy soil needs time to build up desirable soil properties with organic manure application. Nitrate N and available P were significantly increased at the organic input system from its first transition year. Conventional (100% DOA) and reduced (50% DOA + 50% organic manure) input systems produced final yields for the rice crop which is not significantly different from each other. Therefore, it is recommended to replace 50% inorganic chemical fertilizers with organic manure for rice crop under submerged conditions without many consequences.

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REFERENCES

Anderson, J. and Ingram, J. (1994). Tropical Soil Biology and Fertility: A Handbook of Methods. Soil Science*,* 157-265.

Atman, B.B. and.Indrasti, R. (2018). Effect of Cow Manure Dosages as Organic Fertilizer on the Productivity of Organic Rice in West Sumatra, Indonesia. Int. J. Environ. Agric. Biotech., 3: 506-511.

Ayilara, M.S., Olanrewaju, O.S., Babalola, O.O. and Odeyemi, O. (2020). Waste management through composting: Challenges and potentials. Sustainability, 12: 44-56.

Bargali, K.M.V., Padalia, K., Bargali, S.S. and Upadhyay, V.P. (2018). Effect of vegetation type and season on microbial biomass carbon in Central Himalayan forest soils, India. CATENA*,* 171: 125-135.

Beegle, D. (2005). Nitrogen fertilization of corn [Online]. Pennsylvania State University. [Accessed 02.05.2020].

Bender, R.R., Haegele, J.W., Ruffo, M.L. and Below, F.E. (2013). Nutrient uptake, partitioning, and remobilization in modern, transgenic insect-protected maize hybrids. J. Agron., 105: 161-169.

Black, C.A. (1965). Methods of soil analysis: Part I Physical and mineralogical properties. American Society of Agronomy, Madison, Wisconsin*,* 09.

Bremner, J.M. and Muloaney, C.S. (1982). *In methods of soil analysis*, American society of Agronomy,Madison, WI, USA.

Chapman, H.D. (1965). Cation exchange capacity, In: Black, C.A. (Ed.), Methods of soil analysis*.* American Society of Agronomy, Madison.

Casagrande, M., Peigné, J., Payet, V., Mäder, P., Sans, F., Blanco-Moreno, J., Antichi, D., Bàrberi, P., Beeckman, A., Bigongiali, F., Cooper, J., Dierauer, H., Gascoyne, K., Grosse, M., Heß, J., Kranzler, A., Luik, A., Peetsmann, E., Surböck, A. and David, C. (2015). Organic farmers' motivations and challenges for adopting conservation agriculture in Europe. Organic Agriculture*,* 6: 281-295.

Dhanapala, M.P. (2000). Bridging the rice gap in Sri Lanka. *In:* Papademetriou, M.K., Dent, F.J. and Herath, E.M. (Ed.), Bridging the rice yield gap in the Asia-Pacific region. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok, Thailand.

Dissanayake, D.M., Premaratne, K.P. and Sangakkara, U.R. (2015). Integrated nutrient management for lowland rice (*Oryza sativa* L.) in the Anuradhapura district of Sri Lanka. Trop. Agric. R.*,* 25(2): 266-271.

Dobermann, A. and Fairhurst, T. (2000). Rice: Nutrient disorders and nutrient management, Los Baños, Philippines, Potash and Phosphate Institute, Potash and Phosphate Institute of Canada, & International Rice Research Institute.

Du, Z., Xie, Y., Hu, L., Hu, L., Xu, S., Li, D., Wang, G. and Fu, J. (2014). Effects of fertilization and clipping on carbon, nitrogen storage, and soil microbial activity in a natural grassland in Southern China. Plos One, 9(6): e99385.

Fageria, N.K. (2014). Nitrogen management in crop production. Boca Raton, FL: CRC Press.

Gaind, S. (2015). Effect of organic farming on quality of soil under rice cultivation. J. Agroecol. Nat. Resour*.,* 2: 391-393.

Ge, G., Li, Z., Fan, F., Chu, G., Hou, Z. and Liang, Y. (2010). Soil biological activity and their seasonal variations in response to long-term application of organic and inorganic fertilizers. Plant and Soil*,* 326: 31-44.

Hokazono, S. and Hayashi, K. (2012). Variability in environmental impacts during conversion from conventional to organic farming: a comparison among three rice production systems in Japan. J. Clean. Prod.*,* 28: 101-112.

Jackson, M.L. (1958). *Soil chemical analysis*, Prentice-Hall Inc., Englewood.

Jayasinghe-Mudalige, U. (2010). Role of food and agriculture sector in economic development of Sri Lanka: Do we stand right in the process of structural transformation? J. Food. Agri., 1: 1-12.

Krell, J. (2020). Sidedress timing and uptake in corn [Online]. LG Seeds Agronomy Department. Available: https://www.lgseeds.com/agronomy/corn/nitrogen-application-and-uptake-in-corn [Accessed 14.10.2020].

Maharjan, B., Chaulagain, A., Sapkota, P., Gauchan, D.P. and Lamichanne, J. (2017). Soil properties during transition from conventional to organic farming system in kavre district, Nepal J. Eng. Sci. Technol., 13**:** 76-84.

Markus, D. K., Mckinnon, J.P. and Buccafuri, A.F. (1985). Automated analysis of nitrite, nitrate, and ammonium nitrogen in soils. Soil Sci. Soc. Am. J., 49: 1208-1215.

Meena, R.P., Meena, H.P. and Meena, R.S. (2013). Organic farming: Concepts and components. Popular Kheti*,* 1: 5-14.

Nakhro, N. and Dkhar, M.S. (2010). Impact of organic and inorganic fertilizers on microbial populations and biomass carbon in paddy field soil. J. Agron., 9: 102-110.

Nascimento, C.A.C.D., Pagliari, P.H., Faria, L.D.A. and Vitti, G.C. (2018). Phosphorus mobility and behavior in soils treated with calcium, ammonium, and magnesium phosphates. Soil. Sci.Soc. Am. J., 82: 622-631.

Offord, C.A., Meagher, P.F. and Zimmer, H.C. (2014). Growing up or growing out? How soil pH and light affect seedling growth of a relictual rainforest tree. AoB PLANTS, 6: plu011.

Perera, K.T.G.K. and Weerasinghe, T.K. (2014). A study on the corn cultivation (*Zea mays* (L.) family-Poaceae) on the properties of soil. Int. J. Sci. Res., 4: 1-5.

Prommer, J., Walker, T.W.N., Wanek, W., Braun, J., Zezula, D., Hu, Y., Hofhansl, F. and Andreas, R. (2020). Increased microbial growth, biomass, and turnover drive soil organic carbon accumulation at higher plant diversity. Global Change Biology*,* 26: 669-681.

Ranasinghe, H. (2017). Organic agriculture as a sustainable solution to chronic kidney disease unidentified (CKDu). Int. J. Multidiscip. S., 3(2): 71-77.

Rosemary, F., Vitharana, U.W.A., Indraratne, S.P., Weerasooriya, R. and Mishra, U. (2017). Exploring the spatial variability of soil properties in an Alfisol soil catena. Catena*,* 150: 53-61.

Rowell, D. L. (1994). Soil science: Methods and applications, Longman Scientific and Technical, Longman Group UK Ltd.

Sanjeevani, U.K.P.S., Indraratne, S.P., Weerasooriya, S.V.R. and Vitharana, W.A.U. 2015. Characterization of an Alfisol collected from dry zone of Sri Lanka to elucidate the retention mechanisms of pollutants. Tropical Agric. Res.*,* 24: 258-269.

Sheldric, B.H. and C. Wang (Ed.) (1993). Particle size analysis: Lewis Publishers, Boca Raton.

Smith, K.A. and Mullins, C.E. (1991). Oil and environmental analysis physical methods, Marcel Dekker, New York.

Surekha, K., Rao, K.V., Rani, N.S., Latha, P.C. and Kumar, R.M. (2013). Evaluation of Organic and conventional rice production systems for their productivity, profitability, grain quality and soil health. Agrotechnology, 11: 1-6. Doi: 10.4172/2168-9881.1000S11-006

Vidyarathna, D. D., Duminda, D. M. S., Amarasekara, M. G. T. S. andJinadasa, D. M. (2008). Characterization of some of soil fertility parameters along an undulating terrain of Reddish Brown Earth and Low Humic Gley soils. Research and Publications, The digital Repository, Rajarata University of Sri Lanka.

Watanabe, F.S. and Olsen, S.R. (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from the Soil. Soil. Sci. Soc. Am. J., 29: 677-678.

Wickramasinghe, W.M.D.M., Devasinghe, D.A.U.D., Dissanayake, D.M.D., Benaragama, D.I.D.S., Egodawatta, W.C.P. and Suriyagoda, L.D.B. (2021). Growth physiology and crop yields of direct seeded rice under diverse input systems in the dry zone of Sri Lanka. Trop. Agric. R., 32: 325-337.

Yamamuro, S. (1983). Nitrogen cycle in paddy fields. JARQ*,* 17**:** 106-111.

Yoshida, S. (1981). Fundamentals of Rice Crop Science, International Rice Research Institute, Los Baños. Laguna.