GROWTH, PHYSIOLOGY, AND WEED ABUNDANCE IN RICE (*Oryza sativa* L.) UNDER DIVERSE INPUT SYSTEMS IN THE DRY ZONE OF SRI LANKA

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INTRODUCTION

Rice is the single most significant crop which occupied 0.9 million hectares of the total cultivated area in Sri Lanka in 2018 (DOA, 2018). The dry zone is the major rice growing region in Sri Lanka and rice cultivation is mostly carried out through conventional agricultural practices. In conventional agricultural practices, inorganic inputs are applied to the crop to maintain productivity. The problem of using high doses of inorganic fertilizer and increasing the cost of inorganic fertilizers are factors considered harmful to the sustainability of the production systems (Adhikari, 2011). Chronic kidney disease (CKD) has dramatically increased over the past 15 years affecting the low socioeconomic level farming community in the North- central province and CKD is hypothesized to be caused by the high use of inorganic fertilizers (Nanayakkara and Upul, 2012). Therefore, this research was conducted to promote organic and integrated nutrient management systems to overcome the problems caused by conventional farming. The main objectives of this research are to compare plant growth, physiological and yield parameters in organic, integrated and conventional input systems and to understand the effect of these different input systems on weed abundance and weed competition in rice during the *Yala* season of the first year of transition.

MATERIALS AND METHODS

A field experiment was carried out during 2019 *Yala* season at the Research Unit of the Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura (located at 8o 22’14.84” N and 80o 25’13.66” E). This area belongs to the agro- ecological zone of the Low country Dry Zone (DL1b) (Thenabadu, 1988). The mean annual rainfall of this area varies from 1250 to 1750 mm while the average temperature ranges between 25 to 30 oC.

Experimental Design and Treatments

The experimental design was Randomized Complete Block Design (RCBD) and six (6) replicates were used for each treatment combination. The tested rice variety was Bg 300. Three treatments were based on the following three input systems: T1- conventional input system (100% N supplied by an inorganic fertilizer application based on the recommendation of the Department of Agriculture), T2- integrated system (50% N supplied by inorganic fertilizer and 25% N supplied by organic fertilizer application), and T3- organic system. The nitrogen content of organic fertilizer was previously calculated to determine the relevant rate to get the required nitrogen content and this enabled the management of soil fertility. The input systems were defined based on the elemental N supply and the sources (Table 1). The phosphorus and potassium rates were not standardized. The amount of these two elements were dependent on the quality of materials used to supply N.

Table 1. Input systems and their respective nutrient contents

Input system	Mineral nutrient (kg/ha)	Nutrients from alternative sources (kg/ha)
Conventional	N – 103.5 (Urea 46%)	N – 0

	P – 3.9 (P_2O_5 43.7%)	P – 0
	K – 30.0 (K_2O 60%)	K - 0
Integrated	N – 51.8 (Urea 46%)	N – 25.9
	P – 1.9 (P_2O_5 43.7%)	P – 0.65
	K – 15.0 (K_2O 60%)	K – 52.5

Insects, Pest and Disease Management

Carbosulfan 200g L-1 SC was added to the field to control pests such as paddy bugs, brown plant hoppers and thrips in the conventional and integrated systems. Neemzal which is a neem (*Azadirecta indica* L.) based commercial organic pesticide was applied to the organic system.

Weed Management

Weed management of conventional and integrated plots was carried out by applying synthetic herbicide Sofit (Pretilachlor+safener) which is a pre-emergence herbicide. MCPA (2-methyl-4-chlorophenoxyacetic acid) was added 20 days after seeding. Weed management of organic system was carried out by using water management methods.

Data Collection

Plant growth was measured at 20-day intervals at the seedling, panicle initiation, 50% heading and harvesting stages. Physiological parameters were taken at the panicle initiation and 50% heading stages. Grain yield was measured at crop maturity 90 days after the establishment (harvesting stage). The number of weeds per unit area was counted using the 50x50cm quadrate at the seedling stage without uprooting the plants (Nkoa *et al.*, 2015). Weeds from four different locations of a single plot were selected, uprooted with the quadrate and the count pertaining to the categories of broad leaves, sedges and grasses was taken at the 50% heading and maturity stages. The biomass of weed was measured at 50% heading and maturity stages.

Data Analysis

All the parameters were analyzed using ANOVA mixed procedure in SAS. Means were separated using LSD mean at P = 0.05.

RESULTS AND DISCUSSION

Physiological parameters

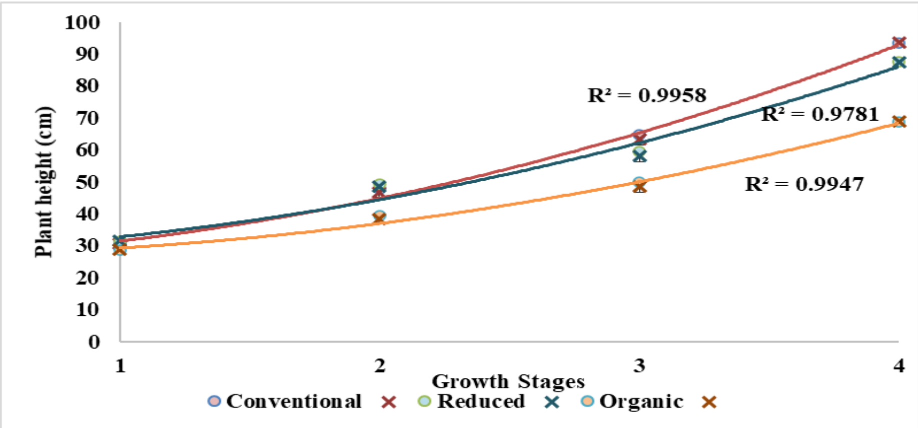
Plant physiological parameters such as leaf chlorophyll content and photosynthesis rate were almost similar and higher in the conventional and integrated systems than in the organic system at all stages mainly because an adequate supply of nutrients was provided to the conventional and integrated systems through inorganic fertilizer (Table 1).

Table 2. Effect of three input systems on leaf chlorophyll content (SPAD value), stomatal conductance to water vapor, leaf temperature, photosynthetic rate, light interception and electrolyte leakage

	Leaf chlorophyll content (SPAD value)	Photosynthesis rate (*u*mol $CO_2/m^2/s$)	Light interception (µmol/ m^2/s)	Electrolyte leakage

	Panicle initiation stage (40DAS)	50% heading stage (60DAS)	Panicle initiation stage (40DAS)	50% heading stage (60DAS)	50% heading stage (60DAS)	Panicle initiation stage (40DAS)
Conventional	36.29[a]	36.24[a]	24.91[a]	14.44[a]	93.02[a]	0.76[b]
Integrated	31.21[b]	32.84[b]	19.07[b]	11.18[b]	97.13[a]	0.97[b]
Organic	25.84[c]	26.98[c]	12.90[c]	7.49[c]	68.05[a]	7.34[a]
Standard Error	1.03	1.40	2.40	1.28	10.33	0.74
Significant (P value)	<.0001	<.0001	0.0003	0.0002	0.14	<.0001

Growth parameters
At seedling stage, crop growth of the input systems did not show a notable difference indicating the less reliance on soil fertility and the reliance on the nutrients stored inside the seeds for growth. However, a higher rate of differences was observed in growth parameters after the seedling stage where conventional and integrated systems showed great plant growth compared to that of the organic system.



1 – seedling stage, **2** – panicle initiation stage, **3** – 50% heading stage, **4** – harvesting stage

Figure 1. Differences in plant height among three input systems at seedling, panicle initiation, 50% heading and harvesting stages

Weed Parameters
There was a significant difference in weed density between the three input systems at seedling, 50% heading and harvesting stages. At all three stages, the organic system had the highest weed density and no significant difference was observed between the integrated and conventional systems (Table 3). It is because no pre-emergent herbicide was applied to the organic system while it was applied to both integrated and conventional systems.

Table 3. Effect of three input systems on weed density

	Weed density (Number of weeds /m^2)

	Seedling Stage (20DAS)	50% heading stage (60DAS)	Harvesting stage (90DAS)
Conventional	160.83[b]	14.67[b]	6.83[b]
Integrated	236.83[b]	30.83[b]	39.17[b]
Organic	2225[a]	158.33[a]	536.33[a]
Standard Error	136.78	6.59	45.81
Significant (P value)	<.0001	<.0001	<.0001

Yield parameters

There was no significant difference in the number of panicles/m2. Regarding the number of spikelets/panicles and the number of filled spikelets/panicles, the conventional system had the highest value, the organic system had the lowest value, and the integrated system had a value in between. Nitrogen deficiency could be the main reason for the low number of filled grains in the organic system. No difference was observed in final grain yield (at 14% moisture) between the conventional and the integrated systems while the organic system had the lowest value. This might be due to the contribution of inorganic fertilizers in the integrated and conventional systems and also due to the high weed density in the organic system compared to the integrated and conventional systems, which positively influenced all the yield contributing factors of the rice plant.

Table 4. Effect of three input systems on yield parameters

	Number of panicles/m2	Filled grain percentage/ panicle	Final grain yield at 14% moisture (tonnes/ha)	Biological yield (tons/ha)	Harvest index
Conventional	261.67[a]	80.4388[b]	4.8519[a]	10.4983[a]	0.4666[a]
Integrated	325.68[a]	83.6165[ab]	4.6661[a]	11.7056[a]	0.3985[b]
Organic	308.67[a]	85.2028[a]	2.7393[b]	6.7679[b]	0.4056[b]
Standard Error	25.39	2.2196	0.3944	1.0102	0.0174
Significant (P-value)	0.22	0.0354	0.0006	0.0009	0.0294

CONCLUSIONS

Overall results indicate that reducing inorganic fertilizer by 50% with a combination of organic manure as in the integrated system gives a grain yield similar to the conventional system of a new improved variety like Bg 300 in a high potential area like Anuradhapura. Also, organic systems can show low crop growth and yield due to the inadequate nutrient supply provided by organic materials and the high weed density during the first year of transition. Therefore, further studies are needed to determine a sustainable organic material that can adequately supply the nutrients required in precise quantities. Moreover, further studies are needed to identify different problems that occur in organic rice cultivation and to ensure the sustainability of the integrated (reduced) nutrient management system.

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