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Short Communication

Integrated Nutrient Management for Lowland Rice (*Oryza sativa* L.) in the Anuradhapura District of Sri Lanka

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ABSTRACT: *The impact of integration of inorganic fertilizer and organic manures on yield of rice (Oryza sativa L.) was evaluated under field conditions over two seasons. The experiment was laid out in a split-plot design with three replicates. The main plots were two rice varieties namely, Kaluheenati and Bg 352, and the sub-plots consisted of five fertilizer/manure combinations viz. T1 – control (without fertilizer and organic manure), T2 – 100% of fertilizer recommendation of the Department of Agriculture (DOA), T3 – 50% of fertilizer recommendation of the DOA, T4 – organic manure alone, T5 – 50% of fertilizer recommendation of the DOA + T4. The variety effect, fertilizer/manure combination effect and interaction effect of variety and fertilizer/manure combination on yield were significant (p<0.05). In Kaluheenati, organic manure (T4) was the most suitable for higher yield. The variety Bg 352 responded positively to organic manures in combination with inorganic fertilizers, which illustrates the possibility of substituting a part of inorganic fertilizers with organic manures (T5) saving 130, 43 and 37 kg urea, Triple Super Phosphate and Muriate of Potash/ha, respectively.*

Keywords: *Inorganic fertilizer, integrated nutrient management, organic manures, rice varieties*

INTRODUCTION

The use of inorganic fertilizer in rice cultivations of Sri Lanka has been progressively increasing since its introduction. Fertilizer use in paddy cultivation increased from 149,700 to 292,600 tonnes during the period of 1999-2008 (Misra, 2011). The state expenditure on the fertilizer subsidy program in 2009 was Rs. 26.935 billion, which was about 2.24 % of total government expenditure (Weerahewa *et al*., 2010). However, available reports indicate that the repeated use of inorganic fertilizer alone fails to sustain desired yield, impairs soil physical conditions and reduces organic matter contents (Mohammad, 2010) leads to environmental pollution especially due to their continuous use (Bhakiyathu, 2005).

Expenditure for inorganic fertilizer is high and thus, identifying appropriate and economically feasible approaches, which are environmentally friendly and healthy, is imperative. Integrated nutrient management seems to be a suitable approach to achieve these goals. The drawbacks associated with inorganic sources of plant nutrients are often overcome when they are used in judicious combinations with organic manures. When used in combination, interactions occur and the yield increase is always more than that from the use of equivalent quantities of these nutrient sources alone (Wickramasinghe & Wijewardena, 2003). Hence, this study investigated the effect of integrating rice straw, green manure (*Gliricidia sepium* leaves) and Eppawala rock phosphate (ERP) and a Gliricidia leaf extract with inorganic fertilizers on yield of traditional (*Kaluheenati*) and new-improved (Bg 352) rice varieties in the Anuradhapura district of Sri Lanka.

MATERIALS AND METHODS

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The experiment was conducted in the rice fields of the Faculty of Agriculture, Rajarata University of Sri Lanka at Puliyankulama in the Anuradhapura district covering two major cropping seasons namely, 2010/2011 *Maha* [wet season (WS)] and 2011 *Yala* [dry season (DS)]. The selected site was a conventional rice field, which was left fallowed over the previous four consecutive seasons. The soil of the experiment site belonged to the great soil group Low Humic Glay (LHG) (Order – Alfisols, Sub order – Aqualfs, Great group – Tropaqualfs) (Panabokke, 1996). The soil was clay loam in terms of texture with high clay and silt contents (Duminda *et al*., 2010).The mean seasonal temperatures were 29 ± 0.34 °C and 26 ± 1 °C for DS and WS, respectively, with an average maximum temperature of 33.5 ± 0.4 °C in DS and 30 ± 1.2 °C in WS. The quantity of rainfall received in DS and WS of this study were 38 mm and 1506 mm, respectively.

Crop establishment and management

Land was prepared by impounding water for two weeks after ploughing and harrowing followed by fine levelling with the help of a wooden leveller. Pre-germinated seeds were broadcast sown at a rate of 137.5 kg/ha on the puddled and levelled field.

Experimental design and treatments

The experiment was laid out in a split plot design with three replicates. The main plots were the two rice varieties, *i.e. Kaluheenati* and Bg 352 and five fertilizer combinations were used as subplots. The main and sub plot sizes were 20 m x 5 m and 4 m x 5 m, respectively. Plots were separated by two bunds (45 cm width and 30 cm height), with a drainage canal in between the two bunds to avoid cross contaminations of added fertilizers and manures. The subplot treatments were T_1: The control (without inorganic fertilizer and organic manure), T_2: NPK as inorganic fertilizer at levels recommended by the Department of Agriculture for 3 ½ month rice varieties (100% DOA), T_3: 50% of DOA recommendation, T_4: Organic manure alone [4 t/ha air-dried Rice straw + 6 t/ha Gliricidia leaves + 350 kg/ha Eppawala Rock Phosphate (ERP) + 600 litres/ha Gliricidia leaf extract (applied fortnightly)], and T_5: INM (50% of DOA + T_4).

Rice straw and Gliricidia leaves and ERP (28% P_2O_5) were incorporated after the first ploughing at two weeks before sowing as per treatments. The Gliricidia leaf extract was prepared by fermentation of 20 kg Gliricidia leaves in 150 litres of water. The extract was applied at a rate of 600 litres/ha, four times at fortnightly intervals over the vegetative period of the rice crop. The inorganic fertilizer was applied at a rate of 120 - 40 - 40 kg of N, P_2O_5 and K_2O/ha respectively, as recommended by the Department of Agriculture. All other management practices were done according to the recommendation of the Department of Agriculture, Sri Lanka (DOA, 2007).

Observation and measurements

Number of panicles/m^2 was counted at harvest using a 1 m × 1 m quadrat. The total number of spikelets and filled spikelets/panicle were determined at harvest by taking 30 random panicles from each plot. Grain and straw yields were obtained excluding the 45 cm borders in each sub plot. The final weight of grain and straw yield were measured after air drying and grain yield was corrected to 14 % moisture content. The harvest index (HI) was obtained from the ratio of grain yield to the grain + straw yield of each plot and expressed as a percentage.

The data were statistically analyzed to determine the significant difference of treatments. Analysis of variance was done using GLM (General Linear Model) procedure and means were separated using Least Square method (LS means).

RESULTS AND DISCUSSION

The interaction effects of variety and fertilizer/manure combinations on yield and harvest index (HI) were significant ($p<0.05$). The grain yield and HI of Bg 352 was significantly higher than that of *Kaluheenati*

(Table 1). The productivity of rice plant is greatly dependent on the panicles/m^2, percentage of filled spikelets/panicle and 1000 seed weight (Siavoshi *et al.,* 2011). In the present investigation, a significantly higher number of panicles/m^2 and filled spikelets/panicle, and thousand seed weight were observed in Bg 352 compared to those in *Kaluheenati.* This variation is due to the genetic characteristics of varieties and these may be the reasons for higher yield in Bg 352.

The seasonal effect on yield was significant ($p<0.05$) while it was not significant ($p>0.05$) in HI. The grain yield during DS (4.82 t/ha) was higher than that obtained during WS (3.64 t/ha) (Table 1). Higher productivity during the DS could be attributed to the higher amount of solar radiation received during the DS (Venkatewaralu & Vispears, 1987).

In both seasons, *Kaluheenati* (traditional variety) with 100 % DOA (T_2) recorded a lower grain yield than in other fertilizer/manure combinations showing low response for applied inorganic fertilizers. The impact of organic manure alone (T_4) and 50 % DOA (T_3) on grain yield was similar in both seasons. In contrast, Bg 352 (new-improved variety) performed differently due to its higher fertilizer responsiveness. Although, the highest yield was recorded in INM-treated plots (T_5), a similar yield was observed in 100% DOA (T_2) in both seasons. There were no differences in yields with organic manure alone (T_4) and 50 % DOA (T_3) in both seasons.

The HI of *Kaluheenati* in100 % DOA (T_2) was significantly lower ($p<0.05$) than that of organic manure alone (T_4) in both seasons. Impact of fertilizer/manure combination on HI of Bg 352 was not significant ($p>0.05$) in WS, but was significant in DS. The variety Bg 352 recorded the highest HI in INM (T_5) and it was statistically similar to those of 100 % DOA (T_2) control (T_1) in DS.

Table 1. Effect of fertilizer/manure combinations on yield and harvest index of variety *Kaluheenati* and Bg 352

Variety	Treatment	*Maha* 2010/2011 (WS)		*Yala* 2011 (DS)	
		GYD, t/ha	HI, %	GYD, t/ha	HI, %
V_1	T_1	2.02 a	37.0 a	3.62 a	40.6 bc
	T_2	3.18 b	35.9 a	4.15 ab	34.8 a
	T_3	3.57 c	40.4 bc	4.34 b	42.1 c
	T_4	3.44 bc	41.06 c	4.41 b	42.8 c
	T_5	3.72 c	39.2 b	4.60 b	36.6 ab
	Root MSE	0.19	2.1	0.32	2.7
	CV %	6.23	2.1	7.75	6.9
V_2	T_1	2.57 a	41.1 a	4.5 a	46.3 b
	T_2	5.10 c	44.6 a	6.09 c	46.5 b
	T_3	3.86 b	43.7 a	5.19 b	42.4 a
	T_4	3.61 b	42.5 a	4.89 b	43.6 a
	T_5	5.32 c	45.2 a	6.33 c	46.7 b
	Root MSE	0.23	1.5	0.24	1.5
	CV %	5.61	3.5	4.49	2.9

V_1 – *Kaluheenati*, V_2 – Bg 352, GYD – grain yield at 14 % moisture, HI – Harvest Index

Generally, the yield of INM (T_5) was higher than in the other treatments irrespective of season and variety. The high yield of INM (T_5) was due to green manures and rice straw, which improves nutrient availability and retention (Hasanuzzaman *et al*., 2010; Mandal *et al*., 2004).

The low yield observed in plots treated with 100% DOA (T_2) in *Kaluheenati* was attributable to severe lodging at early reproductive growth stages due to higher plant height boosted by inorganic fertilizers, resulting in a lower HI. The yield reduction was also caused by the reduction of filled spikelet percentage (Siavoshi *et al.,* 2011). A yield reduction was also evident by the lower correlation coefficients between filled spikelet percentage and grain yield. Lower yield of Bg 352 in 100 % DOA (T_2) than that of INM (T_5) was a special observation made in this study, which might be due to additional supply of micronutrients by the applied organic manures.

Organic manure alone (T_4) produced a significantly lower ($p<0.05$) yield of Bg 352 than that with 100 % DOA (T_2). This might be due to the fact that new-improved varieties were bred for high fertilizer response and when the nutrients supply is inadequate, a significant yield reduction may be possible.

There was a general trend of similar yields in 50% DOA (T_3) and organic manure alone (T_4). This observation confirmed that 50 % of inorganic fertilizer can be substituted by above combination of organic manures.

CONCLUSION

The suitable fertilizers/manure combination for *Kaluheenat*i was organic manure alone. The new-improved variety Bg 352 produced similar yields in INM (T_5) and 100% DOA (T_2) in both seasons. Positive responses of to INM (T_5) illustrates the possibility of substituting part of inorganic fertilizers with organic manures such as straw and Gliricidia leaves, rock phosphate and Gliricidia leaf extract, thereby saving 130, 43 and 37 kg Urea, TSP, MOP/ha respectively. As a result 50% of the expenditure on imported inorganic fertilizer can be saved.

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