Annals of the Sri Lanka Department of Agriculture. 2001. 3: 303-313.

INFLUENCE OF THE LONG-TERM APPLICATION OF ORGANIC MANURE ON THE PRODUCTIVITY OF RICE IN NON-CALCIC BROWN SOILS OF SRI LANKA.

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ABSTRACT

Organic matter contributes to maintain soil fertility. It has been observed that the addition of organic material is particularly important for sandy Non-Calcic Brown soils in the eastern dry zone of Sri Lanka. This investigation was carried out at the Regional Agriculture Research and Development Centre, Aralaganwila with the objective of studying the long-term effects of the addition of organic materials on the productivity of rice, in rice – rice cropping sequence. Organic materials used in this study were rice straw, green manure (*Gliricidia maculata*) and cattle manure alone and also in combinations. Study revealed that the productivity of the soil diminishes with the continuous cultivation. Although, the initial loss in productivity could not be countered by the addition of organic materials, with the continuous addition it could be restored partially. The degree of restoration in productivity was mainly determined by the nature of the material added. The addition of green manure was much promising at the early stages; addition of cattle manure together with straw showed a better distinction later. Study further revealed that the addition of inorganic fertilizer alone is not capable of maintaining the productivity of rice crop in this soil group. Recycling of straw alone did not improve the rice yields during early seasons of cultivation, however yield enhancements were noticed after nine seasons of consecutive recycling of rice straw.

KEYWORDS: Cattle manure, Organic material, Organic rice. Residue recycling, Rice productivity

INTRODUCTION

The eastern dry zone of Sri Lanka is characterized by the presence of Non-Calcic Brown Soils (*Hapluastalfs*). The comparatively sandy alfisol present in this area supports a large extent of rice cultivation, as rice is the major annual crop gown in the region. The lower fertility status of this soil group (De Alwis and Panabokke, 1972) demands an urgent need to identify management practices to improve the soil fertility status and thereby increase the crop productivity. Since soil organic matter content of this soil group is comparatively much lower to its

counterpart the Reddish Brown Earths (*Rhodudalfs*), the need for either improving or at least maintaining the organic matter status was identified as prime importance in maintaining the soil fertility of this great soil group. Different types of organic materials can be added to the soil to improve the soil conditions. (Nagarajah and Amarasiri, 1977; Nagarajah and Nizar, 1982). According to Doberman and Fairhurst (2000) organic materials must be added to rice soils wherever possible for optimum results. However, the suitable type of materials to be added to the soil and their long-term effects in increasing the productivity is not known with certainty. The objectives of this study were to monitor the long-term effects in crop productivity due to the addition of different organic materials and the inorganic fertilizers in rice- rice cropping sequence practiced in Non-Calcic Brown soils in the region.

MATERIALS AND METHODS

A long-term experiment was initiated in non-replicated large plots of 70 M^2 at the Regional Agriculture Research Centre, Aralaganwila in 1992. All the plots were demarcated by a permanent earth bund of 45 cm in width and 20 cm in height. The experimental site was not utilized for any kind of cropping before the start of the experiment. *Imperata cylindrica* (iluk) was the dominant naturally found weed species in this soil before the first season of rice cultivation began in 1992/1993 *maha* season.

The treatments used were as follows:

1. Control (No manure/ fertilizers).
2. Crop Residue (straw) re-cycling only (CR).
3. Green Manure (*Gliricidia maculata*) only (@10 t/ha, fresh weight), (GM).
4. Cattle Manure only (@ 10 t/ha, 55 – 65% moisture), (CM).
5. Crop Residue and Green Manure only (CR + GM).
6. Crop Residue and Cattle Manure only (CR + CM).
7. In-organic fertilizer (N-90 kg/ha, P-25 kg/ha, K- 40 kg/ha) only (NPK).
8. Green Manure with the inorganic fertilizer only. (NPK + GM).

Twenty-one days old seedlings of variety BG 379-2 (4 months) were transplanted at 3 seedlings per hill at a spacing of 15 X 20 cm. A rotary weeder was used to control the weeds and chemical measures were used in controlling pest and diseases whenever necessary. All the plots were irrigated and other cultural practices were followed as recommended. All the organic materials were incorporated two weeks prior to transplanting to the corresponding plots. However crop residue (straw) was returned to the respective treatments soon after harvesting and incorporated at the time of incorporating the other organic

materials. Plots were harvested leaving a border row and the grain yield was recorded at 14 % moisture content. The soils at the experimental site before the establishment of the experiment was loamy sand in texture having a Olsen P content of 6.2 ppm, exchangeable K content of 0.08 c.mol/Kg, organic matter content of 1.1% and pH of 4.4 (1:5 water).

RESULTS AND DISCUSSION

Crop yield

The mean yield produced by each treatment in *yala* and *maha* seasons during the period from 1993 *yala* season to 2000 *yala* season are given in table-1. Results show that rice yields produced in *yala* season are higher than that of the *maha* season irrespective of the treatments. This indicates the actual potential of obtaining higher rice yields is in the dry season especially in major irrigation schemes where water is not scarce. Contrarily, this scenario is different to the national yields, where *maha* records higher yield than that of the *yala*. The higher productivity during *yala* season could be attributed to the higher amount of solar radiation received during the dry season (Venkateswaralu and Vispears, 1987). De Datta (1985), Weerasinghe and Lathiff (1999) have also made similar observations.

Table 1. Mean yields of 16 seasons and their seasonal differences as influenced by the different treatments.

Treatment	*Rice yield t/ha*					
	*Maha**	*SE*	*Yala*	*SE*	*Mean**	*SE*
Control	2.48	± 0.32	2.77	± 0.16	2.64	± 0.13
Straw returned (CR)	2.66	± 0.32	3.10	± 0.13	2.90	± 0.19
Green manure (GM)	3.84	± 0.35	3.98	± 0.30	3.92	± 0.29
Cattle Manure (CM)	4.08	± 0.40	4.40	± 0.24	4.25	± 0.27
CR+GM	4.04	± 0.34	4.41	± 0.38	4.25	± 0.25
CR+CM	4.50	± 0.40	5.13	± 0.42	4.90	± 0.30
Fertilizer (NPK)	4.43	± 0.48	5.29	± 0.36	4.89	± 0.40
NPK+GM	5.06	± 0.55	5.44	± 0.40	5.27	± 0.41

* Excluding the yield in the first season.

According to table 1, the seasonal responses are higher when inorganic fertilizer is added. De Datta (1985) observed that fertilizer N is much efficiently utilized by rice during dry season than during wet season.

Table 1 further shows that the highest average yield was produced when both green manure and fertilizer were applied in both *yala* and *maha* seasons. This further indicates that better yield could be obtained when both organic and inorganic sources are combined than applying it alone. The overall increase in yield due to the addition of green manure with the inorganic fertilizer was around 400 Kg paddy/ ha / season.

Relative yield

In order to eliminate the effects caused due to environmental or seasonal changes, relative yields of all the treatments were calculated using the fertilizer treatment as the standard.

The changes in relative yield during the experimental period are shown in figure 1a and 1b. Yields of the control (no fertilizer or manure) continued to decline throughout the experimental period. During the first 3 season, the mean of the relative yield of the no fertilizer plot was only 62.4 %, but during the last three season this has dropped to 38.6% showing an almost 50% drop in crop productivity due to the exhaustive cropping. On contrary, the straw recycled treatment too showed a similar decline during the early seasons of the experiment, but showed a recovery compared to the control plot. The mean relative yield of the straw recycled treatment during the first three seasons was 62.7% and it dropped only up to 56.6% for the last three seasons. This shows the importance of recycling crop residue in rice-rice cropping system to maintain the productivity of the crop. Several authors reported the importance of recycling the residue in order to achieve the sustainability of the cropping system. (Oh, 1984; Ponnamperuma, 1984).

The relative yields obtained with either green manure or cattle manure was lower than that of the fertilizer application treatment during the study period. However, the cattle manure or the green manure treatments were superior to the straw recycling treatment. The relative yield obtained by the addition of cattle manure was observed to be higher than that of the green manure during the experimental period and this may be due to the insufficient quantity of green manure added to the plots to maintain the yields (figure. 1a).

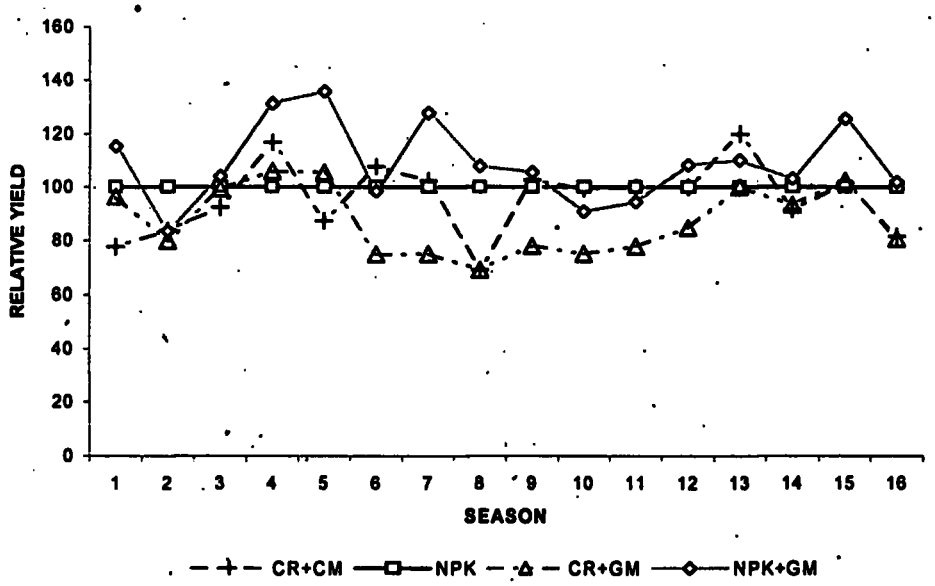

Figure. 1a. Relative yields of the control and organic manure treatments.

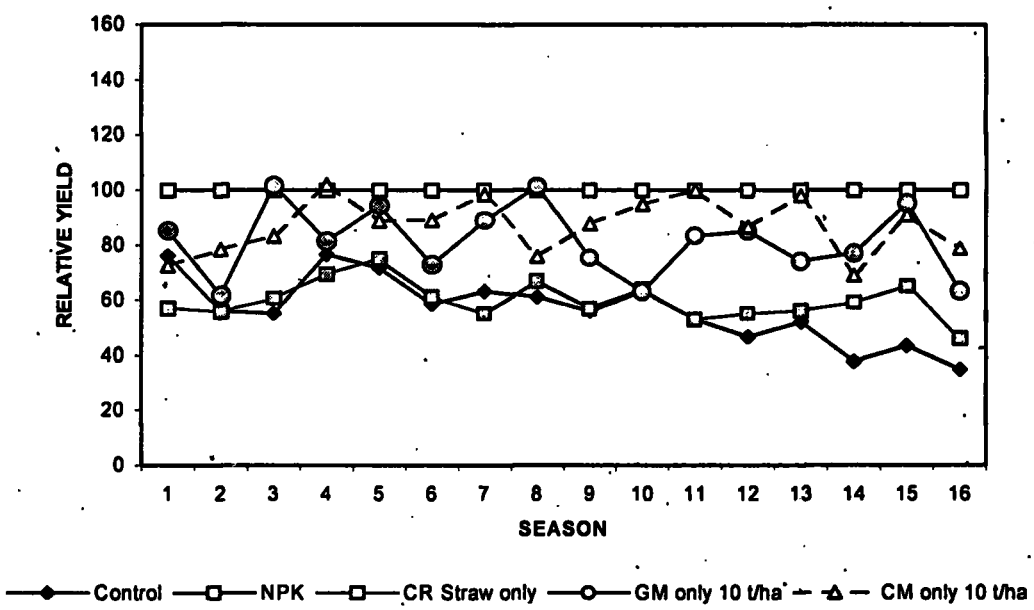

Figure 1b. Relative yields of organic manure combination treatments.

According to figure 1b, relative yields obtained with the addition of green manure together with fertilizer were generally higher throughout the study period. However, it is interesting to note that the gap between fertilizer alone and fertilizer plus green manure has diminished with time. The most noteworthy observation with regard to the relative yield is the behavior of the cattle manure plus residue recycled treatment. This has produced higher relative yields compared to green manure plus crop residue returned treatment and had given almost equal or higher yield compared to the fertilizer alone treatment during the last few seasons consecutively (figure.1b). The green manure plus residue recycled treatment also has been increasing the productivity of the crop gradually during the last several seasons and almost reached the yield level of inorganic fertilizer treatment. The behaviour of these two treatments, especially the cattle manure together with residue recycled treatment suggest the possibility of growing rice totally on organic fertilizers without affecting the crop yield. Thus the feasibility of sustaining the productivity of organic rice farming is a certain speculation in the long run.

Productivity trends

Annual yield calculated for each treatment was fitted with regression models. Except for the control treatment all the other treatments agreed well with the quadratic model. Kumasawa (1984) also recorded quadratic and quartic yield response in rice with the long-term addition of compost. Figure 2a and 2b clearly shows the early declining trend of rice productivity irrespective of the addition of organic manure or fertilizers. This indicates that the productivity of a 'virgin soil' (In true meaning this soil is not virgin; however it was not cultivated before the start of the experiment in the recent past) can not be retained by the addition of fertilizers or organic manure. Though the green manure plus inorganic fertilizer treatment supposed to provide both plant nutrients and some organic materials the initial productivity of the soil was not sustained. Hence this suggests that the productivity of a 'virgin soil' is not totally depend on the presence of plant nutrients or the organic matter content.

According to table 2, the addition of NPK or NPK and green manure had increased the rice yield more than 50% compared to the control treatment in the first season. Nevertheless, this first season increase was not maintained and first the yields started to decline irrespective of the addition of inorganic/organic fertilizers.

Table 2. Rice yield at the first, seventh and 15th seasons of few selected treatments.

Treatment	*Rice yield t/ha*		
	1992/1993 maha	*1995/1996 maha*	*1999/2000 maha*
Control	4.82	2.31	1.86
CM	4.59	4.26	5.20
NPK	6.33	3.66	4.30
NPK + GM	7.29	4.68	5.40

The higher yields reported in the first season of the experiment (table 2) suggest that the maiden productivity of a 'virgin soil' can further be increased by the addition of fertilizers and manure.

According to figure 2a and 2b, as observed in relative yields, the declining trend in the residue returned treatment ceased where as the control treatment continued to decline. This behaviour indicates the improvement in soil conditions due to the return of straw, although the effects were not instantaneous. Ponnamperuma (1984) also reported the yield advantage due to the incorporation of straw when compared with the removal of straw in the long run. The improvements in annual productivity are seen in other treatments too irrespective of the differences observed among them. The addition of cattle manure improved the productivity of the crop much expeditiously than the other types of organic materials. The addition of straw or the return of the crop residue has hasten the process further, and crop productivity improvements can be seen earlier than when each material is added alone (figure. 2a and 2b). The transition time, that is the time taken by each treatment to attain the lowest yield level and starts the rejuvenation, of the each model shows this clearly (table-3).

Table 3. Relationships of yearly yield with time and the transition time of the functions.

Treatment	*Relationship*	*R2*	*Transition time (Yr.)*
Control	$Y = 7.475 - 0.4287t$	0.74	-
Straw recycled (CR)	$Y = 7.546 - 0.858t + 0.086t^2$	0.57	4.99
Green manure (GM)	$Y = 9.937 - 1.070t + 0.1136t^2$	0.65	4.77
Cattle manure (CM)	$Y = 9.750 - 0.08604t + 0.1044t^2$	0.52	4.12
GM + CR	$Y = 13.233 - 2.7708t + 0.3068t^2$	0.79	4.51
CM + CR	$Y = 10.99 - 1.2965t + 0.1749t^2$	0.59	3.70
Fertilizer (NPK)	$Y = 13.18 - 2.0116t + 0.2284t^2$	0.66	4.40
NPK + GM	$Y = 13.94 - 1.9593t + 0.222t^2$	0.91	4.41

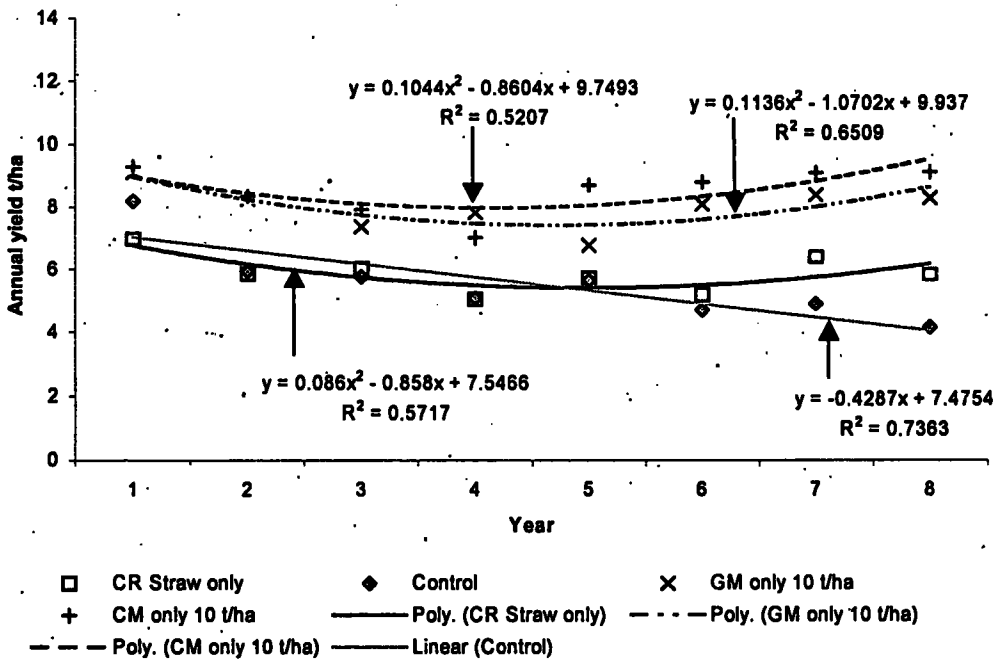

Figure 2a. Yield trends of the control and organic manure treatments.

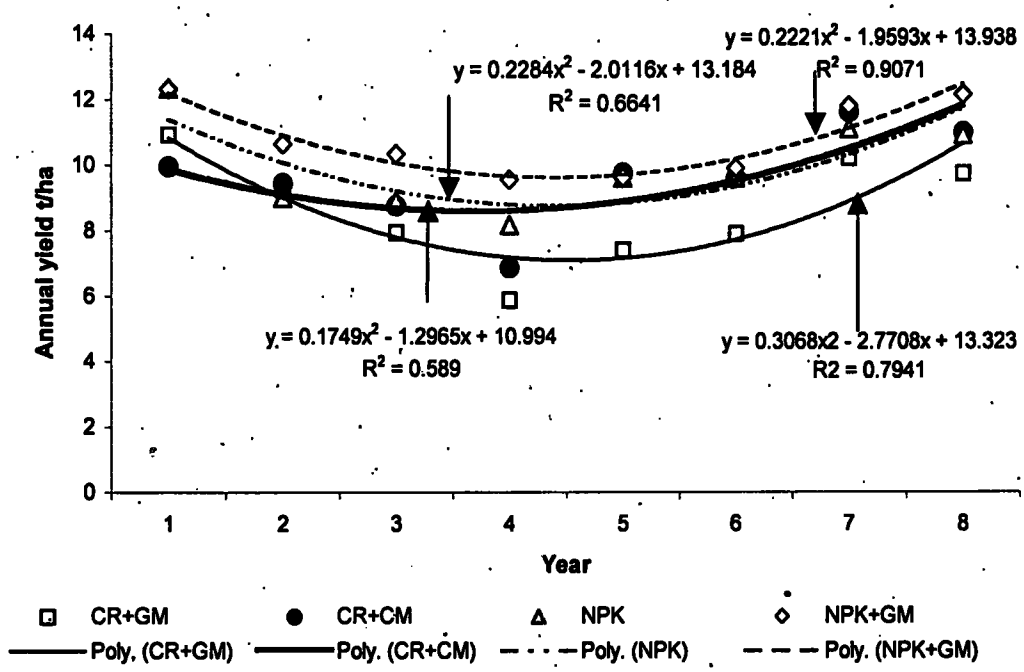

Figure 2b. Yield trends in NPK and other organic manure combinations.

According to table 3, the transition time of cattle manure plus crop residue attained much earlier than that of the other treatments. This was followed by the cattle manure alone treatment. The fertilizer alone treatment took much longer time to attain the lowest point, indicating that yield drop in this case continued beyond the point at which the productivity in cattle manure or cattle manure plus crop residue treatment has started to improve.

Depending on the time taken to restore the crop productivity the treatments could be arranged in the following order: Cattle manure plus Crop residue (CM + CR)> Cattle manure (CM) > Inorganic fertilizer. + Green manure (NPK + GM) =Fertilizer ≥ Green manure + Crop residue (GM + CR) > Green manure (GM) > Crop recycling.

Kumasawa (1984) reported that the addition of straw based compost increase the N absorption process, development of active roots, improve cation exchange capacity and biological N fixation in rice fields. He further reported, rough compost as a better alternative to the more processed compost. Guar (1984) also observed the beneficial effects of farmyard manure on rice yield when applied continuously in each season. The combination of cattle manure and residue recycling might have produced more closer effects to the application of straw based compost and thereby increase the rice yield in the long run. Green manure (*Gliricidia maculata*) on the other hand decomposes very fast and may take a longer time to induce beneficial effects, as it may not have left many residues after the decomposition. The addition of green manure, to the fertilizer treatment (GM+NPK) has not improved the transition time of the fertilizer treatment (NPK) whereas the addition of straw to the green manure treatment (CR+GM) has lessen the transition time taken by the green manure treatment (GM). Handayanto et al., (1994) reported that *Gliricidia maculata* decomposes much quicker and releases its N and the decomposition rates become much slower when the prunnings contained more resistant nature of materials. The addition to straw to green manure might have improved the status of green manure in this context.

The addition of cattle manure and other organic manure had been practiced in Sri Lanka since ancient times and was first recorded in the 13th Century AD (Siriweera, 1993). This practice had been abandoned in the recent industrial era. Although the exact mechanism of yield improvement by the addition of cattle manure, crop residues and green manure is not totally very clear, results of this experiment suggests the need of changing the practice of applying inorganic fertilizer alone in order to sustain the productivity in our soils. In

addition, this study further suggests the need of having crop–livestock combinations in agriculture in order to sustain the productivity of the soils.

CONCLUSIONS

The initial loss in soil productivity of Non-Calcic Brown soils can be restored by the addition of organic materials. The addition of cattle manure @ 10 t/ha is beneficial than adding the same rate of easily decomposable green manure such as *Gliricidia maculata.* Recycling of the residue is an important criterion to be practiced and the effects of recycling are much pronounced with the addition of other sources of organic materials.

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