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EFFECT OF *IN-SITU* DECOMPOSITION OF COIR-DUST AND POULTRY LITTER IN PLANTING HOLES ON YIELD AND FERTILIZER USE EFFICIENCY OF BANANA

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ABSTRACT

An efficient nutrient management technique is needed in order to ensure continuous supply of quality banana fruits to meet export demands. The repeated use of only chemical fertilizers at four-months interval may not be efficient and economically viable under rain-fed conditions prevailing in Sri Lanka. Therefore, the effects of decomposition of coir-dust (CD), poultry litter (PM) and a combination of these in the planting hole along with chemical fertilizers applied at four and six-month intervals on performance of banana were studied during six crop cycles. The changes in C/N ratio of composting mixtures exhibited high correlation with major nutrient contents in plant tissues. Leaf analysis indicated that gradual decomposition of CD and PM mixture was able to regulate a continuous supply of N and K from applied fertilizers to the crop for a longer period, resulting in consistent yields and superior fruit quality performances, when compared to the current recommendation. *In-situ* decomposition of CD and PM in 1:1 ratio was an economically feasible substrate, which enhanced applied fertilizer use efficiency by slow release of plant nutrients and increased sustainable production. *In-situ* decomposition of even only coir-dust also showed a significant contribution in improving applied fertilizer use efficiency, especially, when fertilizer was applied at six-month intervals.

KEYWORDS: Chemical fertilizer, Coir-dust, *In-Situ* decomposition, Poultry litter.

INTRODUCTION

In the recent past, Sri Lanka's local and export markets for banana has increased considerably. Therefore, it is necessary to ensure the continuous supply of quality fruits. Increased and sustainable yields could be achieved through an efficient nutrient management technique, especially, using an Integrated Nutrient Management (INM) system, which plays a key role in achieving optimum crop yields in a sustainable manner (Chundawat, 2001).

Market oriented growers use larger quantities of chemical fertilizers, which account for nearly one third of the cost of cultivation without further yield increase. The integrated use of organic manure and chemical fertilizers under local conditions has been reported to result in growth and yield increases (Pinto, 1986). On the other hand, studies conducted with slow or controlled release fertilizers have shown significant effect on growth, yield and quality of different perennial fruit crops (Ram *et al.*, 1999). Organic materials applied into the planting holes before planting by allowing them to

decompose *in-situ* were found to result in slow nutrient release of applied chemical fertilizers (Mc Connel *et al.*, 1993). On the other hand, CD absorbs and retains moisture for longer periods (Jayasundara, 1997), and this could enhance the efficiency of applied chemical fertilizers. It was also found that problems caused by high concentrations of minerals in organic manures like PM, which are in exchangeable form, could be solved by composting with organic substances having high C/N ratios (Fujiwara, 1998). The C/N ratio and particle size of the material used to mix with PM play a significant role in retaining NPK in the soil (Hansen *et al.*, 1989).

Banana is grown as a mono or mixed crop under coconut in many parts of Makandura region in the low country intermediate zone (IL-1) of Sri Lanka. The rainfall prevailing in this region is not sufficient to retain adequate soil moisture throughout the year (Jayasundara, 1997). Therefore, depletion of soil moisture at the critical stages of the banana crop leads to poor fertilizer use efficiency, which often leads to low yields. In this region, the predominant soils are Red Yellow Podzolic soils with soft and hard laterites (Panabokke, 1967). Low water holding capacity is considered to be the main limiting factor for better fertilizer use efficiency (Jayasundara, 1997). Therefore, fertilizer application at 4 months interval as currently recommended by the Department of Agriculture needs re-assessment under these conditions. Improving soil moisture retention using locally available organic manure may overcome these problems.

An investigation was therefore carried out to study the composting effect of CD and PM (deep litter) in planting holes on the efficiency of applied chemical fertilizers in relation to growth, yield and fruit quality of six crop cycles of banana under rain-fed conditions.

MATERIALS AND METHODS

A field experiment was conducted with kolikuttu banana over six crop cycles at the Regional Agricultural Research Centre, Makandura. The following treatments were tested in a Randomized Complete Block Design (RCBD) with four replicates.

<i>Treatment</i>	<i>Application interval (months)</i>
1. Recommended chemical fertilizers (Rec-4)	(4) control
2. Rec. (4) + CD	(4)
3. Rec. (6) + CD	(6)
4. Rec. (4) + PM	(4)
5. Rec. (6) + PM	(6)
6. Rec. (4) + PM + CD	(4)
7. Rec. (6) + PM + CD	(6)

Planting holes of 60 cm x 60 cm x 60 cm dimension were prepared at 3 m x 3 m spacing, 5 kg each of CD and PM were applied at the beginning of the experiment according to the treatment schedule and mixed with soil and planted with one banana sucker after cutting down the pseudostem 60 cm above the corm in order to obtain a uniform crop at the beginning. The experiment was conducted under rainfed conditions for six crop cycles. Two months after planting, chemical fertilizers were applied to all the treatments according to DOA recommended rates (Urea – 120 g, TSP – 80 g and MOP – 255 g per plant) and mixed with composting mixture. This was repeated at four and six months interval for relevant treatments. Application of PM and CD was repeated every six months into 30 cm deep furrows prepared with the radius of 60 cm away from the base of the plant and thoroughly mixed with topsoil for relevant treatments.

A composite soil sample was collected from the root zone (20 - 30 cm depth) before planting for site characterization. Composite samples of the composting mixture in the planting hole of each treatment were collected after each harvest and analyzed for organic C and total N contents using Walkley and Black (1965) method and Kjeldahl method respectively and C/N was calculated. The central part of the fifth leaf including lamina and midrib was collected at flowering stage (Ray, 1988) from each treatment and analyzed for N by Kjeldhal method and K by flame photometric method.

At harvest, yield parameters such as number of fruits, hands and fruit weight per bunch were recorded. Fruit quality parameters such as fruit length and diameter were also recorded and flesh: peel ratio calculated at a similar ripening stage.

RESULTS AND DISCUSSION

Chemical characteristics of the soil

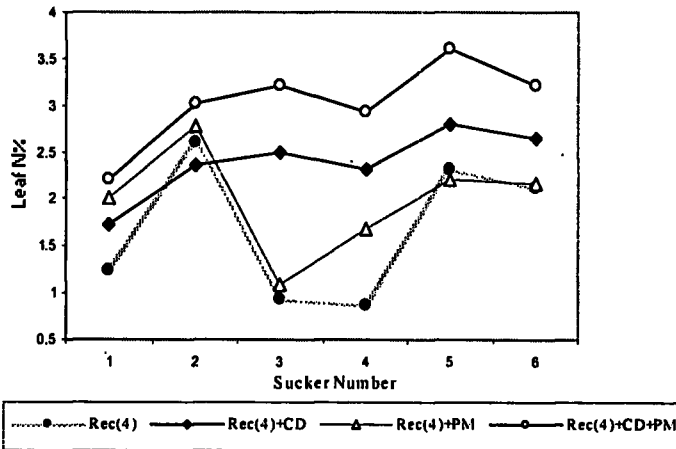
The soil at the experimental site was Red Yellow Podzolic with soft and hard laterites and slightly acidic with low total N, available P and organic matter contents (Table 1).

Table 1. Some important chemical characteristics of the soil at the experimental site.

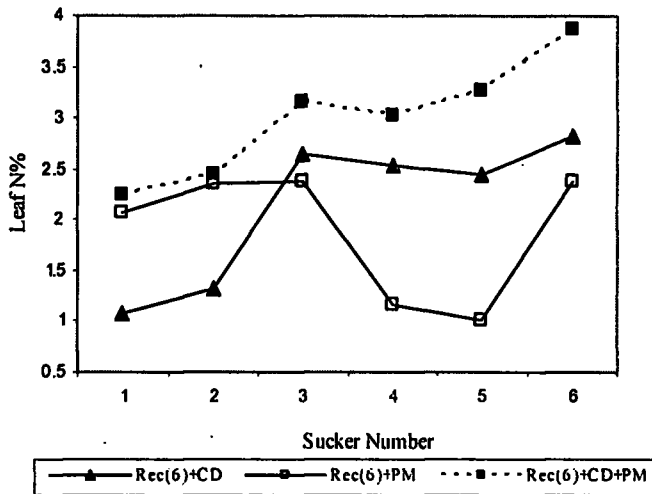
<i>Soil property</i>	<i>Value</i>
pH (1:1) water	5.10
Total N (%)	0.11
Olsen P (mg/kg)	1.60
Exch. K (mg/kg)	28.20
Organic matter (%)	1.13

Concentrations of N and K contents in the leaves of six consecutive banana suckers

Effects of the treatments on of N and K contents in the leaves of six consecutive suckers are presented in Figures 1 and 2, respectively.



Chemical fertilizers applied at 4 months interval



Recommended fertilizers applied at 6 month intervals

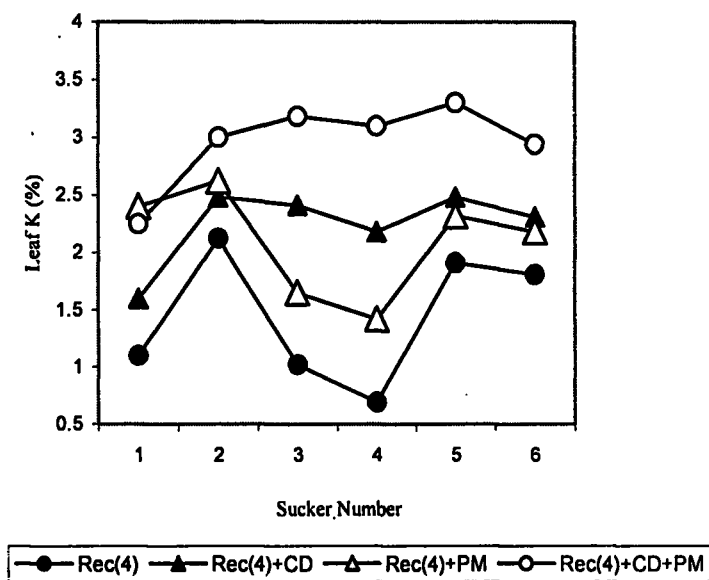
Figure 1. Treatment effects on leaf N of six consecutive banana suckers.

Leaf N status

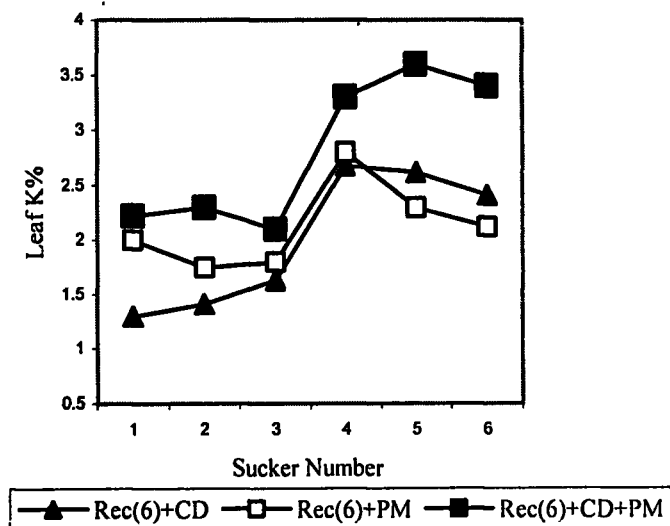
The leaf N in only recommended fertilizer added plants was drastically increased in the second sucker with application of fertilizers at four months interval and drastically reduced in the third and fourth suckers and with application of second dose of fertilizers increased in the fifth sucker. A similar trend was observed when only PM was integrated with recommended fertilizers. In contrast, leaf N content was consistent throughout the study period in CD treated plants. Incorporation of PM with CD showed further

enhancement of leaf N ranging from 3.02 to 3.65 %. When chemical fertilizer was applied even at six months interval, leaf N declined drastically in only chemical fertilizer added plants whereas in CD and PM treated plants showed a sustained and higher N concentration in leaf tissues (Fig. 1).

Bhargava and Chadha (1993) observed the range of concentration of optimum leaf N for higher banana yields as 3.05% -3.35% and maintenance of this range was achieved satisfactorily by CD and PM mixture when fertilizer was applied at either four or six months interval.



Recommended fertilizers applied at 4 month intervals



Recommended fertilizers applied at 6 month intervals

Figure 2. Treatment effects on leaf K of six consecutive banana suckers.

Leaf K status

Leaf K contents in consecutive six suckers also exhibited a similar trend as leaf N. Maximum leaf K was maintained consistently and reached an optimum level of 3.11% in the CD + PM treatment. Similar observations have been reported by Bhargava and Chandha (1993). Integrated use of chemical fertilizers with only CD showed a similar trend but leaf K levels were lower. In contrast, the chemical fertilizer only and in combination with PM treatments gave the lowest K levels (Fig. 2). Thus it is evident that leaf N and K maintenance was not possible when chemical fertilizer was integrated with either CD or PM at four or six months interval (Figs. 1 and 2).

Relationship between C/N ratio of composting mixtures and leaf N and K contents

The relationship between C/N ratio of the composting mixtures in different treatments and leaf N and K contents showed that there was a poor correlation in most treatments. However, a significant negative linear relationship was observed between leaf N content and C/N ratio when CD and PM were used (Fig. 3). Addition of fertilizer N and readily available N from PM promotes decomposition of the composting mixture resulting in the release of mineral N for quick uptake by the plant. As a result, with decrease of C/N ratio of the composting mixture, leaf N concentration increased (Fig.3). The pattern of increase was found consistent throughout the study period (Fig.1) and therefore, regular supply of mineral N was assured. On the other hand, a curvilinear relationship was observed between C/N ratio of the above mixture and the leaf K concentration. The most important factor here is to maintain the soil fertility status for a longer period of time in order to ensure higher and consistent banana yields. This could be achieved when organic materials, which have wide C/N ratio (100 - 200), are subject to slow decomposition. It has been reported that the gradual reduction of C/N ratio of composting mixture has a greater impact on N and K retention in the soil (Hansen et al., 1989). On the other hand, humic substances produced during decomposition of highly lignin containing materials such as CD, sow-dust are capable of retaining N, P and K in the soil for longer periods than fertilizer alone (Prasad and Singhania, 1989). Further, it was evident that, application of already composted organic material into the planting hole is less beneficial than materials, which have to be decomposed under the planting hole conditions (Neilson *et al.*, 1994). This information are in agreement with the results of this study.

Overall results revealed that *in-situ* decomposition of CD and PM has a higher ability to retain N and K for longer period and their application may enhance the efficient use of applied chemical fertilizer. In addition, higher moisture retention capacity of CD promotes regular nutrient

uptake by plants. On the other hand, application of PM increases exchangeable K and available N content in the soil. As a result, combined application of these two materials may provide an excellent composting material that behaves as a controlled or slow-release N and K supplying amendment for perennial fruit crops.

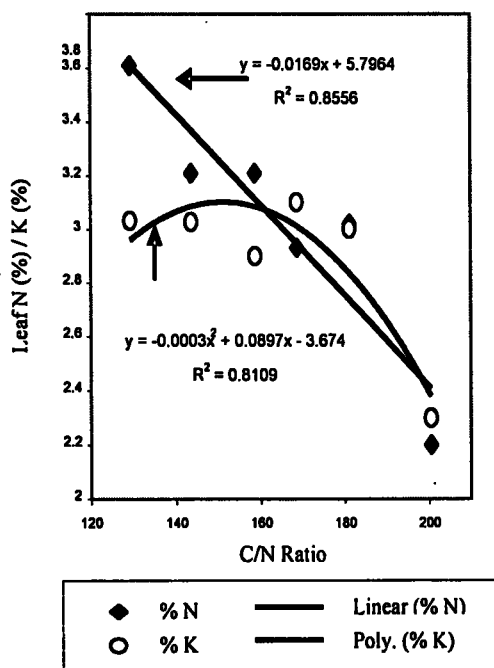


Figure 3. Relationship between C/N ratio of substrate Rec(4)+CD+PM and concentrations of N and K in the leaf.

Crop yield

Yield parameters collected at the harvest of six consecutive banana crops are illustrated in Figure 4 and Table 2.

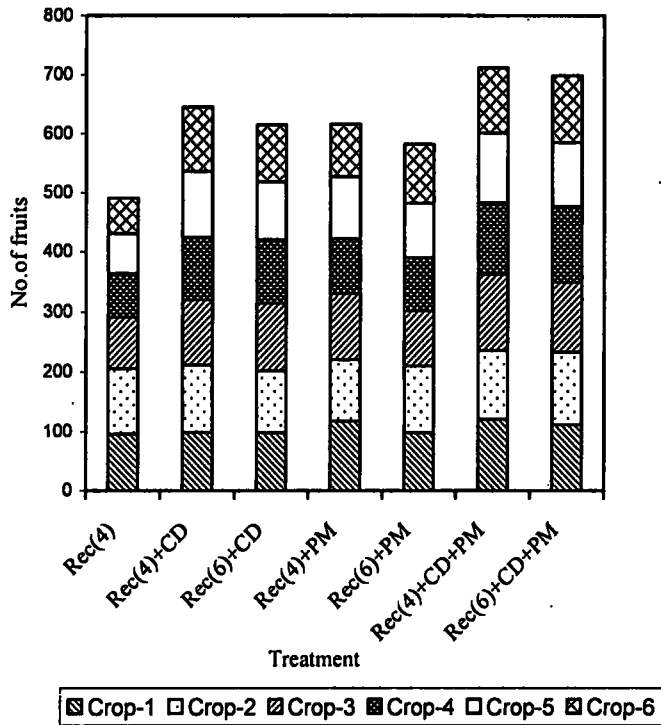


Figure 4. Effect of treatments on total number of fruits in six consecutive bunches.

Table 2. Effect of treatments on fruit weight (kg)/bunch of six consecutive crop cycles.

Treatment	Crop						Total yield (kg)
	1 st	2 nd	3rd	4 th	5 th	6 th	
Rec(4)	8.6 cd	9.8 c	6.3 d	7.0 d	6.2 d	7.1 c	45.0 d
Rec(4)+CD	9.4 c	10.8 b	9.8 b	10.6 b	9.7 b	9.9 b	60.2 b
Rec(6)+CD	8.4 cd	9.2 c	9.0 bc	9.8 c	8.9 bc	9.1 bc	54.4 c
Rec(4)+PM	9.5 c	10.3 b	9.1 bc	10.0 b	8.9 bc	9.1 bc	56.9 bc
Rec(6)+PM	9.1 c	10.0 bc	8.5 c	8.2 bc	7.9 d	7.5 c	51.2 c
Rec(4)+CD+PM	12.6 a	12.8 a	11.9 a	12.1a	11.8 a	11.6 a	72.8 a
Rec(6)+CD+PM	10.9 b	12.2 a	11.9 a	12.0 a	11.1 a	11.0 a	69.1 a
CV (%)	18.5	16.2	21.5	17.3	15.5	19.2	15.4

Means followed by the same letter are not significantly different at the 0.05 probability level in the same column

Fruit weight per bunch obtained with the combined application of CD and PM with chemical fertilizers was superior to the other treatments and produced higher and consistent yields for six consecutive crops (Table 2). No significant yield reduction was observed when chemical fertilizers were applied either at 4 or 6 months interval together with CD and PM. On the other hand, yield was not consistent when only PM was applied with chemical fertilizers (Table 2). However, composting of only CD under *in-situ* conditions also promoted consistent yields but they were lower when

compared to CD and PM combination. The chemical fertilizer only, control treatment, produced the lowest yields and was not consistent during the six crop cycles. The yield increase in CD and PM treated plants was found to be due to increase in number of fruits/bunch. (Fig. 4). Pinto (1986) reported that the yield increase in banana due to application of organic manure was mainly due to increase in number of fruits/bunch and fruit weight.

Cumulative fruit yield

Total number of fruits harvested during six crop cycles increased from 490 to 710 when chemical fertilizer was integrated with CD and PM. Addition of only CD with chemical fertilizer increased the number of fruits from 490 to 630 (Fig. 4). Total fruit weight in the six crops increased from 44 kg to 74 kg with the use of CD and PM compared to chemical fertilizer alone. Fruit yield increased by 16 kg when CD was incorporated with recommended chemical fertilizers. However, no significant yield difference was observed when chemical fertilizer was applied either at 4 or 6 months interval with CD and PM (Table 2).

Fruit quality parameters

The average fruit quality parameters for the six crop cycles are presented in Table 3.

Table 3. Fruit quality parameters of the first ratoon crop of banana with respect to treatments.

<i>Treatment</i>	<i>Fruit length (cm)</i>	<i>Fruit girth (cm)</i>	<i>Flesh:Peel ratio</i>
Rec (4)	7.20 bc	9.90 c	4.60 b
Rec (4) + CD	7.35 b	10.10 b	4.80 ab
Rec (6) + CD	7.30 b	9.92 c	4.60 b
Rec (4) + PM	7.65ab	11.21 ab	5.11 a
Rec (6) + PM	7.32b	10.24 b	5.23 a
Rec (4) + CD+PM	8.40a	11.61 a	5.28 a
Rec (6) + CD+PM	8.36a	11.40 a	5.19 a
CV (%)	28.6	23.3	20.6

Means of each column followed by the same letter are not significantly different at the 0.05 level.

Fruit length and girth increased significantly with application of CD and PM compared to the recommended fertilizer application. However, no differences were observed in fruit length and fruit girth when chemical fertilizer was integrated with CD and PM and applied either at 4 or 6 months interval. It appears that increase in fruit length and fruit girth is another factor that has contributed to yield increase.

Cost effectiveness

The cost effectiveness of the different treatments for six crop cycles is illustrated in Figure 5.

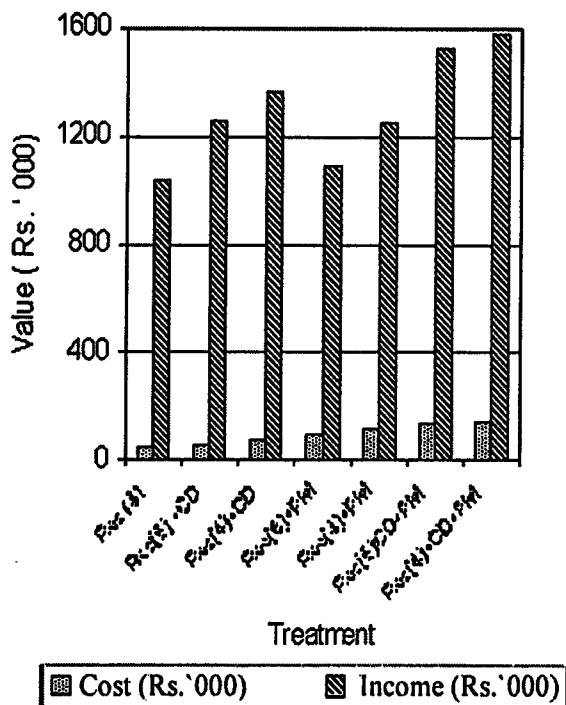


Figure 5. Cost effectiveness of respective treatments.

The maximum and comparable net profit was observed when CD and PM were incorporated with recommended chemical fertilizer applied either at 4 or 6 months interval. The lowest was observed when only PM was incorporated with recommended chemical fertilizer applied at 6-months interval. However, application of CD with fertilizer gave an acceptable rate of return. The net benefit was increased from 1 million to 1.5 million/ha/six crop cycles when both CD and PM were incorporated with recommended chemical fertilizer.

CONCLUSIONS

The information generated by this study indicated that *in-situ* decomposition of 1:1 ratio of CD and PM along with recommended chemical fertilizers in planting holes provides an excellent medium in order to ensure regular and controlled supply of N and K for banana crop. Application of CD alone also regulates the N and K supply of added fertilizer. Higher and consistent yields with good quality characteristics are achievable if CD and

PM are applied to planting holes together with recommended chemical fertilizers either at 4 or 6 months interval with higher economic returns.

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