# Effect of Organic Matter Application on Growth of Rice (*Oryza sativa* L.) in Cadmium Contaminated Sand

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***Abstract*****—** A pot experiment was conducted to investigate the effect of organic matter (OM) on growth of rice plant grown in cadmium (Cd) contaminated sand at the concentration of 10 mg/kg using two Sri Lankan rice varieties, *Bg300* and *Suwandel*, under plant house condition. Cattle manure and paddy straw were used as OM sources and used OM levels were, 0 g/kg (without OM), 1 g/kg and 2 g/kg. Here, the rice plant growth was investigated as plant height, leaf chlorophyll content, leaf area, total number of leaves per pot, ratio of death leaves to total number of leaves per pot and shoot and root dry weight per pot. Cattle manure resulted a significantly highest plant height than paddy straw at both 1 g/kg and 2 g/kg levels compared to the level of 0 g/kg. Under the set experiment conditions, rice variety *Bg300* had a significantly highest leaf chlorophyll content than *Suwandel* variety. Both rice varieties showed a significantly highest leaf area with cattle manure. Application of cattle manure resulted the significantly highest ($P \leq 0.05$) total number of leaves compared to the application of paddy straw. Further, there was a significant increase of total number of leaves when the amounts of OM added to the pots were changed from 0 g/kg to 2 g/kg. Interestingly, a significant reduction of death leaves/total number of leaves ratio was resulted with cattle manure addition. A significant increase in shoot dry weight was observed when the growing medium OM content increased from 0 g/kg to both 1 g/kg and to 2 g/kg. Thus the cattle manure and paddy straw can be used effectively to improve plant growth of rice grown in 10 mg/kg Cd contaminated sites.

***Keywords*****—** Cadmium, cattle manure, growth, paddy straw, rice

## I. Introduction

DUE to various anthropogenic activities, potentially toxic metals are accumulated in soils. The primary risk pathway associated with cadmium (Cd) contaminated soils has been identified as the soil-plant-human pathway and the consumption of crops or by products grown on these contaminated soils [1]. Cd present in the soil and their transfer into human consumable parts of the food plants is considered as the prime pathway to get human exposure to this metal. Contamination of agricultural soils by Cd has become a serious problem in some parts of the world including some Asian countries [2] due to its bio magnification nature.

The well-known Japanese "*Itai Itai*" disease was due to Cd toxicity caused by addition of Cd to water by an industrial accident. In some areas in China and Thailand, production of Cd contaminated rice and renal dysfunctions among populations were reported [3, 4].

Different strategies are employed to reduce the absorption of Cd by plants. The addition of soil amendments can be used to immobilize Cd in soil. It has been reported that application of zeolite can effectively suppress the Cd uptake by rice and wheat than calcium carbonate or manganese oxide application [5]. Natural soil amendments such as farmyard manure and poultry manure can be used to reduce Cd uptake by plants [6].This is due to its large sorption capacity towards metal ions [7, 8]. The protective role of organic matters towards plants lies in forming simple and complex compounds with heavy metal ions. Therefore, maintenance of adequate organic matter levels in the soil is crucial to maintain a better crop which grown in heavy metal polluted sites.

The aim of present study was to determine the effect of cattle manure and paddy straw on growth of rice plant cultivated on Cd contaminated sand.

## II. Materials And Methods

### *A. Experiment Site and Rice Varieties*

A pot experiment was carried out to investigate the effect of organic matters on growth and development of local Sri Lankan rice varieties, *Bg300* and *Suwandel* grown in Cd contaminated sand with added organic matter (OM)s, namely cattle manure and paddy straw. The experiment was conducted in plant house, Department of Plant Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka.

### *B. Preparation, Maintenance of Pots and Experiment Design*

Cattle manure and paddy straw were collected from previous season and were kept as heaps approximately for 4 months in faculty farm to carry out natural decomposition process before using them for the experiment. The paddy straw was cut into approximately one inch sized pieces. Both organic matters were oven dried at 60 $^0$C until obtaining a constant weight. Prepared organic matters were applied in the

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amount of 0 g/kg, 1 g/kg and 2 g/kg to plastic pots, filled with ten kilograms of clean, washed and air dried sand. Cd in the form of $CdCl_2.2\ ½\ H_2O$ was applied to each pot to obtain 10 mg/kg constant Cd level. Two uniform rice seedlings from each variety was transplanted in each pot, according to the treatments. Rice variety, OM type and amount of OM added to the pots were considered as factors for the experiment and the experiment was arranged as three factor factorial experiment. All the treatments were replicated three times and pots were arranged in complete randomized design. Nutrients of the pots were maintained by adding Urea, Triple super phosphate and Murate of potash as recommended by the Department of Agriculture, Sri Lanka [9] and Yoshida nutrient media [10]. Water level of the pots was maintained under submerged condition throughout the growth period.

### *C. Plant Growth Measurements*

When the plants were at one month of age, plant height (height from base to the tip of the first fully expanded leaf in centimeters), leaf chlorophyll content (average soil plant analysis development (SPAD) value of first fully expanded leaf in per pot; measured by using SPAD-502 plus SPAD meter), leaf area (area of second fully expanded leaf from main stem in square centimeters; measured by using CI – 202 leaf area meter), total number of leaves per pot and ratio of death leaves to total number of leaves per pot were measured. At the end of the ripening period, plants were uprooted and thoroughly washed to remove adhered materials from the plant and subsequent plants were oven dried at 60 $^0$C until reaching a constant weight [11] and total shoot dry weight and root dry weight per pot were recorded.

### *D. Data Analysis*

Poisson regression data were analyzed using Genmod procedure and Logistic procedures. The rest of the data of the parameters were analyzed using the General Liner Model (GLM) procedure. All the data were analyzed using Statistical Analysis System (SAS) 9.00 program. The estimate values were used to make comparison among treatments. Least significant difference (LSD) test was used to compare means. Significant level of 0.05 was used in presenting the results.

## III. Results

### *A. Effect of OM Application on Plant Height of Rice Grown in Cd Contaminated Sand*

There was no any significant interaction effect of rice variety, OM type and its levels on rice plant height, but the all individual factors had the significant influence on rice plant height. Rice variety *Suwandel* has resulted a significantly highest plant height than *Bg300*. Cattle manure application resulted a significantly highest plant height than paddy straw application for rice grown in 10 mg/kg Cd contaminated sand. Further, a significantly highest plant height was resulted when amount of OM increased to 1 g/kg and to 2 g/kg from 0 g/kg addition. Interestingly, a slight plant height reduction was obtained when the amount of OM in growing medium has increased from 1 g/kg to 2 g/kg, but this reduction was not significant (Fig.1).

### *B. Effect of OM Application on Chlorophyll Content of Rice Grown in Cd Contaminated Sand*

Rice variety *Bg300* had a significantly highest leaf chlorophyll content than *Suwandel* variety grown under the experimental conditions and the leaf chlorophyll content was not affected significantly by the interaction of individual factors as well as by OM type and amount of OMs added.

### *C. Effect of OM Application on Leaf Area of Rice Grown in Cd Contaminated Sand*

According to the results, there was a significant rice variety and OM interaction effect for leaf area. Addition of cattle manure resulted a significantly highest leaf area in both rice varieties than the addition of paddy straw. Further analysis of results showed the significant increase of leaf area with 2 g/kg OM addition compared to the no addition (Fig. 2).

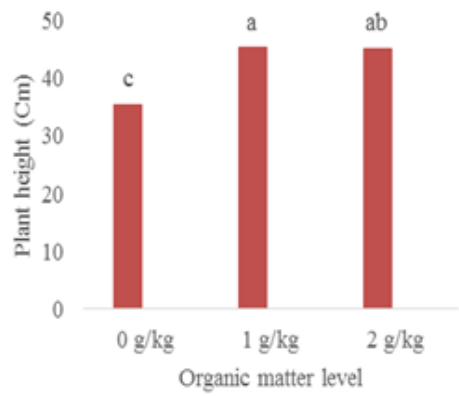


Fig. 1 Effect of OM level on plant height of rice grown in Cd contaminated sand.

### *D. Effect of OM Application on Total Number of Leaves of Rice Grown in Cd Contaminated Sand*

There was a significant influence of OM type and its amount on total number of leaves of the plant. A significant difference of total number of leaves in between *Bg300* and *Suwandel* rice varieties was not observed. Application of cattle manure resulted the significantly highest ($P \leq 0.05$) total number of leaves than the application of paddy straw. Further, 2 g/kg OM addition has resulted a significantly highest total number of leaves than without OM addition. There was no significant difference in between 1 g/kg and 2 g/kg OM addition to total number of leaves. Table 1 shows the parameter estimate values and relevant probability values of the analysis.

### *E. Effect of OM Application on the Ratio of Death Leaves to Total Number of Leaves of Rice Grown in Cd Contaminated Sand*

Results revealed that there was no significant effect by rice variety and organic matter level to death leaf to total leaf ratio in rice plants grown in 10 mg/kg Cd contaminated sand.

Interestingly, there was a significant reduction (*P<0.0001)* of death leaf/total leaf ratio in rice plants when the cattle manure added to their growing medium (Estimated value of cattle manure was -0.4843).

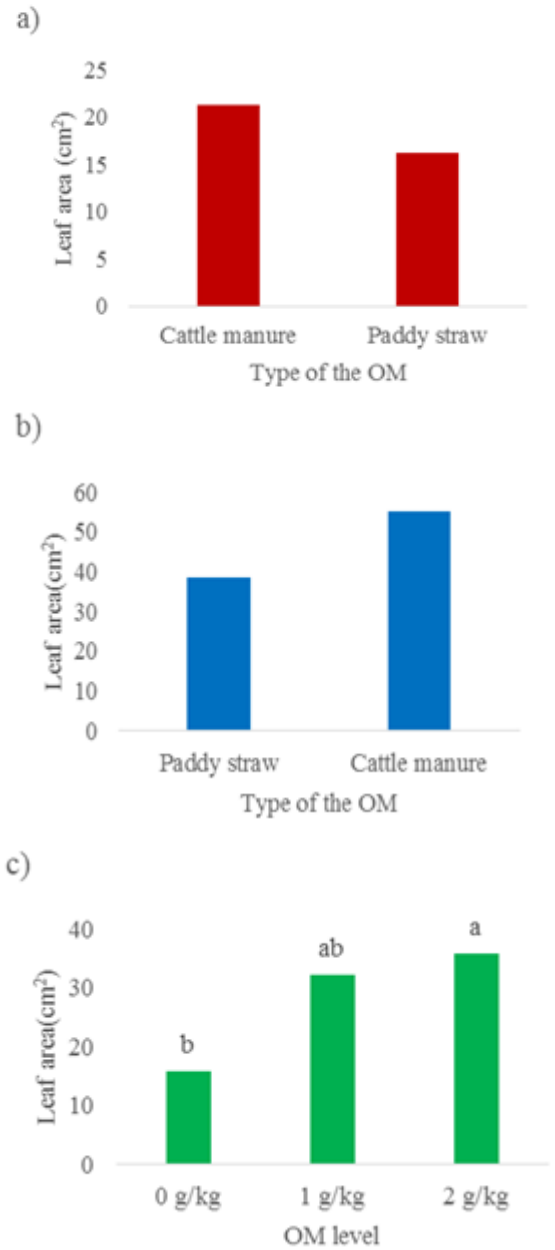


Fig. 2 Effect of OM application on leaf area of a) Bg300; b) Suwandel and c). Effect of OM level on leaf area of rice grown on Cd contaminated sand

### *F. Effect of OM Application on Shoot and Root Dry Weight of Rice Grown in Cd Contaminated Sand*

Amount of OM added to the growing medium had a significant influence on shoot dry weight irrespective to the interaction effects as well as the OM type and rice variety. Here, a significant shoot dry weight increment was obtained when the growing medium OM level increased subsequently to 1 g/kg and to 2 g/kg from 0 g/kg. Further, there was a significant difference of root dry weight in between tested two rice varieties. Rice variety *Suwandel* resulted a significantly highest root dry weight than *Bg300* irrespective to the interaction effect between tested factors and the individual effect of OM type and applied amounts of OMs.

TABLE I
PARAMETER ESTIMATE VALUES AND PROBABILITY VALUES OF TOTAL NUMBER OF LEAVES OF RICE GROWN IN CADMIUM CONTAMINATED SAND

| Parameter | | Estimate value | Probability of Chi-square |
|---|---|---|---|
| Rice variety | *Bg300* | 0.0964 | 0.2716 |
| | *Suwandel* | 0.0000 | . |
| Type of the OM | Cattle manure | 0.2491 | 0.0081 |
| | Paddy straw | 0.0000 | . |
| Level of the OM | 0 g/kg | -0.4980 | 0.0006 |
| | 1 g/kg | -0.0058 | 0.9508 |
| | 2 g/kg | 0.0000 | . |

## IV. DISCUSSION

Cadmium is one of the well-known strong phytotoxic element. Due to its high phytotoxicity, the effect on the plant growth is well established with numerous experiment results. Soil contamination with Cd tends to have an adverse influence several plant growth parameters and yield related parameters in different crops. Ghani [12] observed a significant reduction in shoot growth, root growth and total plant biomass of mung bean plants grown in highest Cd polluted soil. Further, the rice plants exposed to higher levels of Cd have showed the growth and development inhibition in tillering, internode elongation, leaf expansion and dry matter accumulation [13]. Herath et al [14] reported that growth inhibition effect of Sri Lankan rice as the reduction of plant height, leaf area, number of tillers and root dry weight when the plants exposed to higher levels of Cd in the growing medium.

The present study showed a significant growth enhancement with cattle manure and paddy straw application. There are possible explanations for this result. In general, it has been well known that addition of OMs to crop fields has positive effects on crop growth and production. This is because the large amount of macronutrients (N, P, and K) and organic carbon content in organic fertilizers [15]. Therefore, the macro nutrients supplied by the OM application may have contributed positively to enhance crop growth as resulted in the present study. Further, the organic carbonic content from OMs applied can be act as a nutrient pool, thus improves nutrient cycling, increase the buffer capacity and soil physical properties [16]. Furthermore, it has been reported that the organic manures such as cattle and pig manure contains a great proportion of humidified OMs, can decrease the bioavailability of heavy metals in soil [17] by making strong complexes with the positive ions of heavy metals. Thus the immobilization of heavy metals can be resulted. This leads to lower the HM uptake by plants.

## V. Conclusions

Organic matters are beneficial to soils with respect to their productivity as well as to remediation purposes. Results of the present study revealed the significant growth enhancement of rice plants grown under the experimental condition with respect to the addition of OMs to the growing medium. It was realized that OM application can significantly increase plant height, leaf area, total number of leaves and shoot dry weight. Interestingly, the ratio of death leaves to total number of leaves gets significantly reduced when OM added to the crop grown pots. These results are in further conformity with the crop quality improvement through OM application. Therefore, the application of OM to Cd polluted sites can be used effectively to improve rice plant quality in terms of plant growth.

## Acknowledgment

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