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Nutrient Availability and Maize Growth in Soil Amended with Mineral Fertilizer and Pressmud Biocompost

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Keywords: *maize growth, nutrient availability, pressmud biocompost, physical and chemical properties.*

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Strictly as per the compliance and regulations of :

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Abstract- This study was carried out to conform the Nutrient availability and maize growth in soil amended with mineral fertilizer and biocompost. Biocompost is prepared from sugarcane filtercake and other waste material of sugarmills. The biocompost samples were collected from Sugar Mill, Matiari and analyzed for macro nutrients. The pot experiment was conducted with mineral fertilizer and biocompost amendment for maize crop. The pot experiment was replicated three times in a completely randomized block design. Pot experiment results revealed that there were pronounced positive effects of addition of biocompost. Maize crop data showed that the effect of biocompost and mineral fertilizers was non-significant with respect to N, P and K contents. Data describing the soil physical and chemical properties at the end of pot experiment under mineral fertilizers and biocompost showed that the EC values of post harvest samples increased with the application of biocompost while pH was not affected. Soil organic matter, Olsen P and NH_4OA_C-K increased significantly with the application of biocompost, and mineral fertilizer application also increased Olsen P and NH_4OA_C-K contents in soil. The results of this study showed that biocompost can be used along with mineral fertilizers to increase maize growth and yield.

Keywords: maize growth, nutrient availability, pressmud biocompost, physical and chemical properties.

I. Introduction

Present is a rising apprehension among the scientific group of people, environmentalists and policy makers about the safe disposal of the large amounts of organic wastes produced worldwide. Urbanization, industrialization, increasing food demand for growing human population, intensive use of relatively easily available and inexpensive chemical fertilizers and economic force are adding to the production and buildup of large amounts of organic wastes. In Pakistan, a few organic wastes such as farm waste, city waste (sewage and sludge), poultry litter and industrial wastes (food, sugar, cotton and rice industry) are recycled back by applying back to agricultural land but a significant amount of organic wastes. As a result recycling organic wastes by applying on to agricultural land seems to be the only best option in such scenario (Zaman et al., 2002; 2004). However, soil may not be regarded as a dumping place for organic wastes (Cameron et al., 1997).

Organic waste such as pressmud or filter cake is a byproduct of sugar factories and characterized as a soft, spongy, amorphous and dark brown to brownish material. Pressmud is reported to be a valuable resource of plant nutrients and may therefore affect physical, chemical and biological properties of a soil (Rangaraj et al., 2007; Kumar and Verma, 2002; Jamil et al., 2008; Muhammad and Khattak, 2009; Nehra and Hooda, 2002; Ramaswamy, 1999). Razzaq (2001) reported that continuous land application of sugarcane filter cake to agricultural crops for 5-6 years is likely to improve soil health by adding sulfur (S) and organic matter to soil. Therefore land application of pressmud is becoming a common farm practice in the sub-continent countries of Pakistan and India.

Nutrients availability and maize growth yields increased with increasing nitrogen and pressmud rates (Bangar et al., 2000). Memon (2005) reported that the raw pressmud had depressing effect on dry matter yield of maize, and that the benefit of previously applied pressmud was obvious in the succeeding wheat crop. Viator et al. (2002) reported that filter cake increases cation exchange capacity (CEC) for thirty months after its application and its residual effect remains after four years.

Observance in view the significance of pressmud in the present scenario of agriculture and accessibility of nutrients, the purpose of the present study was to examine the influence of mineral fertilizer and biocompost amendments on maize growth and yield.

II. Materials and Methods

a) *Pot experiment*

This work was conduced in the Ware House of the Department of Soil Science. The soil was collected from Latif Experimental Farm of Sindh Agriculture University Tandojam. The soil was air dried and passed through 4 mm garden sieve. Ten kilogram soil was placed in each of the pots. The experiment was laid out with eight treatments with three replications in a randomized complete block design (RCBD). The treatments were factorial combination of four rates of

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mineral fertilizer (0-0-0, 150-0-0, 150-75-0 and 150-75-60 kg ha^{-1} N, P and K respectively) and two rates of biocompost 0 and 10 tons ha^{-1}.

b) Application of biocompost and fertilizers

The quantity of biocompost required for each treatment was calculated as per treatment plan and as per weight of soil per pot (10 kg/pot). Before placing soil in each pot, biocompost was thoroughly mixed with soil for the treatments involving biocompost application. Phosphorus and potassium were applied in the form of single superphosphate (18% P_2O_5) and sulphate of potash (50% K_2O) respectively before planting as per treatment plan. Fertilizers were thoroughly mixed with soil before filling it in the pots. Nitrogen application was made in the form of urea (46% N) in three splits starting from one week after germination of maize and followed by two fortnightly applications afterwards.

c) Maize Planting and agronomic observation

Ten seeds of maize (cv. Akbar) were planted in each pot. After germination, the seedlings were thinned to five per pot. The plants were irrigated as required and harvested after 7 weeks of growth. Before harvesting, height of each plant in each of the treatments was recorded from soil surface to the tip of the longest leaf extension. The plants were harvested at 1cm above the surface of soil, washed clean of any soil particles, and placed in paper bags by each treatment, and kept in oven at 70°C for drying. After achieving constant weight, the plants were weighted to determine dry weight of shoots by each treatment and replication.

d) Soil sampling and analysis

The soil sample from experimental plot was collected from a depth of 0 – 15 cm and air dried in shade. Then sample was ground using wooden pestle and mortar and passed through 4 mm sieve. The sieved sample was preserved in polythene bag for further analysis. The soil sample was analysed for various physical and chemical properties.

e) Biocompost and plant analysis

Biocompost used in this study and the plant samples drawn at harvesting from each treatment were analyzed for total N, P and K. Total N was determined by digestion with concentrated H_2SO_4 along with a mixture of selenium, $CuSO_4$ and K_2SO_4 in 0.1:1:10 ratios using Kjeltech Digestion System 20. The digests were distilled by using Kjeltech Distillation Unit 1002 as described by Winkleman et al. (1986). For P and K, the plant samples were digested in 1:5 $HClO_4$: HNO_3 mixture followed by analysis of the digest by vandomolybdophosphoric acid yellow colour method (Barton, 1954) for P and flame photometer for K (Jackson, 1958).

f) Calculation and statistics

The data were statistically analysed by using software Statistix 8.1 and the calculations were made using following formulas.

1. Standard Error for Difference between Means (S.E.D) was calculated using the following formula: S.E.D = (√2EMS/n) EMS= Error Mean Square. 2. Least
2. Significant Difference (LS.D) = S.E.D x t value for Error df at 5% probability level.
3. Coefficient of Variance (%) = (√MSE / Grand Mean) x 100.

III. Results and Discussion

a) Pot experiment on maize

i *Soil properties*

The soil used for the experiment was analyzed for some physico-chemical properties of soil sample (Table 1). The results revealed that the soil was a clay loam (31% clay) with EC 0.37 dSm^{-1}, and pH 7.83. It was low in organic matter (0.81%), and Olsen P (7.2 mg kg^{-1}), and adequate in NH4OAc – extractable K (330 mg kg^{-1}).

Table 1 : Physico-chemical properties of the soil used for pot experiment on maize

Soil properties	Values
Sand (%)	25.5
Silt (%)	40.5
Clay (%)	31.0
Textural Class	Clay loam
EC (1: 5 soil – water extract) (dS m^{-1})	0.37
pH (1:5 soil – water extract)	7.83
Organic matter (%)	0.81
Olsen P (mg kg^{-1})	7.2
NH_4OAc- extractable K (mg kg^{-1})	330

ii *Effect of biocompost and mineral fertilizer treatments on growth of maize*

a. Plant height

The data regarding plant height of maize as affected by mineral fertilizer and biocompost treatments are given in Table 2. Overall, the plant heights ranged from 34.13 to 55.87 cm. Addition of biocompost as well as mineral fertilizers showed significant increase in plant height. On an average, the plant height increased from 39.83 to 49.63 cm with the addition of biocompost which is equivalent to 24.6 % increase. When biocompost was applied alone to unamended soil, the plant height increased from 35.00 to 46.06 cm. Similarly, the application of N fertilizer also increased it significantly to 45.33 cm. On an average taken over biocompost treatments, the plant height increased significantly from 40.53 cm for unfertilized control to 50.60 cm for the treatment receiving N fertilizer only. Addition of P fertilizer did not help improve the plant height while addition of K fertilizer (NPK treatment) in fact resulted in reduced growth with average plant height of 39.13 cm.

Table 2 : Effect of biocompost and mineral fertilizer treatments on plant height (cm) of 7-week old maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/ha^{-1}	Fertilizer Mean
Control	35.00	46.06	40.53b
N	45.33	55.87	50.60a
NP	44.87	52.47	48.67a
NPK	34.13	44.13	39.13b
Biocompost Mean	39.83b	49.63a	44.73

CV %	*5.94*
S.E	*2.6*
L.S.D @ 5%	
Fertilizer	*3.29*
Biocompost	*2.32*
Fertilizer x Biocompost	*NS*

b. Dry weight of maize

The data in Table 3 showed that there was pronounced positive effect of addition of biocompost as well as mineral fertilizer treatments on dry weights of maize. Overall, the dry weights ranged from 17.23 to 29.93 g pot^{-1}. On an average, the dry weights increased by 28.2% from 19.93 to 25.55 g pot^{-1} with addition of biocompost. When biocompost was applied alone to unamended soil, the dry weight increased from 17.23 to 23.60 g pot^{-1}. Similarly the applications of N fertilizer also increased it significantly to 21.90 g pot^{-1} and to 29.93 g pot^{-1} when biocompost was also added. It was noted that there was no significant improvement in dry matter yield of maize due to P fertilization (NP treatment) and addition of K fertilizer (NPK treatment) to this treatment showed decline in dry matter yield. Thus the application of N fertilizer or biocompost were the most effective treatments in improving the dry matter yield of maize. Since the effect of fertilizer and biocompost treatments was similar in all combinations, the interaction between fertilizer and biocompost treatments was noted to be non significant.

Table 3 : Effect of biocompost and mineral fertilizer treatments on dry weight of 7-week old maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/ha^{-1}	Fertilizer Mean
Control	17.23	23.60	20.42b
N	21.90	29.93	25.92a
NP	22.33	26.26	24.30a
NPK	18.26	22.40	20.33b
Biocompost Mean	19.93b	25.55a	22.74

C V %	*13.49*
S.E	*3.07*
L.S.D @ 5%	
Fertilizer	*3.79*
Biocompost	*2.68*
Fertilizer x Biocompost	*NS*

b) Total N in maize

The results regarding the effect of biocompost and mineral fertilizer tretments are given in Table 4. The values ranged from 0.80 to 0.93%. The data showed that the application of either biocompost or mineral fertilizer treatments did not bring about a significant change in the total N content of maize. The values of total N with and without biocompost application were 0.85 and 0.86% resepectively. In case of fertilizer treatments, these values ranged from 0.83 to 0.88%. It was noted further that the interactions between biocompost and mineral fertilizer treatments were also nonsignificant.

Table 4 : Effect of biocompost and mineral fertilizer treatments on total N in maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/ha^{-1}	Fertilizer Mean
Control	0.83	0.82	0.83a

N	0.86	0.90	0.88a
NP	0.93	0.83	0.88a
NPK	0.80	0.90	0.85a
Biocompost Mean	**0.85a**	**0.86a**	**0.86**

C V% 8.75
S.E 0.08
L.S.D @ 5%
Fertilizer NS
Biocompost NS
Fertilizer x Biocompost NS

c) Total P in maize

The data in Table 5 showed that total P in maize varied from 0.18 to 0.24% and averaged to 0.20% for all treatments. As the values varied within a narrow range, the effects of either biocompost or mineral fertilizer tretments were non significant. Similarly, the interaction between biocompost and fertilizer treatments was also nonsignificant.

Table 5 : Effect of biocompost and mineral fertilizer treatments on total P in maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/ ha^{-1}	Fertilizer Mean
Control	0.20	0.20	0.20a
N	0.21	0.21	0.21a
NP	0.23	0.24	0.23a
NPK	0.18	0.19	0.18a
Biocompost Mean	**0.20a**	**0.21a**	**0.20**

CV% 14.60
S.E 0.03
L.S.D @ 5%
Fertilizer NS
Biocompost NS
Fertilizer x Biocompost NS

d) Total K in plant

The total K contents of maize ranged from 1.12 to 1.23% as a result of biocompost and mineral fertilizer treatments (Table 6). The effects of either biocompost or mineral fertilizer treatments were found to be non significant. Similar was the case with the interactions between biocompost and mineral fertilizer treatments which were found to be nonsignificant.

Table 6 : Effect of biocompost and mineral fertilizer treatments on total K in maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/ h^{-1}	Fertilizer Mean
Control	1.13	1.15	1.13a
N	1.15	1.15	1.15a
NP	1.22	1.23	1.22a
NPK	1.12	1.15	1.14a
Biocompost Mean	**1.16a**	**1.17a**	**1.16**

CV% 5.38
S.E 0.06
L.S.D @ 5%
Fertilizer NS
Biocompost NS
Fertilizer x Biocompost NS

i *Physico-chemical properties of soil after harvest of maize*

a. Effect on soil EC

The data in (Table 7) showed that there was significant effect of biocompost treatments. The EC value was lowest (0.84 dSm^{-1}) for the control treatment not receiving either mineral fertilizer or biocompost. With addition of N, P and K fertilizer, the mean EC value increased from 0.84 to 1.05 dSm^{-1}, while the addition of biocompost increased it to 1.24 dSm^{-1}. Combined application of fertilizers and biocompost contributed to further increase in EC level to a maximum of 1.66 dSm^{-1}. Overall mean of EC values was 0.91 dSm^{-1} where no biocompost was applied. A highly significant increase in mean EC value, to 1.36 dSm^{-1}, was noted for the treatments receiving biocompost. In case of fertilizer treatments, mean EC values showed progressive increase from 1.04 dSm^{-1} for unfertilized control, through N and N+P treatments, to 1.35 dSm^{-1} for N+P+K treatment but the treatment differences were statistically non significant.

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Table 7 : Effect of biocompost and mineral fertilizer treatments on soil EC (dSm^{-1}) after harvest of maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/h^{-1}	Fertilizer Mean
Control	0.84	1.24	1.04b
N	1.24	1.11	0.94b
NP	0.96	1.54	1.20ab
NPK	1.05	1.66	1.35a
Biocompost Mean	0.91b	1.36a	1.13

C V %	*25.47*
S.E	*0.29*
L.S.D @ 5%	
Fertilizer	*NS*
Biocompost	*0.25*
Fertilizer x Biocompost	*NS*

b. Effect on soil pH

The data in (Table 8) showed that the pH values ranged from 7.20 to 7.47 for various treatments. There was slight increase in pH with the addition of either fertilizer or biocompost. However, the treatment differences were non-significant in both cases. Similarly the interactions between fertilizer and biocompost treatments were also non significant.

Table 8 : Effect of biocompost and mineral fertilizer treatments on soil pH after harvest of maize

Fertilizer treatment	No Biocompost	Biocomost 10t/h^{-1}	Fertilizer Mean
Control	7.20	7.37	7.28a
N	7.20	7.30	7.25a
NP	7.37	7.47	7.12a
NPK	7.43	7.47	7.45a
Biocompost Mean	7.30a	7.40a	7.35

C V %	*3.39*
S.E	*0.25*
L.S.D @ 5%	
Fertilizer	*NS*
Biocompost	*NS*
Fertilizer x Biocompost	*NS*

c. Effect on soil organic matter

Soil organic matter contents ranged from 0.70 to 0.93% as a result of mineral fertilizer and biocompost treatments (Table 9). There was no effect of fertilizer treatments on soil organic matter. However, application of biocompost increased it significantly fron 0.72 to 0.90%. This effect was similar for each fertilizer treatment and thus the interaction between mineral fertilizer and biocompost treatments was non significant.

Table 9 : Effect of biocompost and mineral fertilizer treatments on soil organic matter (%) after harvest of maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/h^{-1}	Fertilizer Mean
Control	0.70	0.93	0.82a
N	0.78	0.84	0.81a
NP	0.70	0.90	0.80a
NPK	0.71	0.93	0.82a
Biocompost Mean	0.72b	0.90a	0.81

C V %	*18.86*
S.E	*0.15*
L.S.D @ 5%	
Fertilizer	*NS*
Biocompost	*0.13*
Fertilizer x Biocompost	*NS*

d. Effect on Soil P (Olsen)

The data in (Table 10) showed that soil P contents ranged from 8.17 to 15.00 mg kg^{-1} due to biocompost and mineral fertilizer treatments. A highly significant increase in Olsen P was noted with the application of biocompost, whereby soil P increased, on an average, from 10.17 mg kg^{-1} to 12.65 mg kg^{-1}. Similarly, the effect of fertilizer application also produced highly significant increase in soil P from 10.08 to 13.50 mg kg^{-1}, on an average. Further, it was noted that there was interdependence between biocompost and mineral fertilizer treatments such that the interaction between mineral fertilizer and biocompost were highly significant. When no fertilizer was applied, the P contents increased with biocompost application. This was not the case when N was also applied. However, when N and P fertilizers were applied, there was significant improvement in soil P due to fertilizer as well as due to biocompost.

Table 10 : Effect of biocompost and mineral fertilizer treatments on soil phosphorus (Olsen, mg kg^{-1}) after harvest of maize

Fertilizer treatment	No Biocompost	Biocomost 10 t/h^{-1}	Fertilizer Mean
Control	8.17e	13.25b	10.71bc
N	9.50de	10.67cd	10.08c
NP	12.00bc	15.00a	13.50a
NPK	11.00cd	11.67bc	11.33b
Biocompost Mean	10.17b	12.65a	11.41

C V %	*7.96*
S.E	*0.91*
L.S.D @ 5%	
Fertilizer	*1.12*
Biocompost	*0.79*
Fertilizer x Biocompost	*1.59*

e. Effect on NH4OAC-extractable K in soil

The data in (Table 11) showed that soil K contents ranged from 333 to 500 mg kg^{-1} NH_4OA_C-extractable K due to mineral fertilizer and biocompost treatments. A highly significant increase in extractable K content was noted with the application of biocompost, whereby soil K increased, on an average, from 368 to 346 mg kg^{-1} NH_4OA_C-extractable K. Similarly, the effect of fertilizer application also produced highly significant increase in soil K from 363 mg kg^{-1} for control to 460 mg kg^{-1} where NPK treatment was applied. Further it was noted that the interactions between mineral fertilizer and biocompost were non significant.

Table 11 : Effect of biocompost and mineral fertilizer treatments on soil potassium (NH_4OA_C-extractable, mg kg^{-1}) after harvest of maize

Fertilizer treatment	No Biocompost	Biocomost 10t/h^{-1}	Fertilizer Mean
Control	333	393	363b
N	346	420	383b
NP	373	433	403ab
NPK	420	500	460a
Biocompost Mean	368b	436a	402

C V %	*12.57*
S.E	*50.59*
L.S.D @ 5%	
Fertilizer	*62.65*
Biocompost	*44.29*
Fertilizer x Biocompost	*NS*

We invesitigate the physical and chemical properties of mineral fertilizer and biocompost samples as well as maize growth. This study was conducted at the Department of Soil Science, Sindh Agriculture University Tandojam. The results of this study areas discussion below:

1. *Nutrient composition on pressmud*

The analytical data for the biocompost sample obtained from Matiari Sugar Mill, Matiari showed that the average values of total N, P and K contents were 1.8% N, 1.83% P and 0.9% K. Many studies have reported the nutrient composition of pressmud. Ibrahim *et al.* (1990) collected pressmud samples from five sugarmills of Punjab province of Pakistan and observed variable proportion of plant nutrients from one mill to another. The values ranged from 1.7-2.3, 1.0-1.3 and 0.6-0.8 % N, P and K respectively. Besides this, pressmud also contained sufficient amount of micronutrients, which ranged from 58-71, 4750-5904, 249-330, and 143-220 mg kg^{-1} Cu, Fe, Mn and Zn respectively.

2. *Pot experiment on maize*

The soil used for the experiment was a clay loam (31% clay) in texture, non saline (EC = 0.35 dSm^{-1}), alkaline in reaction (pH =7.87), low in organic matter (0.80%) and Olsen P (7.0 mg kg^{-1}) and high in NH_4OAc–extractable K (320 mg kg^{-1}). Application of biocompost alone increased maize plant height by 31.6% from 35.00 to 46.06 cm. similar increase (29.51%) was obtained with the application of N fertilizer. Application of biocompost along with N fertilizer increased the plant height further to 55.87 cm which corresponds to 59.6 % increase over control. And the interaction between mineral fertilizer and biocompost was non- significant. There was pronounced positive affect of addition of biocompost and mineral fertilizer alone or in combination on the dry weight of maize. Application of biocompost alone increased dry weight by 37% over control. Corresponding increase with N fertilizer was 27.1% whereas combined application of biocompost and N fertilizer increased it by 73.7% over control. And their interaction between mineral fertilizer and biocompost was found to be non- significant. The results of pot study on maize showed that there was pronounced positive effect of addition of biocompost on plant height and dry weights. Similarly, addition of fertilizer, particularly N, increased plant height and dry weights. However, similar study conducted by Memon (2005) revealed that their were pronounced positive effects of addition of fertilizers, particularly nitrogen on plant height and dry weights, and depressing effect of pressmud (5 t ha^{-1}) on maize growth and dry matter. However increase from 5 to 15 tons ha^{-1} slightly improved the growth and yield performance of maize. Drastic decline in maize dry matter yield was observed when the rate of pressmud was increased from 15 to 25 tons ha^{-1}. Plant analysis data revealed significant increase in N contents with the application of N fertilizer but P and K fertilization and pressmud did not significantly influence the N contents. It was hypothesized that the initial depressing effect of pressmud was related to presence of unrecompensed organic matter and the high rates of pressmud. Thus the benefit of pressmud was observed in a follow up experiment on wheat involving same soil and previously applied pressmud. These data therefore show that pressmud could be used in the fields for increasing crop production.

There was no effect of either biocompost or mineral fertilizer on the total N, P and K contents of maize. The interaction between mineral fertilizer and biocompost treatments were also non-significant.

3. *Physico-chemical properties of soil after harvest of maize*

The electrical conductivity of post harvest soil increased significantly with the application of biocompost, and also with combined application of fertilizer N, P and K. However, the interaction between biocompost and mineral fertilizer was non-significant. Post-harvest soil pH values did not show any effect of the mineral fertilizer biocompost treatments. There was no effect of fertilizer on the organic matter content of post-harvest soil. However the biocompost treatments showed highly significant increase in soil organic matter from 0.72 to 0.90 %, on an average. The interaction between mineral fertilizer and biocompost was non-significant. Olsen P content of post-harvest soil showed highly significant increase as a result of P fertilization (10.08 to 13.05 mg kg^{-1}) and biocompost (10.17 to 12.65 mg kg^{-1}) application. The interaction between mineral fertilizer and biocompost was also highly significant. Soil potassium (NH_4OA_C-extractable) increased significantly due to fertilizer from 363 to 460 mg kg^{-1}, on an average. In case of biocompost, a highly significant increase in soil K from 368 to 436 mg kg^{-1} was noted. The interaction between mineral fertilizer and biocompost was found to be non-significant. In one study Aziz *et al.* (2010) evaluated the beneficial effects of different sources of organic manures on soil physico-chemical properties and growth of maize. Organic manures viz. farm yard manure, poultry manure and pressmud were added in soil filled earthen pots at 10 t ha^{-1}. Results revealed that organic matter content, phosphorus and potassium bioavailability in soil and their uptake by plants were increased by organic manure application irrespective of the source. Likewise organic manure substantially improved the plant height, leaf area and shoots and root fresh and dry weights. Similarly shoot phosphorus and potassium contents were also improved by the application of organic manures.

IV. Conclusions and Recommendations

It is concluded that biocompost can be used as a soil amendment for improving soil organic matter and available nutrients and for increasing crop production. It is prepared to supplement this work through field studies on different crops for determining its real value to the former.

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