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Biocompost Application for the Improvement of Soil Characteristics and Dry Matter Yield of *Lolium perenne* (Grass)

Ghulam Sarwar, Nazir Hussain, Fakhar Mujeeb, [1]H. Schmeisky and Ghulam Hassan
Soil Salinity Research Institute, Pindi Bhattian District Hafizabad, Punjab, Pakistan
[1]University of Kassel, Witzenhausen Germany

Abstract: A pot experiment was conducted at University of Kassel, Witzenhausen Germany. Three types of soils were used for this purpose. Biocompost is the form of compost prepared from kitchen wastes. This compost was analyzed before application (pH = 7.7 and C: N ratio = 14.2:1). Biocompost was applied to each soil type at 5 and 10% of soil volume. ***Lolium perenne*** grass was grown in all the pots. The experiment had four replications. This grass was harvested at the age of one month and was oven dried at 60 °C. This plant material was then analyzed for organic matter; N, Ca, Mg, K and P contents. Soil samples were also taken from all the pots and analyzed for pH, EC, organic matter, N, C, C/N ratio and mineral nutrients (Ca, Mg, K, P and Cl). All data were analyzed statistically. It was observed that use of biocompost at both the levels (5 and 10%) enhanced the soil pH, EC, organic matter, N and C% with a net decrease in C/N ratio. Organic matter and N percentages in plant material were increased with the application of biocompost. Contents of mineral nutrients in the soil were also increased by the use/addition of biocompost. The resultant improvements in soils, contributed towards significant enhancement in dry matter yield of *Lolium perenne* grass.

Key words: Soil characteristics, dry matter, yield, *Lolium perenne* (Grass)

Introduction

Environmentalists around the globe believe that human actions are responsible for the land degradation and environmental pollution. Among major factors responsible for such degradation are increasing human population pressure, deforestation, faulty irrigation, overgrazing and mismanagement of lands. The consequences of such actions are salinity, waterlogging, moisture stress, surface crusting, soil compaction, loss of nutrients and low fertility. Land degradation due to low fertility impairs the productivity on sustained basis. Vast areas in the country are categorized as poor due to low organic matter and hence poor nutrient supply capacity (Zia *et al*., 1998). On the other hand, the abuse of forest resources and rangelands has caused the serious disturbances in natural ecosystems leading towards loss of biodiversity and top fertile soil (Salim *et al*., 1992).

Because of continued cultivation, the soils of Pakistan are becoming low and deficient in organic matter contents. According to Nizami and Khan (1989) Pakistan soils exhibit poor aggregates stability and are low in iron and aluminium contents. High human population in rainfed areas forces the farmers to maintain large number of livestock as an alternate source of income. For the animals, they grow fodder crops like sorghum, maize, millet etc., which usually exhaust the soils of the areas resulting in poor soil fertility status. Therefore, rainfed areas are not only thirsty but also hungry.

Organic matter makes its greatest contribution to soil productivity. It provides nutrients to the soil, improves its water holding capacity and helps the soil to maintain good tilt and thereby better aeration for germinating seeds and plant root development (Zia *et al*., 1993). Pakistan's soils are extremely low in organic matter (Zia *et al*., 1998). Out of a total of 33,7714 samples analyzed in the Punjab, 96% of the samples were in the poor to medium range of organic matter and only 4% exhibited a moderate to adequate level. Micronutrients deficiency such as Zinc is widespread in all rainfed areas (Rafique *et al*., 1990). Cultivation of high yielding crop varieties and multiple cropping is depleting the fertility of soils at a rapid pace. The soils which were once well supplied with available nutrients are now gradually becoming deficient (Zia *et al*. 1994). Organic matter is being regarded as a very important parameter of soil productivity. It has a number of important roles to play in soils, both in their physical structure and as a medium for biological activity.

Use of compost can be beneficial in this regard, as a rich source of nutrients with high organic matter content. Physical and chemical properties of soil can be improved by using compost which will ultimately increase crop yields. Depletion of nutrients and poor organic matter content in Pakistani soils can only be replenished by applying compost to these soils. So, use of compost is the need of time. Beside improving the physical structure of the soil, using compost has these other benefits (Smith, 1995):

- Modifies temperature extremes in the soil, keeping it cooler in the summer and warmer in winter.
- Utilizes rainfall or irrigation water more efficiently, because less moisture is lost due to evaporation and runoff by permitting better absorption.
- Adds a bank of biological activity to the soil, which contributes to more efficient nutrient uptake and tying up of certain ions.
- A buffering capacity (resist change in pH) is added to the soil with the addition of compost. The effects of over-fertilization are not as critical.
- Because of its tremendous cation-holding capacity, the addition of compost to the soil would allow for the holding of plant nutrients for a longer period of time.

Growing grasses and incorporation into the soil is very useful strategy to increase the organic matter content of soil. *Lolium perenne* grass highly responds to compost application and grows rapidly. This is a cool season perennial grass native to Europe, temperate Asia and North Africa and can tolerate a wide range of pH from 5.1 to 8.4. In these studies, effect of compost was investigated on *Lolium* grass as an indicator plant and resultant improvement in soil parameters, especially the increase in organic matter content was observed. The main objective was to devise a workable strategy for increasing organic matter content of the depleted marginal soil and enhance its nutrient supplying capacity.

Materials and Methods

Three different types of soils used were I) normal cultivated soil, ii) nutrient deficient sandy soil, iii) soil from industrial area dominant in $CaSO_4$.

Biocompost made mainly from kitchen wastes was applied to all soil types at 5 and 10% of the soil volume. *Lolium perenne* grass was sown in all the pots at 1.1g pot^{-1}. Thus, experiment had 9 treatments with four replications. All the pots were irrigated with ground water having pH = 7.75 and EC = 387 μS cm^{-1}. After one month, grass was harvested from all the pots, oven dried and analyzed for various chemical characteristics. The plant samples were ignited and then desiccated. Ignition was done at 550 °C to ensure the destruction of all organic matter by the oxidation of CO_2 and water (Saywer, 1994). After the completion of ignition process, all the material along with crucibles were cooled down to room temperature in desiccator while keeping the relative humidity near to zero. Then 5 ml 32% HCl was added to each crucible-containing sample in it. After 24 h, this material was shifted to 100 ml volumetric flask and was subsequently filtered. This filtrate was used to measure various determinations of mineral nutrients like Ca, Mg, K and Cl percentage.

Soil samples were also obtained from all the pots and were analyzed for pH, EC, organic matter, N, C, C/N ratio, Ca, Mg, K, P and Cl contents. Before addition to the soil, compost was also analyzed for various chemical characteristics.

Treatments of the experiment were as under:

T1	Soil A
T2	Soil A + Biocompost at 5% of soil volume
T3	Soil A + Biocompost at 10% of soil volume
T4	Soil B
T5	Soil B + Biocompost at 5% of soil volume
T6	Soil B + Biocompost at 10% of soil volume
T7	Soil C
T8	Soil C + Biocompost at 5% of soil volume
T9	Soil C + Biocompost at 10% of soil volume

Results and Discussion

Biomass of *Lolium* grass: Very wide variation was observed in the original potential of three soils of the experiment (Fig. 1). The recorded biomass was significantly more in normal cultivated soil A compared with nutrient deficient sandy soil B and $CaSO_4$ dominated soil C from the industrial area. The later two soils indicated non-significant differences in case of treatment means as well as applied levels of compost. Compost application significantly enhanced the oven dry biomass of the grass at both the levels and in all the three soils. The application of compost improves the physical conditions of the soil and enhances its nutrient supplying capacity (Smith, 1995). Similar observations were also recorded in these studies. Hence the biomass of *Lolium* grass was increased in all the three soils with the two levels (5 and 10% by volume) of compost.

Impact on chemical composition of *Lolium* grass biomass: The organic matter percentage of the biomass was not affected in soil A (Fig. 2). The differences were significant at both the compost levels in soil B. However, the response for this parameter of the two levels was non-significant among themselves but significant to control. The nitrogen percentage of biomass was enhanced differently in different soils due to compost levels when adjudged with the soil and treatment means (Fig. 3). However, the interactions were found to be non-

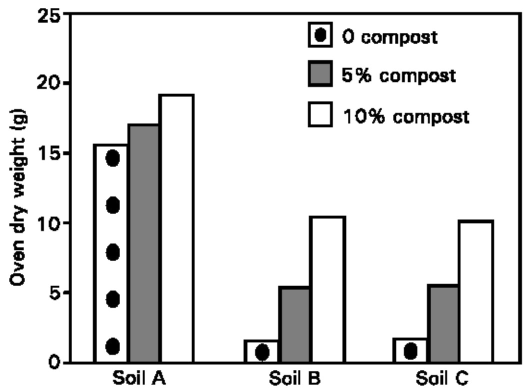


Fig. 1: Oven dry biomass of *Lolium* grass

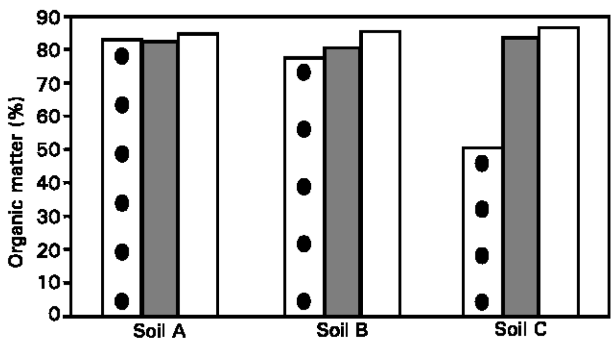


Fig. 2: Organic matter percentage in *Lolium* grass biomass

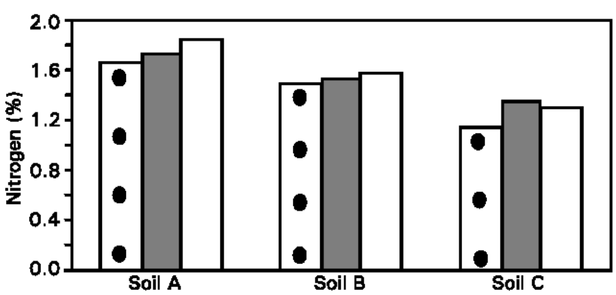


Fig. 3: Nitrogen percentage in *Lolium* grass biomass

significant. The calcium contents were affected differently in the three soils of the study. No significant impact due to compost was found in soil A and B, although it was increased slightly (Fig. 4). But this parameter was significantly affected in soil C where calcium percentage was rather decreased. The differences of compost were appreciable compared to control but similar among the applied levels. The magnesium percentage was decreased in soil A and C but increased in soil B (Fig. 4). The differences were significant only for the second level (10%) in soil A, both the levels in soil B and C when compared with control.

Table 1: Composition of Biocompost

Characteristics	Unit	Value
pH	-	7.7
EC	$\mu S\ cm^{-1}$	3360.0
Organic matter	%	43.8
Total Carbon	%	25.6
Total Nitrogen	%	1.8
C / N	-	14.2
Calcium	$g\ kg^{-1}$ compost	36.73
Magnesium	$g\ kg^{-1}$ compost	6.31
Potassium	$g\ kg^{-1}$ compost	12.63
Total Phosphorus	$g\ kg^{-1}$ compost	4.25
Chlorides	$g\ kg^{-1}$ compost	5.47

All weights are on oven dry basis.

Table 2: Effect of Biocompost application on soil pH and EC

Treatment	Soil A	Soil B	Soil C	Mean
pH				
0 Biocompost	7.20a	5.140f	6.44d	6.260C
5% Biocompost	7.26a	6.217e	7.03b	6.836B
10% Biocompost	7.31a	6.750c	7.04b	7.033A
Mean	7.257A	6.036C	6.837B	
EC (dSm^{-1})				
0 Biocompost	0.09265	0.02795	2.220	0.7802
5% Biocompost	0.12038	0.03463	2.225	0.7933
10% Biocompost	0.14065	0.04715	2.223	0.8036
Mean	0.1179B	0.03658C	2.223A	

Table 3: Different soil parameters (organic matter, C: N ratio and Phosphorus) as affected by Biocompost application.

Treatment	Soil A	Soil B	Soil C	Mean
Organic matter (%)				
0 Biocompost	3.98b	0.12g	1.22e	1.773C
5% Biocompost	4.07b	0.15g	1.49d	1.903B
10% Biocompost	4.57a	0.37f	1.69c	2.210A
Mean	4.207A	0.2133C	1.467B	
C: N Ratio				
0 Biocompost	10.90def	19.00a	11.96c	13.95A
5% Biocompost	10.43fg	15.50b	11.40cd	12.44B
10% Biocompost	10.17g	10.71efg	11.04de	10.64C
Mean	10.15C	15.07A	11.47B	
Phosphorus ($g\ kg^{-1}$)				
0 Biocompost	0.84b	0.025c	0.00c	0.2883B
5% Biocompost	0.87b	0.041c	0.00c	0.3048AB
10% Biocompost	0.96a	0.045c	0.00c	0.3350A
Mean	0.8911A	0.037B	0.00B	

Table 4: Effect of Biocompost on soil cations (Ca^{2+}, Mg^{2+} and K^{1+})

Treatment	Soil A	Soil B	Soil C	Mean
Calcium ($g\ kg^{-1}$)				
0 Biocompost	2.76	0.150	32.77	11.893
5% Biocompost	3.34	0.193	33.98	12.282
10% Biocompost	3.29	0.369	36.51	13.390
Mean	2.908B	0.237C	34.42A	
Magnesium ($g\ kg^{-1}$)				
0 Biocompost	1.88c	0.20 f	0.46d	0.8467C
5% Biocompost	1.96b	0.22ef	0.47d	0.8833B
10% Biocompost	2.29a	0.27e	0.51d	1.023A
Mean	2.043A	0.230C	0.480B	
Potassium ($g\ kg^{-1}$)				
0 Biocompost	1.83b	0.13 d	0.61c	0.8567B
5% Biocompost	1.88b	0.15 d	0.63c	0.8867B
10% Biocompost	2.03a	0.16 d	0.65c	0.9467A
Mean	1.913A	0.1467C	0.63B	

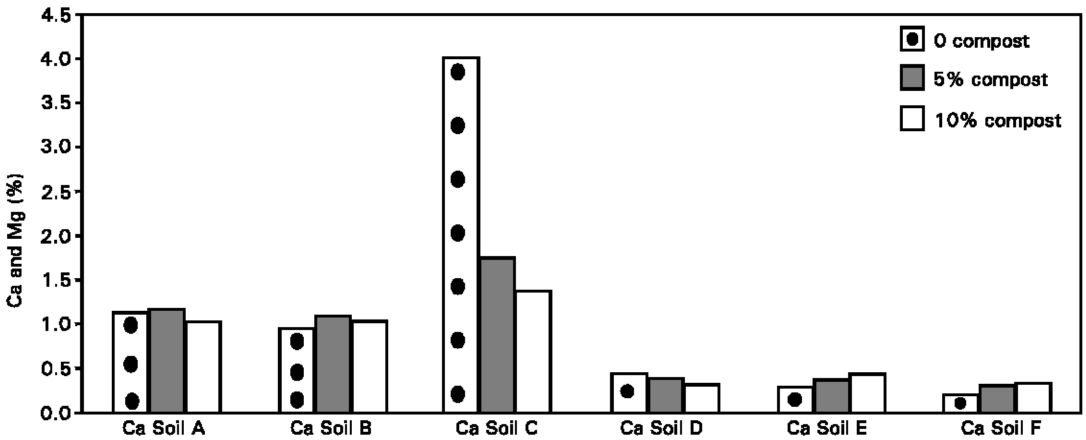


Fig. 4: Calcium and magnesium concentration (%) in biomass of *Lolium* grass

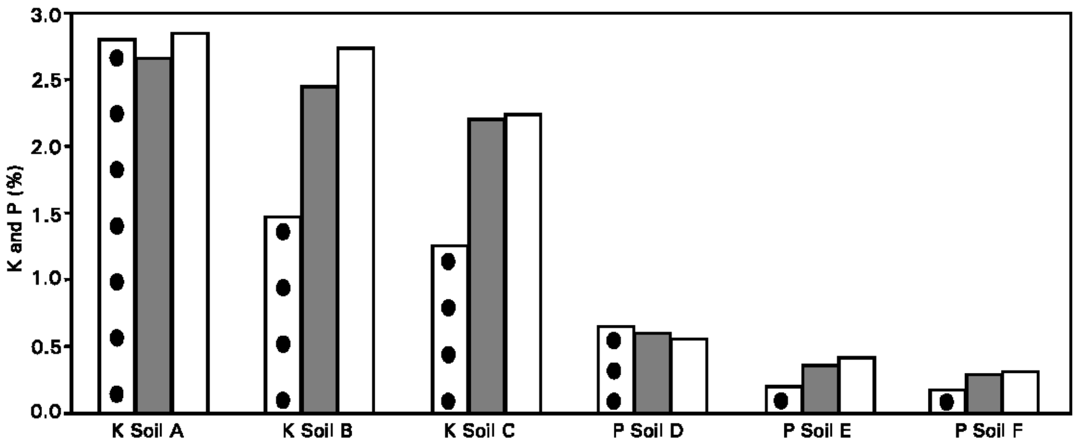
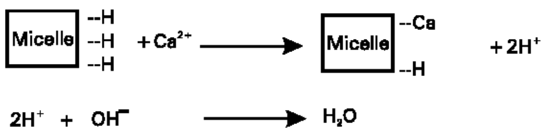


Fig. 5: Potassium and phosphorus concentration (%) of *Lolium* grass biomass

The soil and treatment means of potassium percentage of *Lolium* biomass indicated significant differences in both cases (Fig. 5). The K^+ values were the highest in soil A and only the level of 10% compost slightly increased this constituent. The responses were very clear in soil B where both the levels significantly enhanced K^+ concentration. The plants of soil C were having the least value of this parameter. Both compost levels were found significantly higher than control but similar among themselves. In respect of phosphorus percentage in *Lolium* grass, the recorded values for soil A were significantly higher than soil B and C (Fig. 5). The mean consecutive differences due to compost levels were non-significant. However, the highest level caused significantly more P concentration compared with control. The interactions of soils and compost levels remained non-significant.

The overall results of plant analysis revealed that nutrient concentration was the highest in soil A because it was normal cultivated soil. The responses of compost application were positive and high in soil B being a depleted nutrient deficient sandy soil. Almost similar behaviour was found for that of soil C that was industrial area $CaSO_4$ dominant soil. The compost application improved the overwhelming effects of Ca^{+2}. Even the response of lower level of compost indicated significant effect. In general, the application of compost enhanced the concentration of all the studied nutrients.

Soil characteristics: The impact of compost application (at both levels) on pH was non-significant in soil A (Table 2). However, the pattern with increase pH in all the three soils became significant in soil B and C. Both the compost levels had similar effect in soil B remaining non-significant to each other but significantly higher than control. Al^{3+}, Fe^{3+} and base forming (Ca^{+2} and Mg^{+2}) cations control the pH of a soil. The application of compost released some of Ca and Mg (Table 4). These cations released H^+ from the exchange site, which formed water. Resultantly, the pH was raised (Brady, 1990). This reaction can be indicated as follows:



In general, the EC of the soils was enhanced when compost was applied (Table 2). The increase was more pronounced in soil A and B while in soil C, it was negligible. The differences were non-significant. Organic matter content of all the three soils was significantly increased due to compost application (Table 3). In soil A and B, only the higher level (10%) proved effective while in soil C even the lower level (5%) significantly increased this parameter. The C: N ratio narrowed down in the soils of the study but effect in soil B was very much prominent (Table 3), because this soil was nutrient deficient. The differences created in soil A and B were only significant at 10% level of applied compost.

The parameters of K and P were least affected with the application of compost (Table 3 and 4). The results were non-significant in soil B and C but significant in soil A only with the highest level of compost. The total P and K contents of applied compost were low (Table 1). Hence, the impact on soil parameters was not found to be significant. The Ca concentration of soil was slightly increased due to compost application but results were non-significant. The differences among the soils were however, appreciable indicating different original potentials of soils for these parameters (Table 4). The impact on soil Mg due to compost was significant in soil A and B but non-significant in soil C. The higher level of compost revealed significant difference only in soil A.

In general, it may be concluded that compost application increased soil pH, EC, organic matter, Ca^{2+}, Mg^{2+}, K^+ and P while C: N ratio was narrowed in acidic soil. Hence there was a general increase in nutrient supplying capacity of soils. The impact on various parameters was different in soils. Generally, responses were poor in soil B and C due to their original lower potential. However, compost application was a good strategy for enhancing fertility status of depleted soils.

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