Research article

Effect of Bio-slurry and Chemical Fertilizer on Soil Enzyme Activity

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Abstract Organic nutrient sources are an effective way to improve soil fertility and increase crop yield. Bio-slurry provides tremendous nutrient potential for the vegetative and reproductive growth of field crops and its long-term sustainability. Application of the bio-slurry on the field can help to reduce fertilizer use, maintain productivity, and improve soil health. Soil enzyme activity was enhanced by swine slurry. Enzyme activity following fertilization takes precedence over microbial biomass in the short term. The study aimed (1) to study the effect of bio-slurry and chemical fertilizer on soil enzymes activity, and (2) to compare the biomass growth of corn using bio-slurry and chemical fertilizer. The research was conducted from November to December 2022 at the Throckmorton Plant Sciences Center, Department of Agronomy, Kansas State University, United States. The experiment was conducted in pots under greenhouse conditions with 5 treatments, including Treatment 1: Control (without fertilizer), Treatment 2: bio-slurry, Treatment 3: urea, Treatment 4: NH_4NO_3 and Treatment 5: KNO_3+$NaNO_3$. Each treatment was conducted in 3 replications with 1 pot per replication and 2 seeds per pot. The activities of soil enzymes, biomass of corn above ground and root were collected and analyzed. Corn plants treated with bio-slurry and inorganic fertilizer were found to have a non-significant growth of corn soil β-glucosidase enzyme with 4.41 mg/L, 3.83 mg/L, 4.23 mg/L, 4.11 mg/L, and 4.14 mg/L, respectively. With regard to aboveground and belowground biomass, no significant differences between the control and other treatments were observed. The results showed that bio-slurry released low amounts of enzyme activity to the soil and provided good growth conditions to corn.

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Keywords crop, corn, slurry, soil fertility, soil health

INTRODUCTION

Corn (*Zea mays* L.) is the most vital cereal worldwide (Ka et al., 2022). USA, China, and Brazil contribute 63% of the global corn production while Mexico, Argentina, India, Ukraine, Indonesia, France, Canada and South Africa are also major corn-producing countries (FAO, 2010). In Cambodia, commercial pig farms have increased due to their ability to control the environment necessary for fast pig growth and effective disease prevention (MAFF, 2019). Daily wastewater generated from the pig farm depends on the type of pigs such as sows, fatteners, and piglets at 64 m^3/head, 24 m^3/head, and 20 m^3/head, respectively (Kulpredarat, 2016).

Bio-slurry is a by-product of anaerobic digestion. The bio-slurry contains 93% water and 7% dry matter, of which 4.5% is organic matter and 2.5% inorganic matter, easily available plant nutrients, and high amount of nutrients and micronutrients. Total nitrogen, total phosphorus, and potassium were 2.1%, 1.1%, and 0.98% and micronutrients like Fe, Cu, Mn, and Zn were 0.34 ppm, 0.004 ppm, 0.088 ppm, and 0.023 ppm respectively. It's can be used as fertilizer directly or added with other organic materials on crops. (Kumar et al., 2015).

Soil enzymes are produced by animal manure, plants, and microorganisms. They are prominently secreted by microbes and stimulate microbial activity in this biome (Chernysheva et al., 2021). Soil microorganisms mainly synthesize extracellular enzymes such as β-glucosidase, hydrolases urease, phosphatase, glycosylating enzymes, and many more. Soil enzymes play a vital role in the biodegradation of organic compounds in soil and become the most delicate indicator of change in microbial activities that occur in the soil environment (Hueso et al., 2012).

OBJECTIVE

The objectives of the study were to determine study the effect of bio-slurry and chemical fertilizer on soil enzyme activities and to compare the biomass growth of corn using bio-slurry and chemical fertilizer.

METHODOLOGY

The experiment was conducted at Throckmorton Plant Sciences Center, Faculty of Agronomy, Kansas State University, The United States (39°11'37.3"N 96°35'04.2"W), during the autumn from November to December 2022. DKC59-82RIB corn variety was used and planted in pots in greenhouse condition. The experimental plots were followed a completely randomized design (CRD) with five treatments and 3 replications. The treatments were T1 (control), T2 (bio-slurry), T3 (urea), T4 (NH_4NO_3), and T5 (KNO_3+$NaNO_3$). Recommended doses of fertilizer applied for corn were 190, 30, and 100 kg/ha for N, P, and K, respectively. The soil was watered before planting the seeds, following maximum water holding capacity (MWHC) equivalent to 1 liter of water per pot.

The bio-slurry was collected from the College of Civil Engineering, at KSU, and used swine manure as substrate. Four samples, each about 1 kg of bio-slurry, were taken for nutrient content analysis. The samples contained 957.72 mg/L TN, 43.71 mg/L TP, 598.74 mg/L TP, 120.50 mg/L, 22.68 mg/L Mg, 12.13 mg/L S, and micronutrients (0.10 mg/L Al, 0.37 mg/L Fe, and 152.49 mg/L Na) (Kansas State Soil Testing Lab., 2022)

Soil samples were taken from two locations in each pot at the depth of 0-5 cm at 3 weeks after planted and transported back to the laboratory in plastic trays. For enzymatic analysis, 1-g of the wet soil was mixed with 1 mL of p-Nitrophenyl-β-D-glucosidase (PNG) solution, 4 mL MUB at pH 6.0-, and 0.25-mL toluene. The solution was hand-shaken slowly a few seconds, capped, and then placed in the incubator for 1 hour at 37 ^{0}C. Afterwards, the sample was withdrawn, cooled down at the room temperature, and then added with 1 mL of 0.5M $CaCL_2$ and 4 mL of 0.1M THAM buffer pH 12. This second mixture was hand-shaken for another few seconds and then poured into a beaker through a paper filter Watman No. 2. Before the prepared soil solution was tested in the spectrophotometer, this equipment had to be first tested with six levels of pre-prepared solutions to verify its accuracy. Those solutions contained p-nitrophenol diluted solutions of 0, 1, 2, 3, 4, and 5 mL; six levels of water in reverse order from 5 to 0 mL; each 1 mL of $CaCl_2$; and each 4 mL of THAM pH 12. After the accuracy was verified, the soil samples were then analyzed using this equipment. (Eivazi and Tabatabai, 1978). Values were corrected for a blank (Substrate added immediately after the addition of $CaCL_2$ and Tris NaOH) and for adsorption of released para-nitrophenol ρNP in the soil (Vuorinen, 1993). β-glucosidase activity is expressed as $\mu mol\ \rho NP\ released\ g^{-1}$ dry soil h^{-1}.

Each soil was air-dried 24 hours. Afterwards, the dried soil was ground and sieved to obtain soil particles of less than 2 mm for soil pH, soil moisture content, and plant nutrients analysis. Soil pH was determined using ORION Star A11 Bench top pH meter with a soil-water ratio of 1:10 (Bruce et al., 1982). Soil moisture content was calculated by subtracting the weight of the dry soil, oven-dried at 105 ^{0}C for 48 hours until it reached a constant weight.

Two kinds of corn biomass were measured four weeks after planting. Aboveground biomass was collected by cutting all corn stems in each pot from the stem base, then oven-dried at 60 ^{0}C for 72 hours and weighed. Underground biomass was collected by separating the soil clods and brushing the roots gently before soaked in distilled water to ensure that all soil was removed. Then, clean roots were oven-dried at 60 ^{0}C for 72 hours and weighed.

RESULTS AND DISCUSSION

Soil Enzyme (β-glucosidase)

In terms of β-glucosidase activity, there were no significant differences among the treatments (Table 1). On the other hand, the mean concertation of β-glucosidase in soil was found to decrease among grand mean of 4.13 $\mu mol\ \rho NP$ (Table 1)

Table 1 Effect of different fertilizer on Soil enzyme activity

Treatments	Mean ($\mu mol\ \rho NP$)
Control	4.33
Bio-slurry	3.83
Urea	4.23
NH_4NO_3	4.11
KNO_3+$NaNO_3$	4.14
Grand mean	4.13
SE	0.08
Pr (>F)	0.69

Source: Kansas State Soil Testing Lab., 2022

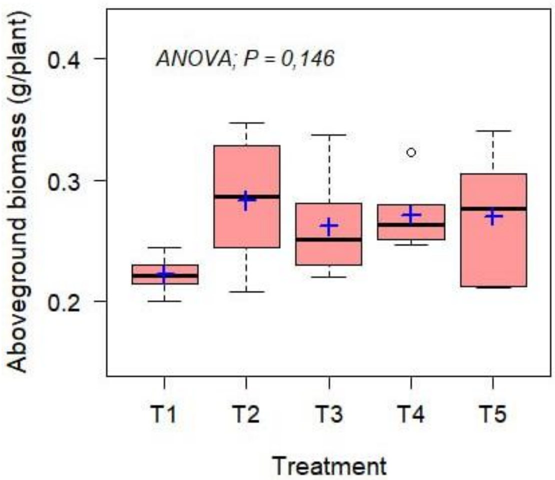

Fig. 1 Competition of corn aboveground biomass in different treatments

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Soil Moisture Content

The result showed no significant difference among the treatments (P > 0.05). We were able to maintain the soil moisture evenly among the treatment (Table 2). In terms of aboveground biomass, it was observed that there are no significant differences between the control and the other treatments with reactions of 10.1%, 9.20%, 8.90% and 8.70%, respectively (Fig. 1; P > 0.05). However, aboveground biomass of swine slurry treatment was higher than others.

No significant differences in the underground biomass were observed between the control and other treatments (P > 0.05), with reduction of 20.10%, 20.60%, 22.07%, and 21.50% for the swine slurry, urea, NH_4NO_3 and $KNO_3 + NaNO_3$ treatments, respectively (Fig. 2).

Table 2 Effect of different fertilizer on Soil moisture

Treatment	Mean (%)	SD
Control	2.71	0.08
Bio-slurry	2.63	0.08
Urea	2.79	0.21
NH_4NO_3	2.65	0.08
$KNO_3 + NaNO_3$	2.68	0.11

Kansas State Soil Testing Lab (2022)

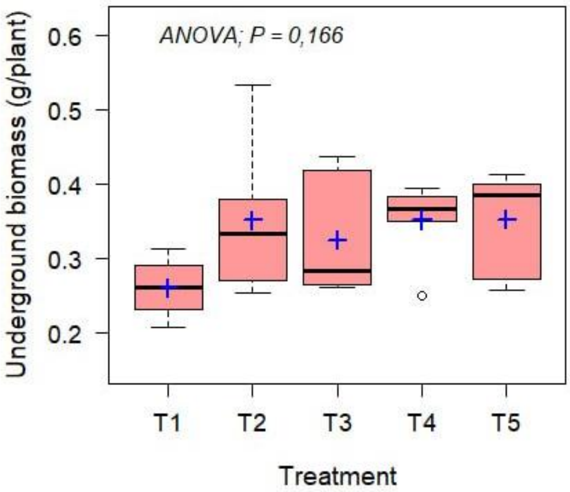

Fig. 2 Underground biomass

CONCLUSION

The results of this research demonstrated that swine slurry treatment cannot affect to soil enzyme activity (β-glucosidase), aboveground biomass, and underground biomass for a short term. According to the results obtained in this study, it is proposed to continue studying the soil enzyme activities for a long term and Phospholipid fatty acid (PLFA).

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