ANALYTICAL CHEMISTRY

Influence of Varied Treatments and Masses of Organic Residue of Sesame Plant on Some Soil Nutrients of Sabon Kaura, Bauchi, Nigeria

R. K. Adebayo[1], U. F. Hassan[1], H. M. Adamu[1], D. A. Ajiya[1], F. H. Halima[2], D. S. John[3], Fatimah Jumat[1]

[1]Department of Chemistry, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria
[2]Department of Internal Medicine, Talba Housing Estate Hospital, Minna, Niger State, Nigeria
[3]Department of Chemical Sciences, Federal University of Kashere, Gombe State, Nigeria

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Abstract

Management of crop residue is necessary to improve the quality of soil for agricultural practices. The influence of varied duration of treatments and different masses of organic residue of Sesame on some soil nutrients was evaluated in soil of Sabon Kaura, Bauchi, Bauchi State, Nigeria. A complete randomized design was used. Neither water nor the organic residue of sesame plant was added to the 0 day incubation period (control). Each treatment was replicated four times and contains 1.00 kg of the soil sample incubated for two, four and six months with organic residue of sesame plant. A 100.00 cm3 of water was added to the mixtures in two, four and six month treatments. Soil samples were taken from the treatments at the end of each incubation period and analysed for micronutrients (Mn, Fe, Cu and Zn) and electrical conductivity (EC) using standard methods. The results showed that addition of organic residue of sesame plant increases the level of EC of the soil from 130.00 µS/cm to 182.00 µS/cm. The experimental results of the treated soils showed variations in the range of Cu (10.00-41.00 mg/kg), Fe (7.00-49.00 mg/kg), Mn (12.40-46.50 mg/kg), Zn (0.92-2.00 mg/kg), EC (150.00- 182.00 µS/cm) respectively. The levels (mg/kg) of manganese, copper, zinc and iron of the control soil are: 3.00, 2.00, 0.50 and 6.50 respectively. All the parameters were found to be statistically different ($p \leq 0.05$) from the control with the exception of EC using Double factor Analysis of Variance and Least Significance Difference Test (LSD). It is therefore recommended that the organic residue of sesame plant can be used to improve the EC and micronutrients of the soil studied.

Keywords: Micronutrients; electrical conductivity; sesame residue; soil fertility; analysis of variance; least significant difference

1 Introduction

Urgent need is required for quick research on dry land crop production to lower poverty and increase food production in developing countries. The decrease in the level of soil organic matter can lead to reduction of farm produce and this is a major problem in maintaining soil fertility. The addition of crop residues (organic materials) plays an important role in the recycling of nutrients. When organic residues of plant origin are added to the soil, they can increase some physicochemical parameters of the soil and hence improves soil quality and productivity. Most of the dry matter in the harvest of agricultural products is in form of crop residues and are in most developing countries. The levels of nutrients in crop residues are greater than the amount used as fertilizers [1].

Most crop residues when left in the field after harvesting, could act as a thermal isolator reducing the exchange of heat between the soil and atmosphere, thereby reducing the rate of water evaporation

from the soil. This effect is higher when the residue is fresh and reduces as the residue decomposes [2].

Intensive agriculture aiming at increasing crop yield per unit area has negatively affected the soil fertility. In recent decades, there has been great demand for increasing the production of food, which lowers the available land for the production of crops. Long term studies in agricultural practices have shown that plant residue could be used to enhance soil health and sustain agricultural production. Small content of crop residue is used as fodder for animals, mulching or composting [1].

Crop residues that cover soil surface acts as physical barriers, making it easily not affected by rain and wind erosion. The maintenance of crop residues can enhance water storage in the soil and may lower the influence of droughts and reduce water erosion which leads to loss of soil fertility [2]. This research was aimed at evaluating the influence of varied treatments and masses of Sesame plants on the levels of electrical conductivity and micronutrients of Sabon-Kaura Soil, Bauchi.

2 Materials and methods

2.1 Soil

Bulk soil samples were collected randomly at a depth of 0-30 cm from different sampling points in Sabon Kaura Bauchi after removing the debris. The soil samples were homogenized, air-dried for ten hours, ground using a wooden pestle and mortar, sieved to pass through a 2 mm mesh with the aim of getting rid of small stones and impurities. The sieved soil samples were labelled appropriately prior to the laboratory analyses.

2.2 Sesame residue

Sesame plants (Sesamum indicum) were collected at Old Airport, Bauchi. The plant was collected from various locations within the sampling site and mixed up in order to ensure sample homogenization. The plant was washed with water to get rid of foreign substances from the sampling location. The samples were air-dried for five days, weighed until constant mass was obtained, ground using a wooden pestle and mortar, sieved through a 2 mm mesh so as to obtain the finest possible powder for analyses. The sieved samples were kept in air-tight plastic containers and labelled appropriately before analyses.

2.3 Treatments and experimental design

The experiment was a complete randomized design with four treatments. Each treatment consisted of three separate pots. A mass of 1.00 kg of soil was weighed into each pot and neither water nor sesame residue was added to the control soil. The remaining three separate treatments of two, four and six months contained 100.00 (M1), 200.00 (M2) and 300.00 g (M3) each of Sesame residue respectively. A volume of 100.00 cm3 of water was added daily to each treatment in order to keep the soil slightly moist. At the end of each treatment period (months), soil from each treatment was air-dried, pounded using a wooden mortar and pestle, sieved through a 2.00 mm mesh and analysed for its electrical conductivity (EC) and extractable micronutrients (Cu, Fe, Mn and Zn).

2.4 Soil chemical analysis

The electrical conductivity of the soil was evaluated in a saturated soil-water suspension in a ratio of 2:1 [3]. Extractable micronutrients (Cu, Fe, Mn and Zn) were extracted using hydrochloric acid solu-

tion [4] and determined using BUCK Scientific Atomic Absorption Spectrophotometer Model 210/11 VGP.

2.5 Statistical analysis

The experimental values obtained from the two-months, four-months and six-months treatments were subjected to two-way ANOVA and Least Significant Test (LSD). Most of the parameters were statistically different ($p \leq 0.05$). The interaction effects of duration (months) of treatments and masses of sesame residue was documented for zinc and iron, while the impacts of interaction between the treatments and varied masses of sesame on manganese and copper were respectively found not to be statistically different.

3 Results and discussion

3.1 Levels of micronutrients and electrical conductivity before and after treatment with sesame residue

The levels of micronutrients and electrical conductivity both before and after treatments is shown in Table 1.

Table 1. Levels of soil micronutrients (mg/kg) and electrical conductivity (µS/cm) before and after treatment with sesame residue.

Treatment (months)	Mass of sesame (g)	Cu	Fe	Mn	Zn	EC
0 (control)	0	2.00±0.00	6.50±0.00	3.00±0.00	0.50±0.00	130.00±0.02
2	100	10.00±0.02	7.00±0.01	12.40±0.03	0.92±0.03	150.00±0.01
4	100	13.50±0.01	11.00±0.01	14.00±0.00	1.30±0.03	163.00±0.02
6	100	16.00±0.02	16.00±0.03	17.00±0.00	1.50±0.01	173.00±0.01
2	200	21.50±0.01	15.00±0.03	26.00±0.01	1.32±0.02	152.00±0.00
4	200	25.50±0.00	23.50±0.02	29.50±0.00	1.50±0.03	167.00±0.02
6	200	28.00±0.03	33.00±0.00	35.00±0.02	1.82±0.01	176.00±0.00
2	300	35.50±0.03	23.00±0.01	36.40±0.02	1.68±0.00	155.00±0.03
4	300	37.00±0.01	34.00±0.00	40.00±0.03	1.74±0.01	170.00±0.00
6	300	41.00±0.02	49.00±0.01	46.50±0.01	2.00±0.02	182.00±0.02

Note: Values are mean ± standard deviation (n = 4). EC = electrical conductivity.

The levels of electrical conductivity (µS/cm) as shown in Table 1 was significantly enhanced in the treated soil from 130.00 µS/cm in the control to 150.00–173.00 µS/cm with 100 g, 152.00–176.00 µS/cm with 200 g and 155.00–182.00 µS/cm with 300 g of sesame residue over two to six months. The observed EC is below the established critical range (750.00-3490.00 µS/cm) for proper plant growth [5]. The increase in the EC depends on the addition of nutrients and salts present in the residue. Previous literature also reported higher EC (265.00 µS/cm) in a soil treated with rice and wheat straw [6]; 745 µS/cm in a soil treatment [7]. The interaction effect of varied masses of sesame residue and incubation periods is less significant on the level of EC. Increase in EC of this study might be attributed to decay of sesame residue which releases components that increases the amounts of ions in soil solution which eventually improved the soil electrical conductivity.

Extractable micronutrients (Cu, Fe, Mn and Zn) increase with increase in the mass of sesame residue and duration of treatments. The concentrations (mg/kg) of Cu (41.00) Fe (49.00), Mn (46.50), and Zn (2.00) were highest after six months treatment incorporated with 300.00 g of sesame which were superior over other treatments. The lowest levels of Cu (2.00), Fe (6.50), Mn (3.00) and Zn (0.50) were obtained in the control soil. The results depicted that micronutrients increased with increasing mass of sesame residue. This corresponds with the findings of [8]. Increase in the concentrations of micronutrients is also reported by other authors [9, 4, 10] and [11].

The levels of zinc (0.92–2.00 mg/kg) were modified when sesame residue was incorporated into the soil, they differed significantly ($p \leq 0.05$) among the treatments. An observation of 13.00 mg/kg of zinc was made in a wheat-straw treatment [12]. The observed Zn is within the threshold levels of Zn (99.40 mg/kg) given in Table 2, as spelt out by [13].

Table 2. Critical limits of soil parameters.

Soil parameter (mg/kg)	WHO [18]	Edori and Kpee [17]
Cu	73.30	36.00
Fe	425.50	–
Mn	2.60	850.00
Zn	99.40	–
EC (µS/cm)	400-600	–

Source: [13].

An increasing trend was observed in the concentration of Fe and was within the permissible limit of 425.50 mg/kg (Table 1). The observation in this study agrees with [11]. An increase in the concentration of Fe was noted in rice and wheat straw treatments [14]. The effect of interaction between varied durations of treatment and masses of sesame residue was observed on the level of iron. Statistical significant difference ($p \leq 0.05$) was found on the concentrations of Fe.

The addition of sesame residue has a positive effect on the levels of Mn and Cu with the highest value observed after six months treatment (Table 1). This might be due to the addition of organic matter of sesame residue. The statements of this study correspond with that of [15] and [16]. The observed values as shown in Table 1 are within the permissible limit of 850.00 mg/kg [17] and 73.30 mg/kg [18]. The two-way ANOVA showed that there was statistical significant difference in the concentrations of copper and manganese based on varied durations (months) and masses of sesame plant residues.

3.2 Effects of interaction

Table 3 shows that the interactions between the different durations of treatments and varied masses of sesame residue are significantly different with the exception of the interaction between Fe2 (after 2 months) and M1 (2.33) and Fe4 (after 4 months) and M1 (3.67). The best interaction is 16.33 which is the interaction between Fe6 (after 6 months) and M3, followed by Fe4 (after 4 months) and M3 (11.33).

Table 4 reveals the interaction between the addition of varied masses of sesame residue and different conditions of treatments on the concentration of manganese is significant (LSD0.05 7.08). The best interaction is the combination of Mn6 and M3 (46.50), followed by 40.00 (the interaction between Mn4 and M3). All other interactions were also significantly different.

Table 5 shows the significant effect was observed between the combinations of different treatments and varied masses of sesame plant on the concentration of zinc. As shown, the difference between any two combinations is greater than the LSD (0.094). Therefore, all the interactions are significantly different, the best interaction is 2.00 which is the interaction between Zn6 (after 6 months treatments) and M3 followed by Zn6 and M2 (1.82), all other interactions were also significantly different. The effects of interaction between the varied masses of sesame residue and different months of treatment are not significant on the concentration of copper.

Table 3. Interaction effects of treatment duration and mass of sesame residue on the level of iron (LSD = 2.31).

Duration	M1 (100 g)	M2 (200 g)	M3 (300 g)
2 months	2.33	5.00	7.67
4 months	3.67	7.83	11.33
6 months	5.33	11.00	16.33

Table 4. Interaction effects of treatment duration and mass of sesame residue on the level of manganese (LSD = 7.08).

Duration	M1 (100 g)	M2 (200 g)	M3 (300 g)
2 months	12.40	26.00	36.40
4 months	14.00	29.50	40.00
6 months	17.00	35.00	46.50

Table 5. Interaction effects of treatment duration and mass of sesame residue on the level of zinc (LSD0.05 = 0.094).

Duration	M1 (100 g)	M2 (200 g)	M3 (300 g)
2 months	0.92	1.32	1.68
4 months	1.30	1.50	1.74
6 months	1.50	1.82	2.00

4 Conclusion

The incorporation of Sesame residue has led to the increase of all the parameters determined in the soil. The increase in micronutrients was greatly influenced by incorporating sesame residue into the soil which is expected to be a temporary change. Soil parameters (Fe, Cu and Zn) were statistically influenced by sesame residue. The interaction effects of duration of treatments and masses of sesame residue were observed in manganese and iron. This implies that input of sesame residue into the soil can improve the levels of Fe, Mn, Cu and Zn in the soil investigated.

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