

EVALUATION OF EGGSHELL WASTES AS ORGANIC FERTILIZER AND ITS PLANT GROWTH PROPERTIES

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Abstract

Chicken eggshell can be utilized as a fertilizer which is important for the plants in order for them to grow healthy into a big tree and produce various types of fruits for the humankind. In this research work, the eggshell waste samples were collected from Bakery, Meiktila Township, Mandalay Region during December 2021. In this research, eggshell powder fertilizer was prepared. This sample was taken to analyze its physicochemical properties such as bulk density and water holding capacity. In addition, bulk density, percents of moisture content, calcium and organic carbon from eggshell powder were also determined. Finally, the prepared powder fertilizer was applied in lettuce plants (Salad).

Keywords: eggshell wastes, powder fertilizer, bulk density, water holding capacity, lettuce plants

Introduction

Everyday huge quantities of eggshell are generated as a bio-waste around the globe. Eggshells are waste materials collected from house and fast-food industries. The eggshells waste disposal contributes to be very costly, leads to environment pollution and un-availability of disposal sites. Odor of eggshell which provides site for flies and abrasiveness leads to dissemination of various diseases in the society. The eggshell constitutes about 11% of a total of weight of the whole egg containing along with 91% of CaCO_3 . The eggshell was also found helpful in reducing the blossom end rot disease in plants and in increasing the nutritional uptake of plants by reducing cultivation cost (Andhare *et al.*, 2018). Since eggshells are often considered waste with no economic value, they are usually thrown away after the contents of the eggs are removed. The high calcium content has the potential to be used as organic fertilizer for plants. The high calcium content in eggshell can function to activate the formation of root and seed hairs and strengthen the stems (Anugrah *et al.*, 2021).

Organic fertilizers can improve the physical, chemical and biological properties of the soil and also help reduce the use of inorganic fertilizer so that it is more environmentally friendly (Zurbano, 2018). The utilization of organic fertilizer greatly helps to improve soil structures, increase soil permeability and reduce land dependence on inorganic fertilizers (Herawati *et al.*, 2020). Organic fertilizers reduce acidity in the soil and do not cause leaching. They do not kill beneficial micro-organisms in the soil. Organic fertilizers also help to improve the structure of the soil including the circulation of air, which sustains beneficial micro-organisms that help release nutrients to the soil (Assefa & Tadesse, 2019).

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Materials and Methods

Sample Collection and Preparation of Eggshell Wastes

The eggshell waste sample was collected from Bakery, Meiktila Township, Mandalay Region during December 2021. The collected eggshell wastes were washed with water to get the purified eggshell wastes. After cleaning, it was crushed into tiny pieces to extract the calcium easily. The crushed eggshell wastes were placed in a frying pan and set the stove in low heat. It was constantly stirred until the colour became from light brown to brownish colour. Then it was grinded by motor and pestle. The eggshell powder was stored in an air-tight container and was used throughout the research.

Physicochemical Properties of Purified Eggshell Wastes

Determination of bulk density

The bulk density of eggshell powder was determined by using graduated cylinder. A clean dry 10 mL graduated cylinder was weighed. It was then filled with the purified eggshell powder to the 10 mL mark and reweighed. The graduated cylinder was placed in a tapping box and the cylinder was tapped gently until there was no more reducing in volume. (Cresswell and Hamilton, 2002)

Calculation

$$\text{Bulk density (g cm}^{-3}\text{)} = \frac{\text{Weight of sample (g)}}{\text{Final volume of sample (cm}^3\text{)}}$$

Determination of moisture content

Moisture content was determined by oven drying method at 110 ± 5 °C. An accurate weight of eggshell powder about 1 g was put into a pre-dried and cooled dish with a cover. The uncovered dish was placed in an electric oven and dried at 110 ± 5 °C for two hours. After heating, the cover was placed in its position and weighing dish removed from the oven. And then it was placed in a desiccator for cooling and weighing and was repeated until a constant weight was obtained (AOAC, 2005). The moisture percent was calculated by the lost in weight.

Calculation

$$\text{Moisture (\%)} = \frac{\text{Loss in weight of sample}}{\text{Weight of sample}} \times 100$$

Determination of organic carbon

The organic carbon (%) in soil sample were determined by Walkley-Black chromic acid wet oxidation method. About 1 g of purified eggshell powder was added to 10 mL of 1 N potassium dichromate solution and 20 mL of concentrated sulphuric acid. The content of the flask was swirled two or three times and allowed the flask to stand for 30 minutes, for the reaction complete. Then 200 mL of distilled water was added to the flask to dilute the suspension. A deep violet colouration was appear when 10 mL of orthophosphoric acid and 1 mL of diphenylamine indicator was added to the flask. Then the solution was titrated with 0.5 N ammonium iron (II) sulphate, till

the colour changes from violet to blue and finally bright green. The volume of the ammonium iron (II) sulphate solution was noted (Nathan, 1998). The same procedure was carried out without eggshell powder (blank titration).

Calculation

$$\% \text{ of Carbon} = [10 - (10 B / A)] \times 0.3$$

B = Sample titration reading

A = Blank titration reading

Determination of calcium

Calcium content (%) present in eggshell was evaluated by titration method. About 1 g of purified eggshell powder was added to 1 mL of 1 M hydrochloric acid in a 100 mL measuring cylinder and it was dissolved in distilled water and was made up the volume to the mark. Then about 10 mL of purified eggshell powder diluted solution was placed in conical flask. Then about 2 mL of ammonia ammonium chloride buffer solution (pH 10) and three drops of Eriochrome Black T were added in conical flask. Then the solution was titrated with 0.01 M standard EDTA solution from burette till the colour of the solution changed from wine red to blue (Lawani. *et al.*, 2014). This procedure was repeated at least three times. The resultant data for bulk density, percent of moisture content, organic carbon and calcium from powder eggshell was shown in Table 1.

Calculation

$$\% \text{ Ca} = \text{mmol of EDTA reacted} \times \frac{100}{10} \times 10^{-3} \times 40 \times 100 \text{ g of Ca}^{+2}$$

Preparation of Powder Fertilizer from Eggshell Wastes

About 10 g of purified eggshell powder were mixed with 1000 g of soil and were used as powdered fertilizer form. The same procedure was carried out by using 20 g and 30 g of purified eggshell powder. The resultant prepared fertilizers were denoted as ES I, ES II and ES III according to 10 g, 20 g and 30 g of eggshell powder respectively.

Physicochemical Properties of Eggshell Powder Fertilizer

Determination of bulk density

The bulk density of eggshell powder fertilizer (ES I, ES II and ES III) was determined by using the same procedure for the determination of bulk density of eggshell powder.

Determination of water holding capacity

About 10 g of eggshell powder and 25 g of garden soil were mixed thoroughly. A filter paper was placed in the bottom of a tin box and the weight of this was noted. The soil and eggshell powder mixture were placed in filter paper containing tin box. A glass rod was taken and tapped the box gently several time, so that the mixture was compactly filled and formed a uniform layer at the top. Then the weight of this was noted. A Petri dish was taken and filled with water. The two small glass rods were taken and placed them parallel to and at a small distance from each other. Tin box filled with the mixture was placed on the two glass rods in such a

manner that its bottom was in contact with water. The mixture was leaved the set up undisturbed until water was appeared on the upper surface of the mixture. All of the mixture surface was entire wet. Then the tin box was removed and allowed all the gravitation water to flow out from the bottom. There was no more water percolated, and wiped the bottom to dry it with a filter paper. Finally, the tin box was weighed again and noted its weight (Keen & Raczkowski, 1921). The same procedure was carried out for ES II and ES III of 20 g, 30 g eggshell powder respectively. The experimental data for bulk density and water holding capacity of eggshell powdered fertilizer was expressed in Table 2.

Calculation

$$\text{Water holding capacity (\%)} \times 100 = \frac{\text{Mass of absorption water}}{\text{Mass of dry garden soil and eggshell powder}}$$

Sample Collection and Preparation of Soil Sample

The soil sample was collected from Myoethit Quarter, Meiktila Township, Mandalay Region during March 2022. Soil sample was collected 0-20 cm deep from the soil surface. The collected soil sample was dried at room temperature for 3 weeks and was stored in plastic container for the further analysis.

Physicochemical Properties of Soil Sample

Determination of soil pH

The pH of the soil sample was determined by pH meter. 2.0 g of soil sample was placed in a beaker and 50 mL of distilled water was added and the solution was shaken for half an hour. Then the solution was allowed to stand for clear solution. The resultant data are shown in Table 3.

Determination of organic carbon

The determination of organic carbon for soil sample was carried out by using the same procedure of eggshell powder.

Determination of available nitrogen, phosphorus and potassium

Nitrogen, phosphorus and potassium in soil sample were determined by alkaline permanganate method at irrigation water quality analysis laboratory, soil science, water utilization and agricultural engineering division, water utilization research section, Yezin, Naypyitaw.

Seeds Germination and Transplantation

The seeds of lettuce (Salad) were germinated on fertilized soil. After two weeks, the seedlings were transferred to three fertilization treatments (the prepared powder fertilizers ES I, ES II and ES III). The plants were watered with tap water regularly to keep the soil always moist until the plants were being transported and recorded the growth rate. The number of leaves and stem height of each of the plant growth using the treatments were recorded at 14, 28, 42, 56 and 70 days after transplantation.

Results and Discussion

Eggs can be produced in numerous countries in the world as an important nutrient source, and the world eggshell consumption amounts to millions metric tons per year. Most of the waste is commonly disposed of in a landfill without any pretreatment, causing odors from biodegradation, destroying microbial action, and changing the quality of soil. Eggshell are a better source of calcium for calcium oxide, calcium carbonate, calcium hydroxide, calcium phosphate, or hydroxyl apatite.

Physicochemical Properties of Eggshell Powder

Table 1 Physicochemical Properties of Eggshell Powder

Parameter	Units	Results
Bulk density	(gcm ⁻³)	1.11
Moisture Content	(%)	1.01
Organic carbon	(%)	1.78
Calcium	(%)	90

The bulk density of eggshell powder was found to be 1.11 gcm⁻³. Bulk density explains the solid and pores spaces proportion in soil, followed that the better the pores spaces in proportion, the lesser is the bulk density of a solid. Lower bulk density indicate more pore spaces which augment the prospective quality for soil aeration and improve water content in soil, consequently a good sign of soil quality. According to the bulk density values, eggshell powder may be useful in soil conditioner.

The moisture content of purified eggshell powder was found to be 1.01 % which showed a low moisture content, indicating that the eggshell would be very stable with good quality and shelf life. The high moisture content tends to promote microbial contamination and chemical degradation in many substances.

The organic fraction of eggshell powder is expressed either as the dry organic matter or as the total organic carbon and its degree of decomposition is proportional to the content in eggshell. The inorganic content is inferred from the total carbon content (being low as the total carbon content is high). It was found that total organic content of eggshell powder was 1.78 %. The amount of organic material in the soil also influences the water holding capacity. As the level of organic matter increases in the soil, the water holding capacity also increases, due to the affinity of organic matter for water. Consequently, the results were good agreement with the water holding capacity values.

The calcium from eggshell is also welcome in garden soil, where it moderates soil acidity while providing nutrients for plants. Eggshell contains such as abundant of calcium that they can be used almost like lime. It was found that the total calcium content in 1 g eggshell powder contained 90%. Moreover, the crushed eggshell or powder eggshell was used to block holes in plant while providing soil with nutrient as they decompose. According to the physiochemical properties of eggshell powder, the prepared eggshell powder was suitable in using as powder fertilizers.

Physicochemical Properties of Prepared Eggshell Powder Fertilizer**Table 2** Physicochemical Properties of Prepared Eggshell Powder Fertilizer

Parameter	ES I	ES II	ES III
Bulk density (gcm^{-3})	1.38	1.41	1.43
Water holding capacity (%)	72	68	60

The bulk density of eggshell powder fertilizers ES I, ES II and ES III were 1.38 gcm^{-3} , 1.42 gcm^{-3} and 1.43 gcm^{-3} , respectively. By using powder eggshells fertilizer in soil as an organic source, improve the physical condition of soil by improving the aggregate stability of soil and reducing the compactness of soil which result in decrease in bulk density and increase in porosity of soil and finally improved the water infiltration. Thus, from the bulk density values, the eggshell powder fertilizer was suitable for using soil conditioner.

The water holding capacity of a soil is a very important agronomic characteristic. The most important function of eggshell powder fertilizer within the soil is their ability to hold water. The eggshell powder fertilizer create a desirable soil structure that facilitates water infiltration and helps hold water within the root zone. The water holding capacity of the eggshell powdered fertilizer and their ability to bind trace mineral elements are related through their roles in eggshell structure and function together in water bridging. Water bridging is believed to improve the mobility of nutrient ions through the soil solution to the root. These mechanisms also help reduce leaching of plant nutrients into the subsoil. From the experimental values, it was found that ES I possessed more water holding capacity than ES II and ES III.

Soil Compositions and pH

The soil physicochemical properties were analyzed before planting. The analysis had indicated that the pH was neutral (7.2) and organic carbon content was low (0.33 %), total N content was very high (435 ppm), available phosphorus was low (5.80 ppm) and available potassium was high (501.2 ppm). In this determinations, soil condition before planting indicated that the soils of the experimental fields were needed to apply prepared eggshell fertilizers. The percent of organic carbon(C), nitrogen (N), phosphorus (P) and potassium (K) in soil sample are presented Table 3.

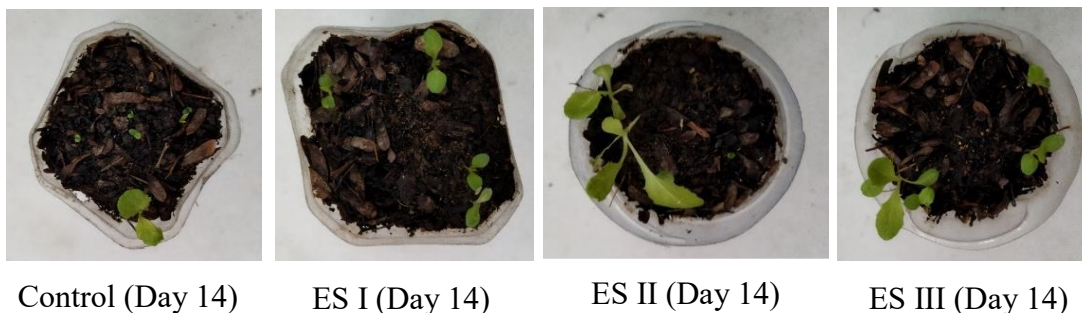
Table 3 Percent of Organic Carbon(C), Nitrogen (N), Phosphorus (P) and Potassium (K) in Soil Sample

Sample	C (%)		Available (ppm)						pH
			N		P		K		
	Value	rating	Value	rating	Value	rating	Value	rating	
Soil	0.33	Low	435	Very High	5.80	Low	501.2	High	7.2

Evaluating the Effect of Prepared Powder Fertilizers on Growth Rate of Lettuce (Salad) Seeds

Germination rate of lettuce (Salad) seeds

From the observation of germination rate of lettuce (Salad) by using prepared eggshell powder fertilizer, it was found that the prepared eggshell powder fertilizer ES II was more growing rate than the other two. Moreover, the eggshell powder fertilizers were more growth rate than control. Therefore, the prepared powder fertilizers were suitable for planting.

**Figure 1** Seeds germination of lettuce (Salad) by using eggshell powder fertilizers

Evaluating the Effect of Prepared Powder Fertilizer on Horticulture Plantation Plant's height of lettuce (Salad)

From the resultant data, at the age of 14 DAP and 70 DAP, the highest plant height (6.5 centimeters and 74.0 centimeters) was found in plant applying the prepared powder fertilizer ES II. According to the literature, eggshell helps in lowering acidity for plants that are unable to grow in higher acidic mediums. Moreover, eggshell help the soil to enrich with nitrogen and other minerals. Other major advantage is that they supply plants with lots of calcium, which is an essential nutrient for proper growth of the pants and vegetables. Therefore, the application of prepared powder fertilizers ES II is good as the growth of plant height.

Number of leaves of lettuce (Salad)

From the experimental data, it was found that the application of prepared powder fertilizer ES II, the number of leaves were (6) for 14 DAP and (38) for 70 DAP. It was seen that the greatest number of leaves compared with the other prepared powder fertilizers ES I and ES III. The resultant data was shown in Table 4 and Figure 2.

Table 4 Effect of Prepared Powder Fertilizer on the Plant's Height of Leuttce (Salad)

Time interval (Days)	Plant's height (centimeters)			
	Control	ES I	ES II	ES III
14 DAP	2.9	3.9	6.5	3.4
28 DAP	7.1	11.2	14.0	11.0
42 DAP	16.2	20.5	24.0	22.3
56 DAP	36.1	39.0	42.5	41.5
70 DAP	59.8	64.5	74.0	60.0

DAP- Days after planting

Table 5 Effect of Prepared Powder Fertilizer on the Number of Leaves of Leuttce (Salad)

Time interval (Days)	Number of leaves			
	Control	ES I	ES II	ES III
14 DAP	3	5	6	4
28 DAP	7	8	10	8
42 DAP	10	13	15	13
56 DAP	16	25	29	23
70 DAP	28	36	38	26

DAP- Days after planting

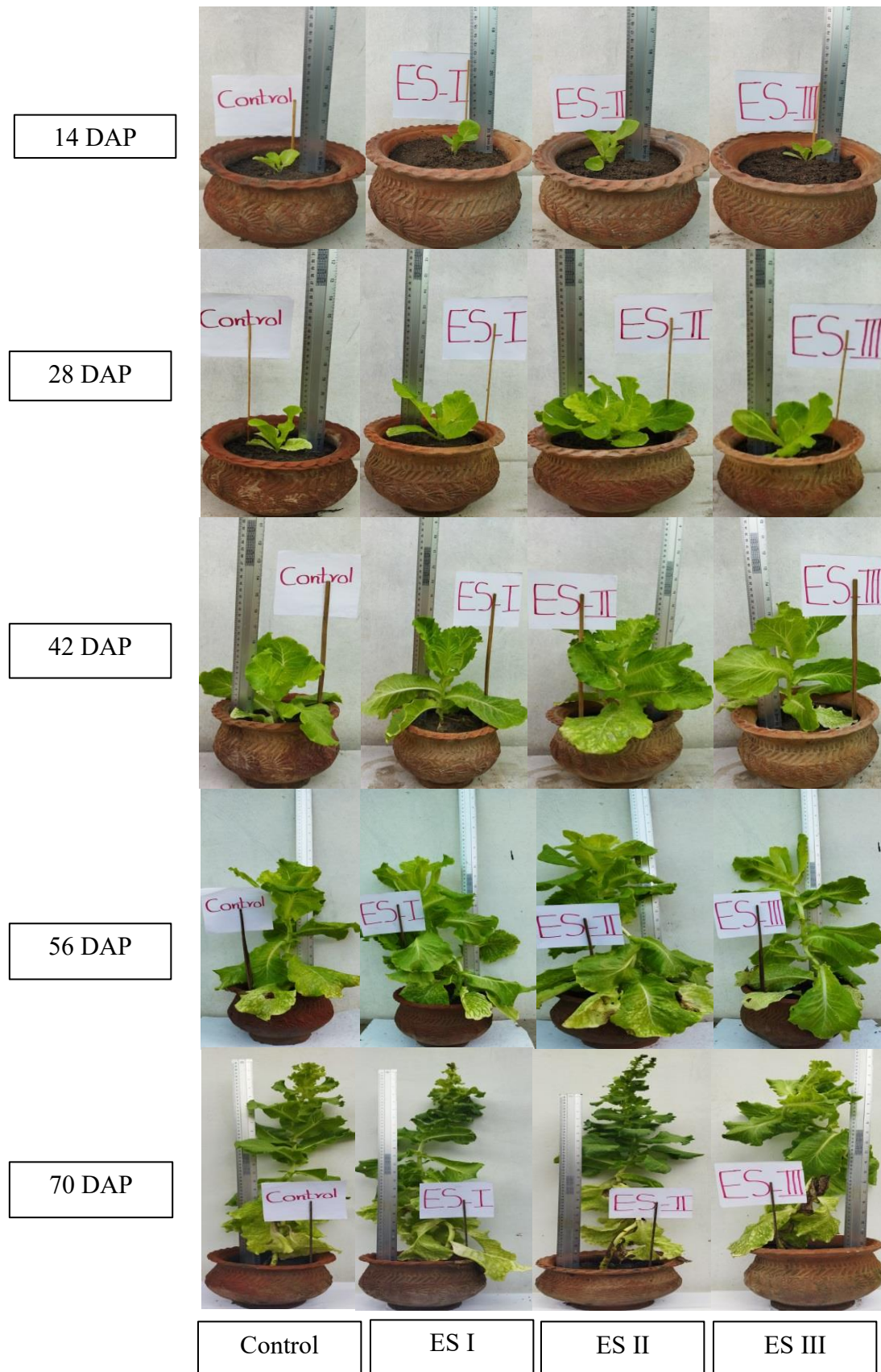


Figure 2 Effect of prepared powder fertilizer on growth and leaves of leuttce (Salad)

Conclusion

Agriculture sector plays an important role to improve the economic growth of developing countries apart from fulfilling the food security of the growing population globally. Organic fertilizers are used to enhance soil quality and add other nutrients essential for plant growth. In the present study, calcium was given in the form of calcium carbonate from eggshell.

From the physicochemical properties of eggshell powder studies, it was found that eggshell powder (1) g contained 90 % of calcium and 1.78 % of carbon. Therefore, the eggshell powder was very useful for plant and it has benefit to prepare powder fertilizer. In powdered eggshell fertilizers, ES I (10 g), ES II (20 g) and ES III (30 g) of eggshell powder were used with 1000 g of soil. If it was seen that amount of eggshell powder fertilizer was added, the bulk density was slightly increased (1.38, 1.41, 1.43) and water holding capacity was gradually decreased (72 %, 68 %, 60 %). These studies indicated that all of the eggshell powdered fertilizers were suitable for planting of leuttce (Salad). Plants like tomatoes, peppers, eggplants and lettuce have particular benefit of eggshell fertilizer. By observing the germination and the planting of leuttce (Salad) in eggshell powdered fertilizers, it was seen that the prepared eggshell fertilizer ES II was more effective than the others. The highest plant's height 74.0 cm and the greatest number of leaves 38 leaves were found in ES II at 70 days after planting. After planting 56 days, the distinct growth rate change was found in powdered eggshell fertilizers due to its biodegradable rate in soil. Therefore, these studies indicated that the use of eggshell wastes as organic fertilizer is more valuable and economically important where it not only replenishes soil organic matter but also gives the sustainable production.

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