



Evaluation of Soil and Nutrient Characteristics of *Gongronema latifolium* Benth Near Palm Oil Mill Sites in Ogoja, Nigeria

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Abstract

Gongronema latifolium, a tropical rainforest plant usually used as spice and vegetable as well as a medicinal specie is often cultivated in gardens near palm oil mill sites. The study area is a region characterized by excessive production of organic waste that serve as alternate form of fertilizer, which could be used as soil conditioner to improve soil properties and increase crop yields. This study was conducted to examine the response of the test crop mineral nutrient contents to extreme palm oil mill waste as well as the effects of such condition on the chemical properties of experimental soil. Soil samples (0-20cm depth) and leaf samples of *G. latifolium* were collected from three (3) sampling locations (P0-control, P1, and P2) in the study area, and analysed for chemical characteristics and nutrient contents, respectively, using standard procedures. The results of this study showed that soil pH significantly decreased ($P < 0.05$) with increase in distance from the palm oil mill site. The pH values of the experimental soil near the palm oil mill site were relatively alkaline with pH values of 7.40 and 7.20 at P1 and P2, compared to the value of 5.30 recorded at the control. The organic matter, potassium and sodium contents at P1 and P2 were significantly ($P < 0.05$) higher relative to the control. The values for Effective Cation Exchange Capacity and electrical conductivity at P1 and P2 were comparatively ($P < 0.05$) higher than that of the control. Conversely, the calcium, phosphorus, magnesium, nitrogen, copper and zinc contents of the control treatment were higher than those of P1 and P2 sampling locations. The contents of potassium (P1-14.32mg/100g, P2-14.10 mg/100g), calcium (P1-23.72mg/100g, P2-22.56mg/100g), magnesium (6.70 mg/100g, P2- 6.38mg/100g) and sodium (11.40mg/100g, P2-11.21mg/100g) in leaves of *G. latifolium* increased significantly ($P < 0.05$) at P1 and P2 sampling locations relative to the control. This study showed increased levels of K, Ca, Mg, and Na in soil and plant tissues in soils treated with palm bunch waste, suggesting beneficial impacts on growth and productivity of *G. latifolium*. This study recommends the use of locally available bio-wastes such as palm oil bunch waste as a sustainable option for soil conservation and improvement in soil fertility in local communities.

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1.0 Introduction

Elaise guineensis commonly known as oil palm plant belongs to the family Aceraceae, and it is utilized for the production of oil used for culinary and industrial purposes. In the oil palm industry, both the fields and palm oil mills generate plenty of oil palm biomass, such as fronds, oil palm trunks, mesocarp fiber, empty fruit bunches, palm shells, effluent (wastewater), solid waste, and polluted air (Paridah *et al.*, 2022; Hau *et al.*, 2020). According to Kassim *et al.* (2011) and Kheang *et al.* (2012), oil palm empty fruit bunch is generated in the palm oil mills during the processing of fresh fruit bunch and constitutes approximately 23% of the weight of the fresh fruit bunch. Oil palm empty fruit bunch is used as a source of organic waste for humus and biofertilizer production for agricultural crops (Then *et al.*, 2016; Sayara *et al.*, 2020; Kaniapan *et al.*, 2021)

Palm oil mill effluent is an organic waste water usually characterized by unpleasant odour, alkaline in nature and capable of polluting the environment (Ahmad *et al.*, 2008, Rupani *et al.*, 2010). It contains high levels of organic load and some organic acids, hence could impact soils and cultivated plants negatively if discharged without being treated. It contains high concentrations of polyphenols, which possess antibacterial properties, and therefore confer the phytotoxic properties on it (Nwoko *et al.*, 2010). Palm bunch wastes contain appreciable amounts of nitrogen, phosphorus, potassium,

magnesium and calcium, which are some important mineral nutrients required for plant growth (Carron *et al.*, 2015). Its rich contents of mineral elements have been explored for the production of fertilizer and animal feed for agricultural purposes (Rupani *et al.*, 2010).

Several reports exist on the deteriorative effects on plant growth and development in addition to alteration of soil properties such as cation exchange capacity resulting from application of palm oil mill effluent (Osubor & Oikeh, 2013; Onyia *et al.*, 2001). However, the use of organic manure in sustainable agriculture to provide balanced supply of nutrients to the soil and agricultural crops remains a significant aspect in improving soil fertility for enhanced crop performance (Etukudo *et al.*, 2011; Singh, 2021). In spite of the importance of organic manure in improving the organic matter contents of soil by increasing the soil concentrations of organic carbon, nitrogen, phosphorus, and potassium (Wang *et al.*, 2018; Etukudo *et al.*, 2016), inappropriate discharge and improper use of waste water from some organic sources could lead to degradation of soil properties and deterioration of plant growth and development. It is important to note that application of organic waste materials to soils must, however take into account certain factors such as crop needs, pH interaction with the soil medium and the potential for environmental contamination (Etukudo *et al.*, 2014). Other concerns include, the potential of organic fertilizers to harbour pathogens and soluble salts, in addition to their

relatively low levels of nutrients, necessitating higher quantities to adequately supply the necessary nutrients for optimal plant growth and development (Bhatt *et al.*, 2019; Sheoran *et al.*, 2022)

Gongronema latifolium, the test crop belongs to the family Apocynaceae, and is commonly called 'utazi' and 'aroakeke' in the South Western and South Eastern parts of Nigeria. It is a tropical rainforest plant usually used as spice and vegetable as well as a medicinal plant in the treatment of various diseases (Ugochukwu & Babady, 2002; Ugochukwu *et al.*, 2003), and contains essential oils, and phytochemicals (Morebise *et al.*, 2002). The aqueous and ethanolic *G. latifolium* extracts has been reported to show hypoglycemic, hypolipidemic and antioxidative properties (Ugochukwu & Babady, 2003), as well as exhibit anti-inflammatory properties (Morebise *et al.*, 2002).

The test crop *G. latifolium* and other plant species are usually cultivated in secondary forest habitat. Some farm lands in local areas often situate near palm oil mill sites with the resultant interaction between agricultural crops and organic wastes. This study will provide baseline data for local farmers in palm oil producing region, with which management of the test crop and other species can be achieved in relation to palm fruit wastes. Again, the findings from this study will provide information on palm oil mill waste as an economical route to sustainable agriculture in local communities and other regions, where there is limited use of mineral fertilizers to improve soil properties for crop production. Several studies exist on the effects of palm oil mill wastes based on ex-situ trials on soil and plants (Osu *et al.*, 2020; Gbosidom & Teme, 2015; Samadhi *et al.*, 2020), but scanty data are available on in-situ response of *G. latifolium* and other related species. Therefore, this present study was conducted to assess the soil and nutrients characteristics of *Gongronema*

latifolium near palm oil mill sites in Ogoja, Cross River State, Nigeria.

2.0 Materials and Methods

2.1 Study Area

A plot was carefully selected on three sampling locations, P0, P1 and P2 at Ogoja, Cross River State. The research area is in the tropical climatic zone of Nigeria and characterized by rainforest, secondary forest vegetation and derived savanna as well as marshy terrain, eroded ridges and different sized hill slopes. Ogoja is located at coordinates of Latitude 6°39'17"- 6.65472°N and Longitude 8°47'51"- 8.79750°E. Average precipitation of 3000mm occurs annually along the coastal areas of Cross River State with an ambient minimum and maximum temperature of 22.4°C and 33.2°C, respectively, and altitude of 32m (105ft). It has two distinct seasons: a rainy season that spans from March to October and a dry season from November to February. Ogoja is a largely rural settlement where most residents engage in farming, fishing, and petty trading (Niger Delta Budget Monitoring Group, 2025).

2.2 Sample Collection

Soil samples were collected (0 – 20 cm depth) from three (3) sampling locations (P0, P1, and P2) in triplicates, giving a total of nine (9) representative samples. P1, and P2 were sampling units at the palm oil mill processing site, while P0 sampling unit was the control treatment (an area outside the palm oil mill processing site). Soil samples obtained from P1 was 10m away from the Palm oil mill, and with a corresponding distance from P1 to P2. Similarly, Leaf samples of *Gongronema latifolium* were obtained according to the sampling units. Complete randomized block design was used as research design. The samples were collected using an acid clean soil auger pack in a well labeled black polythene bag and taken to the laboratory for analysis.

2.3 Analysis of soil samples

Soil samples (0 – 20 cm depth) collected from the study site, Ogoja, Cross River State, were analyzed using standard methods for physico-chemical properties. Soil particles were sieved through 2 mm stainless steel sieve, and subjected to chemical analysis. Soil pH was determined by pH meter after preparing the soil: water suspension at ratio 1: 5. Electrical conductivity (EC) was measured using an electrical conductivity meter. Each sample was diluted in a ratio of 1:5 with distilled water, stirred and allowed to settle overnight before getting the reading (Tadesse *et al.*, 1991). ECEC was calculated by the summation of the exchangeable bases and acidity (Tan, 1996). Exchangeable bases (Ca, K, Mg and Na) were extracted using 1N ammonium acetate solution at pH 7.0. Atomic absorption spectrometer (Unicam model) was used to measure exchangeable calcium (Ca) and magnesium (Mg) contents after extracting the sample using the method Peterson, (2002) whereas potassium and sodium were by flame photometer. Colorimetric method was used to determine available phosphorus (P) content. Total nitrogen (TN) was determined using the modified Kjeldahl distillation methods (Juo, 1979). Copper (Cu), zinc (Zn) and iron (Fe) were extracted with DTPA and determined with spectrometer according to the method of Peterson (2002).

2.4 Determination of Mineral Elements in Plant Samples

The method of Ano *et al.* (2007) was used for mineral elements analysis in plant samples. Leaf samples of *Gongronema latifolium* were washed several times with water and rinsed with distilled water. They were placed in polybags, and thereafter dried in an oven maintained at 60° C to a constant weight. The samples were macerated to powder, and stored in sample bottles for analysis. The powdered plant samples were placed in an oven for 2 hours, 1.0g weighed into a platinum crucible and placed in a muffle

furnace maintained at 400°C. The powdered plant materials were ashed for 5 hours and then dissolved with 10cm³ of 1M HCL. The solution obtained was filtered through Whatman No. 1 filter paper into 50cm³ volumetric flask and made up to the required mark with distilled deionized water. Standard reagents for analytical experiment were used, and contents of mineral elements in the solution were determined using Atomic Absorption Spectrophotometer (AAS) of Unicam Model.

2.5 Statistical Analysis

Standard errors of the mean values were calculated and data were subjected to analysis of variance (ANOVA) test to compare the means at the probability level of ($P < 0.05$) (Obi, 2002).

3.0 Results

The physico-chemical properties of the experimental soils (P0, P1, and P2) are shown in Fig. 1. The soil pH decreased with increase in distance from the palm oil mill site; however, these values were significantly ($P < 0.05$) lower than that of the control treatment. In this study, the pH values of the experimental soil near the palm oil site were relatively alkaline with pH values of 7.40 ± 0.50 and 7.20 ± 0.63 at location P1 and P2, respectively, compared to the control (5.30 ± 0.13) treatment. The organic matter (P1 - $3.22 \pm 0.45\%$, P2 - $3.21 \pm 0.72\%$), potassium (P1 - 10.23 ± 0.90 cmol/kg, P2- 8.07 ± 0.51 cmol/kg) and sodium (P1 - 5.93 ± 0.82 cmol/kg, P2 - 4.67 ± 0.26 cmol/kg) contents as well as Effective Cation Exchange Capacity (P1 - 7.23 ± 0.61 cmol/kg, P2 - 6.37 ± 0.87 cmol/kg) and electrical conductivity (P1 - 0.13 ± 0.04 ds/m, P2 - 0.09 ± 0.06 ds/m) values were higher near palm oil mill sites (P1 and P2) relative to the control. The calcium, phosphorus, magnesium, nitrogen, copper and zinc contents in the control site were higher than those at P1 and P2 sampling locations (Fig. 1). The experimental soil near palm oil sites in the study area significantly ($P < 0.05$) increased the calcium (P1 - 23.72 ± 0.23 , P2 - 22.56 ± 0.40),

magnesium (P1 - 6.70 ± 0.17 mg/100g, P2 - 6.38 ± 0.23 mg/100g), sodium (P1 - 11.40 ± 0.32 mg/100g, P2 - 11.21 ± 0.51 mg/100g) and potassium (P1 - 14.32 ± 0.24 , P2 - 14.10 ± 0.33 contents of *Gongronema latifolium* relative to the control. Other mineral elements like phosphorus (P1 - 2.66 ± 0.14 mg/100g, P2 - 2.75

± 0.40 mg/100g) and iron (P1 - 0.12 ± 0.02 mg/100g, P2 - 0.17 ± 0.04 mg/100g) were found in appreciable proportion in *G. latifolium* near the palm oil mill sites, although their contents were comparatively lower than that of the control (Fig. 2).

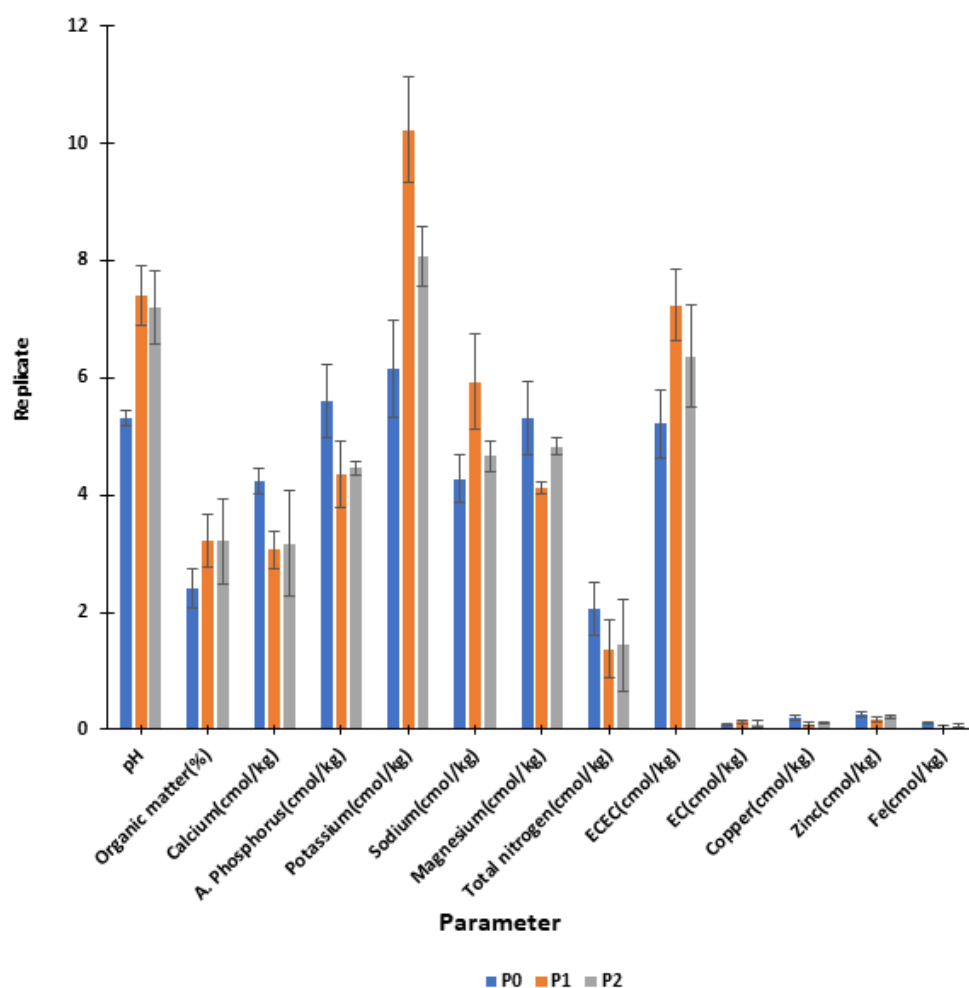


Fig 1: Soil chemical properties near palm oil mill

4.0 Discussion

The soil pH decreased with increase in distance from the palm oil mill site; however, these values were significantly lower than that of the control treatment. These results show that the study area is a humid tropical soil with characteristic acidic nature with low (pH, cation exchange capacity, base saturation, organic matter) and consequently low nutrient reserve as evident in the works of Ikpe *et al.* (2003), Onwugbuta-Enyi & Kpekot (2018). Soil pH

influences myriads of soils biological, chemical, and physical properties and processes that affect plant growth and biomass yield, hence, readily gives a hint of the soil condition and the expected direction of many soil processes. (Minasny *et al.*, 2016). Palm bunch ash increased soil pH as observed at P1 (7.40) and P2 (7.20) compared to control (5.30), supporting the liming effect observed by Etukudo *et al.* (2014). This indicates a relatively alkaline pH at the experimental soil near the palm oil sites.

Alkaline pH values of 5.76, 6.87, and 6.93 at 100g, 200g and 300g levels of palm bunch ash were recorded by Ogbueh (2016), although these values were slightly lower than those recorded in this study. Similarly, increased soil pH due to application of palm bunch ash has been reported by Ojeniyi *et al.* (2009), while a pH of palm

bunch ash in water was found to be 12.5 (Ebeniro *et al.*, 2014), a value relatively higher than those recorded in this study. Soils near palm oil mill sites would therefore have high pH levels due to the prevalence of palm bunch ash (Osu *et al.*, 2022) as a demonstrated in this study.

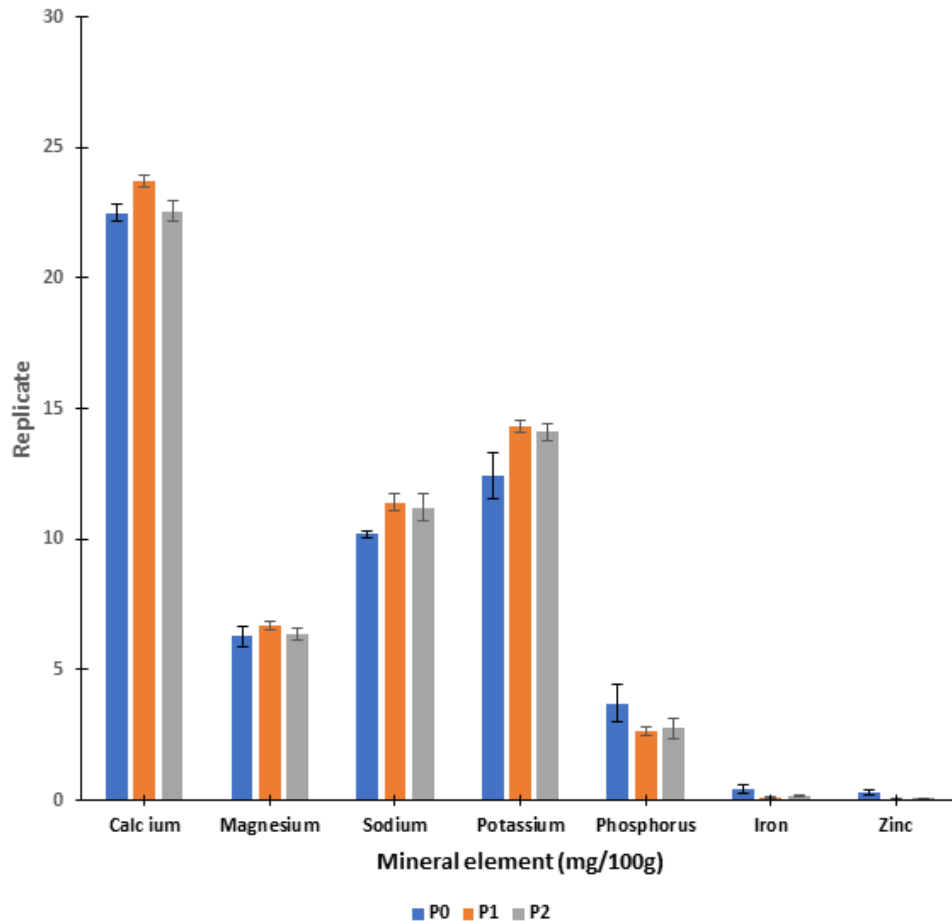


Fig 2: Mineral elements in leaves of *Gongronema latifolium* near palm oil mill

The organic matter, potassium and sodium contents as well as Effective Cation Exchange Capacity (ECEC) and electrical conductivity (EC) values were higher near palm oil mill sites (P1 and P2) relative to the control, while the calcium, phosphorus, magnesium, nitrogen, copper and zinc contents in the control site were higher than those at P1 and P2 sampling locations (Fig. 1). This observation corroborates the report that organic waste such as palm bunch ash improves soil fertility and water holding capacity of the soil, hence proves effective as organic manure to improve crop growth and performance (Odiete *et al.*, 2005). This also

agrees with the work of Rickson *et al.* (2015) that the application of organic amendments can increase soil organic matter, and ameliorate degraded soils. The presence of certain nutrients like potassium oxide and its eco-friendly characteristic supports its use as fertilizer and in neutralizing acidic soil effectively (Agriscap, 2007; Lim, 2000). Palm bunch waste can be used as liming material to reduce low soil pH as well as a valuable nutrients source due to its rich contents of P, K, Mg, and Ca (Ahaiwe, 2008). Busari *et al.* (2009) noted that improvement in soil physical properties could be attributed to application of organic amendment, since manure

supplies both nutrients for crops together with organic matter thus improving soil fertility (Goss *et al.*, 2013). These conditions result in the improved soil characteristics as recorded in the surrounding soils in this study. Palm bunch in any form either as mulch, primarily enhance soil water retention or when applied in the composted form or as biochar, improve soil water and nutrient content (Ahmad, 2018). This could be possibly due to the losses of C from the anaerobic respiration involved in composting or the pyrolysis involved in biochar preparation (Adu *et al.*, 2022).

The experimental soil near palm oil processing sites in the study area significantly ($P < 0.05$) increased the potassium, calcium, magnesium and sodium contents of *Gongronema latifolium* relative to the control. Other mineral elements like phosphorus and iron were found in appreciable proportion in *G. latifolium* near palm oil processing sites, although their contents were comparatively lower than that of the control (Fig. 2). Similar observations were made by Nnah *et al.* (2010), and Awodun *et al.*, (2007) who stated that, palm bunch ash is used as a liming material, and leads to increased soil nutrients like N, P, K, and Mg which in turn enhance nutrient release to the plants for growth and development. This observation is in line with the report of Akata, (2015) that organic supplements such as oil palm bunch enhance good growth and yield of crops grown in tropical soils of southern Nigeria. Palm bunch wastes and ash contain rich proportion of nutrients such as potassium, hence its use in enhancing the growth and yield of crops as reported by Osu *et al.* (2022) that palm oil mill effluent contain appreciable amounts of nitrogen, phosphorus, potassium, magnesium and calcium, which are required for plant growth. In a similar study by Adu *et al.*, (2022), the application of empty fruit bunch (EFB) to soils led to approximately 49.2% increase in crop growth and yield compared to unamended soils with crops grown on soils amended with pyrolyzed EFB, raw EFB,

composted, and ash EFB recording growth and yield increase by ~78.4%, 33.8%, 30.9%, and 21.0%, respectively. In addition, it improves the physical structure of the soil as well as supplies the nutrient requirement of the crops (Onunka, 2005). In general, palm bunch as organic waste manure, serve as a material for improvement of soil fertility and as a source of vital nutrients like N, P K and Mg, and a root reinforcement (Donn *et al.*, 2014) as well as increase in soil organic carbon content and microbial activity (Scotti *et al.*, 2015).

5.0 Conclusion

Palm oil mill sites as evidenced in this study is a good source of organic manure due to the presence of organic waste that is sufficiently rich in desirable nutrients for plant growth. Palm oil mill waste is a potential organic amendment for improving soil fertility and enhancing nutrient uptake in *G. latifolium*. Its application increased levels of K, Ca, Mg, and Na in soil and plant tissues, suggesting beneficial impacts on plant growth and productivity. In addition, it is an effective liming material for optimum crop production under acidic soil condition. The test crop *Gongronema latifolium* recorded enhanced nutrient contents relative to the control treatment. This clearly proves that organic amendment is an effective material to improve soil aeration, water infiltration, water and nutrient holding capacity of soils. This study suggests that palm oil mill site proves effective as a rich source of nutrients and suitable soil medium for the growth of *G. latifolium*. Using renewable organic supplements such as oil palm waste for crop production in a carbon-constrained future economy will become imperative. This study recommends the use of locally available bio-wastes such as palm oil bunch waste among the most sustainable options for soil conservation and improvement in soil fertility, particularly for resource-poor regions. Again, future studies should investigate long-term nutrient dynamics and potential environmental impacts of organic effluent

accumulation from palm oil mill sites. To optimize the use of palm oil waste in crop production, a better knowledge of the dynamics of its mineralization and the release of mineral nutrients, depending on soil and environmental conditions, is critical.

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