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Effect of oil palm cultivation on the micronutrient status of soils in a coastal plain sands area of Akwa Ibom State, Nigeria

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ABSTRACT

High levels of micronutrients may cause metabolic disorders and become growth inhibitors to most plant species. Therefore, the study assessed the levels of micronutrient in soils under oil palm cultivation in a coastal plain sands area of Akwa Ibom State, Nigeria. Three oil palm blocks of varying ages; l7 years (B-17), 39 years (B-39) and 57 years (B-57) and no oil palm block (B-O), which served as the control, were identified and selected for the study in the Nigeria Institute for Oil palm Research (NIFOR) sub-station, Ibesit Ekoi, Oruk Anam Local Government area of Akwa Ibom State. Three profile pits were sunk in each of the location, and soil samples were collected and subjected to laboratory and statistical analysis. The results showed that zinc had the highest level in the study area soils while copper had the lowest level among the micronutrients tested. All the micronutrients tested were within the permissible range for agricultural soils. Copper, Mn, Zn, and Fe contents of the soil in B-17 were significantly higher than in the other blocks. The trend of Cu and Mn was as follows: B-17> B-57> control > B-39, while that of Zn and Fe was as follows; B-17> B-57> B-39> control. Oil palm increased the soils Cu, Mn, Zn and Fe levels. This shows that oil palm positively influences the soil's micronutrient content and will significantly release some of the extractable micronutrients previously sequestered in the dry matter back into the soil with time.

1.0 Introduction

Micronutrient elements are those elements needed in minute quantity by plants. When they exceed the required amount, they become toxic to the plants. Micronutrients in most soils are ordinarily insoluble and are not as quick readily available to plants. There are established deficiencies of these micronutrient elements worldwide. The deficiency of Zn is prevalent, but those of Cu, Fe and Mn have also occasionally been identified (Lopes, 1982).

Growing tree crops such as oil palm imply that nutrients are removed from the soil through harvest for food, refibre or wood and crop residues. Nutrient removal may result in a decline in soil fertility if replenishment with inorganic fertilizers or manure is inadequate. A decline in soil fertility implies a decline in the quality of the soil, and soil fertility decline is defined as the decline in chemical soil fertility, or a decrease in the levels of soil organic C, pH, CEC and plant nutrients and includes acidification (Hartemink, 2005). Oil palm has an established high demand for nutrients. These nutrients must be supplied as amendments and in a suitable balance (Tarmizi, 2000), for yields to be maximized and the environment sustained, as they may not be released on a sustained basis in the soil. Ng (1977) suggested that the nutrient budget of oil palm must be compared with the capacity of the soil while designing fertilizer or nutrient management schemes for economic production. For instance, an increased supply of nitrogen and potassium without an adequate supply of magnesium on soils with a low magnesium status can lead to the development of "orange frond" symptoms in younger palms (a nutritional disorder which later depresses growth and eventually yields). Appropriate micronutrients in the nutrient budget will equally enhance the efficiency of use of nitrogen, phosphorus and potassium and also meet the crop needs. The deficiency of micronutrients is the nutritional disorders that manifest with the commonly expected incidence of chlorotic and desiccated leaves due to copper and zinc deficiency (Singh 1983; Pauli *et al*., 2014).

The soils of the study area (Akwa Ibom State soils) are generally known as acid sands, low fertility and low soil quality. However, there is almost no research information on the impact of the plantation on the fertility of the soil. Therefore, the objective of this study was to assess the micronutrient level of soils under oil palm cultivation in a coastal plain sands area of Akwa Ibom State, using the Nigerian Institute for Oil Palm Research (NIFOR), Substation, Oruk Anam LGA as the study site.

2.0 Materials and Methods.

2.1 Description of the Study Location.

The study site was in Nigerian Institute for Oil Palm Research (NIFOR) substation Ibesit Ekoi in Oruk Anam Local Government Area of Akwa Ibom State Nigeria. Oruk Anam Local government Area is bounded by latitudes 4°'45' and 5°'00' N and longitudes 7°'30'and 7°'45' E. Oruk Anam Local Government Area falls within the area covered by coastal plain sands. Soils on coastal plain sands are usually generally deep, dominantly sandy with low clay, organic matter content and pH.

The area's climate of the area is the humid tropical climate, characterized by heavy rainfall with a mean annual rainfall of about 4000 mm and a mean annual temperature of 27°C. The rainy season is from April to November and characterized by high relative humidity and high cloud covers resulting in low incipient solar radiation. The soils of the area are formed from the Quaternary sedimentary deposits. The relief of the area is low-lying coastal topography and has the major topographic unit, namely, Alluvial plains (mangrove and flood plains) beach ridge sands and oiling sandy plains (Udoh, 2003). The vegetation of the area is the forest vegetation in the tropical forest zone.

2.2 Field Studies

Four locations were identified in the Nigerian Institute for Oil Palm Research (NIFOR) sub-station located at Ibesit Ekoi in Oruk Anam Local Government Area of Akwa Ibom State, Nigeria, which was oil palm blocks of varying ages: (i) 1960-2017 (B-57); (ii) 1978 -2017 (B-39); (iii) 2000-2017 (B-17) and a no oil palm block (B-0), which served as the control. The NIFOR plantation covers an area of 286 hectares. The area covered by each block was 5.8 ha (B0), 5.2 ha (B-17), 5.0 ha (B-39) and 5.75 ha (B-57). The 57 years old palm plantation was selected because it is the oldest palm in the NIFOR plantation as of 2017 and has almost far past the expected age of replacement of oil palm stand (35 years) as reported by Ukuteno *et al*. (2012). The oil palm block of 39 years was selected because it is the available palm block which is a little bit past the suggested age for replacement of oil palm (35 years). The 17 years old palm was selected because it falls within the age of optimum yield of 15-20 years (Verheye, 2010), while the no-oil palm block (B-0) was used as the control.

The free survey was used to locate representative positions for profile pits. The profile pits were sunk along the middle slope in each of the four blocks to maintain uniformity in topography. Three profile pits were sunk in each of the four blocks (B-57, B-39, B-17 and B-0), which summed up to 12 profile pits used for the study. Soil samples were collected according to the horizon designation as observed in the profile pits. A total of 72 samples were collected for the study. The soil samples were air dried, sieved with a 2mm mesh sieve and subjected to laboratory analysis.

2.3 Laboratory analysis

2.3.1 Micro Nutrients

Micronutrients such as Cu, Mn, Fe and Zn were analyzed for the study. The soil samples were digested with perchloric and nitric acid and extracted, and the extracts were read using the Atomic Absorption Spectrophotometer. (UNICA 936 model) (AOAC, 2005).

Statistical Analysis

Data obtained were subjected to statistical analysis using the statistical software package of SPSS 18.0 (SPSS, 2011) to obtain the following: Descriptive statistics to determine the mean, minimum and maximum values. Analysis of Variance (ANOVA) to compare the differences in soil characteristics among the different locations.

3.0 Results and Discussion

3.1 Micro Nutrients of Soils under Oil Palm Plantation (Block) of Different Ages

3.1.1 Non-Oil Palm Block (B-O) - Control

The details of the soil analysis for micronutrients (copper, zinc, manganese and iron) content in the four blocks (B-0, control, B-17, B-39 and B-57) are presented in Tables 1, 2, 3 and 4 and Figure 1-3 respectively.

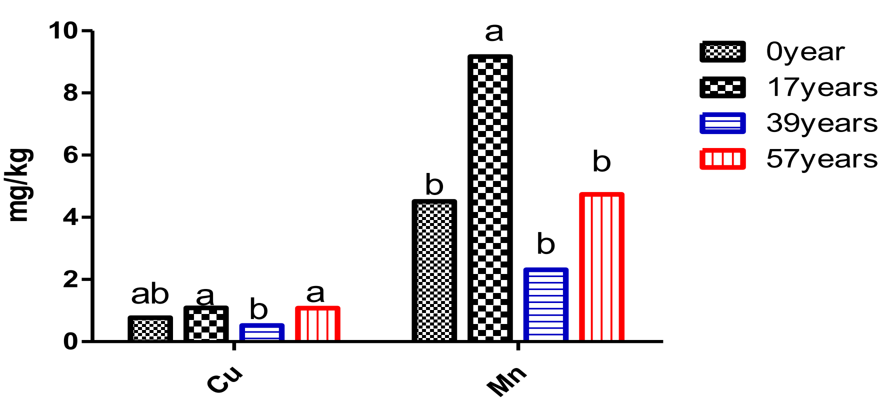

Figure 1: Comparing means of copper and manganese content among blocks of the study area

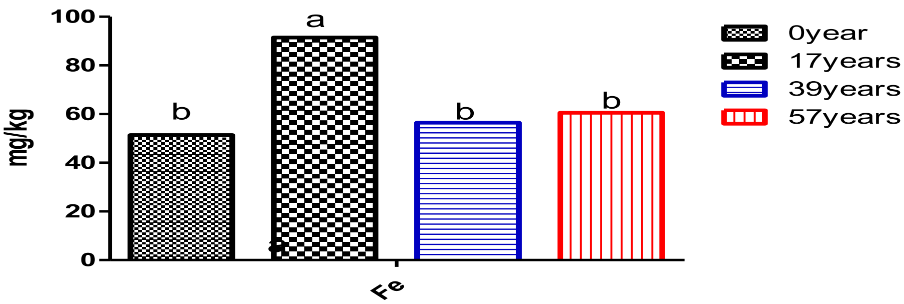

Figure 2: Comparing means of iron content among blocks of the study area

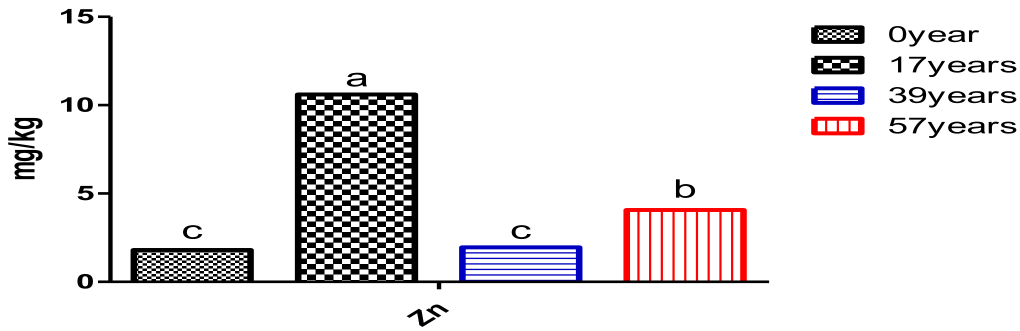

Figure 3: Comparing means of zinc content among blocks of the study area

Table 1: Micronutrients of soils of the no-oil palm block (B-0)

Horizon Depth	Horizon Design	Cu	Zn	Mn	Fe
		←	mg/kg	→	
Profile 1					
0-30	Ap	1.12	1.70	5.90	64.00
30-57	Bt1	0.46	1.71	3.40	79.80
57-91	Bt2	1.14	1.50	2.40	39.10
91-130	Bt3	0.75	1.68	1.80	23.70
130-165	Bt4	0.73	1.92	2.30	22.20
165-200	C	0.20	1.72	1.90	17.90
Mean		0.73	1.87	2.95	41.12
Maximum value		1.14	2.50	5.90	79.80
Minimum value		0.20	1.68	1.80	17.90
Profile 2					
0-30	Ap	0.85	2.89	5.90	61.20
30-62	Bt1	0.76	1.58	4.10	91.10
62-94	Bt2	1.11	2.10	4.60	65.10
94-125	Bt3	0.84	1.89	5.40	35.60
125-160	C1	0.49	1.43	6.20	23.50
160-200	C2	0.84	1.81	5.00	21.10
Mean		0.82	1.95	5.20	49.60
Maximum value		1.11	2.89	6.20	91.10
Minimum value		0.49	1.43	4.10	21.10
Profile 3					
0-29	Ap	0.37	1.59	12.90	44.60
29-62	Bt1	0.59	1.30	5.90	102.90
62-92	Bt2	1.11	1.53	4.00	105.10
92-122	Bt3	1.13	1.57	3.40	62.70
122-158	C1	0.78	1.86	4.10	41.00
158-200	C2	0.54	1.87	1.90	24.30
Mean		0.75	1.62	5.37	63.43
Maximum value		1.13	1.87	12.90	105.10
Minimum value		0.37	1.30	1.90	24.30

Source: Field Data (2017)
Fe=Iron, Zn=zinc, Cu-copper, Mn=manganese,

The result presented in Table 1 shows that iron in the control block (B-0) ranged from 17.90 - 79.80 mg/kg (mean 41.12 mg/kg) in profile 1; 21.10 - 91.10 mg/kg (mean 49.60 mg/kg) in profile 2 and 24.30 - 105.10 mg/kg (mean 63.43 mg/kg) in profile 3.

Zinc ranged from 1.68-2.50 mg/kg (mean 1.87 mg/kg) in profile 1; 1.43-2.89 mg/kg (mean 1.95 mg/kg) in profile 2 and 1.30-1.87 mg/kg (mean 1.62 mg/kg) in profile 3. Copper ranged from 0.20-1.14 mg/kg (mean 0.73 mg/kg), 0.49 -1.11 mg/kg (mean 0.82 mg/kg) and 0.37-1.13 mg/kg (mean 0.75 mg/kg) in profiles 1, 2 and 3, respectively. Manganese was within the range of l.80-12.90 mg/kg (mean 5.37 mg/kg) in all the profiles.

3.1.2 Seventeen Years Old Oil Palm Block (B-17)

The result for micronutrients of B-17 is presented in Table 2. The result shows that iron ranged from 38.10-120.00 mg/k (mean 84.08 mg/kg) in profile 1, 67.2 - 143.00 mg/kg (mean 99.00 mg/kg) in profile 2 and 33.00-168.00 mg/kg (mean 91.37 mg/kg) in profile 3. Zinc ranged from 9.32 -11.98 mg/kg (mean 10.31 mg/kg) in profile 1, 8.46-11.90 mg/kg (mean 10.60 mg/kg) in profile 2 and 8.36-12.33 mg/kg (mean 10.92 mg/kg) in profile 3.copper ranged from 0.85-1.66 mg/kg (mean 1.12 mg/kg), 1.01-1.70mg/kg (mean 1.38 mg/kg) and 0.52-0.94 mg/kg (mean 0.77 mg/kg) in profiles 1, 2 and 3, respectively.

Manganese ranged from 8.10-11.70 mg/kg (mean 9.65 mg/kg), 8.50-27.10 mg/kg (mean 12.63 mg/kg) and 1.33-7.10 mg/kg (mean 5.22 mg/kg) in profiles 1,2 and 3, respectively. Manganese was irregularly distributed within the profiles.

Table 2: Micro nutrients of soils of the 17 years old oil palm block (B-17)

Horizon Depth	Horizon Design	Cu	Zn mg/kg	Mn	Fe
Profile 1					
0-20	Ap	11.05	0.85	11.70	84.4
20-40	Bt1	9.32	0.93	8.10	120.0
40-70	Bt2	11.98	1.66	10.00	116.0
70-110	B	9.62	1.05	8.60	90.0
110-148	BC	9.82	1.29	9.50	55.90
148-200	C	10.06	0.91	10.00	38.10
Mean		10.31	1.12	9.65	84.08
Maximum value		11.98	1.66	11.70	120.0
Minimum value		9.32	0.85	8.10	38.1
Profile 2					
0-20	Ap	10.26	1.01	27.10	67.2
20-48	Bt1	11.34	1.05	11.00	76.9
48-89	B1	11.42	1.70	9.10	143.0
89-124	Bt2	8.46	1.48	8.50	127.0
124-160	B2	10.37	1.57	9.90	104.9
160-200	C	11.90	1.49	10.20	74.7
Mean		10.60	1.38	12.63	99.0
Maximum value		11.90	1.70	27.10	143.0
Minimum value		8.46	1.01	8.50	67.2
Profile 3					
0-30	Ap	10.89	0.84	1.33	86.7
30-60	Bt1	11.31	0.84	5.40	133.0
60-97	Bt2	12.33	0.94	6.60	168.0
97-126	C1	11.73	0.61	7.10	79.60
126-154	C2	8.36	0.52	5.10	47.90
154-2000	C3	10.88	0.86	5.80	33.0
Mean		10.92	0.77	5.22	91.37
Maximum value		12.33	0.94	7.10	168.0
Minimum value		8.36	0.52	1.33	33.0

Source: Field Data (2017)
Fe=Iron, Zn=zinc, Cu=copper, Mn=manganese,

3.1.3 Thirty-Nine Years Old Oil Palm Block (B-39)

The result of soil analysis for micronutrients of the B-39 is presented in Table 3. The result shows that iron ranged from 11.20-160.00 mg/k (mean 71.50 mg/kg) in profile 1; 14.20-87.90mg/kg (mean 42.43 mg/kg) in profile 2 and 16.40-107.40 mg/kg (mean 55.32 mg/kg) in profile 3. Zinc ranged from 1.84-2.48 mg/kg (mean 2.17 mg/kg) in profile 1, 1.43-2.41 mg/kg (mean 1.76 mg/kg) in profile 2 and 1.52-2.67 mg/kg (mean 1.91 mg/kg) in profile 3. Copper ranged from 0.31-0.70 mg/kg (Mean 0.54 mg/kg), 0.11-0.68 mg/kg (mean 0.46 mg/kg) and 0.35-0.78 mg/kg (mean 0.57 mg/kg) in profiles 1, 2 and 3, respectively. Manganese ranged from 2.30-3.00 mg/kg (mean 2.65 mg/kg), 0.80-3.00 mg/kg (mean 1.95 mg/kg) and 1.70-4.30 mg/kg (mean 2.32 mg/kg) in profile 1, 2 and 3, respectively. Manganese was irregularly distributed within the profiles.

Table 3: Micronutrients of soils of the 39 years old oil palm block (B-39)

Horizon Depth	Horizon Design	Cu	Zn	Mn	Fe
		←	mg/kg	→	
Profile 1					
0-23	Ap	0.39	2.48	2.60	92.50
23-52	Bt1	0.66	2.28	2.40	11.20
52-87	B	0.62	2.28	2.90	160.0
87-121	Bt2	0.70	2.11	3.00	92.30
121-154	C1	0.31	1.84	2.30	51.50
154-200	C2	0.54	2.01	2.70	21.80
Mean		0.54	2.17	2.65	71.50
Maximum value		0.70	2.48	3.00	160.0
Minimum value		0.31	1.84	2.03	11.20
Profile 2					
0-24	Ap	0.36	2.41	3.00	87.90
24-55	Bt1	0.11	1.60	2.70	77.80
55-87	B	0.59	1.92	2.40	37.50
87-120	Bt2	0.63	1.53	1.80	20.00
120-150	C1	0.68	1.43	1.00	17.20
150-200	C2	0.38	1.68	0.80	14.20
Mean		0.46	1.76	1.95	42.43
Maximum value		0.68	2.41	3.00	87.90
Minimum value		0.11	1.43	0.08	14.20
Profile 3					
0-25	Ap	0.37	2.67	2.20	100.80
25-54	Bt1	0.60	1.87	1.90	107.40
54-79	Bt2	0.78	2.08	1.70	53.80
79-107	Bt3	0.69	1.53	1.90	33.90
107-130	C1	0.61	1.77	1.90	19.60
130-200	C2	0.35	1.52	4.30	16.40
Mean		0.57	1.91	2.32	55.32
Maximum value		0.78	2.67	4.30	107.40
Minimum value		0.35	1.52	1.70	16.40

Source: Field Data (2017)
Fe=Iron, Zn=zinc, Cu=copper, Mn=manganese,

3.1.4 Fifty-Seven Years Old Oil Palm Plantation (B-57)

The result for micronutrients of B-57 is presented in Table 4. The result shows that iron ranged from 47.90-141.00 mg/k (mean 104.52 mg/kg) in profile 1; 19.70-70.50mg/kg (mean 42.82 mg/kg) in profile 2 and 12.80-50.70 mg/kg (mean 55.32 mg/kg) in profile 3. Zinc ranged from 1.64 - 12.28 mg/kg (mean 8.05 mg/kg) in profile 1; 1.65-2.28mg/kg (mean 1.92 mg/kg) in profile 2 and 1.78-3.17 mg/kg (mean 2.26 mg/kg) in profile 3. Copper ranged from 0.56-1.79 mg/kg (Mean 1.05mg/kg), 0.41-1.52mg/kg (mean 0.95 mg/kg) and 0.71-2.88mg/kg (mean 1.25mg/kg) in profiles 1, 2 and 3, respectively. Manganese ranged from 4.10-23.80 mg/kg (mean 11.45mg/kg), 3.00-6.60mg/kg (mean 4.85mg/kg) and 4.90-13.50mg/kg (mean 8.47mg/kg) in profiles 1, 2 and 3, respectively. Manganese was irregularly distributed within the profiles

The result has shown that iron had the highest values in all the four blocks of the study area. This attributes to the – yellowish-red colour observed in the profiles of all the soils in the study area. Iron was within the permissible level of 3000-5000 mg/kg for natural soils in all the blocks (European Commission, 1984).

Manganese was also higher than Zinc and Copper in all the blocks but was within the permissible level of 200-9000 mg/kg for natural soils in all the blocks (European Commission, 1984). On the same note, zinc was within the permissible level of 10-300 mg/kg for natural soils in all the blocks (European Commission, 1984). Copper had the lowest value compared to other micronutrients in all the blocks and was within the permissible level of 7-80 mg/kg for natural soils in all the blocks (European Commission, 1984).

Copper, Mn, Zn, and Fe contents of the soil in B-17 were significantly higher ($P<0.05$) than in the other blocks (Figure 1-3). The trend of Cu and Mn was as follows: B-17>B- 57> control>B-39, while that of Zn and Fe was as follows; B-17>B- 57>B-39> control. This shows that oil palm positively influenced the micronutrient content of the soil. It increased the Cu, Mn, Zn and Fe content of the soil with the highest increase at age 17 (B- 17). This finding is similar to the findings of Obi and Udoh (2012) that as oil palm tends to release some of the extractable micronutrients previously sequestered in the dry matter back into the soil with time.

Table 4: Micronutrients of soils of the 57 years old oil palm block (B-57)

Horizon Depth	Horizon Design	Cu	Zn mg/kg	Mn	Fe
Profile 1					
0-27	Ap	0.56	12.09	0.79	96.10
27-50	Bt_1	0.79	10.18	0.78	141.0
50-84	Bt_2	1.79	12.28	0.88	132.0
84-116	C_1	1.47	10.38	0.96	138.0
116-160	C_2	0.81	1.64	1.12	72.10
160-200	C_3	0.85	1.70	0.90	47.90
Mean		1.05	8.05	0.91	104.52
Maximum value		1.79	12.28	1.12	141.0
Minimum value		0.56	1.64	0.78	47.90
Profile 2					
0-27	Ap	0.41	1.65	6.40	68.70
27-57	Bt_1	1.14	1.94	6.60	70.50
57-90	Bt_2	1.52	2.07	4.90	45.10
90-120	Bt_3	0.90	1.75	4.30	28.30
120-155	C_1	0.67	1.82	3.90	24.60
155-200	C_2	1.06	2.28	3.00	19.70
Mean		0.95	1.92	4.85	42.82
Maximum value		1.52	2.28	6.60	70.50
Minimum value		0.41	1.65	3.00	19.70
Profile 3					
0-29	Ap	2.88	1.94	10.40	44.70
29-60	BA	0.85	2.69	5.60	36.60
60-92	B_1	0.74	2.07	4.90	50.70
92-124	B_2	1.07	3.17	8.50	36.80
124-160	C_1	1.22	1.78	13.50	28.40
160-200	C_2	0.71	1.91	7.90	12.80
Mean		1.25	2.26	8.47	34.17
Maximum value		2.88	3.17	13.50	50.70
Minimum value		0.71	1.78	4.90	12.80

Source: Field Data (2017)
Fe=Iron, Zn=zinc, Cu=copper, Mn=manganese,

4.0 Conclusion

The deficiency of Zn is prevalent in most of our agricultural soils, but those of Cu, Fe and Mn has also occasionally been identified. Hence, the study showed that Zinc had the highest level in the soils of the study area while copper had the lowest level among the micronutrient analyzed. All the micronutrients tested were within the permissible range for agricultural soils, the soil's copper, Mn, Zn and Fe contents in B-17 were significantly higher than the other blocks. The trend of Cu and Mn was as follows: B- 17 > B- 57> control> B-39, while that of Zn and Fe was as follows; B- 17> B- 57> B-39> control. Oil palm increased the soil's Cu, Mn, Zn and Fe content. This shows that oil palm positively influences the soil's micronutrient content and will significantly release some of the extractable micronutrients previously sequestered in the dry matter back to the soil with time.

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