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SOIL IMPROVEMENT POTENTIAL OF *MONODORA MYRISTICA* (GAERTN.) DUNAL LEAVES AND ITS EFFECT ON THE GROWTH AND YIELD OF *ABELMOSCHUS ESCULENTUS* (L.) MOENCH

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ABSTRACT: *The persistent decline in soil fertility due to continuous cultivation, erosion, and nutrient depletion poses a major threat to food security and sustainable crop production in Nigeria. While poultry manure remains a common organic soil amendment often used by farmers to enhance soil fertility, its limited availability and rising costs have brought about the need for alternative, readily available organic resources. This study focused on assessing the soil improvement potential of the medicinal plant, Monodora myristica (African nutmeg). Leaves of the plant were collected, added to soil samples, and over a period of ten weeks, were observed and compared with a known organic amendment (poultry dung) and an untreated soil to ascertain its effectiveness in improving soil fertility as well as its impact on the growth and yield of a common crop in Nigeria (Abelmoschus esculentus). Soil samples were collected before and after amendment application to analyze changes in pH, organic matter, and key macronutrients. Okra growth parameters such as plant height, number of leaves, etc., were monitored over a period of ten weeks, with the final yield results under each treatment taken. The results showed that Monodora myristica leaves significantly ($P<0.05$) enhanced soil fertility by increasing organic matter content, improving soil structure, and contributing essential nutrients such as potassium, calcium, and phosphorus to the soil. Results from the findings of this study prove Monodora myristica leaves to be effective, plant-based soil amendments capable of improving soil fertility, boosting crop performance and nutrients, and advancing sustainable agricultural practices in Nigeria and the world at large.*

KEYWORDS: Abelmoschus esculentus, African Nutmeg, Organic Fertilizer, Soil Amendment, Soil Fertility.

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INTRODUCTION

Soil fertility is a fundamental factor influencing agricultural productivity, crop health, and food security across the globe. It refers to the soil's capacity to supply essential nutrients in adequate proportions for plant growth and optimum yield (Brady & Weil, 2008). In tropical regions such as Nigeria, continuous cultivation, erosion, poor soil management practices, and limited access to soil-enriching inputs have led to declining soil fertility, thereby threatening the productivity of food crops such as okra (*Abelmoschus esculentus*). Due to this rising threat, the exploration of cost-effective and sustainable soil fertility restoration strategies has become a critical concern for sustainable agriculture (Ayoola & Makinde, 2008).

Over the years, organic soil amendments have gained a lot of attention and interest because of their ability to improve soil properties and help increase soil productivity without any extra side effects. Among these, poultry manure has proven to be effective and has become a widely recognized organic material used for improving soil fertility due to the presence of rich macronutrients like nitrogen, phosphorus, and potassium, as well as its natural ability to improve soil physical properties such as structure, porosity, and water retention (Tiamiyu *et al.,* 2012; Agbede & Adekiya, 2017). Despite these benefits, access to poultry manure is not always convenient for local farmers due to cost, availability, or the absence of integrated livestock systems. As a result, there is a growing need for alternative and complementary organic resources that are locally available and potentially beneficial to the environment.

Recent advances in organic soil fertility management have shifted attention toward the use of plant residues, particularly underutilized plant-based materials, due to their local availability. These materials contribute organic matter, stimulate microbial activity, and gradually release nutrients as they decompose (Almagro *et al.,* 2021; Lal, 2005). Other benefits of using plant residues for soil fertility management include improvement in the soil's biological and structural health, reduction in the presence of soil pathogens, enhanced soil aeration, and promotion of moisture retention within the soil (Brady & Weil, 2008).

One of such plant materials with soil improvement potential is the African nutmeg plant (*Monodora myristica),* which is native to West Africa and known for its culinary and medicinal properties. Key interest is on its leaves, which are rich in organic compounds and essential minerals such as calcium, magnesium, potassium, and decomposable biomass that can contribute significantly to the nutrient cycling process when used as green manure or soil amendment (Okunlola & Akinrinde, 2020; Oseni *et al.,* 2021). The decomposition of its leaves has the potential to enhance soil organic matter, improve soil structure, stimulate microbial activity, and also release macro and micronutrients vital for crop growth. This is particularly promising in the face of declining soil fertility across sub-Saharan Africa, where the cost of synthetic fertilizers remains a barrier for many local farmers (Vanlauwe *et al.,* 2015). However, despite its potential, there is limited experimental data on its effectiveness on the soil as compared to commonly used organic manures like poultry droppings. This gap forms the basis of this research, which seeks to investigate the soil improvement potential of African nutmeg leaves while also comparing its effect on the growth and yield of a commonly grown and economically beneficial crop (okra).

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Statement of Problem

Among the many challenges limiting sustainable agricultural productivity in Nigeria and sub-Saharan Africa, soil fertility depletion remains one of the most pressing of these challenges. Many soils within the region have become nutrient-deficient and are no longer able to support optimal crop growth due to factors like continuous cropping, leaching, and low organic matter inputs (Vanlauwe *et al,* 2015; Chivenge *et al.,* 2011). While chemical fertilizers are widely recommended, they are expensive, not always accessible to local farmers, and often times, they lead to long-term degradation of the soil when overused, hence the need for alternative sources that serve as fertilizer and don't impact the soil/crop negatively. African nutmeg (*Monodora myristica)* shows promising potential as a soil amendment based on preliminary findings, which suggest its leaves are rich in essential nutrients that could be beneficial to soil and crop health (Okunlola & Akinrinde, 2020; Oseni *et al.,* 2021). However, there is limited experimental data validating its direct impact on soil properties and crop performance. This lack of empirical evidence presents a gap in knowledge and practical application, making it a necessity to investigate its potential for soil fertility improvement and sustainable crop production.

The main objective of this research is to determine the effect of African nutmeg (*Monodora myristica)* leaves as a soil amendment and also evaluate its effect on the growth and yield of okra, in comparison with poultry manure and a no-treatment control. Specific objectives include:

1. To determine the effect of *Monodora myristica* leaves on the soil, growth performance of okra and nutrient composition of okra.

2. To observe and compare its effect on the yield of okra with a commonly used alternative (poultry dung).

MATERIALS AND METHODS

Study Location

The experiment was conducted along Board Road, Alihame, within the main campus of the University of Delta (UNIDEL), Agbor, Delta State, Nigeria. The study area lies within the rainforest agro-ecological zone of southern Nigeria and is characterized by a humid tropical climate with distinct wet and dry seasons. Annual rainfall ranges between 1,800 and 2,500 mm, while mean temperatures vary from 24°C to 32°C throughout the year (NIMET, 2022). A comparative experimental design was employed using a Completely Randomized Design (CRD) to evaluate the effects of African nutmeg (*Monodora myristica*) leaf amendment on the growth and yield of okra (*Abelmoschus esculentus*), a design considered suitable for experiments conducted under relatively uniform environmental conditions.

Experimental Materials

The experiment consisted of three treatment groups: a control (no soil amendment), poultry dung applied at 100 g per planting bag, and African nutmeg leaves applied at 100 g per planting bag. Three replicates were used for each treatment, resulting in a total of nine

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experimental bags. Treatments were randomly assigned to the experimental bags to minimize bias. Viable and uniform okra seeds were sourced from a local market in Agbor, Delta State, and were selected based on uniformity in size and physical integrity. Topsoil used for planting was collected from a single homogeneous site near the study area to ensure consistency in soil properties, and each planting bag was filled with 35 kg of soil.

Fresh poultry manure was obtained from a nearby poultry farm and air-dried prior to application to reduce moisture content and microbial activity. African nutmeg leaves were collected from nearby vegetation, chopped into smaller pieces, and applied fresh to the soil. Nine planting bags were arranged at approximately 18 cm spacing. Four okra seeds were sown per bag on April 1, 2025, and five days after germination, seedlings were thinned to one plant per bag to ensure uniform growth conditions. Watering was carried out regularly to maintain adequate soil moisture throughout the experimental period. At 38 days after planting, the bottoms of the planting bags were perforated to improve drainage, enhance aeration, and facilitate root development following observed signs of chlorosis in some plants.

Data Collection, Samples and Statistical Analysis

Vegetative growth parameters measured included plant height, number of leaves, and stem girth, while reproductive performance was assessed based on the number of pods produced per plant. Morphological characteristics were also documented through periodic photographic records. Pre-planting soil samples and plant leaf samples were subjected to laboratory analysis at the Department of Microbiology, University of Benin, Nigeria, using standard microbiological and biochemical procedures. Microbial isolation was carried out using the serial dilution method, with nutrient agar (NA) used for bacterial cultures and potato dextrose agar (PDA) for fungal cultures. Bacterial samples were incubated at 37°C for 48 hours, while fungal samples were incubated at 28±2°C for 72 hours. Colonies were enumerated, and isolates were identified based on morphological and biochemical characteristics.

Bacterial identification involved Gram staining and a series of biochemical tests, including catalase, oxidase, coagulase, urease, indole, citrate utilization, and sugar fermentation tests, following standard procedures. Fungal isolates were identified microscopically using lactophenol cotton blue staining. Total bacterial and fungal counts were determined using standard plate count techniques, with culture media prepared, sterilized, and inoculated under aseptic conditions before incubation. Data collected from the study were analyzed using both descriptive and inferential statistical methods. One-way analysis of variance (ANOVA) was performed using SPSS software to determine significant differences among treatment groups. Results were expressed as mean ± standard deviation, and statistical significance was established at $p < 0.05$.

RESULTS AND DISCUSSION

The results of the experiment provide interpretations based on the effects of African nutmeg leaves (*Monodora myristica)* as a soil amendment on okra (*Abelmoschus esculentus)*. The results are discussed with references to existing studies, highlighting the implications of the treatments on soil fertility, plant growth performance, physiological parameters, and

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proximate composition of okra fruits. Comparisons are made between African nutmeg leaf treatments, poultry manure, and control plots to determine the effectiveness of the organic amendments used.

Soil Physicochemical Results

Table 1 shows the physicochemical properties of the soil without treatment and the soils treated with African nutmeg leaves and poultry dung. From the results below, both treatments led to an increase in the nutrient content of the soil as compared to the soil without any treatment. However, soil treated with African nutmeg leaves outperformed those treated with poultry dung. This can be attributed to the presence of phytochemicals embedded in *Monodora myristica* leaves. These compounds which include terpenoids, saponins and steroids stimulate microbial activities and improve nutrient mineralization in the soil, thereby improving crop growth and yield.

Table 1: Physicochemical Properties of Soil Before and After Treatment Application

	Units	Ordinary Soil	Poultry Dung Treatment	African Nutmeg Treatment
Ph	-	6.46	6.16	6.80
Electric conductivity	µS/cm	50.44	58.81	57.16
Total Organic Carbon	%	0.59	0.80	0.88
Total Nitrogen	%	0.06	0.11	0.22
Exchangeable Acidity	meq/100g of soil	0.59	0.73	0.60
K	meq/100g of soil	0.21	0.27	0.31
Ca	meq/100g of soil	0.54	0.76	0.79
Mg	meq/100g of soil	0.59	0.73	0.74
Available phosphorus	mg/kg	1.74	2.23	2.93
NH_4N	mg/kg	5.38	7.64	7.97
NO_2	mg/kg	0.64	0.81	0.82
NO_3	mg/kg	4.50	6.34	6.60
SO_4	mg/kg	3.26	4.94	5.83
Clay	%	13.13	13.78	12.98
Silt	%	7.36	8.24	8.82
Sand	%	77.51	77.93	78.21

Leaf Physiological Parameters Result

The physiological characteristics of okra leaves as influenced by *Monodora myristica,* poultry dung and the control are presented in Table 2. The parameters evaluated in the table include chlorophyll content, proline content, and nitrate reductase activity.

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Table 2: **Results of Leaf Physiological Parameters of Okra Under African Nutmeg Leaves Treated Soil, Poultry Dung, and the Control**

SAMPLE	Chlorophyll (mg/mL)	Proline (µg /g)	Nit. red. ((NO_2//g)
Control			
Row 1	2.28	1.00	64.93
Row 2	2.82	0.74	54 .93
Row 3	1.87	0.65	133.06
African Nutmeg Leaves			
Row 1	2.68	1.13	84.00
Row 2	2.49	1.65	77.33
Row 3	2.64	1.71	149.33
Poultry Dung			
Row 1	2.69	0.94	39.73
Row 2	2.73	1.08	560.00
Row 3	2.88	0.58	124.00

Proximate Composition of Harvested Okra Fruits

Table 3 presents the proximate composition of okra fruits harvested from the different treatment plots. It shows the percentage of the moisture content, ash content, crude fibre, crude fat, crude protein, and carbohydrate content present in the fruits grown on the soils containing poultry dung and African nutmeg leaves as treatment.

Table 3: Proximate Composition of Harvested Okra Fruits Under Different Treatments

SAMPLE	Moisture Content	ASH Content	Crude fibre Content	Crude Fat	Crude Protein	Carbohydrate
ID	%	%	%	%	%	%
A1	68.50	3.30	8.10	0.12	1.94	17.94
A2	70.80	3.90	9.10	0.18	1.83	14.90
A3	67.10	2.80	7.00	0.17	1.87	20.96
B1	75.70	4.40	11.90	0.14	3.21	10.86
B2	74.30	5.20	10.70	0.24	3.70	15.86
B3	75.30	4.10	10.10	0.21	2.38	17.91

KEY:
A = POULTRY DUNG SAMPLE
B = AFRICAN NUTMEG LEAF SAMPLE

Morphological Parameters of Okra

Table 4-6 reveals the plant height, stem girth, number of leaves, number of pods, and pod length under the control and the different treatments over a period of 10 weeks, with measurements taken every two weeks.

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Table 4: Morphological and Reproductive Data of Okra Grown On Soil Without Treatment

Control	Plant Height	Number of Leaves	Stem Girth	Number of Pods	Pod Length
2 WAP	(cm)		(cm)	(cm)	(cm)
Bag 1	4cm	3	0.5cm	-	-
Bag 2	5cm	3	0.5cm	-	-
Bag 3	6cm	4	0.8cm	-	-
4 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	13cm	6	1.27cm	-	-
Bag 2	11cm	5	1.27cm	-	-
Bag 3	14cm	7	1.8cm	-	-
6 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	15cm	6	1.27cm	-	-
Bag 2	12cm	5	1.27cm	-	-
Bag 3	22cm	7	1.8cm	-	-
8 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	22cm	12	1.8cm	-	-
Bag 2	20cm	6	1.27cm	-	-
Bag 3	41cm	17	2.8cm	-	-
10 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	23cm	12	2.5cm	-	-
Bag 2	21cm	6	1.8cm	-	-
Bag 3	44cm	35	4.3cm	2	9cm (both)

Table 5: Morphological and Reproductive Data of Okra Grown On Soil With African Nutmeg leaves as Treatment

African Nutmeg leaves	Plant Height	Number of Leaves	Stem Girth	Number of Pods	Pod Length
2 WAP	(cm)		(cm)	(cm)	(cm)
Bag 1	6cm	4	1.27cm	-	-
Bag 2	8cm	4	1.27cm	-	-
Bag 3	9cm	5	1.52cm	-	-
4 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	14cm	9	2.54cm	-	-
Bag 2	26cm	10	3.30cm	-	-
Bag 3	28cm	11	3.04cm	-	-
6 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**

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Bag 1	33cm	21	4.31cm	-	-
Bag 2	39cm	19	5.08cm	-	-
Bag 3	41cm	17	3.81cm	-	-
8 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	64cm	28	6.60cm	-	-
Bag 2	49cm	26	6.60cm	4	10cm, 10cm, 11cm, 10cm
Bag 3	62cm	22	6.09cm	-	-
10 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	69cm	47	6.60cm	-	-
Bag 2	56cm	23	6.60cm	4	10cm, 11cm, 10cm, 10cm.
Bag 3	62cm	15	6.09cm	-	-

Table 6: Morphological and Reproductive Data of Okra Grown On Soil With Poultry Dung As Treatment

Poultry Dung	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
2 WAP	(cm)		(cm)	(cm)	(cm)
Bag 1	7cm	4	0.8cm	-	-
Bag 2	9cm	4	1.27cm	-	-
Bag 3	9cm	4	1.27cm	-	-
4 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	15cm	7	1.5cm	-	-
Bag 2	22cm	9	2.8cm	-	-
Bag 3	26cm	9	2.5cm	-	-
6 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	28cm	7	2.5cm	-	-
Bag 2	33cm	9	3.8cm	-	-
Bag 3	28cm	9	3.3cm	-	-
8 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	44cm	12	3.6cm	-	-
Bag 2	45cm	34	3.8cm	2	11cm
Bag 3	42cm	30	4.1cm	-	-
10 WAP	**Plant Height**	**Number of Leaves**	**Stem Girth**	**Number of Pods**	**Pod Length**
Bag 1	54cm	12	4.1cm	-	-
Bag 2	52cm	34	4.1cm	3	10cm, 11cm, 11cm.
Bag 3	53cm	39	5.3cm	-	-

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Table 7: ANOVA Summary on morphological data of Okra grown on African nutmeg leaves, poultry dung and untreated soil.

Parameter	F-value	P-value	Decision
Plant Height	12.663	0.007	Significant
Number of Leaves	0.475	0.643	Not Significant
Stem Girth	12.841	0.007	Significant

DISCUSSION

The application of African nutmeg (*Monodora myristica*) leaves as an organic amendment significantly ($P<0.05$) influenced the physicochemical properties of the soil, as seen in Table 1. Among the three treatments—African nutmeg leaves, poultry dung, and control. African nutmeg-treated soil recorded the highest pH value (6.80), compared to 6.16 for poultry dung. This slightly acidic to near-neutral pH range helps enhance nutrient availability in tropical soils, thereby promoting better root development and microbial activity. The result aligns with the findings of Nwite *et al.* (2012), who reported that plant-based amendments can exert a liming effect, helping to neutralize soil acidity.

Additionally, African nutmeg-treated soils exhibited the highest total organic carbon (0.88%), indicating a substantial input of organic matter into the soil, which is critical for maintaining good soil structure, water retention, and biological activity. As noted by Brady and Weil (2014), organic carbon plays a key role in improving the physical, chemical, and biological qualities of soil. The nutrient profile of the soil was also significantly enhanced by the nutmeg leaf application. In particular, nitrogen (0.22%), potassium (0.31 meq/100g), calcium (0.79 meq/100g), and phosphorus (2.93 mg/kg) contents were notably higher in the nutmeg-treated soil than in the poultry dung and control plots. This suggests that *Monodora myristica* leaves, though less commonly used than animal manures, possess considerable nutrient-releasing potential when incorporated into the soil. This supports the observations of *Ojeniyi et al.* (2012), who highlighted the role of green manures in long-term soil fertility management.

In terms of plant physiological responses as seen in Table 2, poultry dung treatment resulted in the highest chlorophyll content (2.88 mg/mL), indicating greater photosynthetic capacity and possibly better growth performance under this treatment. This confirms the well-established view that animal manures are typically rich in readily available nutrients that promote rapid vegetative growth (Adekiya *et al.,* 2019). However, okra plants grown under African nutmeg treatments recorded higher proline content, a known marker of osmotic stress adaptation. This suggests that while nutrient release from nutmeg leaves may be slower or less consistent than from poultry dung, it may still trigger physiological responses that prepare plants for environmental stress, such as water or nutrient deficiency, which was evidently observed in the field during the course of the study.

The nitrate reductase activity (NRA), an important enzyme responsible for nitrate assimilation, was highest in okra plants treated with poultry dung (560.00 NO_2//g), and lowest in those treated with African nutmeg (77.33 NO_2//g). This difference signifies more efficient nitrogen metabolism in poultry dung-treated plants, which is likely due to faster mineralization and more readily available nitrogen. These results support the conclusions of

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Makinde and Ayoola (2010), who emphasized that poultry manure enhances rapid nutrient uptake and metabolism due to its high decomposition rate.

Proximate analysis of okra fruits (Table 3) further revealed the differences in nutritional quality based on soil amendment. As seen on the table, okra grown on African nutmeg-treated soils contained higher crude protein (3.70%), crude fiber (11.90%), ash content (5.20%), and moisture content (75.70%) than those grown under poultry dung and control plots. This enhanced nutritional profile could be linked to the secondary metabolites and micronutrients present in African nutmeg leaves, which may influence metabolic pathways related to nutrient accumulation in fruits. Ogunyemi *et al.* (2016) similarly noted that certain green manures can enhance the nutritional composition of vegetables. Conversely, fruits from poultry dung plots had the highest carbohydrate content (20.96%), which may reflect better sugar synthesis and energy accumulation, possibly due to more efficient photosynthesis and nutrient assimilation.

In terms of growth and yield performance over the 10 weeks, African nutmeg was observed to produce the most robust vegetative growth. Plants reached an average height of 69 cm, developed up to 47 leaves, and had thicker stem diameters (6.60 cm) by the 10th week. These parameters strongly suggest that African nutmeg facilitated more vigorous shoot development, likely due to the high micronutrient present in African nutmeg. Poultry dung-treated plants also performed better than the control in these aspects, though not as significantly as the African nutmeg leaf treatment. These results correspond with the findings of Oseni *et al.* (2021), who highlighted the superior effects of poultry manure on vegetative development in okra.

Furthermore, reproductive traits such as the number of pods, pod length, and pod weight were all higher in okra plants treated with poultry dung compared to those treated with African nutmeg leaves or left untreated. This reinforces the idea that animal manures, due to their nutrient richness and faster decomposition, support both vegetative and reproductive growth more effectively. However, the improved nutritional quality of okra grown on African nutmeg-amended soil presents a compelling case for its use in sustainable agriculture particularly in systems that prioritize produce quality and long-term soil health over sheer volume of yield.

CONCLUSION

This research supports the view that African nutmeg (*Monodora myristica*) leaves can serve as an effective and sustainable organic soil amendment capable of significantly enhancing both soil fertility and the nutritional quality of okra (*Abelmoschus esculentus*) fruits. From the results and findings, the incorporation of African nutmeg leaves into the soil helps increase essential soil parameters such as pH, total organic carbon, nitrogen, phosphorus, potassium, and calcium, all of which are vital for healthy plant growth. These improvements contribute to the enhanced nutrient uptake and metabolic performance of the plant. The findings from this study help support the idea of integrated use of African nutmeg leaves as a cost-effective, locally sourced, and environmentally friendly compared to animal-based manures and synthetic fertilizers.

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