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Full Length Research Article

Restoration Potential of Organic Manure on Abandoned Farmlands for *Solanum* Crops in Awka, Nigeria

[1]Agulefoh, C. O., [1]Ekwealor, K. U., [2]Okereke, K. E. and [1]Ozigbo, C. C.

[1]Department of Botany, Nnamdi Azikiwe University, Anambra State.
[2]Department of Plant Science and Biotechnology, University of Nigeria, Enugu State.

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Abstract

This study assessed the ecological characteristics of two abandoned farmlands within Nnamdi Azikiwe University, Awka, Nigeria, and evaluated the effectiveness of cow dung manure in restoring soil fertility and enhancing the early growth of *Solanum melongena* (eggplant) and *Solanum lycopersicum* (tomato). The study was conducted at two sites within the Nnamdi Azikiwe University campus. An ecological survey was carried out using standard quadrat sampling techniques (20 quadrats of 25 m² per site) to assess floristic composition, species diversity, and phytosociological attributes. Soil samples were collected and analysed for physico-chemical properties, including nitrogen, phosphorus, potassium, organic matter, organic carbon, pH, and particle size distribution. A pot experiment employing a Randomised Complete Block Design (RCBD) was conducted to evaluate the effects of cow dung manure on germination percentage and early seedling growth parameters. A total of 535 and 587 individual plants were recorded in Site 1 and Site 2, comprising 21 species in 10 families and 18 species in 9 families, respectively. Vegetation in both sites was dominated by herbaceous species, particularly members of Poaceae and Asteraceae, indicating disturbed ecosystems undergoing secondary succession. The Shannon–Wiener diversity index values of 2.56 (Site 1) and 2.47 (Site 2) indicated moderate species diversity with low evenness. The Sørensen similarity index of 31.03% revealed low floristic similarity between sites, suggesting pronounced spatial heterogeneity. Soil analysis showed that Site 1 had higher nitrogen (5.41 ± 0.72%) and organic matter (2.67 ± 0.67%), while Site 2 exhibited higher phosphorus (7.85 ± 1.10 mg/g) and organic carbon (9.44 ± 0.73 µg/g). Both sites were classified as sandy loam with slightly alkaline pH conditions. Organic manure application significantly ($p < 0.05$) improved germination

percentage, seedling height, leaf number, and root length of both test crops across both sites. Germination rates increased from 65.4% to 89.6% in *S. melongena* and from 68.2% to 91.3% in *S. lycopersicum* under organic manure treatment at Site A. The findings show that although abandoned farmlands in this landscape support moderately diverse vegetation, they are dominated by opportunistic species, reflecting nutrient limitations and disturbance pressures. The findings also demonstrate that cow dung manure is an effective, low-cost soil amendment for restoring soil fertility and supporting the establishment of vegetable crops on such lands.

Keywords: Abandoned farmland; Organic manure; Ecological restoration; Species diversity; Soil fertility; *Solanum*

Introduction

Land degradation arising from farmland abandonment is among the most pressing environmental challenges of the twenty-first century. Between 1992 and 2015, approximately 83 million hectares of Cropland Were Abandoned Globally, Equivalent To About 5% Of Current Arable Land (Naess *Et Al*., 2021). In Sub-Saharan Africa, Including Nigeria, Abandonment Is Driven Chiefly By Declining Soil Fertility, Rural–Urban Labour Migration, Limited Access To Inputs, Land Tenure Insecurity And Socio-Political Instability (Lambin *Et Al*., 2001; Santos *Et Al*., 2021). This Is In Contrast To The Economic And Policy-Driven Land Retirement More Typical Of Europe And North America (Macdonald *Et Al.*, 2000; Navarro And Pereira, 2012; FAO, 2022).

Abandoned Farmlands Are Already Disturbed Landscapes Because They Have Been Previously Subjected To Agricultural Activities That Have Altered And Interfered With Their Natural State. Once Cultivation Ceases, Abandoned Land May Recover Through Secondary Succession or continue to degrade, depending on prior land-use intensity, soil condition and propagule availability (Chazdon, 2003; Cramer *et al.*, 2008). Unmanaged abandoned land commonly develops compacted, organically depleted soils with accelerated erosion and nutrient leaching (Guo and Gifford, 2002; Lal, 2004), and its vegetation frequently becomes dominated by a small number of highly competitive, often invasive, species that suppress native flora and resist restoration (Prach and Pyšek, 2001; Cramer *et al*., 2008). Restoring such land is important not only for reviving agricultural productivity and food security but also for biodiversity conservation and carbon sequestration, priorities underscored by the UN Decade on Ecosystem Restoration, 2021–2030 (SER, 2004; UNEP, 2021).

Among active restoration strategies, organic manure application is a widely promising option for improving soil fertility and supporting vegetation recovery on degraded land (Edmeades, 2003; Diacono and Montemurro, 2010). Unlike synthetic fertilizers, which supply short-lived nutrient pulses, organic amendments such as cow dung improve soil structure, water-holding capacity and cation exchange capacity, and stimulate the microbial activity that drives nutrient mineralization (Brady and Weil, 2002; Mäder *et al*., 2002; Nannipieri *et al.,* 2003). Cow dung in particular is widely used in tropical farming systems for its favourable nutrient composition, availability and low cost, and its comparatively slow decomposition provides a longer-term nutrient supply than poultry litter (Goyal *et al*., 1999; Adediran *et al.*, 2004; Oyewole, 2011).

Solanum melongena (eggplant) and *Solanum lycopersicum* (tomato) are economically important, fast-establishing Solanaceae crops that are highly responsive to soil fertility, making them practical indicator species for evaluating restoration inputs under controlled conditions (Weese and Bohs, 2007; Kumar *et al*., 2017). Despite growing global literature on farmland restoration and organic manure use, baseline ecological data for Nigerian abandoned farmlands remain sparse, most manure research has focused on actively cultivated rather than abandoned soils, and comparative multi-site studies capturing spatial heterogeneity in degradation and restoration response within a single landscape are scarce (Adesodun *et al.*, 2005; Ayeni, 2010; Kent, 2012).

This study therefore conducted an ecological survey of two abandoned farmlands in Awka, Nigeria, and evaluated the restorative effect of cow dung manure on the early seedling growth of *S. melongena* and *S. lycopersicum* as test crops.

Materials and Methods

Study Area

The study was carried out within Nnamdi Azikiwe University, spanning between Awka North and South Local Government Area of Anambra State, Nigeria, which lies within the tropical rainforest zone. The area has a humid tropical climate with rainy season from March–October, interrupted by the "August break", mean annual rainfall of about 2000 mm, mean annual temperature of 25–28°C, and relative humidity ranging from 50–60% in the dry season to about 98% in the rainy season (ADP, 2010).

Site Selection

Two abandoned farmlands within the university were selected:

Site 1: an abandoned farmland beside the new boys' hostel, adjacent to the Department of Economics, Faculty of Social Sciences.

Site 2: an abandoned farmland beside the Gauze pharmacy, opposite the Department of Architecture, Faculty of Environmental Sciences.

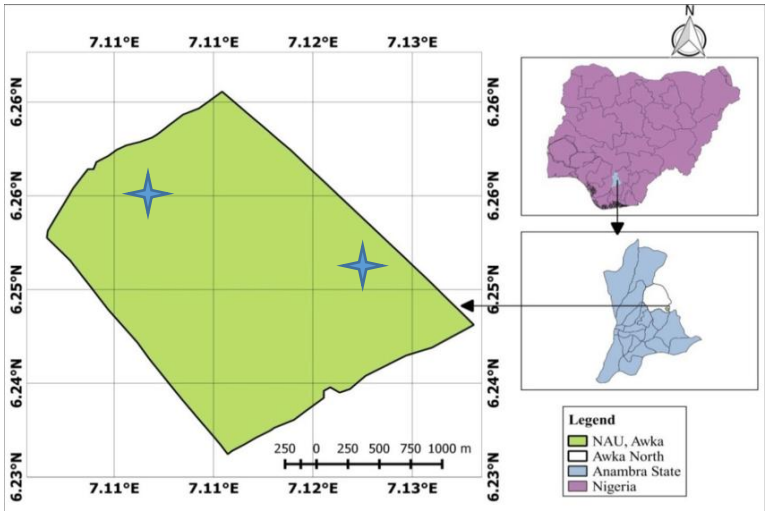


Figure 1: Map of Nnamdi Azikiwe University, Awka, showing the location of Site 1 (Faculty of Social Sciences, top left of the map) and Site 2 (Faculty of Environmental Sciences, down right side of the map) within Awka North LGA, Anambra State, Nigeria.

Source: Authors' field mapping, adapted from Awka North LGA and Anambra State administrative boundaries.

Sampling Technique

A systematic sampling method was employed, using quadrats as the sampling technique to assess vegetation at both sites. Each farmland measured 100 m × 50 m (5,000 m²), of which 10% (500 m²) was sampled. This sampled area was divided into twenty 5 m × 5 m (25 m²) quadrats, laid out at fixed, regular intervals along two perpendicular baseline transects (labelled AB and BC) that traversed the length and breadth of each farmland. This design ensured that the sampled quadrats were evenly distributed across the site and captured its spatial heterogeneity, while a sampling intensity of 10% kept the survey logistically feasible without compromising representativeness, consistent with standard practice for herbaceous vegetation surveys (Kent, 2012). All rooted plant individuals within each quadrat were identified, counted and recorded.

Collection and Identification of Plant Species

Plant species were identified in the field using morphological features of the leaves and stems, with reference to two standard, widely used regional floras: Tropical Weeds of West Africa (Akobundu and Agyakwa, 1998) and Flora of West Tropical Africa (Hutchinson and Dalziel, 1963). Specimens whose identity could not be resolved with certainty in the field were matched against the descriptions and illustrations in these two references.

Computation of Phytosociological Data

Species density, frequency and their relative values were computed as follows:

Density = Number of individuals of a species ÷ Total area sampled

Relative density (RD, %) = (Density of a species ÷ Total density of all species) × 100

Frequency (F, %) = (Number of quadrats in which a species occurred ÷ Total number of quadrats sampled) × 100

Relative frequency (RF, %) = (Frequency of a species ÷ Total frequency of all species) × 100

Abundance (A) = Number of individuals of a species ÷ Number of quadrats in which it occurred

Relative abundance (RA, %) = (Abundance of a species ÷ Total abundance of all species) × 100

Because the vegetation at both sites was overwhelmingly herbaceous and graminoid, with clonal and rhizomatous growth forms (e.g., *Pennisetum purpureum, Imperata cylindrica*) for which basal-area cover is not a meaningful or reliably measurable quantity under quadrat counts, relative abundance rather than basal-area-based relative dominance was used as the third component of the Importance Value Index, following common practice for herb-layer phytosociological surveys. The Importance Value Index (IVI) was therefore computed as:

IVI = Relative density + Relative frequency + Relative abundance (maximum possible value = 300)

Computation of Species Diversity

The Shannon–Wiener diversity index (H) was computed as $H = -\Sigma(Pi \times \ln Pi)$, where

Pi is the proportion of individuals belonging to species i and ln is the natural logarithm, summed across all species (S) recorded at a site.

Sørensen Similarity Coefficient (Cs)
Floristic similarity between the two sites (A and B) was computed as Cs = [D ÷ (A + B + D)] × 100, where D is the number of species common to both sites, A is the number of species unique to Site 1, and B is the number of species unique to Site 2, following the method of Ogunleye *et al*. (2004).

Analysis of Soil Productivity for the Two Farmlands
Solanum melongena and *S. lycopersicum* seeds were sourced from the Anambra Agricultural Development Programme (ADP). Seed viability was checked by immersion in water; seeds that sank were retained as viable. Cow dung was collected from the cattle market at Amansea, Awka, North LGA Anambra state and soil samples were collected from multiple points within each farmland, bulked, and transported to the departmental screen house at the Botanical Garden, Science Village, for the pot experiment.

Study Design and Treatment
The pot experiment was arranged in a Randomized Complete Block Design (RCBD) using plastic bags (30 cm × 15 cm), with three replicate bags per treatment per crop per site. For the manure treatment, 2 kg of soil was thoroughly mixed with 0.5 kg of cow dung manure and left to stand for seven days to allow ammonification. Ten seeds of each crop were then sown per bag; the control received no manure and was planted in moisturized, untreated soil. A reference peg (tip projecting 2 cm above the soil surface) was placed in each bag to standardize height and root-length measurements. Germination and growth parameters were recorded daily for 10 days after germination.

Measurement Of Growth Parameters
Seedling height and root length were measured with a measuring tape from the reference point to the shoot apex and root tip, respectively, and recorded in centimetres. Germination percentage which can as well be addressed as just Germination was calculated as (number of seeds germinated ÷ total seeds sown) × 100. The number of leaves per seedling was counted, and the mean per replicate was calculated.

Soil Textural and Chemical Analysis
Soil total nitrogen was determined by the micro-Kjeldahl method (AOAC, 1999); available phosphorus by the ammonium molybdate–hydrazine sulfate colorimetric method (Ganesh *et al*., 2012); exchangeable potassium and other metals by atomic absorption spectrophotometry following wet digestion (APHA, 1995; Sun, 2000); soil pH in a 1:10 soil–water suspension using a digital pH meter; organic carbon by the Walkley–Black chromic acid method with colorimetric determination (Walkley and Black, 1934; Sims and Haby, 1971); particle size distribution by the Bouyoucos hydrometer method (Bouyoucos, 1962); and organic matter by loss-on-ignition at 550°C (AOAC, 1999).

Statistical Analysis
All data were subjected to analysis of variance (ANOVA) at the 0.05 significance level, with means separated using Duncan's Multiple Range Test (DMRT), using SPSS version 20.

Results
Floristic Composition of Site 1
A total of 535 individuals belonging to 21 species and 10 families were recorded in Site 1 (Table 1). The vegetation was dominated by *Pennisetum purpureum* (155 individuals), followed by *Chromolaena*

odorata (51), *Aspilia africana* (42), *Tridax procumbens* (38) and *Abrus precatorius* (32); *Rhynchospora corymbosa* (5), *Asystasia gangetica* (6) and *Costus spiralis* (8) were the least represented. Fabaceae had the highest number of species (four), while Poaceae was the most abundant family owing to the dominance of *P. purpureum*.

Table 1: Species Composition and Abundance in Site 1 (Faculty of Social Sciences)

S/N	Plant Species	Family	Common Name	Number Sampled
1	*Pennisetum purpureum*	Poaceae	Elephant grass	155
2	*Aspilia africana*	Asteraceae	Wild sunflower	42
3	*Rhynchospora corymbosa*	Cyperaceae	Golden beaksedge	5
4	*Sorghum halepense*	Poaceae	Johnson grass	24
5	*Mimosa pigra*	Fabaceae	Bashful plant	18
6	*Passiflora foetida*	Passifloraceae	Wild maracuja	14
7	*Mesophaerum suaveolens*	Lamiaceae	Pignut	22
8	*Megathyrsus maximus*	Poaceae	Guinea grass	20
9	*Commelina diffusa*	Commelinaceae	Climbing dayflower	25
10	*Acanthus montanus*	Acanthaceae	Mountain thistle	9
11	*Mimosa pudica*	Fabaceae	Touch-me-not	12
12	*Abrus precatorius*	Fabaceae	Rosary pea	32
13	*Calopogonium mucunoides*	Fabaceae	Calopo	17
14	*Asystasia gangetica*	Acanthaceae	Creeping foxglove	6
15	*Costus spiralis*	Costaceae	Insulin plant	8
16	*Combretum malabaricum*	Combretaceae	Bush willow	9
17	*Chromolaena odorata*	Asteraceae	Siam weed	51
18	*Euphorbia heterophylla*	Euphorbiaceae	Milkweed	9
19	*Tridax procumbens*	Asteraceae	Coatbuttons	38
20	*Commelina benghalensis*	Commelinaceae	Tropical spiderwort	9
21	*Hyptis suaveolens*	Lamiaceae	Pignut weed	10
Total				535

The phytosociological attributes of Site 1, computed with the formulae in Section 2.4, are presented in Table 2. *Pennisetum purpureum* recorded the highest relative density (28.97%), relative frequency (17.25%), relative abundance (9.45%) and consequently the highest Importance Value Index (IVI = 55.67), confirming its dominance and wide distribution. *Chromolaena odorata* (IVI = 24.79), *Tridax procumbens* (IVI = 20.02) and *Aspilia africana* (IVI = 20.98) were the next most ecologically significant species, while *Rhynchospora corymbosa* (IVI = 7.95) and *Asystasia gangetica* (IVI = 5.91) had the lowest ecological significance.

Table 2: Phytosociological Attributes of Species in Site 1

S/N	Plant Species	N	RD (%)	F (%)	RF (%)	A	RA (%)	IVI
1	*Pennisetum purpureum*	155	28.97	93.0	17.25	8.16	9.45	55.67
2	*Aspilia africana*	42	7.85	33.3	6.18	6.00	6.95	20.98
3	*Rhynchospora corymbosa*	5	0.93	6.6	1.22	5.00	5.79	7.95
4	*Sorghum halepense*	24	4.49	20.0	3.71	6.00	6.95	15.15
5	*Mimosa pigra*	18	3.36	20.0	3.71	4.50	5.21	12.29
6	*Passiflora foetida*	14	2.62	20.0	3.71	3.50	4.05	10.38
7	*Mesophaerum suaveolens*	22	4.11	26.6	4.93	4.40	5.10	14.14
8	*Megathyrsus maximus*	20	3.74	26.6	4.93	4.00	4.63	13.31
9	*Commelina diffusa*	25	4.67	33.3	6.18	3.57	4.14	14.99
10	*Acanthus montanus*	9	1.68	13.3	2.47	3.00	3.47	7.62
11	*Mimosa pudica*	12	2.24	20.0	3.71	3.00	3.47	9.43
12	*Abrus precatorius*	32	5.98	33.3	6.18	4.57	5.29	17.45
13	*Calopogonium mucunoides*	17	3.18	20.0	3.71	4.25	4.92	11.81
14	*Asystasia gangetica*	6	1.12	13.3	2.47	2.00	2.32	5.91
15	*Costus spiralis*	8	1.50	13.3	2.47	2.67	3.09	7.05
16	*Combretum malabaricum*	9	1.68	13.3	2.47	3.00	3.47	7.62
17	*Chromolaena odorata*	51	9.53	53.3	9.89	4.64	5.37	24.79
18	*Euphorbia heterophylla*	9	1.68	13.3	2.47	3.00	3.47	7.62
19	*Tridax procumbens*	38	7.10	40.0	7.42	4.75	5.50	20.02
20	*Commelina benghalensis*	9	1.68	13.3	2.47	3.00	3.47	7.62
21	*Hyptis suaveolens*	10	1.87	13.3	2.47	3.33	3.86	8.20
Total		535	100.0		100.0		100.0	300.0

N = number of individuals; RD = relative density; F = frequency; RF = relative frequency; A = abundance; RA = relative abundance; IVI = Importance Value Index (RD + RF + RA; maximum = 300).

The Shannon–Wiener diversity index for Site 1 was H = 2.56 (Table 3), reflecting moderate species diversity with uneven distribution of individuals among species; *P. purpureum* alone contributed the largest proportion (Pi = 0.289) to total abundance.

Table 3: Species Diversity Computation for Site 1 (Shannon–Wiener Index)

Plant Species	n	N	Pi	ln(Pi)	Pi × ln(Pi)
Pennisetum purpureum	155	535	0.289	-1.241	-0.359
Chromolaena odorata	51	535	0.095	-2.353	-0.224
Aspilia Africana	42	535	0.078	-2.551	-0.199
Tridax procumbens	38	535	0.071	-2.645	-0.188
Commelina diffusa	25	535	0.046	-3.079	-0.142
Sorghum halepense	24	535	0.044	-3.123	-0.137
Abrus precatorius	32	535	0.059	-2.830	-0.167
Mesophaerum suaveolens	22	535	0.041	-3.194	-0.131
Megathyrsus maximus	20	535	0.037	-3.297	-0.122
Mimosa pigra	18	535	0.034	-3.381	-0.115
Calopogonium mucunoides	17	535	0.031	-3.473	-0.108
Passiflora foetida	14	535	0.026	-3.649	-0.095
Mimosa pudica	12	535	0.022	-3.817	-0.084
Hyptis suaveolens	10	535	0.019	-3.963	-0.075
Acanthus montanus	9	535	0.016	-4.135	-0.066
Combretum malabaricum	9	535	0.016	-4.135	-0.066
Euphorbia heterophylla	9	535	0.016	-4.135	-0.066
Commelina benghalensis	9	535	0.016	-4.135	-0.066
Costus spiralis	8	535	0.015	-4.199	-0.063
Asystasia gangetica	6	535	0.011	-4.510	-0.049
Rhynchospora corymbosa	5	535	0.009	-4.710	-0.042
Total ($H = \Sigma -Pi \times \ln(Pi)$)	535				2.560

Floristic Composition of Site 2

Site 2 recorded 587 individuals in 18 species and 9 families (Table 4), dominated by *Imperata cylindrica* (161 individuals), *Cyperus rotundus* (59), *Tridax procumbens* (47), *Chromolaena odorata* (46) and *Ageratum conyzoides* (43). Asteraceae had the highest number of species (four).

Table 4: Species Composition and Abundance in Site 2 (Faculty of Environmental Sciences)

S/N	Plant Species	Family	Common Name	Number Sampled
1	*Imperata cylindrical*	Poaceae	Cogon grass	161
2	*Cyperus rotundus*	Cyperaceae	Coco-grass	59
3	*Euphorbia heterophylla*	Euphorbiaceae	Milkweed	18
4	*Striga sp.*	Orobanchaceae	Witchweed	7
5	*Commelina benghalensis*	Commelinaceae	Tropical spiderwort	9
6	*Hyptis spicigera*	Lamiaceae	Black sesame	38
7	*Ipomoea muricata*	Convolvulaceae	Moonvine	32
8	*Aspilia Africana*	Asteraceae	Wild sunflower	28
9	*Tridax procumbens*	Asteraceae	Coatbuttons	47
10	*Ageratum conyzoides*	Asteraceae	Billygoat weed	43
11	*Acanthus montanus*	Acanthaceae	Mountain thistle	6
12	*Asystasia gangetica*	Acanthaceae	Chinese violet	21
13	*Justicia flava*	Acanthaceae	Yellow justicia	13
14	*Rhynchospora corymbosa*	Cyperaceae	Golden beaksedge	12
15	*Chromolaena odorata*	Asteraceae	Siam weed	46
16	*Mimosa pudica*	Fabaceae	Touch-me-not	12
17	*Hyptis suaveolens*	Lamiaceae	Pignut weed	26
18	*Croton hirtus*	Euphorbiaceae	Hairy croton	9
Total				587

Table 5 presents the phytosociological attributes for Site 2. *Imperata cylindrica* had the highest relative density (27.43%), relative frequency (15.12%), relative abundance (11.73%) and IVI (54.27), confirming its ecological dominance, followed by *Cyperus rotundus* (IVI = 27.30), *Chromolaena odorata* (IVI = 22.30) and *Tridax procumbens* (IVI = 22.27).

Table 5: Phytosociological Attributes of Species in Site 2

S/N	Plant Species	N	RD (%)	F (%)	RF (%)	A	RA (%)	IVI
1	*Imperata cylindrica*	161	27.43	86.6	15.12	9.47	11.73	54.27

2	*Cyperus rotundus*	59	10.05	66.6	11.63	4.54	5.62	27.30
3	*Euphorbia heterophylla*	18	3.07	26.6	4.64	3.60	4.46	12.17
4	*Striga sp.*	7	1.19	13.3	2.32	2.33	2.89	6.40
5	*Commelina benghalensis*	9	1.53	13.3	2.32	3.00	3.72	7.57
6	*Hyptis spicigera*	38	6.47	40.0	6.98	4.75	5.88	19.34
7	*Ipomoea muricata*	32	5.45	40.0	6.98	4.00	4.95	17.39
8	*Aspilia africana*	28	4.77	33.3	5.81	4.00	4.95	15.54
9	*Tridax procumbens*	47	8.01	40.0	6.98	5.88	7.28	22.27
10	*Ageratum conyzoides*	43	7.33	40.0	6.98	5.38	6.66	20.96
11	*Acanthus montanus*	6	1.02	6.6	1.15	6.00	7.43	9.60
12	*Asystasia gangetica*	21	3.58	20.0	3.49	5.25	6.50	13.57
13	*Justicia flava*	13	2.21	20.0	3.49	3.25	4.02	9.73
14	*Rhynchospora corymbosa*	12	2.04	20.0	3.49	3.00	3.72	9.25
15	*Chromolaena odorata*	46	7.84	46.6	8.14	5.11	6.33	22.30
16	*Mimosa pudica*	12	2.04	20.0	3.49	3.00	3.72	9.25
17	*Hyptis suaveolens*	26	4.43	26.6	4.64	5.20	6.44	15.51
18	*Croton hirtus*	9	1.53	13.3	2.32	3.00	3.72	7.57
Total		587	100.0		100.0		100.0	300.0

The Shannon–Wiener diversity index for Site 2 was H = 2.47, slightly lower than Site 1, consistent with its lower species richness (18 vs. 21 species) despite its higher total abundance (587 vs. 535 individuals).

Family-Level Composition and Comparative Analysis

Across both sites combined, 13 plant families were recorded (Table 6). Poaceae (360 individuals) and Asteraceae (295) were overwhelmingly dominant, followed by Fabaceae (79), Cyperaceae (76) and Lamiaceae (74); Passifloraceae (14), Combretaceae (9), Costaceae (8) and Orobanchaceae (7) were the least represented (Figure 2, Figure 3).

Table 6: Family-Level Composition of Plant Species across the Two Sites

S/N	Family	Total Individuals
1	Poaceae	360
2	Asteraceae	295
3	Fabaceae	79
4	Cyperaceae	76
5	Lamiaceae	74
6	Commelinaceae	43
7	Acanthaceae	42
8	Euphorbiaceae	36
9	Convolvulaceae	32
10	Passifloraceae	14
11	Combretaceae	9
12	Costaceae	8
13	Orobanchaceae	7

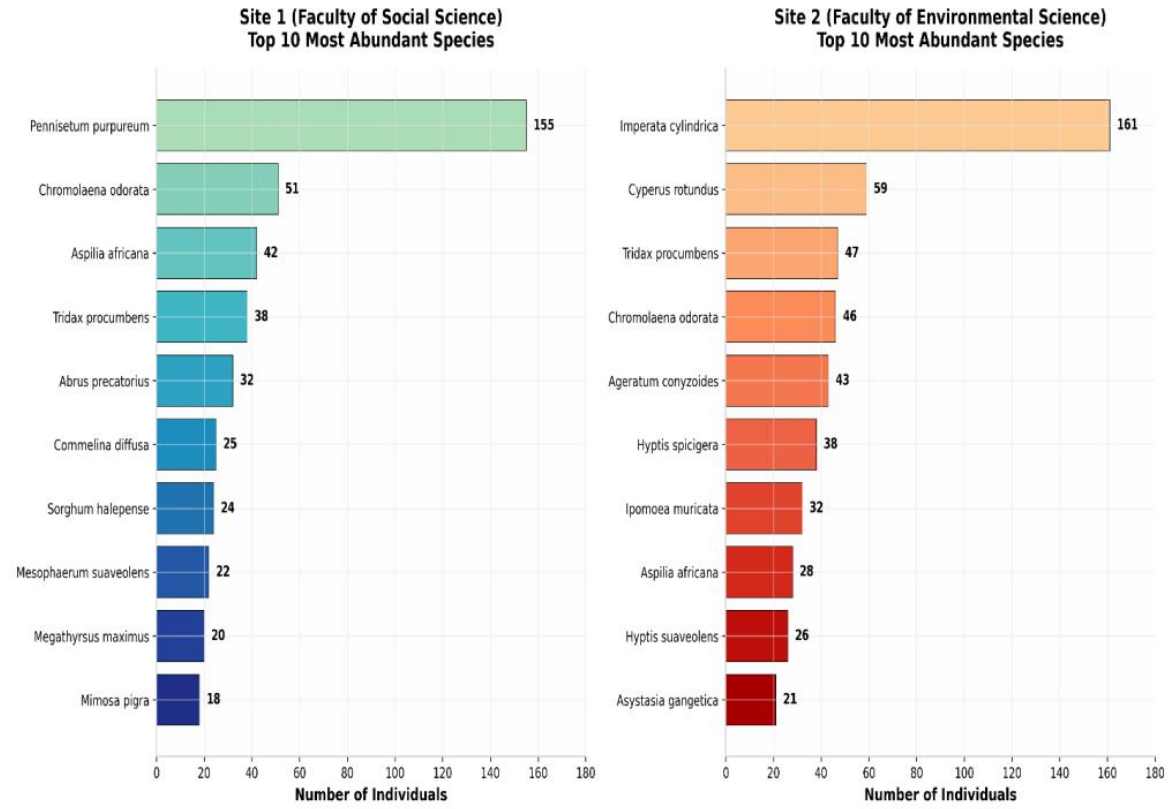


Figure 1: Ten Most Abundant Species in Site 1 and Site 2.

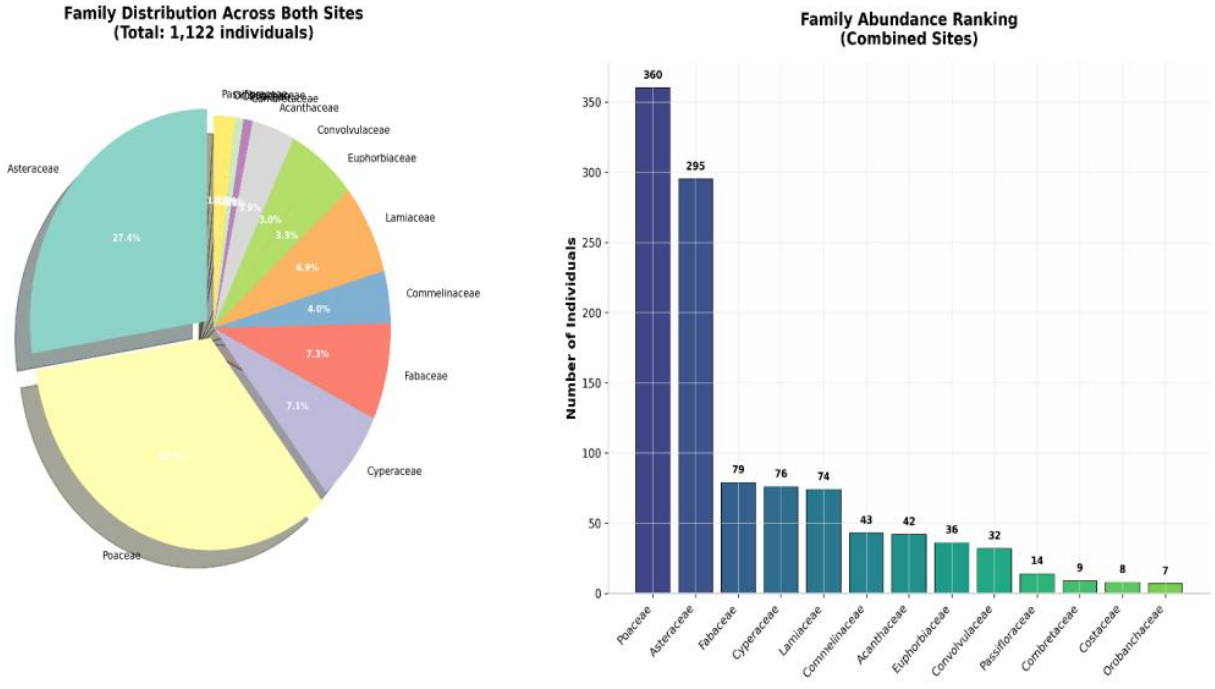


Figure 2: Family-Level Distribution and Abundance Ranking Across the Two Sites.

Table 7 compares species richness and similarity between the two sites. Site 1 had higher species richness (21 vs. 18 species); the two sites shared 9 species, with 12 unique to Site 1 and 9 unique to Site 2. The Sørensen similarity coefficient was 31.03%, indicating low floristic similarity and a high degree of species turnover (beta diversity = 68.97%) between the two sites despite their proximity within the same institution.

Table 7: Comparative Species Composition between Site 1 and Site 2

Parameter	Site 1	Site 2
Total species richness (S)	21	18
Shared species	9	9
Unique species	12	9
Sørensen similarity coefficient	31.03%	31.03%
Shannon–Wiener index (H)	2.56	2.47

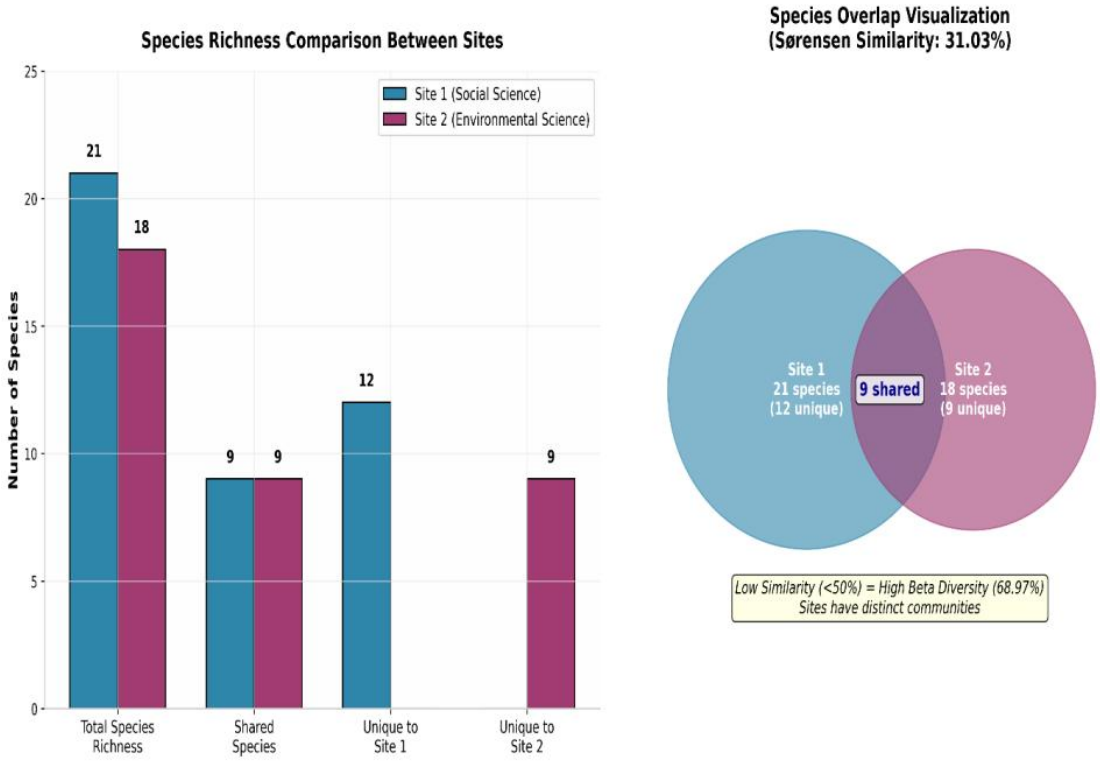


Figure 3: Species Richness Comparison and Species Overlap Between Site 1 and Site 2.

Soil Physicochemical Properties

Table 8 presents the physicochemical properties of soils from the two sites. Site 1 had higher nitrogen (5.41 ± 0.72%) and organic matter (2.67 ± 0.67%) than Site 2 (3.34 ± 0.71% and 2.00 ± 0.29%, respectively), while Site 2 recorded higher phosphorus (7.85 ± 1.10 mg/g vs. 2.38 ± 0.38 mg/g) and organic carbon (9.44 ± 0.73 µg/g vs. 7.59 ± 0.41 µg/g). Potassium levels were similar between sites (31.02 ± 0.07 ppm at Site 1 vs. 29.76 ± 0.23 ppm at Site 2). Both soils were slightly alkaline (pH 7.82–7.96) and sand-dominant in texture (58.7–65.0% sand), consistent with well-drained but nutrient-leaching-prone conditions typical of disturbed tropical soils.

Table 8: Physicochemical Properties of Soils from Site 1 and Site 2 (Mean ± SD)

Parameter	Site 1	Site 2
Nitrogen (%)	5.41 ± 0.72	3.34 ± 0.71
Phosphorus (mg/g)	2.38 ± 0.38	7.85 ± 1.10
Potassium (ppm)	31.02 ± 0.07	29.76 ± 0.23
Organic matter (%)	2.67 ± 0.67	2.00 ± 0.29
Organic carbon (µg/g)	7.59 ± 0.41	9.44 ± 0.73
pH	7.82 ± 0.03	7.96 ± 0.02
Sand (%)	65.00 ± 2.28	58.67 ± 2.43
Silt (%)	26.67 ± 1.67	25.67 ± 0.67
Clay (%)	13.33 ± 0.88	12.67 ± 0.88

Effect of Organic Manure on Germination and Early Seedling Growth

Cow dung manure significantly ($p < 0.05$) improved all measured growth parameters of both crop species at both sites relative to the untreated control (Table 9). At Site 1, germination in *S. melongena* rose from 65.4 ± 5.2% (control) to 89.6 ± 3.1% (manure), and in *S. lycopersicum* from 68.2 ± 4.5% to 91.3 ± 2.8%; seedling height, leaf number and root length showed corresponding increases in both crops. A similar pattern was observed at Site 2, where germination rose from 62.1 ± 6.0% to 85.4 ± 3.5% in *S. melongena* and from 66.5 ± 5.1% to 88.7 ± 3.0% in *S. lycopersicum*. Across both sites, *S. lycopersicum* consistently outperformed *S. melongena* under both treatments, and manure-treated plants at Site 1 (higher soil N and organic matter) showed marginally greater growth than those at Site 2, though the site × treatment interaction was not significant ($p > 0.05$), indicating that manure was similarly effective at both sites.

Table 9: Effect of Organic Manure on Germination and Early Seedling Growth of *S. melongena* and *S. lycopersicum* (Mean ± SD)

Site	Crop	Treatment	Germination (%)	Height (cm)	Leaves (no.)	Root Length (cm)
Site 1	*S. melongena*	Control	65.4 ± 5.2	4.2 ± 0.8	3.1 ± 0.6	5.1 ± 1.1
		Organic Manure	89.6 ± 3.1	8.5 ± 1.0	6.8 ± 0.9	9.8 ± 1.4
	S. lycopersicum	Control	68.2 ± 4.5	5.1 ± 0.9	3.5 ± 0.7	5.8 ± 1.2
		Organic Manure	91.3 ± 2.8	9.2 ± 1.1	7.2 ± 0.8	10.5 ± 1.5
Site 2	*S. melongena*	Control	62.1 ± 6.0	3.9 ± 0.7	2.8 ± 0.5	4.5 ± 1.0
		Organic Manure	85.4 ± 3.5	7.9 ± 0.9	6.1 ± 0.7	9.0 ± 1.2
	S. lycopersicum	Control	66.5 ± 5.1	4.8 ± 0.8	3.2 ± 0.6	5.2 ± 1.1
		Organic Manure	88.7 ± 3.0	8.8 ± 1.0	6.9 ± 0.9	9.9 ± 1.3

Means followed by manure treatment differed significantly from the corresponding control at $p < 0.05$ (ANOVA, DMRT) for all parameters.

Discussion

The floristic composition of both study sites reflects the ecological condition typical of abandoned, disturbed tropical farmland. The dominance of Poaceae and Asteraceae in both sites is consistent with reports that abandoned farmlands are typically colonized by fast-growing, ruderal pioneer species with broad environmental tolerances (Prach and Pyšek, 2001; Cramer *et al*., 2008). In Site 1, the overwhelming dominance of *Pennisetum purpureum* (RD = 28.97%, IVI = 55.67) reflects the competitive spread of this tall, fast-growing C4 grass, often taken as an indicator of moderate soil fertility and adequate moisture (Akobundu and Agyakwa, 1998). In Site 2, dominance by *Imperata cylindrica* (RD = 27.43%, IVI = 54.27) is notable because this species is widely regarded as one of the most problematic

tropical weeds, typically indicating poorer soil fertility, compaction or more frequent disturbance (Holm *et al*., 1977; MacDonald, 2004), suggesting that Site 2 may be more degraded, or has been more recently or more frequently disturbed, than Site 1.

The recurrence of invasive Asteraceae such as *Chromolaena odorata, Tridax procumbens* and *Ageratum conyzoides* at both sites is consistent with their known status as aggressive colonizers of disturbed humid-tropical land (Prasad and Singh, 1990; Gautier, 1992); *C. odorata* in particular is known to form dense, allelopathic thickets that suppress native regeneration (Ambika and Jayachandra, 1990). The presence of nitrogen-fixing Fabaceae, especially in Site 1 (four species, 79 individuals, including *Mimosa pigra, M. pudica, Abrus precatorius* and *Calopogonium mucunoides*), offers a plausible explanation for the higher soil nitrogen recorded at that site (5.41% vs. 3.34%), consistent with the known nitrogen-enrichment role of rhizobial symbioses in legumes (Giller, 2001); however, *M. pigra* and *M. pudica* are themselves invasive in parts of the tropics (Lonsdale, 1999), so any deliberate introduction of legumes for soil-fertility restoration should favour non-invasive, regionally native species.

The moderate Shannon–Wiener diversity recorded at both sites (H = 2.56 and 2.47) falls within the range reported for other disturbed tropical vegetation in Nigeria, and the marginally higher value at Site 1 is attributable to its greater species richness (21 vs. 18 species) despite comparable dominance by a single species at each site; illustrating that the Shannon index balances richness against evenness rather than tracking either alone. The low Sørensen similarity between the two sites (31.03%), despite their proximity (< 500 m) and shared macroclimate, indicates that local-scale soil properties, microtopography and disturbance history rather than distance are the principal drivers of floristic composition in this landscape. Differences in soil texture (Site 1: 65.0% sand vs. Site 2: 58.7% sand), nitrogen and organic matter align with, and plausibly explain, the divergent dominance of *P. purpureum* at Site 1 and *I. cylindrica* at Site 2, consistent with the resource-availability hypothesis that nutrient-richer conditions favour more competitive species while nutrient-poorer, more disturbed conditions favour stress-tolerant pioneers (Tilman, 1982).

Both soils were sand-dominant and slightly alkaline (pH 7.82–7.96), conditions that favour good drainage but limit cation exchange capacity and nutrient retention, making both soils prone to leaching and dependent on organic inputs for sustained fertility (Brady and Weil, 2002). Site 2's higher phosphorus and organic carbon relative to Site 1 may reflect differences in prior land use or slower organic matter turnover, while Site 1's higher nitrogen and organic matter are consistent with its greater legume cover and, potentially, a longer period since abandonment allowing litter accumulation.

The most significant finding of this study is the strong, consistent improvement in germination and early seedling growth of both *S. melongena* and *S. lycopersicum* following cow dung manure application at both sites. The improvements observed germination gains of 20–27 percentage points, and marked increases in seedling height, leaf number and root length are consistent with the established mechanisms by which organic amendments enhance plant growth: direct supply of macro- and micronutrients, improved soil structure and water-holding capacity, and stimulation of microbial activity that drives nutrient mineralization (Mäder *et al*., 2002; Edmeades, 2003; Diacono and Montemurro,

2010). These findings agree with previous reports of organic manure outperforming untreated controls for Solanaceous and other vegetable crops in Nigeria (Adesodun *et al*., 2005; Ayeni, 2010; Kumar *et al*., 2017). The consistently better performance of *S. lycopersicum* relative to *S. melongena* under both treatments may reflect inherent differences in germination vigour or seed quality between the two species, though both responded similarly in relative terms to manure application. That manure improved growth similarly at both sites, despite their differing baseline soil fertility, indicates that cow dung manure is a robust, site-independent restoration input for these crops.

Overall, these findings support the use of cow dung manure as a practical, low-cost soil amendment for re-establishing vegetable crops on abandoned farmland in this landscape. However, because this study assessed only the first 10 days after germination under pot conditions, the persistence of these benefits under field conditions, over longer growth periods, and in the presence of weed competition, remains to be established and should be a focus of future field-based trials. Likewise, the dominance of aggressive, invasive species (*I. cylindrical* and *C. odorata*) at both sites suggests that natural succession alone may not yield a desirable vegetation outcome, and that active management of these species would likely be necessary alongside any soil-fertility restoration effort.

Conclusion

This study shows that the two abandoned farmlands surveyed in Awka, Nigeria, support moderately diverse but structurally simple plant communities dominated by a small number of opportunistic, disturbance-adapted species *Pennisetum purpureum* at Site 1 and *Imperata cylindrica* at Site 2 and that the two sites, despite their proximity, differ substantially in floristic composition (Sørensen similarity = 31.03%) and in soil nitrogen, phosphorus, organic matter and organic carbon content. Cow dung manure significantly improved germination, seedling height, leaf number and root length of *Solanum melongena* and *Solanum lycopersicum* at both sites, confirming its value as an accessible and effective amendment for restoring soil fertility and supporting crop establishment on degraded, abandoned farmland. Restoration planning in this landscape should therefore combine site-specific ecological and soil assessment with organic soil amendment and active management of invasive pioneer species, and should be validated through longer-term field trials beyond the early seedling stage assessed here.

Authors contributions

Agulefoh Chioma O.: Conceptualization; methodology; validation; formal analysis; writing original draft; writing review and editing.
Ekwealor Ken U.: Conceptualization; project administration; supervision.
Okereke Kingsley E.: Investigation (field experiments); investigation (soil sampling and analysis); data curation; visualization.
Ozigbo Chisimdiri C.: Investigation (growth parameters of *Solanum* species); investigation (laboratory analyses); validation; visualization (preparation of figures and tables).

Conflict of interest

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