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Ummul-Khair Muhammad Sa'idu
Department of Plant Science, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University Sokoto, Nigeria

Altine Fakku Waziri
Department of Plant Science, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University Sokoto, Nigeria

Amina Musa Rabe
Department of Plant Science, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University Sokoto, Nigeria

Aliyu Sarkin Baki
Department of Microbiology, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University Sokoto, Nigeria

Corresponding Author:
Ummul-Khair Muhammad Sa'idu
Department of Plant Science, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University Sokoto, Nigeria

The potentials of pink morning glory (*Ipomoea carnea* jacq.) in soil conservation of Sokoto semi-arid zone

Ummul-Khair Muhammad Sa'idu, Altine Fakku Waziri, Amina Musa Rabe and Aliyu Sarkin Baki

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Abstract
Ipomoea carnea, family Convolvulaceae. Soil samples were collected from invaded and non-invaded areas in Biological Science garden UDUS. Dry seeds and Vegetative stalk of *Ipomoea carnea* was collected. Seeds were sown in nursery bed and vegetative stalk were planted. The result of soil texture analysis before planting shows that experimental site had the highest percentage of sand. Non-invaded had the highest percentage of silt and clay. After planting, control site had the highest percentage of sand, whereas the experimental site had the highest percentage silt. Experimental site had the highest electrical conductivity. EC, CEC, pH and Ca are higher in control site. Stem length was higher in vegetative propagation. For soil texture, sand had the highest percentage of all the four sites which led to high water percolation. Soils in the four sites investigated were slightly acidic and acidity in soils affects microbial activities on organic matter which might enhance the binding of soil to resist erosivity of rain runoff. It is concluded that planting of *Ipomoea carnea* in a sandy soil for erosion control should be considered. This study recommended the use of *Ipomoea carnea* as hedges, planting it in deserted areas to curtail erosion, soil degradation, and rehabilitation.

Keywords: UDUS and Sokoto, *Ipomoea carnea,* dry seed, vegetative stalk

Introduction
Ipomoea carnea Jacq, commonly called Pink Morning Glory is a species of morning glory plants. This evergreen, flowering shrub grows to height of 5 m. The stem is thick and develops into a solid trunk over several years with many branches from base. The stem is erect, woody, hairy, and more or less cylindrical in shape and greenish in colour. It has alternate leaves normally it attains 1.25-2.75 m long and 0.5-0.8 cm diameter. The leaves are green, heart shaped or somewhat lanceolate and 10-25 cm long. The upper surface of leaf is dull green and the lower surface is paler. The leaves which receive lesser sunlight may grow larger than the leaves which receive full sunlight (Sharma and Buchheti, 2013). It is locally called in Hausa, Yoruba, and Fulbe as Kashe gebe, Atewogba Tanpopo, and Dhol kolmi respectively. *Ipomoea Carnea* has been reported to be poisonous and cause severe nervous disorder when ingested by cattle, goats or sheep (Tokarnia *et al*., 2000; Shaltout *et al*., 2006) [57]. Allelopathy of *Ipomoea Carnea* and other invasive plants have been proposed as a strong mechanism for their remarkable success over the native species, which may be devoid of these innate allelopathic potentials (Callaway, 2000) [9]. Generally the agro-ecological applications of allelopathy has provided alternatives to develop more environmental friendly synthetic herbicides for weed control (Vyvyan, 2002) [61] with lower impact on the environment (Duke *et al*., 2002; Uddin *et al*., 2013) [18, 59].
Soil conservation is the practice of protecting the soil from degradation, erosion, and depletion. It involves implementing various strategies to maintain or improve soil health and productivity for sustainable land use. Conservation tillage techniques, such as no-till or reduced tillage, minimize soil disturbance by leaving crop residues on the soil surface. This helps to reduce erosion, improve water infiltration, and enhance soil organic matter content (Lal, 1997) [35]. Contour farming involves plowing and planting crops along the contour lines of the land, perpendicular to the slope, to reduce water runoff and soil erosion. Cover crops are planted primarily to protect and enrich the soil rather than for harvest. They help to prevent erosion, suppress weeds, improve soil structure, and enhance nutrient cycling (Blanco-Canqui and Lal 2009) [7].

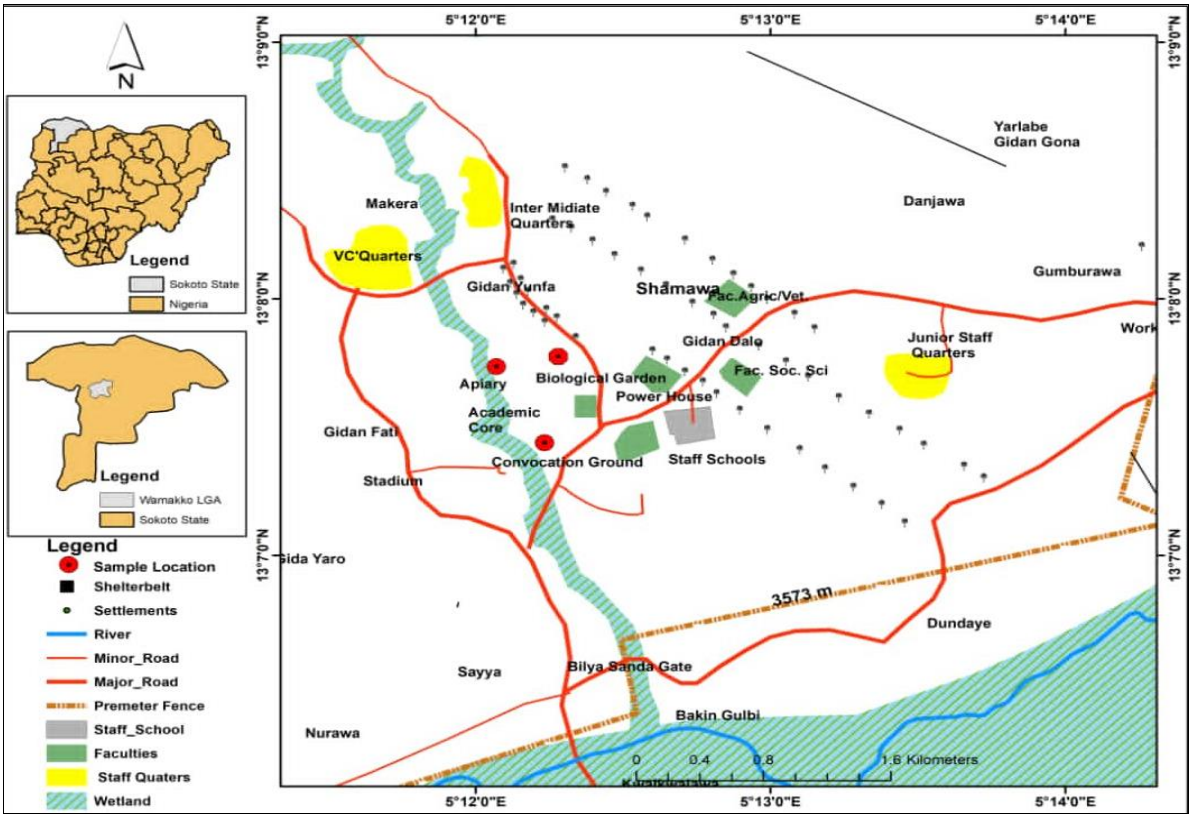
Agroforestry integrates trees and shrubs into agricultural landscapes to provide multiple benefits, including erosion control, improved soil fertility, carbon sequestration, and biodiversity conservation (Kumar and Nair 2006) [33]. Terracing involves constructing level platforms on steep slopes to create flat areas for agriculture, reducing soil erosion by slowing down water runoff and preventing soil from being washed away (Gikonyo *et al*., 2013) [23].

Soil conservation in regions like Sokoto, located in the Sudan Savanna ecological zone, typically involves addressing challenges such as soil erosion, nutrient depletion, and desertification. Implementing agroforestry systems, such as integrating drought-resistant trees like Acacia species with crops, helps in improving soil structure, enhancing water retention, and preventing erosion in arid and semi-arid regions (Mohammed and Whitbread 2018) [44]. Utilizing contour farming techniques combined with water harvesting structures like stone bunds and micro-catchments helps in reducing soil erosion by controlling surface runoff and enhancing soil moisture retention (Lawal *et al*., 2019) [37]. Employing practices such as mulching, where crop residues or organic materials are spread on the soil surface, aids in conserving soil moisture, reducing evaporation, and improving soil fertility (Abdulkadir and Tsado 2016) [1]. Adopting sustainable soil fertility management practices such as the use of organic amendments (e.g., compost, manure) and appropriate fertilizer application techniques helps in replenishing nutrients and maintaining soil health (Bello *et al*., 2019) [5]. The study aimed at identification of the Potentials of Pink morning glory (*Ipomoea carnea* jacq.), in Soil Conservation of Sokoto semi-arid zon

Materials and Methods

Study Area

The research was conducted at Biological Garden in the Main Campus of Usmanu Danfodiyo University Sokoto (UDUS). Sokoto State lies on Latitudes 11° 30'N and 14° 00'N, Longitudes 4°00'E and 6° 40' E and altitude 351.0m above sea level, (SERC, 2015) [51]. It falls within the Sudan savanna zone and is characterized by distinct wet and dry seasons. The seasons vary year to year in terms of duration and also intensity. The duration of wet season also may be about three to five months which may start from May/June to August/September with maximum rainfall recorded in July and August, which is around 600 mm-700 mm. Significant plant growth takes place during this period, (Tsoho and Salau, 2012) [58]. Average Temperature is 30ºC, minimum temperature is 20 ºC while maximum may be up to 40 ºC (World Weather Information Services Sokoto, 2016). The vegetation consists of scattered, short trees and shrubs, with dominant green cover.



Map 1: Map of the study area showing the Biological Sciences garden, UDUS

Collection of Soil sample

Soil samples were collected from both invaded and non-invaded areas around Biological Sciences garden located in Usmanu Danfodiyo University Sokoto permanent site. The samples were put in a sterilized polythene bags and transported to the Agricultural/Chemical Laboratory in chemistry department for further analysis. For each invaded and non-invaded areas, five soil samples were randomly collected along the study area at a depth of 0-50 cm in clean plastic bags.

Collection of Plant Sample

Dry seeds of *Ipomoea carnea* were collected near the Apiary site of Usmanu Danfodio University Sokoto. The vegetative stalk (cuttings) of plant's stem or stalk were also collected from the area where it is found naturally. At each

site a number of cuttings was obtained. The length of stem (30 cm) with a common girth (9cm) was used in this study based on a previously documented work (Gautam *et al.*, 2015) [22].

Experimental Design

A complete randomize design was used for the collection. Each location was replicated, while for the growth experiment, seed and vegetative propagation was conducted in triplicates for each (Lira Junior *et al.*, 2012; Alvarez *et al.*, 2013) [39, 3].

Soil Treatment

All soil samples were air-dried, grounded and passed through 2mm sieve for physicochemical analysis (Markos, 2019). The air-dried and sieved soil was kept in the laboratory and the garden for further analysis.

Soil Texture Determination Before and after Planting *Ipomoea carnea*

The common procedures used for particle size analysis or mechanical analysis were the hydrometer method according to Sahlemedhin and Taye (2000) [49] and FAO (2013) [21]. Forty gram of air-dried soil (2 mm) was weighed into a 600 ml beaker. Sixty (60) ml dispersing solution were added and the beaker was closed with a watch-glass, and then left to stand for 24 hours. Quantitatively, the content of the beaker was transferred to a soil-stirring cup, and the cup was filled to about three-quarters with water. The suspension was stirred at high speed for 3 minutes using a stirrer. The stirring paddle was rinsed into a cup, and allowed to stand for 1 minute. The suspension were transferred quantitatively into a one litter calibrated cylinder (hydrometer jar), and then bring to volume with water.

Determination of Silt and Clay in soil samples collected

The suspension were mixed in the hydrometer jar, using a special paddle carefully, the paddle has been withdrawn, and immediately inserted in to the hydrometer. The froth was dispersed with one drop of amyl alcohol, and hydrometer reading was taken after 40 seconds of withdrawing the paddle. Calculations of Percentage Silt plus clay in soil

$$\% \text{ [Silt + Clay] (w/w)} = (\text{Rsc - Rb}) \times \frac{100}{\text{Oven-dry soil (g)}} \quad (1)$$

Key: RSC-the hydrometer readings in seconds.
RB:-The blank hydrometer readings.

Determination of Clay percentage

The suspension was mixed in the hydrometer jar with paddle by withdrawing the paddle with great care, leaving the suspension undisturbed. After 4 hours, the hydrometer was inserted, and thereby taking the hydrometer reading, the percentage of clay were determined using the following formular:

$$\% \text{ Clay (w/w)} = (\text{Rc - Rb}) \times \frac{100}{\text{Oven-dry soil (g)}} \quad (2)$$

Determination of Sand

After the readings required for clay and silt soil was taken, the suspension was poured through a 50mm sieve. The sieve was washed until the water passing the sieve is clear and then the sand was transferred into the 50ml beaker of known weight. The sand in the beaker was allowed to settle, and excess water has been decanted. The dried beaker with sand was kept at 105 °C for at least 12 hours. It was allowed to cool in a desiccator, and beaker with sand was weighed again. The percentage of sand in the soil is:

$$\% \text{ Sand (w/w)} = \frac{\text{Sand weight}}{\text{Oven dry soil (g)}} \times 100 \quad (3)$$

Where: Weight of sand follows from:

Sand weight (g) = [Beaker + Sand (g)]-[Beaker (g)]

Determination of Electrical Conductivity (EC)

Electric conductivity was expressed as milliohms /cm in 1:2.5 soil/water extract (m ohms/cm = 1000 mmohms/cm, mm ohms/cm = 1000 micro ohms/cm). According to the method described by John *et al.* (2003) [67], Ten grams air-dried soil sample were put in 100 ml beaker, and 25 ml distilled water was added and stirred for 10 minutes, Stirring was repeated four times at thirty minutes intervals. The suspension temperature was measured with a thermometer.

Determination of Cation Exchange Capacity (CEC)

CEC was determined by using ammonium acetate according to Juo (1976) [28]. The 2 mm sieved soil 10 g were weighed into a 100 ml plastic beaker and 40 ml of 1 M ammonium acetate was added, stirred, and allowed to stay overnight. The soil was filtered with light suction using a 55 mm Buchner funnels and before the soil dried; it was leached with 1 M ammonium acetate to a volume of 250 ml. The leachate from the soil were tested with 3 drops of ammonium oxalate and heated which will give white precipitates indicating that Ca^{2+} is present the soil was further been leached until the leachate is calcium free. The soil was leached again four times with 25ml portion of 1 M ammonium chloride and once with 25 ml of 0.25 M ammonium chloride. Fifty milliliters (50 ml) of 2% boric acid were measured into 250 ml conical flask and 3 drops of mixed indicators were added. The acidified sodium chloride leachate was poured into a 500 ml Kjeldahl flask and connected to the still. Ten miles (10 ml) of 1 M sodium hydroxide were added into the flask and distilled over the boric acid in the conical flask. One-hundred and fifty milliliters (150 ml) of the distillate were collected and titrated with a standard acid (0.1 M HCl). A blank was prepared by taking 50 ml of Boric acid and mixed indicator which were titrated with the standard acid (0.1 M HCl). Using the equation below. CEC (cmol / kg) = AT-BT × C×100 /weight of soil.

Key:
Where AT = Actual titre value
BT = Blank titre value
C = Concentration of the standard acid (0.1).

Determination of Soil pH

This was conducted according to John *et al.* (2013) [67] Methods. Soil pH were determined based on the ratio of 1:2.5 soil /water extract by extraction where twenty-five milliliter (25 ml) distilled water were added to 10 g air-dried

sample in a beaker of 50 ml. Then the pH meter electrode was washed with distilled water. The contact switch was opened, waited for 5minutes, temperature knob was adjusted to room temperature. This was followed with calibration. The electrode was rinsed and then adjusted the pH dial with a standard pH solution followed by an acid or alkaline. The electrodes were rinsed again with distilled water, and were stirred; the readings of pH value of the soil suspension were taken

Determination of Soil Mineral Elements

Determination of Calcium (Ca^{2+}): This was done according to Method described by John *et al.,* (2013) [67]. One ml of each sample were taken into 250 ml conical flask and was diluted to 50 ml. Likewise another 1 ml of 10% NaOH were added to raise the pH of the solution to 12 ml. Drops of each of 2% KCl, 5% NH_2OH, HCl and Triethanolamine were added, then 0.1 g of murexide (indicator) were added and titrated with 0.01 EDTA until the pink color changes to purple.

Determination of Nitrogen: Organic and nitrate nitrogen were converted to ammonium sulphate and the ammonium is distilled into boric acid and titrated with hydrochloric acid (HCl) or sulphuric acid (H_2SO_4) using appropriate indicator. This is followed by digestion, five gram of soil was weighed into digestion flask with 5 g digestion mixture and 20 ml of concentrated Sulphuric acid (H_2SO_4) were added and then heated gradually by putting the flask on digestion board with electric heaters for a period of 10-30 minutes. After the end of fuming, the digestion was continued for an hour after the solution had cleared with white color of digestion mixture. The sample was transferred into 250 ml volumetric flask, and completed the volume with distilled water. In distillation, 20 ml H_3BO_3 were place in Erlenmeyer flask with four drops of the indicator. The flask was put to the lower tip of the glass receiver tube below the boric acid surface. The cooling water were runnel in condenser and 25 ml of the sample were put in the funnel with distilled water. Released ammonia was trapped in Boric acid. Ammonia was titrated with hydrochloric acid (HCl) or sulphuric acid (H_2SO_4). At end point the green color will disappear (John *et al.,* 2013) [67].

Determination of Phosphorus: Five grams air dried soil sieved with 1-2 mm sieve was suspended in 100 ml of Sodium carbonate (Na HCO_3) solution. The suspension was shaken for a period of 30 minutes. The solution has been filtered through a whatman 40 or other suitable filter paper. The concentration of phosphorus in the filtrate was determined by the following method: Micro-Vanadate-Molybdate method using spectrophotometer. This method is sensitive to 20-200 / ug p / 50 ml. The developed yellow color was stable for 6 hours at least. One to thirty five milliliters of soil extract were transferred to a 50 ml volumetric flask. Ten millilitres of the vanadate solution were added and the volumes were made to 50 ml with distilled water. Readings has been taken after 10 minutes at 405 nm using spectrophotometer.

Determination of Potassium and Sodium: Potassium and sodium ions were determined quantitatively using Flame photometer when they were atomized from solution and led to burner and exited to spectral emission in a flame. The intensity of the light emitted by each element depends primarily on the concentration of its atoms in the flame at any given instant, a measurement of the light intensity produced by a given element makes possible quantitative determination of that element. The following reagent was prepared. Potassium chloride 1000 ppm, was dissolved in distilled water and 1litre volume was made. Sodium chloride 1000 ppm was dissolved in distilled water and make to one litre volume. The following dilutions was also be prepared, 10, 20, 30…100 ppm from the standard 1000 ppm solution in solution of 1 M ammonium acetate pH 7.0, an aliquot of the solution to be analyzed into a 50 ml volumetric flask was pipetted, completed with one milliliter (1 ml) ammonium-acetate solution (pH-7). The potassium concentration was determined by use of the flame photometer and the appropriate calibration curve.

Determination of Magnesium: Magnesium was determined according to atomic adsorption spectrometry by John *et al.,* (2013) [67]. A Standard stock solution 1000 ppm was diluted and prepared for making up a series of standards for the calibration curve, from 0.1 to 8 ppm.

Seed and Vegetative Cultivation of *Ipomoea carnea*

Planting of Seeds: Seeds were sown in nursery bed in Biological Sciences garden (UDUS). Hundred seeds (100) were evenly broadcasted in $5m^2$ nursery beds and thinly covered with soil and replicated three times (Abdullah and Aliero, 2005) [2]. A shallow pit was dug around it to enable effective fertilization and watering Joost *et al.* (2014) [26]. Watering was done daily using 500 ml water for a period of 12 weeks (84 days). All the growth measurement was carried out at week intervals after 2 weeks of seedlings for a period of 12 weeks.

Vegetative cultivation of *Ipomoea carnea* stalk: *Ipomoea carnea* plants collected from invaded area, and vegetative stalk (stem cuttings) of uniform length (30 cm) and girth (9 cm) were planted. The plant cuttings were planted in double rows at spacing of 1 cm between plants. Each stem cutting was planted in a pit hole of 30 cm depth and width, by placing the lower cut in an oblique position as described by Gautam (2015) [22]. Watering was done daily, using 500 ml water for a period of twelve (12) weeks (84 days). All the growth measurement was carried out at week interval after 2 weeks of planting for twelve (12) weeks.

Assessment of Vegetative Growth of *Ipomoea carnea* Seed and Vegetative Stalk

Seed germination and viability test: Total number of seed germination was determined using counting method as described by Akram *et al*., (2014). Growth measurements of *Ipomoea carnea* planted through seeds and vegetative stalk was assessed for the following parameters; stem height, leaf number, leaf diameter, and stem girth were studied from a sample of individual plants in each plot. Growth measurement began at 2 weeks after emergence, and it was repeated at weekly interval up to the end of the growing period (Abdullahi and Aliero, 2005) [2].

Assessment of Root Biomass of *Ipomoea carnea*

Determination of Root biomass: After growing to the targeted period, fresh weight of the plant were cut above the soil level and was excavated; roots were counted at

randomly selected locations at 30, 60, and 90 cm depth and width (Knox *et al*., 2003) [32].

Root Number: Root was removed from the plant at the soil level. It was traced and the number was counted as described by Wood and Roper (2000) [65].

Root Length: The root length was determined using tape and thread. After growing to the targeted period plant was uprooted a single stem with its roots) and the roots were detached from the stem and measuring tape was placed at the end of the stem taking the length of the root (Knox *et al*., 2003) [32].

Results

Soil Texture Analysis before Planting

The result of soil texture analysis in table 1 showed that the experimental site had the highest percentage of sand (84.30%) followed by control site (81.58%) and the least was non-invaded site (68.80%). Non-invaded had the highest percentage of silt (20.20%) followed by invaded (11.90%) and the least is control site (8.54%). However, in the percentage clay non-invaded had the highest percentage of (11.00%) followed by control site (10.20%) and the least was experimental site (6.64%). Based on the result of analysis of variance, there is significant difference in the soil texture measured after planting (P-value ≤ 0.05).

Soil Texture Determined after Planting

The result of percentage soil texture determined after planting in table 2 shows that the control site had the highest percentage of sand and clay (91.40 and 4.50%) as compared to experimental site which are (90.10 and 4.10%), whereas the experimental site had the highest percentage of silt (5.70%) and control site (4.10%).

Physico-chemical Composition for all Sites before Planting

From the result obtained in table 3, it shows that electrical conductivity of experimental site is higher (2885 mmohms) followed by non-invaded site (921.4 mmohms) and control site (675.9 mmohms) while the invaded site had the least (563 mmohms). However, the CEC is higher in non-invaded site (48.60 meq/100 g)), followed by control site (40.00 meq/100g), invaded site (meq/100g**)** and the least is the experimental site with (36.80 meq/100 g).

Physico-chemical Composition of Soils after Planting

The result obtained in Table 4 shows that the electrical conductivity, CEC, pH, Ca^{2+} and other minerals are higher in the control site when compared to the experimental site.

Assessment of growth for seed and vegetative propagations

The growth parameters for both the seed and vegetative propagation in table 5 shows significant difference between all the treatments for the stem length, stem girth, leaf length, leaf breath and total number of leaves. Seed propagation had the highest number of leaves (5.667 ± 1.094^{a}) when compared to vegetative propagation (3.000 ± 1.095^{b}). But all other agronomic parameters are higher in vegetative propagation than the seed propagation.

Root Biomass of *Ipomoea carnea* planted by seed and vegetative propagation

The results for root biomass of propagated *Ipomoea carnea* showed that shoot length is higher in vegetative planting (56.20 cm) as well as the fresh weight shoot (99.6g), fresh weight root (96.00 g) and dry weight shoot (79.00 g) were higher too**.** The remaining were shoot dry weight (69.00 g), shoot fresh weight (99.60 g), root length (23.13 cm), root dry weight (38.50 g) and root fresh weight (96.00 g). P-value ≤ 0.05 shows significant difference while P-value ≥ 0.05 shows no significant difference in Root Biomass.

Table 1: Soil texture analysis of invaded, non-invaded, experimental, and control sites before planting

Soil Composition				
Site	**Sand (%)**	**Silt (%)**	**Clay (%)**	**P-value**
Invaded soil	81 ± 1.095^{a}	11.9 ± 1.095^{b}	7.1 ± 0.00^{c}	0.000
Non-invaded soil	68.8 ± 1.095^{a}	20.2 ± 1.095^{b}	11.0 ± 0.00^{c}	0.000
Experimental site	84.30 ± 1.095^{a}	9.06 ± 1.626^{b}	6.64 ± 2.136^{b}	0.000
Control site	81.58 ± 0.850^{a}	8.54 ± 1.24^{b}	10.20 ± 0.00^{c}	0.000

Mean that do not share the same superscript across the rows are significantly different 5% level of significance. Based on the result of analysis of variance, there is significant difference in the soil texture measured at (P-Value ≤ 0.05).

Table 2: Soil texture determined after planting

Site	Sand (%)	Silt (%)	Clay (%)	P-Value
Experimental site	90.10 ± 3.17^{a}	5.70 ± 2.97^{b}	4.10 ± 0.00^{b}	0.000
Control site	91.40 ± 0.00^{a}	4.10 ± 0.89^{b}	4.50 ± 0.89^{b}	0.000

Mean that do not share the same superscript across the rows are significantly different.

Table 3: Physico-chemical composition investigated for all sites before planting for the study locations.

Sites	EC(mmohms	CEC(meq/100g)	P^{H}	Ca(mg/L)	N(mg/L)	P(mg/L)	K(mg/L)	Na(mg/L)	Mg(mg/L)
Invaded area	733.40 ± 2^{c}	37.00 ± 1.0^{c}	8.010 ± 1.9^{a}	2.60 ± 1.0^{a}	0.204 ± 1.0^{c}	4.28 ± 0.0^{ab}	2.56 ± 1.01^{b}	1.83 ± 0.99^{ab}	1.13 ± 1.10^{a}
Non-invaded area	921.40 ± 2^{b}	48.60 ± 2.0^{a}	9.60 ± 2.0^{a}	4.35 ± 1.0^{a}	0.376 ± 2.0^{a}	5.27 ± 0.99^{a}	5.87 ± 0.99^{a}	3.13 ± 1.0^{a}	2.80 ± 1.10^{a}
Experimental site	$2882\pm2,0^{a}$	36.80 ± 1.0^{c}	8.500 ± 1.0^{b}	2.20 ± 1.0^{a}	0.257 ± 1.0^{b}	3.69 ± 1.01^{b}	3.53 ± 0.99^{ab}	1.46 ± 0.01^{b}	2.15 ± 0.99^{a}
Control site	675.9 ± 1.0^{c}	40.00 ± 1.0^{b}	$9.0.70\pm1.0^{a}$	3.05 ± 2.0^{a}	0.266 ± 1.0^{b}	3.86 ± 0.01^{b}	4.01 ± 0.99^{ab}	1.99 ± 1.0^{ab}	1.65 ± 0.99^{a}
P-value	0.000	0.000	0.001	0.288	0.000	0.095	0.020	0.182	0.383

Mean that do not share the same superscript are significantly different across the column

Table 4: Physico-chemical composition of soils obtained after planting for the study location

Sites	EC(mmohms	CEC(meq/1000g)	pH	Ca(mg/L)	N(mg/L)	P(mg/L)	K(mg/L)	Na(mg/L)	Mg(mg/L)
Experimental	576.48 ± 1.12^{a}	7.36 ± 0.17^{a}	4.80 ± 0.00^{a}	0.44 ± 0.02^{a}	0.051 ± 0.002^{a}	0.738 ± 0.005^{a}	0.706 ± 0.023^{a}	0.292 ± 0.018^{a}	0.430 ± 0.027^{a}
Control	135.18 ± 0.85^{b}	8.00 ± 0.2^{b}	6.14 ± 0.06^{b}	0.60 ± 0.4^{b}	0.059 ± 0.002^{b}	0.772 ± 0.005^{b}	0.802 ± 0.016^{b}	0.398 ± 0.018^{b}	0.330 ± 0.057^{b}
P-value	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.008

Mean that do not share the same superscript across the rows are significantly different across Column (within a column)

Table 5: Assessment of agronomic growth for seed and vegetative propagations of *Ipomoea carnea*

Agronomic growth parameters	Seed Propagation (cm)	Vegetative Propagation (cm)	p-value
Stem length	0.873±0.264[a]	2.295±0.582[b]	0.000
Stem girth	1.228±0.644[a]	1.852±0.808[a]	0.170
Leaf length	1.567±1.001[a]	2.247±0.641[a]	0.191
Leaf breath	1.028±0.790[a]	1.850±0.892[a]	0.122
Number of leaves	5.667±1.094[a]	3.000±1.095[b]	0.002

Means that share the same super script are not significantly different at 5% level using LSD

Table 6: Assessment for root biomass planted by seed and vegetative propagations

Propagation	SL(cm)	RL(cm)	SFW(cm)	RFW(cm)	SDW(cm)	RDW(cm)
Seed	30.67±15.50[a]	17.67±6.51[a]	32.90±12.88[a]	35.50±24.10[a]	14.77±5.08[a]	12.13±9.00[a]
Vegetative	56.17±3.88[a]	23.13±0.81[a]	99.60±79.30[a]	96.00±49.50[a]	69.00±18.20[b]	38.50±19.80[a]
P-value	0.051	0.222	0.223	0.130	0.008	0.104

Values are mean±standard deviation. Mean that share the same superscript, are not significantly different within a column

SL-Shoot Length, RL-Root Length, SFW-Shoot Fresh Weight, RFW-Root Fresh Weight, SDW-Shoot Dry Weight, RDW-Root Dry Weight

Discussion

The findings of this work on the soil texture in all the four sites studied (area of planting, non-invaded area, invaded area and control site) showed that sand had the highest percentage followed by silt and the least was clay (Table 1). This is in agreement with what was previously documented in a similar study in Gombe (Balzerek *et al*., 2003; Bitoye *et al*., 2010) [4, 6]. This may be explained by the fact that both Sokoto and Gombe are located in northern part of the country specifically within Sudan Savanna vegetation zone. This zone is prone to desertification characterized by preponderance of sandy soil (Kabara, 2013) [29].

The observation of this study on low percentage of Cation Exchange Capacity (CEC) for the four sites studied on the physico-chemical composition of the soil which ranges from 36.80±1.0-48.60±2.0 meq / 100g before planting was in line with what Malum *et al*., (2019) [41] reported in Cross River state. This is not surprising considering the fact Cation Exchange Capacity (CEC) describes the total capacity of a soil to hold exchangeable cations which influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification and erosion (Hazelton and Murphy, 2007) [24]. A soil with a low CEC value (<5) is an indication that the soil is sandy with little or no organic matter that cannot hold many cations (Ernest, 2016) [20]. This may explain the vulnerability of these areas to erosion as it occurred in some parts of Rivers state and similar areas.

It is strikingly interesting that the index study observed a high CEC after planting. High CEC value is a good indicator that a soil has a high clay and /or organic matter content and can hold a lot of cations. This also agrees with the findings of the study carried out in the Lower Benue River Basin. The variation in pH levels observed in the experimental and control sites before and after planting *Ipomoea carnea* which were 8.5 and 9.0 and 4.8 and 6.1 respectively demonstrated clearly that both experimental and control sites were high and mildly acidic correspondingly compared to before planting which were highly alkaline in nature. The witnessed shift in pH values to acidity in both the experimental and control sites, showed the effect of the plant on the soil pH. Acidity in soils affect microbial activities on organic matter which might enhance the binding of soils to resists erosivity of rain runoff effect as indicated by (Tafida, 2011; Quirine *et al*., 2016) [55, 46]. Otherwise high acidity dissociates soils which might be prone to erodibility. This also shows that the soils were highly acidic, the acidity is going high there by the increase in pH value (Tafida, 2011) [55].

On the other hand on elements, the percentage composition of Calcium ($Ca2^{+}$) from the experimental and control sites explored before planting were 2.2 and 3.1 mg/L respectively. Remarkable decrease was noticed in composition of the minerals in the soils at post-planting in both spots studied as depicted in table 4. This finding is not in agreement with what was reported in a previous study in Benue state where high calcium was detected. High calcium content usually indicates the presence of suspected dolomite, gypsum as well as the excessive use of lime on the soil (Chikezie *et al*., 2017) [13], Calcium also affects the ability of plants to absorb other elements (Weng *et al*.,2022) [62]. This observation was noticed across all the remaining elements investigated (Nitrogen, phosphorus, potassium, sodium and magnesium). The general decrease may be due to the absorption of the nutrients by the plant itself. Studies have shown that calcium plays critical role in plants growth and development and greatly influences the roots absorption of several other minerals.

Both Ca^{2+} and Mg^{2+} are secondary nutrients providers in soils, they function to bind soil particles together (Tausick, 2017) [52]. If calcium and magnesium are the predominant cations in a soil, exchange complex, tends to be easily permeable, thereby leaving the soils in granular structure, (Uttam *et al*., 2015) [60] and therefore susceptible to erosion. Acidity in soils affect microbial activities on organic matter which might enhance the binding of soils to resists erosivity of rain runoff effect as indicated by (Tafida, 2011; Quirine *et al*., 2016) [55, 46]. Otherwise high acidity dissociates soils which might be prone to erodibility. Sodium (Na^{+}) physico-chemical composition from the four sites investigated ranged between 1.83, 3.13, 1.46 and 1.99 mg/L. Sodium readily reacts with other substances in chemicals processes in soils. High sodium concentration contributes to the weakening of soil aggregates and their dispersion under rain drop impact (Domenico *et al.*, 1990) [17]. For phosphorus (P) from the four sites showed the concentration was high at non-invaded area and tends to decrease at area of planting and control site and falls within medium standard ratings of (Malum *et al*., 2019) [41]. Potassium (K) concentrations fluctuate between 2.56, 5.97, 3.58 and 4.01 mg·kg/L. These concentrations are higher by standard rating with range of (0.15 to > 0.30) and values of > 1.2 mg kg/L as very high according to Quirine *et al*., (2016) [46].

So also, these trace elements composition searched after planting of seed decreased as compared to pre planting sites. This may be as a result of increase in pH values that has control on leaching of basic cations such as Ca^{2+}, Mg, K and Na^{2+} from far beyond their release from minerals (White, 2006). The pH of the soil has an enormous influence on soil physicochemical properties and processes that affect plant growth and biomass yield (Brady *et al.* 1999; Minasmy *et al.*, 2016) [8, 43].

On the growth parameters, this study demonstrated that propagation by stem cutting grows faster than by seed of *Ipomoea carnea* studied which was consistent with what was reported in earlier similar work (Lovett-Doustt, 1981) [40]. At the tip of horizontal branch, a secondary shrub (ramet) develops. The laid-down branch becomes a functional stolon, which persists and keeps mother and daughter plant connected. Individual plants thus can easily expand in each direction with in-line offspring, covering dozens of square meters (Lovett-Doustt, 1981a) [40]. This mechanism of extension which contributes most to vegetative regeneration, and thus is a most potential process that may have intriguing consequences for the concepts of individuality and its evolutionary implementations. This is in line with the works of (Lovett-Doustt, 1981a) [40]. The seed do not germinate immediately because of a hard seed coat which is impervious to water which is similar to the findings of Keeler (1975) [31] who reported 8-9 hours for the anthesis, 1-2 days for the development or abortion of fruits and 4-5 weeks for the maturation of the seeds of *Ipomoea carnea*.

The findings of the index study on the root biomass of seeds and stem cuttings is in congruent with what was documented in the earlier work (Rostamza *et al.*, 2013) [48]. This observation was also reechoed by a similar study in Rhinelander, USDA Forest Service. (Coleman *et al.*, 2004) [14]. Furthermore, this research showed that only two parameters of shoot length and dry weight were noticed to be statistically significant which also agreed with what Coleman reported. The root biomass plays critical role in the overall plants survival. It absorbs water, macro and micronutrients from soil for onward distribution to various parts of the plants. Root biomass also contributes immensely in mitigating climate change through soil carbon absorption (Heinemann, 2023) [25].

In root biomass, most of the mean values did not differ for seed and stem cuttings. However, it is reported that root biomass tends to increase with the density of roots, stem cuttings produces fibrous root as compared to seed which produces fine. Although, there is significant difference in SDW of roots of both seed and stem cuttings as it goes according to the results of the Scott-Knott method 1974 [50].

Conclusion

It could be seen that the soil was sandy in all the four sites with slightly higher CEC. Mineral element, the Electric conductivity was higher in the experimental site followed by non-invaded, and control sites. Meanwhile after planting Electrical conductivity was higher, CEC, pH, Ca, and other minerals were higher in the control site as compared to experimental site. The soils were found to be acidic as pH composition from the experimental and control sites decreases by increase in pH value. The general agronomic traits also could be noticed as the propagation by stem cuttings grow faster than propagation by seed as all the parameters recorded were higher .In order to sustain the biomass of this plant material with efficiency means, the using of stem cuttings can be used instead of seeds for uniform plant material.

Recommendations

Based on the findings of this study, it is recommended

1. The planting of *Ipomoea carnea* in a sandy soil for erosion control should be considered.
2. Vegetative propagation should be considered in planting *Ipomoea carnea* to control soil erosion due to its faster growth than seed planting.
3. Encourage people to use *Ipomoea carnea* as hedges and also planting it in a deserted areas to curtail erosion, soil degradation, and rehabilitating soils.
4. Further research on *Ipomoea carnea* should be encourage as CEC is a good indicator in holding essential nutrients and provision of buffer against soil acidification and erosion.

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