International Journal of Research Publication and Reviews, Vol 6, Issue 5, pp 10063-10075 May 2025

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effects of Decapitation, Cattle Dung Manure and NPK 15:15:15 Fertilizer on Soil Characteristics and Okro (*Abelmoschus Esculentus* [L.] Moench) Growth and Yield in Makurdi Local Government Area (Lga), Benue State, Nigeria

[1]Oroduen Joshua Ahile, [2*]Monday Akpegi Onah, [3]Lanre Tajudeen Ajibade, [4]Patricia I. Ali [5]Johnson Orfega Mage, [6]Terwase Shabu, [7]Elizabeth Nguwanger Jeiyol and [8]Marcellinus Akaangee Hula

[1, 2*, 4, 5, 6, 7 and 8]*Department of Geography, Benue State University, Makurdi, Nigeria.*

[3]*Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria.*

[2*] *Email - onah1982akpegi@gmail.com*

ABSTRACT

Decapitation stops auxins' production at a plant's growing tips, thereby stimulating the development of lateral shoots. Vegetable crops, when decapitated, can respond differently to applied soil amendments. A field experiment was undertaken during the 2024 cropping season at Agan Settlement in Makurdi LGA of Benue State to assess the effects of decapitation, cattle dung manure (CDM) and NPK 15:15:15 fertilizer on soil characteristics and growth and yield components of 'Erguru' okro variety. Each experimental plot measured 3 m x 3 m (area = 9 m^2), with a furrow space of 1 m between the main plots/sub-plots. The experiment was arranged in a split plot design with eight treatments replicated thrice. The CDM and NPK 15:15:15 fertilizer treatments occupied the main plots and consisted of 15 t/ha CDM, 30 t/ha CDM, 300 kg/ha NPK 15:15:15 fertilizer treatments, and the control/non-amended soils. The decapitation treatments occupied the sub-plots and consisted of 'decapitated okro plants' (DOPs) and 'non-decapitated okro plants' (NDOPs/'control plants'). Pre-amendment and post-harvest soil analyses (0-30 cm depth), post-soil amendment and post-decapitation analyses of okro growth and yield parameters, and pre-application analysis of the CDM's chemical/mineralogic composition were undertaken. In April, the CDM was incorporated into soils at the cleared experimental site and allowed to decompose for 4 weeks before sowing of the okro seeds. Thinning was done at 2 weeks after planting (WAP); manual weeding at 3 WAP and 6 WAP; NPK fertilizer was applied in 2 split doses (at 4 WAP and 7 WAP); insect pests were controlled chemically with cypermethrin; decapitation at 8 WAP, while post-soil amendment and post-decapitation measurement of okro growth and yield parameters (shoot height at 14 WAP, number of green leaves at 14 WAP, days to 50% flowering after germination, days to first fresh pod harvest after flowering, number of pods harvested, fresh green pod yield, and dry shoot matter) began at 14 WAP. The data generated on soil properties and okro growth and yield parameters were analyzed using arithmetic mean and ANOVA. The pre-application CDM had a moderately alkaline pH (H_2O) (8.31) and high OC (16.9%), OM (29.14%), TN (1.7%), AP (86.08 mg/kg), Na (3.05 cmol/kg), K (6.52 cmol/kg), Mg (7.93 cmol/kg) and Ca (8.7 cmol/kg) contents. The pre-amended soils had a sandy texture, medium/moderately acidic solution pH (H_2O) (5.7) and low OC (1.06%), OM (1.83%), TN (0.16%) and AP (6.69 mg/kg) contents and low exchangeable cations (Na^+: 0.12, K^+: 0.14, Mg^{2+}: 0.33, and Ca^{2+}: 1.78 cmol/kg) levels. Decapitation had no effect on the soils' investigated properties. Similarly, decapitation, CDM and NPK fertilizer did not alter the soils' textural class. The post-harvest soils had a sandy texture, significantly ($P \leq 0.05$) improved solution pH (H_2O) status of 6.5 (slightly acidic reaction), high OC (2.63%), OM (4.53%), TN (1.39%) and AP (18.7 mg/kg) contents, and high exchangeable cations (Na^+: 0.28, K^+: 1.41, Mg^{2+}: 1.52, and Ca^{2+}: 3.79 cmol/kg) levels. The DOPs had a lower mean shoot height (120 cm at 14 WAP), more green leaves per plant (56 at 14 WAP), and produced more harvested pods (15), fresh pod yield (2.98 t/ha) and dry shoot matter (39.7 g/plant), but took a longer mean time-period to attain 50% flowering after germination (71 days) and first pod harvest after flowering (50 days). The NDOPs possessed a greater shoot height (145 cm at 14 WAP), fewer green leaves per plant (43 at 14 WAP) and produced fewer harvested pods (9) and lower mean fresh pod yield (2.33 t/ha) and dry shoot matter (26.4 g/plant), but took a shorter time-length to attain 50% flowering after germination (66 days) and first pod harvest after flowering (45 days). Soils amended with 30 t/ha CDM produced okro plants with the greatest mean shoot height (164 cm at 14 WAP), highest mean number of green leaves (63 at 14 WAP) and harvested pods (27) and greatest mean fresh pod yield (5.58 t/ha) and dry shoot matter (51.7 g/plant), but took the lowest time-period to attain 50% flowering after germination (54 days) and first pod harvest after flowering (42 days). However, the control/non-amended soils produced okro plants with the lowest mean shoot height (129 cm at 14 WAP), least mean number of green leaves (30 at 14 WAP), fewest harvested pods (10) and lowest mean fresh pod yield (2.13 t/ha) and dry shoot matter (23.3 g/plant), and delayed longest to attain 50% flowering after germination (79 days) and first pod harvest after flowering (60 days). Thus, it was concluded that decapitation had no effect on soil properties; CDM and NPK fertilizer had no effect on soil texture, but both exerted significant positive effects on the investigated soil characteristics (except texture) and, hence, on the vegetative growth and yield components of okro; the 30 t/ha CDM application rate (followed by the 300 kg/ha NPK 15:15:15 fertilizer application rate) made the best impacts on okro growth and yield components; and decapitation, *CDM and NPK 15:15:15 fertilizer had significant positive effects on the growth and yield of okro. Decapitation at 8 WAP and soil amendment with either 30 t/ha CDM or 300 kg/ha NPK 15:15:15 fertilizer were, therefore, recommended as being economical for soil amendment and, hence, optimum growth and yield of okro in the study area.*

Key words: Decapitation, cattle dung manure, NPK 15:15:15 fertilizer, soil characteristics, growth and yield components of 'Erguru' variety of okro.

INTRODUCTION

Okro, Lady's Finger, or Gumbo (*Abelmoschus esculentus* [L.] Moench or *Hibiscus esculentus* L.) is a native of the tropical parts of Africa. Okro seeds were probably taken from Ethiopia to Arabia over 1300 years ago and from there it was introduced to Egypt, reaching Spain across northern Africa. French colonists carried okro to the New World soon after 1700. It is now a widely grown vegetable crop in all parts of the tropics and subtropics (during the wet season), and also in warmer temperate regions (during the summer season) (Kochhar, 1986).

The increased importance of okro in the farming systems of Africa, in particular, and other parts of the tropics, subtropics and warmer temperate areas, in general, has triggered increased demand for this crop (Ikeorgu, Wahua & Ezumah, 1989; Olasantan, 2001; Olasantan & Bello, 2003). The ripe okro seeds contain approximately 20% edible oil. The edible portion of the okro fruit, on average, contains approximately; 86.1% moisture, 9.7% carbohydrates, 2.2% proteins, 1% fibres, 0.2% fats, and 0.9% ash. Okro is a good source of vitamins A and B, and also contains vitamin C and minerals, especially iodine (I) (Kochhar, 1986, p. 264), iron (Fe), calcium (Ca), magnesium (Mg), phosphorus (P) and zinc (Zn) (AVRDC, 1991). Okro's edible part represents 90% of the total weight of the fruit, with an energy value of 31 Kcal/100 g (De Lannoy, 2001).

The fresh and green tender fruits are used as a vegetable. The fruits are often sliced and dehydrated to conserve them for later use. A large proportion of the crop is processed by canning, freezing or preserving in brine. As the young tender fruits are mucilaginous, they are often used in tropical cookery to thicken soups, sauces and stews. Besides the fruits, okro leaves may also be consumed as a pot-herb. Europeans sometimes roast okro seeds and use them as a substitute for coffee. Mucilage from okro stem and roots (obtained after immersion in water) is used for clarifying sugarcane juice during *gur* (jaggery) manufacture in India and is also used for sizing paper, particularly in China. A mucilage preparation from the fruit can be used as a plasma replacement or 'blood-volume expander'. The stems and mature pods produce a fibre which is used in paper making and for textiles (Kochhar, 1986: 264).

Kochhar (1986, p. 264) has noted that the crop (okro) requires a long warm growing season; it is quite susceptible to frost and will not thrive even when there is a continued cold spell. It grows in all types of soil, thriving best in a moist, friable, well-manured soil with a soil solution pH between 6.0 (medium or moderately acidic) and 6.8 (slightly acidic) (Havlin, Tisdale, Nelson & Beaton, 2014, p. 50). Okro seeds are sown directly in the field in rows or on ridges. Okro fruits are picked when immature, usually about two and a half months after planting. Picking is continued for a period of two months, usually on every second or third day.

According to Ferguson and Dun (undated), as cited in Olasupo, Muhammad, Z.Y., Muhammad, L., Maigatari, Muhammad, A. and Danladi (2018, p. 308), the term *apical dominance* is described as the mechanism by which the apex of a plant shoot inhibits the outgrowth of secondary or lateral shoots. The plant hormone, auxin, has been observed to be involved in the process. This observation is supported by research findings that high levels of the bioactive form of auxin, IAA, are secreted/produced in the apex and transported basipetally (that is, downwards) along the stem, where the lateral/secondary shoot buds are located. This mechanism is best demonstrated through decapitation (removal of the tip of a plant's shoot), which removes the apical source of IAA and thereby halts the secretion/production of auxins at the plant's apices (growing tips). This stimulates the outgrowth of lateral shoot buds and leads consequently to the development of lateral shoots/branches, leaves and flowers.

The application of soil amendments (organic manures and inorganic commercial fertilizers) to sustain tropical agriculture or cropping systems on most tropical soils is necessary due to the soils' low inherent fertility/nutrient status (Adetunji, 1991; Lombin, 1999; Ojo-Atere, Ogunwale & Oluwatosin, 2011). The sole application of inorganic chemical/mineral fertilizers to maintain soil fertility and improve agricultural productivity/crops' field performance (i.e., growth and yield) or to sustain cropping systems on a long-term basis in the tropics has not proved to be very effective and efficient. The major demerits usually associated with the sole use, continuous and/or indiscriminate application of inorganic fertilizers to soils, particularly in the humid tropics include introduction of plant-nutrient imbalance, toxicity and immobilization, and deficiency of essential micro-nutrients of plants in soils; resulting in diminished soil fertility in the long run, and rapid acidification and pollution/contamination of soils; adverse impacts on soil biological/microbial activity and populations as well as on soil pH and temperature; unsafe feeding for the consumers of the crop products; scarcity, inaccessibility and expensiveness, especially for small-holder or resource-poor/peasant farmers; pollution of ground/sub-surface water sources; susceptibility of plant nutrients, contained in inorganic fertilizers, to leaching; physical degradation of soils/destruction of soils' physical structure and loss of soil coherence, leading to human-increased soil erosion in the long run; inadequate laboratory analysis of soils before application; inorganic fertilizer application without following soil scientists' fertilizer recommendations based on soil test results; farmers' inadequate knowledge/experience of the appropriate inorganic fertilizer handling and storage rules and methods as well as its application and combination rates, methods, procedures and regulations to safely meet the varying nutrient needs of different soils and crops; and various other unfavourable social, economic, physical and environmental/ecological consequences (Hausenbuiller, 1974; Ayuso, Pascal, Garcia & Hernadez, 1996; Doran, Sarrantonio & Liebig, 1996; Adinna, 2001; Adelekan, Laleye & Idowu, 2003; Aweto, 2006a; Okaro, 2006; Edem, 2008; Ojo-Atere *et al*., 2011; Havlin *et al*., 2014; Brady & Weil, 2015).

In view of the various negative effects of the sole application of inorganic fertilizers on soils, crops and the entire environment, farmers'/researchers' attention has now been globally drawn to organic manures which are, or can be, used as a cheap, simple, easy, low-input and suitable alternative/complementary agricultural technology to inorganic fertilizers. When judiciously and timely applied, organic manures decompose and release plant nutrients, into soils, slowly and steadily over a longer time-period, thus preventing nutrient toxicity in soils/plants. They also safely improve soils' nutrient/fertility status by activating the soil microbial biomass. Thus, the right application of organic manures sustains cropping systems through better nutrient recycling, improved physical structure of soils, and increased capacity of soils for retaining water and nutrients (Cook, 1982). Summarily, the principal advantages which the sole application of organic manures has over the sole use of inorganic fertilizers include prevention of rapid soil acidification, salinity, pollution, nutrient toxicity in soils/plants and rapid spread of weeds, pests and diseases on farmlands; increased water- and nutrient-retention and plant-nutrient recycling capacities and nutrient status of soils; soil-fertility maintenance and improved crop performance/productivity on a sustainable long-term basis; cost and labour effectiveness; reduced soil compaction, hardening, desiccation, bulk densities, surface sealing/crusting and leaching, surface runoff and soil erosion intensities; regulation/moderation of soil temperature and pH; and improvement of soil physical (porosity, aeration, permeability, percolation, infiltration capacity, physical structure/aggregate stability, etc.), biological (activity and populations of soil organisms and/or microbes, etc.) and chemical (pH, base saturation [BS], cation exchange capacity [CEC], soil organic matter [SOM] and nutrient contents, etc.) properties (Hausenbuiller, 1974; Cook, 1982; Ayuso *et al*., 1996; Doran *et al*., 1996; Adinna, 2001; Adelekan *et al*., 2003; Aweto, 2006a; Okaro, 2006; Edem, 2008; Ojo-Atere *et al*., 2011; Havlin *et al*., 2014; Brady & Weil, 2015).

Hausenbuiller (1974, pp. 337-338) has noted that the benefits derived from the use/application of organic materials on soils are many but relate principally to key functions: (1) the contribution of N and other essential plant nutrients in readily available form(s); and (2) the improvement of the physical conditions (properties) of mineral soils. Since an adequate nutritional status can be maintained in most soils with commercial (inorganic) fertilizers, the use of organic materials for soil conservation must be encouraged primarily on the basis of their effects on soil physical properties. To get desirable results, therefore, combined application of organic and inorganic amendments to soils (i.e., integrated soil fertility management [ISFM]) is being highly advocated by modern soil scientists, agronomists and ecologists across the globe (Ojeniyi, Owolabi, Akintola & Odedina, 2009; Ojeniyi, 2010; Odeyemi, Awodun & Ojeniyi, 2013; Adekiya, Aboyeji, Dunsin & Oyinlola, 2018; Babalola, Adigun & Abiola, 2018a & b; Chukwuemeka, 2018; Kekong, Attoe & Adiaha, 2018; Mohammed, A., Mohammed, T., Zakari & Ahmed, 2018; Olasupo *et al*., 2018).

Different crops, when decapitated, can respond differently to applied soil amendments or inputs. To this end, several studies have been undertaken to examine the response of diverse soils and crops to different cultural/agronomic practices in different parts of the world. These include effects of melon (*Citrillus lanatus*) and okra on the soil moisture and leaf water status of intercropped cassava/maize in Nigeria (Ikeorgu, Wahua & Ezumah, 1989), use of chromolaena mulch to improve yield of late season okra (Ojeniyi & Adetoro, 1993), effects of goat manure on soil nutrients and okra yield in a rain forest area of Nigeria (Ojeniyi, 2000), optimum plant populations for okra in a mixture with cassava (*Manihot esculenta*) and its relevance to rainy season-based cropping systems in south-western Nigeria (Olasantan, 2001), optimum sowing dates for okra in monoculture and mixtures with contrasting cassava during the rainy season in south-western Nigeria (Olasantan & Bello, 2003), response of okra seed crop to sowing time and plant spacing in south-eastern hilly region of Bangladesh (Moniruzzaman, Uddin & Choudhury, 2007), effect of pruning on growth, leaf yield and pod yield of okra (Olasantan & Salau, 2008), growth, dry matter and fruit yield components of okra under organic and inorganic sources of nutrients (Akanbi, Togun, Adediran & Ilupeju, 2010), growth and yield response of okro varieties to weed interference in south-eastern Nigeria (Iyagba, Onuegbu & Ibe, 2012), growth and yield of okra with rock phosphate-amended organic fertilizer (Makinde, 2013), effects of cultivar and sowing date on okra leaf growth, fruit set and harvest duration (Salau & Makinde, 2014), effects of planting density and variety on okra growth, yield and yield duration (Salau & Makinde, 2015), effect of pruning on growth and fresh fruit yield of okro in Sokoto, Nigeria (Aliyu, Sukuni & Abubakar, 2015), effect of urea fertilizer and maize cob ash on performance of okra and soil chemical properties in a derived savanna ecology (Adekiya, Aboyeji, Dunsin & Oyinlola, 2018), and effect of decapitation and soil amendment on growth, cumulative yield and dry biomass of okra in Sudan Savanna of Nigeria (Olasupo *et al*., 2018).

The preceding empirical studies suffice to show that the application of organic and inorganic fertilizers to soils may stimulate varied growth and yield responses in okro when decapitated. However, limited or no research has been carried out to empirically investigate these phenomena in Benue State, which is one of the leading okro producers in Nigeria; hence, the need for, and necessity of, this work. The present study, therefore, specifically examined the response of soil characteristics and growth and yield of 'Erguru' okro variety to decapitation, cattle dung manure (CDM) and NPK 15:15:15 fertilizer application during the 2024 cropping season at Agan Settlement in Makurdi LGA of Benue State.

MATERIALS AND METHODS

The research was undertaken during the 2024 cropping season (i.e., between April and October) at Agan Settlement in Makurdi LGA of Benue State, Nigeria. Agan is part of Makurdi Town, which lies between approximately Latitudes 7°43'N and 45°N of the Equator and Longitudes 8°28'E and 32°E of the Prime Meridian. The town is sited almost entirely on the vast flood plains of the R. Benue in the R. Benue Trough. The land surface is generally low-lying and characterized by gently-undulating slopes in most parts. The area experiences the Koppen's Aw (i.e., tropical, seasonally wet and dry) climate, which is characterized by two distinct alternating seasons of wet (April-October) and dry (November-March), annual rainfall totals ranging from 1000 mm to 2000 mm, and a single maximum regime of rainfall (September) each year (Lyam, 2005a). Temperatures here fluctuate between 23℃ and 35℃ within a year, with the diurnal mean of about 23℃. Owing to its location in the valley of the R. Benue, Makurdi Town experiences warm temperatures for most parts of the year (Tyubee, 2003, 2005). This kind of climate (combined effects of rainfall/moisture and temperature) regime is able to support only the Guinea Savanna Biome, with its characteristic coarse grasses and scattered trees that become more stunted and less dense towards the northern parts of Benue State. Ancient (very hard) and young (not very hard) sandstones of sedimentary formation generally underlie the town and its environs. The dominant soils in the area are the ferruginous tropical soils, which broadly comprise lithosols, hydromorphic soils, and alluvial soils. The hydromorphic and alluvial soils characterize the flood plains of the R. Benue and its tributaries, whereas the lithosols develop outside the flood plains and overlie the original bedrocks on steep bare rock slopes, especially on the hillslopes. Soil surfaces in the area generally have a sandy texture. The most prominent drainage feature here is the R. Benue and its tributaries (Lyam, 2005a).

The main experimental materials used for the field trial were cattle dung manure (CDM), NPK 15:15:15 fertilizer, hydrochloric acid (HCl), and 'Erguru' variety of okro (as the test crop), which was purposively selected because it is an erect, fast-growing and early- and high-yielding okro variety. The major agronomic practices used were land clearing/preparation, tillage/ridging, decapitation, weeding, organic manuring, inorganic fertilizer application, pest control, sowing, and harvesting. The CDM was bought from cattle sheds/pens in Wadata Market; NPK fertilizer was bought from Makurdi Modern Market; HCl was obtained on official permission from the Chemistry and Geography Departments of Benue State University, Makurdi (BSUM), while seeds of 'Erguru' okro variety were sourced from the Crop Science Department of JOSTUM. Prior to the commencement of the actual field experiment, a reconnaissance survey of the study area was conducted during which ten soil profile pits were randomly dug to the depth of 30 cm at the experimental site. One representative soil sample was obtained from each pit. The field-collected samples were properly prepared (i.e., air-dried, ground, sieved through a 2-mm sieve, bagged, numbered, and labelled) and submitted at the soil science laboratory of JOSTUM for the pre-planting analysis of the soils' texture and chemical properties following standard procedures of the International Institute of Tropical Agriculture (IITA) (1979) or as described by Carter (1993) and Udo, Ibia, Ogunwale, Ano and Esu (2009). Pre-cropping and pre-application analysis of the CDM to determine its chemical/mineralogic composition was undertaken at the Benue State Ministry of Agriculture, Makurdi, while post-soil amendment and post-decapitation analysis of the okro growth and yield parameters (i.e., plant analysis) was carried out in the crop science laboratory of JOSTUM.

At the beginning of the rainy season, the study/experimental site was manually cleared (using a large hoe, spade, rake, machete, axe, head pan, and wheelbarrow). The CDM was thoroughly pounded and mixed with HCl to enhance its rapid decomposition. The CDM was then broadcast over soil surfaces and incorporated (buried; ploughed; hoed) into the soils (about 30 cm deep), after which the cleared and CDM-incorporated piece of land was tilled/prepared into ridges. The incorporated CDM was allowed to decompose inside the ridges for at least four weeks before the okro seeds were sowed on these ridges.

Each experimental plot measured 3 m × 3 m (i.e., the physical size/areal extent of 9 m^2), with a furrow space of 1 m between the main plots/sub-plots. The field experiment was arranged in a split plot design with eight treatments replicated thrice, giving the total of twenty four treatments. The organic (CDM) and inorganic (NPK 15:15:15 fertilizer) amendments applied to soils at the experimental site occupied the main plots and consisted of 15 t/ha CDM, 30 t/ha CDM, and 300 kg/ha NPK 15:15:15 fertilizer (as the inorganic check) treatments, as well as the control/non-amended soils. The decapitation treatments occupied the sub-plots and consisted of 'decapitated okro plants' (DOPs) and 'non-decapitated okro plants' (NDOPs/'control plants'). At four weeks after CDM application, three okro seeds were sowed per hole on the ridges at an inter-row and intra-row spacing of 0.6 m, respectively, giving the total okro-plant population of 27,778 plants/ha. At two weeks after planting (WAP) or sowing, thinning to one okro plant per stand was carried out, followed by manual weeding using a small hoe (twice: at three WAP and also at six WAP) before NPK 15:15:15 fertilizer treatment/application. The NPK 15:15:15 fertilizer was applied to the soils in two split doses (i.e., at four WAP and seven WAP, respectively). Insect pests were controlled chemically with cypermethrin applied at the rate of 30 ml per 10 litres of water. Decapitation was performed at eight (8) WAP using a disinfected budding knife.

Measurement/determination of the okro growth and yield parameters began at fourteen (14) WAP. Ten plants were randomly sampled/selected from each plot/sub-plot for this purpose. The okro growth parameters (components) measured were shoot height of each plant (by the use of metre rule or inelastic meter tape), number of leaves per plant (by counting), days to 50% flowering after germination (by counting), and days to first fresh green pod harvest after flowering (by counting). The okro yield parameters determined were number of pods harvested (by counting), fresh green pod yield (or weight) (Pod weight was evaluated based on the cumulative number of pods at eight [8] harvests. Edible pods were harvested at four [4] days' interval and weighed), and dry shoot matter/weight (using a weighing machine).

During the field reconnaissance survey of the study area, ten soil profile pits were randomly dug (0-30 cm depth) at the study/experimental site. One representative soil sample was obtained from each pit. The field-collected samples were properly prepared and submitted at the soil science laboratory of JOSTUM for the pre-planting (pre-treatment) analysis of the soils' texture and chemical properties following standard procedures of the IITA (1979) or as described by Carter (1993) and Udo *et al*. (2009). The soil samples were analyzed for texture or mineral particle-size distribution (PSD), pH, and organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (AP), and exchangeable calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+) contents. After harvest of okro, soil profile pits were randomly excavated (0-30 cm depth) in each plot. Representative soil samples (one from each pit) were collected on an individual plot basis and similarly prepared and analyzed for texture and chemical properties. The succeeding paragraph summarizes the methods used.

Soil PSD was determined by using hydrometer method (Gee & Or, 2002), pH with a digital electronic soil pH meter using a soil-water (H_2O) medium in the ratio of 1:2 (IITA, 1979; Carter, 1993; Lombin, 1999), and OC by the modified procedure of Walkley and Black using the dichromate wet oxidation method (Shamshuddin, Jamaila & Ogunwale, 1995; Nelson & Sommers, 1996). The percentage soil OC content was then calculated using the relationship: % Org. Carbon = N (V1-V2) 03 f. The percentage soil OM content was calculated from the relationship: % Org. Matter = % OC x 1.724 (i.e., by multiplying the obtained % OC content by the conversion factor of 1.724). It is common to use a conversion factor of 1.724 to convert a measured OC value to OM, implying that OM contains 58% C, though this is based on work conducted in the 19th Century. Values up to 2.0 for surface soils and 2.5 for subsoils have been published (Nelson & Sommers, 1996). Soil TN was determined using the regular modified macro-Kjeldahl digestion apparatus/method as described by Bremner and Mulvaney (1982) and Bremner (1996), and AP by the Bray-1 Extraction Method, followed by molybdenum blue colorimetry (Bray & Kurtz, 1945). Exchangeable cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) were extracted from each soil sample using 1N of normal ammonium acetate (NH_4OA_c) extraction method buffered at pH 7 (Thomas, 1982), after which the K and Na levels/contents in the NH_4OA_c

extract were measured by a flame photometer (Helmke & Sparks, 1996), while the Ca and Mg contents/levels in the NH_4OA_c extract were determined by atomic absorption spectrophotometry (AAS) using the 0.01N of EDTA titration method (Chapman, 1965).

The data generated on soil properties and okro growth and yield parameters were statistically analyzed using arithmetic means and Analysis of Variance (ANOVA). ANOVA was performed on the okro growth and yield components using the Computer Software (Genstat 2005) and the means were separated using the Standard Error of the Mean (SEM) at 5% level of probability.

RESULTS AND DISCUSSION

Pre-application Chemical/Mineralogic Composition (Analysis) of the Cattle Dung Manure (CDM) used in this Research

The pre-application chemical/mineralogic composition of the cattle dung manure (CDM) used in this study is presented in Table 1. The CDM had a pH (H_2O) value of 8.31 (moderately alkaline reaction) and high levels or contents of OC (16.90%), OM (29.14%), TN (1.70%), AP (86.08 mg/kg), Na (3.05 cmol/kg), K (6.52 cmol/kg), Mg (7.93 cmol/kg) and Ca (8.70 cmol/kg). The high pH value and rich nutrient contents of the CDM indicate that, upon substantial decomposition (provided the right environmental conditions for organic decomposition are satisfied), it has a high potential (prospect; capacity) to improve soil chemical properties for sustainable cropping purpose if judiciously and timely applied to soils.

Table 1: Pre-application chemical/mineralogic composition (analysis) of the cattle dung manure (CDM) used in the study

SN	Parameter/Property/Component	Value/content
1	pH (H_2O)	8.31
2	OC (%)	16.90
3	OM (%)	29.16
4	TN (%)	1.70
5	AP (mg/kg)	86.98
6	Na (cmol/kg)	3.05
7	K (cmol/kg)	6.52
8	Mg (cmol/kg)	7.93
9	Ca (cmol/kg)	8.70

Source: Results of Researchers' Field Survey and Laboratory Data Analysis (2024).

Pre-amendment (Pre-cropping) Status of Soil Properties in the Study Area

The pre-amendment status of soil properties at the experimental site is presented in Table 2. Before the treatment of soils in the study area with CDM (organic manure/amendment) and NPK 15:15:15 fertilizer (inorganic amendment), the soils had a sandy texture, medium or moderately acidic solution pH (5.7), and 1.06% OC, 1.83% OM, 0.16% TN, 6.69 mg/kg AP, and exchangeable Na^+ (0.12 cmol/kg), K^+ (0.14 cmol/kg), Mg^{2+} (0.33 cmol/kg) and Ca^{2+} (1.78 cmol/kg) contents. The soils' TN, AP and exchangeable K^+ contents were all low (Table 2) according to the limits defined by the Federal Fertilizer Department of Nigeria (Chude, Daudu, Olayiwola & Ekeoma, 2012). The soils were low in OM, TN, AP and exchangeable K^+, Mg^{2+} and Ca^{2+} because their contents were below the critical level of 3% OM, 0.20% N, 10.0 mg/kg AP, 0.16-0.20 cmol/kg exchangeable K^+, 0.40 cmol/kg exchangeable Mg^{2+}, and 2.0 cmol/kg exchangeable Ca^{2+} recommended for crop production in ecological zones of Nigeria (Akinrinde & Obigbesan, 2000; Adekiya *et al*., 2018, p. 289). The soils, therefore, required organic and inorganic fertilizing and liming to enhance environmentally sustainable and economically profitable crop production.

Table 2: Pre-amendment (pre-cropping) status of soil properties and post-harvest (post-cropping; post-amendment harvest) status of soil properties (i.e., the observed effects of decapitation, cattle dung manure [CDM] and NPK 15:15:15 fertilizer application on soil properties) at the study/experimental site

SN	Soil property/parameter (0-30 cm profile depth)	Pre-amendment Soil Property Status (value)	Post-harvest Soil Property Status (value)
1	Sand (g/kg)	840	840
2	Silt (g/kg)	96	96
3	Clay (g/kg)	64	64
4	Textural class	Sandy	Sandy

5	pH (H_2O) and pH (KCl)	5.7 (medium/moderately acidic reaction) and 4.7 (very strongly acidic), respectively	6.5 (slightly acidic reaction) and 5.5 (strongly acidic), res pectively
6	Percentage OC content (%)	1.06	2.63
7	Percentage OM content (%)	1.83	4.53
8	TN content (%)	0.16	1.39
9	AP content (mg/kg)	6.69	18.7
10	Exchangeable Na^+ concentration (cmol/kg)	0.12	0.28
11	Exchangeable K^+ concentration (cmol/kg)	0.14	1.41
12	Exchangeable Mg^{2+} concentration (cmol/kg)	0.33	1.52
13	Exchangeable Ca^{2+} concentration (cmol/kg)	1.78	3.79

Source: Results of Researchers' Field Survey and Laboratory Data Analysis (2024).

The soils' pre-treatment low OM and nutrient contents and moderately acidic reaction are partly the characteristic feature of Nigerian rain forest and guinea savanna soils due to torrential rains of high durations and intensities with their accompanying rapid OM decomposition, deep chemical weathering and extensive/thorough leaching of exchangeable bases. This soil condition has been earlier documented/reported by Harpstead (1973), Chude (1998), Lombin (1999), Raji and Mohammed (2000), Faniran and Jeje (2002), Faniran, Jeje and Ebisemiju (2006), Thornbury (2011) and Kekong *et al*. (2018). The soils' low OM and nutrient contents could also be due to intensive/continuous cropping and intensive conventional tillage to which the study area had been previously subjected. The observed pre-treatment low OM and nutrient contents and moderately acidic reaction of soils in at the experimental site agree with Nyagba (1995b) and Lyam (2005a).

Post-treatment (Post-cropping; Post-harvest) Status of Soil Properties in the Study Area (i.e., the Observed Effects of Decapitation, CDM and NPK 15:15:15 Fertilizer Application on Soil Properties in the Study Area)

The obtained results of the post-application status of soil properties at the experimental site are presented in Table 2. After soil treatment/okro harvest, it was observed that decapitation (performed at eight [8] WAP) had no effect on all the investigated soil properties. Similarly, the soils' textural class remained unaltered by the agronomic practices (including tillage and decapitation) and the CDM and NPK 15:15:15 fertilizer treatments used in this study. This finding agrees with Hausenbuiller (1974), Lombin (1999), Aweto (2006a) and Brady and Weil (2015) who noted that texture is a property inherited by a soil from its parent rock; it is probably the most important of all soil characteristics, a basic property of a soil that influences the agricultural and engineering uses to which the soil can be put, and a relatively permanent feature of a soil in the field which will ordinarily not change during a man's lifetime. However, due to the substantial decomposition of the applied CDM and the complete dissolution of the applied NPK 15:15:15 fertilizer, the chemical properties of the amended soils improved significantly ($P \leq 0.05$) over the pre-treatment status of the soils' chemical properties. The soils' chemical/nutrient status improved significantly to pH (H_2O) 6.5 (slightly acidic soil solution reaction), 2.63% OC (high), 4.53% OM (high), 1.39% TN (high), 18.7 mg/kg AP (high), 0.28 cmol/kg exchangeable Na^+ (high), 1.41 cmol/kg exchangeable K^+ (high), 1.52 cmol/kg exchangeable Mg^{2+} (high) and 3.79 cmol/kg exchangeable Ca^{2+} (high) contents (Table 2).

The observed improvement in the post-treatment/post-harvest soil solution pH indicates the release of basic cations by the decomposition of the organic amendment (CDM) used in this experiment. The released cationic bases significantly reduced the acidifying effect/activity of exchangeable hydrogen (H^+) and aluminium (Al^{3+}) ions in these soils. The increase/improvement in soil solution pH due to the decomposition of organic amendments applied to soils in different locations has been reported earlier by Olayinka (1990), Natschner and Schwetmann (1991), Ojeniyi and Adetoro (1993), Olayinka, Adetunji and Adebayo (1998), Ojeniyi (2000, 2010), Ano and Agwu (2005), Akanbi and Ojeniyi (2007), Ojeniyi, Awodun and Odedina (2007), Adekiya *et al*. (2018), Babalola *et al*. (2018a & b), Kekong *et al*. (2018), Mohammad *et al*. (2018) and Olasupo *et al*. (2018). The observed increase in the soils' OM content is attributable to the release of appreciable OC amounts into the soils during the decomposition of the CDM initially incorporated into these soils. The improvement in SOM level by the judicious application of organic amendments to soils has been documented/reported by earlier works, such as Olayinka (1990), Olayinka *et al*. (1998), Osundare (2004), Akanbi and Ojeniyi (2007), Odedina, Ojeniyi and Awodun (2007), Havlin *et al*. (2014), Brady and Weil (2015) and Kekong *et al*. (2018).

The high TN content obtained in the post-cropping soil-analysis results, compared with the soils' low pre-treatment TN value (Table 2), could be due to the enhanced rapid mineralization of N, P and K from the applied soil amendments, particularly from the inorganic (NPK 15:15:15 fertilizer) amendment (Aweto, 2006a; Edem, 2008; Ayeni, 2010; Havlin *et al*., 2014; Brady & Weil, 2015; Kekong *et al*., 2018). The significant improvement in the soils' AP content that resulted from the applied organic and inorganic soil amendments could be attributed to the appreciable increase in the soils' solution pH, which, in turn, was capable of unlocking fixed P in these acidic soils. The sole or combined application of organic and inorganic amendments to improve/raise soil pH and consequently unlock fixed P in acidic soils has been variously assessed and documented, and all the P values reported were above the critical minimum level (Adeoye & Agboola, 1985; Olayinka, 1990; Olayinka *et al*., 1998; Ojeniyi, 2000, 2010; Ano & Agwu, 2005; Akanbi & Ojeniyi, 2007; Ojeniyi *et al*., 2007; Kekong *et al*., 2018).

The significant increase in the soils' post-cropping concentrations of exchangeable Na^+, K^+, Mg^{2+} and Ca^{2+} over their low pre-treatment values (Table 2) indicates that the OM-, Na-, K-, Mg- and Ca-rich CDM decomposed substantially and released appreciable amounts of OM into the soils. In turn, the SOM was rapidly and considerably mineralized and, hence, it exerted significant positive effects on the soils' concentrations of these basic cations, so that even with the crop's (okro's) absorption and use of these cationic bases and other soil nutrients, there was no depletion in soils' contents of these cations during the period of the field experiment. Aweto (2006a) earlier noted that various essential nutrients, including N, P, sulphur (S), Mg, K, molybdenum (Mo), and boron (B), are sourced almost wholly from SOM upon its decomposition. The observed increase in soils' status of exchangeable cations due to judicious sole application of organic manures or in combination with inorganic mineral fertilizers has been variously investigated empirically and reported by earlier works, including Olayinka (1990), Ano and Agwu (2005), Odedina *et al*. (2007), Ayeni (2010), Babalola *et al*. (2018a & b), Kekong *et al*. (2018) and Olasupo *et al*. (2018).

The Observed Effects of Decapitation on Okro Growth and Yield Components in the Study Area

The results obtained from the analysis of data on the effects of decapitation on okro growth and yield parameters in the study area are summarized in Table 3. The results revealed that the decapitated okro plants (DOPs) had a lower average shoot height at 14 WAP (120 cm) and a higher mean number of number of green leaves at 14 WAP (56) (which physiologically implied, or translated biologically to, a greater rate of photosynthesis); they took a longer (extended) time-length to attain 50% flowering after germination (71 days) and first pod harvest after flowering (50 days), and produced a higher mean number of harvested pods (15) and, hence, a greater mean fresh pod yield (2.98 t/ha) than the non-decapitated okro plants (NDOPs) in the study area. On the other hand, the NDOPs had a greater mean shoot height at 14 WAP (145 cm) and a lower average number of number of green leaves at 14 WAP (43) (which translated biologically to a lower rate of photosynthesis); they took a shorter time-length to reach 50% flowering after germination (66 days) and first pod harvest after flowering (45 days), and gave a lower average number of harvested pods (9) and, hence, a lower average fresh pod yield (2.33 t/ha).

Table 3: The observed effects of decapitation on okro growth and yield components/parameters in the study area

SN	Treatment applied	Mean shoot height (cm) at 14 WAP	Mean number of green at 14 WAP	Days to 50% fl-owering after germin-ation	Days to first pod harvest after fl-owering	Mean number of harv-ested pods	Mean fresh pod yield (t/ha)
1	Decapitated okro Plants (DOPs)	120	56	71	50	15	2.98
2	Non-decapitated okro Plants (NDOPs)	145	43	66	45	9	2.33
3	SEM (at 0.05 probab-ility level)	5.8	11.4	4.6	1.1	0.6	0.19

Source: Results of Researchers' Field and Laboratory Surveys and Office Data Analysis (2024).

The observed lower mean shoot height of the DOPs and their extended time-length to attainment of 50% flowering after germination and first pod harvest after flowering (Table 3) could be due to the effects of decapitation on the growth and yield of the test crop (okro). These findings agree with Olasupo *et al*. (2018), who found/reported that decapitation removed the apical source of IAA and thereby halted the secretion of auxins at the plant's growing tips. This practice, rather than encouraging vertical growth (increase in shoot height), stimulated the outgrowth of lateral shoot buds and led consequently to the development of lateral shoots/branches, higher number of green leaves, flowers, harvested pods and fresh pod yield in the DOPs. Overall, these findings imply agronomically that, even though DOPs develop comparatively shorter shoots and take a longer time-period to attain reproductive development, they produce a higher number of lateral shoots/branches, green leaves (i.e., a higher rate of photosynthesis), flowers, fresh green pods and, hence, a greater fresh pod yield and dry shoot matter than NDOPs.

The delay of the DOPs in achieving 50% flowering after germination and first pod harvest after flowering could be attributed to the altered partitioning of assimilates, because decapitated plants tend to partition assimilates to the development of lateral buds, shoots/branches and leaves at the expense of timely production of flowers. The higher number (15) and greater yield of fresh pods (2.98 t/ha) produced by the DOPs could be adduced to development of more lateral branches, leaves and flowers as a result of the removal of okro plants' shoot tips. These findings agree with Olasantan and Salau (2008), Aliyu *et al*. (2015) and Olasupo *et al*. (2018). Olasantan and Salau (2008) reported that pruning significantly increased the number of okro pods per plant by 10-40% over the number of pods produced by the non-pruned okro plants (i.e., the control plants). Aliyu *et al*. (2015) reported that pruning delayed reproductive development (flower production), enhanced partitioning of assimilates to the development of lateral buds, shoots/branches and leaves and significantly increased the fresh fruit yield of okro in Sokoto State, Nigeria.

The Observed Effects of CDM and NPK 15:15:15 Fertilizer Application on the Growth and Yield Parameters of Okro in the Study Area

The data-analysis results in respect of the effects of CDM and NPK 15:15:15 fertilizer application on the growth and yield components of okro in the study area are presented in Table 4. The results revealed that the CDM had high OM and nutrient contents to boost/enrich the soils' fertility and, hence, support okro growth and yield in the study area. This made it comparable in effects to the conventional NPK 15:15:15 fertilizer, which was used in this field trial as an inorganic check. The application (to soils of the study area) of 15 t/ha CDM resulted in the production of okro plants with a mean shoot height of 148 cm at 14 WAP; the soils' treatment with 30 t/ha CDM gave the greatest average shoot height of 164 cm at 14 WAP; the soils' amendment with 300 kg/ha NPK 15:15:15 fertilizer produced the mean shoot height of 151 cm at 14 WAP, while the control (non-amended) soils gave the lowest average shoot height of 129 cm at 14 WAP. These results indicate that the applied CDM and NPK 15:15:15 fertilizer significantly improved the soils' fertility status and, hence, had a significant positive effect on the vertical growth (height increase) of okro plants in the study area, with the 30 t/ha CDM treatment exerting the greatest favourable effect on the shoot height. This effect was obvious because the control soils produced the lowest shoot height at 14 WAP. This finding is comparable to the research findings reported by Olasantan and Salau (2008), Akanbi *et al*. (2010), Aliyu *et al*. (2015) and Olasupo *et al*. (2018).

Table 4: The observed effects of CDM and NPK 15:15:15 fertilizer application on the growth and yield components of okro in the study area

SN	Treatment applied	Mean shoot height (cm) at 14 WAP	Mean number of green at 14 WAP	Days to 50% fl-owering after germin-ation	Days to first pod harvest after fl-owering	Mean number of harv-ested pods	Mean fresh pod yield (t/ha)
1	15 t/ha of CDM	148	52	66	53	16	3.49
2	30 t/ha of CDM	164	63	54	42	27	5.58
3	300 kg/ha of NPK 15:15:15 fertilizer	151	57	60	48	21	4.67
4	Control (no CDM and NPK fertilizer application)	129	30	79	60	10	2.13
5	SEM (0.05)	2.4	6.3	6.1	1.3	1.2	0.4

Source: Results of Researchers' Field and Laboratory Surveys and Office Data Analysis (2024).

Table 4 similarly shows that the soils amended with 15 t/ha CDM produced okro plants with 52 green leaves each at 14 WAP; the 30 t/ha CDM-treated soils produced the highest number (63) of green leaves per plant at 14 WAP (which translated physiologically to the greatest photosynthetic rate); the soils amended with 300 kg/ha NPK 15:15:15 fertilizer resulted in the development of 57 green leaves per plant at 14 WAP, whereas the control soils produced okro plants with the lowest number of green leaves (30) per plant at 14 WAP. These results show that CDM and NPK 15:15:15 fertilizer application had significant favourable effects on soil fertility and, hence, on the leaf-production component of okro growth in the study area, with the 30 t/ha CDM amendment having the highest positive effect on leaf development. This effect was obvious as the control soils gave the lowest mean number of green leaves at 14 WAP, which biologically implied or translated to the lowest rate of photosynthesis. This finding agree with the reported findings of Olasantan and Salau (2008), Akanbi *et al*. (2010), Ojeniyi *et al*. (2009), Aliyu *et al*. (2015) and Olasupo *et al*. (2018).

According to Table 4, the soils' amendment with 15 t/ha CDM, 30 t/ha CDM and 300 kg/ha NPK 15:15:15 fertilizer produced okro plants that delayed for 66, 54 and 60 days, respectively, to attain 50% flowering after germination, while the control soils produced plants that delayed longest (79 days) to reach 50% flower production after germination. The 30 t/ha CDM soil treatment led to the development of plants with the highest growth rate and lowest time-period of delay to achieve reproductive development (54 days). In the same vein, the soils' treatment with 15 t/ha CDM, 30 t/ha CDM and 300 kg/ha NPK 15:15:15 fertilizer produced plants that delayed for 53, 42 and 48 days, respectively, before the first pod harvest after flowering, while the control soils produced plants that delayed longest (60 days) before the first pod harvest after flowering. The 30 t/ha CDM soil amendment produced plants with the highest growth rate and lowest delay time-period before the first pod harvest after flowering (42 days). These results indicate that the applied CDM and NPK 15:15:15 fertilizer significantly improved the soils' fertility status and consequently exerted a significant positive influence on both the growth and yield parameters of okro in the study area by considerably accelerating its growth, thereby enabling the okro plants sown on the amended soils to attain reproductive development earlier than the okro plants grown on the control soils. This observed effect was obvious since the plants raised on the control soils took the longest time-period to achieve reproductive development. Olasantan and Salau (2008), Akanbi *et al*. (2010), Ojeniyi (2010), Aliyu *et al*. (2015) and Olasupo *et al*. (2018) reported similar research findings.

The obtained data-analysis results presented in Table 4 revealed that the highest number of okro pods (27 pods) was harvested from the soils with 30 t/ha CDM treatment, followed by the soils amended with 300 kg/ha NPK 15:15:15 fertilizer (21 pods) and 15 t/ha CDM treatment (16 pods), whereas the lowest number of okro pods (10 pods) was harvested from the plants grown on the control soils. In the same vein, the obtained fresh okro pod yield was highest (5.58 t/ha) in the soils amended with 30 t/ha CDM, followed by the soils treated with 300 kg/ha NPK 15:15:15 fertilizer (4.67 t/ha) and 15 t/ha CDM (3.49 t/ha), while the control soils produced okro plants with the lowest fresh pod yield (2.13 t/ha). The significant increase in both fresh okro pod/fruit production and dry matter accumulation in the amended soils over the control (Tables 4 and 5, respectively) could be attributed/linked to the favourable effects of the release of adequate amounts and right proportions of essential plant nutrients from the applied CDM and NPK 15:15:15 fertilizer as well as the availability and accessibility of the nutrients for use by the growing plants. The significant increase in the soils' nutrient content, therefore, significantly improved both the growth and fruit/pod yield components of okro plants in the study site, including greatly improved vegetative growth rate, number of green leaves and flowers, and synthesis and translocation of photosynthates from the source to the sink and, hence, significantly increased number and weight of fresh pods/fruits and the subsequent fresh pod yield (Olasantan & Salau, 2008; Akanbi *et al*., 2010; Aliyu *et al*., 2015; Adekiya *et al*., 2018; Olasupo *et al*., 2018).

Despite the slow and gradual decomposition rate and the slow pattern of OM and plant-nutrient release from the incorporated CDM, a considerably higher rate of CDM application (30 t/ha) triggered the highest okro vegetative growth rate (164 cm shoot height at 14 WAP in Table 4) and encouraged the production of the greatest fresh pod yield (5.58 t/ha pod yield in Table 4). The enhanced decomposition of the applied organic amendments due to the abundant presence of agents of organic decay (bacteria, fungi and actinomycetes) and soil moisture and the high ambient temperature of soils in the study area (Nyagba, 1995b) could have also contributed beneficially to the accelerated release of appreciable amounts of essential plant nutrients into the soil solution for absorption and use by the growing okro plants. Thus, the obtained results in Table 4 indicate that timely and appropriate/judicious incorporation of soils with CDM and NPK 15:15:15 fertilizer had a significant positive influence on the soil nutrient content and, hence, on the field performance (i.e., vegetative growth and fruit yield components, and dry shoot matter) of okro in the study area. The findings of the present work, therefore, confirm the reported research findings of Olasantan and Salau (2008), Akanbi *et al*. (2010), Aliyu *et al*. (2015) and Olasupo *et al*. (2018).

The Observed Effects of Decapitation and CDM and NPK 15:15:15 Fertilizer Application on the Dry Shoot Matter of Okro in the Study Area

Table 5 presents the obtained results of data analysis in respect of the effects of decapitation and CDM and NPK 15:15:15 fertilizer application on okro dry shoot matter in the study area. The results showed that the decapitated okro plants (DOPs) had a higher dry shoot matter (39.7 g/plant) than the non-decapitated okro plants (NDOPs) (26.4 g/plant). This could be due to the production of a higher number of lateral buds, shoots/branches, green leaves and flowers by the DOPs than the NDOPs as stimulated by their decapitation. It could also be attributed to the combined positive effects of decapitation and CDM and NPK 15:15:15 fertilizer application on the vegetative growth (including the development of both vertical/apical and lateral shoot) okro in the study area (see also Table 4). This finding is in line with the research findings reported by Olasantan and Salau (2008), Akanbi *et al*. (2010), Aliyu *et al*. (2015), Adekiya *et al*. (2018) and Olasupo *et al*. (2018).

Table 5: The observed effects of decapitation and CDM and NPK 15:15:15 fertilizer application on okro dry shoot matter in the study area

SN	Treatment applied *(A)* (i.e., Decapitation)	Mean dry shoot matter of okro (g/plant)
1	Decapitated Okro Plants (DOPs)	39.7
2	Non-decapitated Okro Plants (NDOPs)	26.4
3	SEM (0.05)	8.05

SN	Treatment applied *(B)* (i.e., CDM and NPK fertilizer application)	Mean dry shoot matter of okro (g/plant)
1	15 t/ha of CDM	32.9
2	30 t/ha of CDM	51.7
3	300 kg/ha of NPK 15:15:15 fertilizer	45.6
4	Control (no CDM and NPK fertilizer application)	23.3
5	SEM (0.05)	9.17

Source: Results of Researchers' Field and Laboratory Surveys and Office Data Analysis (2024).

According to the results in Table 5, the CDM applied to soils at the experimental site at the rate of 30 t/ha produced okro plants with the highest mean dry shoot matter (51.7 g/plant), followed by the 300 kg/ha NPK 15:15:15 fertilizer application rate (45.6 g/plant) and the 15 t/ha CDM application rate (32.9 g/plant), while the control soils produced plants with the lowest dry shoot matter of 23.3 g/plant. The results indicate that appropriate incorporation of soils with suitable rates of CDM and NPK 15:15:15 fertilizer had significant positive effects not just on the vegetative growth and fruit yield components of okro (Table 4), but also on the dry shoot matter of the crop (Table 5). The findings of the present study, therefore, confirm the empirical research findings earlier reported by Olasantan and Salau (2008), Akanbi *et al*. (2010), Aliyu *et al*. (2015), Adekiya *et al*. (2018) and Olasupo *et al*. (2018).

CONCLUSION

On the basis of the key findings emerging from this work, the present research concluded that: (i) decapitation, tillage and CDM and NPK 15:15:15 fertilizer application had no effect on the texture of soils in the study area; (ii) CDM and NPK 15:15:15 fertilizer incorporation had a significant positive influence on the investigated soil chemical characteristics, including their nutrient contents; (iii) decapitation, CDM and NPK 15:15:15 fertilizer application exerted significant favourable effects on the vegetative growth and yield components and dry shoot matter of ‘Erguru’ variety of okro in the study area; and (iv) the application rate of 30 t/ha CDM made the best impacts on the crop’s growth and yield parameters and dry shoot matter.

Arising from the major findings made, the study recommended, therefore, that: (a) combined application of 30 t/ha CDM and 300 kg/ha NPK 15:15:15 fertilizer should be timely and judiciously undertaken to improve soil chemical characteristics and, hence, enhance environmentally sustainable and economically profitable cropping of ‘Erguru’ okro in the study area; (b) decapitation at eight (8) WAP and soil amendment with 30 t/ha CDM and 300 kg/ha NPK 15:15:15 fertilizer are economical for the optimum growth and yield of the crop in the study area; (c) there is need to empirically examine the sole and combined/joint effects of decapitation earlier or later than eight (8) weeks after sowing and lower or higher rates of CDM and NPK 15:15:15 fertilizer application on soil characteristics and growth and yield parameters of the crop in the study area; and (d) there is need to scientifically investigate the influence of decapitation and other organic and inorganic amendments on soil characteristics and field performance (growth and yield) of the crop in the study area.

REFERENCES

Adekiya, A.O., Aboyeji, C.M., Dunsin, O. and Oyinlola, O.T. (2018). Effect of Urea Fertilizer and Maize Cob Ash on Performance of Okra (*Abelmoschus esculentus* [L.] Moench) and Soil Chemical Properties in a Derived Savanna Ecology. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 286-295) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Adelekan, B.A., Laleye, A.O. and Idowu, O.J. (2003). *Spectrum Agricultural Science for Junior Secondary Schools 2* (Reprinted 1st Edition). Ibadan, Nigeria: Spectrum Books Ltd.

Adeoye, G.O. and Agboola, A.A. (1985). Critical Levels for Soil pH, Available Phosphorus (P), Potassium (K), Zinc (Zn) and Manganese (Mn) in Sedimentary Soils of South-eastern Nigeria. *Fertilizer Research*, 6, 65-71.

Adetunji, M.T. (1991). An Evaluation of the Soil Nutrient Status for Maize Production in South-western Nigeria. *Samaru Journal of Agricultural Research*, 8, 101-113.

Adinna, E.N. (2001). The Adverse Impacts of Agriculture on the Environment. In: G.E.K. Ofomata and P.O. Phil-Eze (Eds.), *Geographical Perspectives on Environmental Problems and Management in Nigeria* (pp. 215-235). Enugu, Nigeria: JAMOE Enterprises (Nigeria).

Akanbi, O.S. and Ojeniyi, S.O. (2007). Effect of Siam Weed Mulch on Soil Properties and Performance of Yam in South-western Nigeria. *Nigerian Journal of Soil Science (NJSS)*, 17, 120-125.

Akanbi, W.B., Togun, A.O., Adediran, J.A. and Ilupeju, E.A.O. (2010). Growth, Dry Matter and Fruit Yield Components of Okra under Organic and Inorganic Sources of Nutrients. *American-Eurasian Journal of Sustainable Agriculture*, 4 (1), 1-13.

Akinrinde, E.A. and Obigbesan, G.O. (2000). Evaluation of the Fertility Status of Selected Soils for Crop Production in Five Ecological Zones of Nigeria. In: O. Babalola (Ed.), *Proceedings of the 26th Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 279-288) held from 30th October to 3rd November, 2000 in Ibadan, Nigeria. Published by the SSSN.

Aliyu, U., Sukuni, M. and Abubakar, L. (2015). Effect of Pruning on Growth and Fresh Fruit Yield of Okra in Sokoto State, Nigeria. *Journal of Global Biosciences*, 4 (7), 2636-2640.

Ano, A.O. and Agwu, J.A. (2005). Effects of Animal Manures on Selected Soil Properties. *Nigerian Journal of Soil Science (NJSS)*, 15, 14-19.

Asian Vegetable Research Development Council (AVRDC) (1991). *Vegetable Research and Development in the 1990s – A Strategic Plan*. Shanhua, Taiwan: AVRDC.

Aweto, A.O. (2006a). *GEO 416: Soil Study*. Ibadan, Nigeria: Distance Learning Centre, University of Ibadan, Ibadan, Oyo State, Nigeria.

Ayeni, L.S. (2010). Effect of Combined Cocoa Pod Ash and NPK Fertilizer on Soil Properties, Nutrient Uptake and Yield of Maize (*Zea mays* [L.]). *Journal of American Science*, 6 (3), 79-84.

Ayuso, M.A., Pascal, J.A., Garcia, C. and Hernadez, T. (1996). Evaluation of Urban Wastes for Agricultural Use. *Soil Science and Plant Nutrition*, 142 (1), 105-111.

Babalola, O.A., Adigun, M.O. and Abiola, I.O. (2018a). Effect of Urea and Compost on Maize, Soil Microbial Activities and Chemical Properties. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 214-222) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Babalola, O.A., Adigun, M.O. and Abiola, I.O. (2018b). Variation in Soil Chemical and Microbiological Properties as a Result of Yearly Amendment with Organic Fertilizer. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 234-241) held from 12th to 16th March, 2018 at the IART, Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Brady, N.C. and Weil, R.R. (2015). *The Nature and Properties of Soils* (14th Edition). Noida, India: Pearson India Education Services Pvt. Ltd.

Bray, R.H. and Kurtz, L.T. (1945). Determination of Total Phosphorus, Organic Phosphorus, and Available Phosphorus in Soils. *Soil Science*, 59, 39-45.

Bremner, M.J. (1996). Total Nitrogen. In: C.A. Black (Ed.), *Methods of Soil Analysis, Part 2* (pp. 1149-1178). Madison, Wisconsin, USA: Published by the American Society of Agronomy (ASA).

Bremner, M.J. and Mulvaney, C.S. (1982). Total Nitrogen. In: A.L. Page, R.S. Miller and D.R. Keeney (Eds.), *Methods of Soil Analysis, Part II: Chemical and Microbiological Properties* (pp. 643-698). Madison, Wisconsin, USA: Published by the ASA.

Carter, M.R. (1993). *Soil Sampling and Methods of Analysis*. Canadian Society of Soil Science. Boca Raton, FL, Canada: Lewis Publishers.

Chapman, H.D. (1965). Cation Exchange Capacity (CEC). In: C.A. Black (Ed.), *Methods of Soil Analysis, Agronomy 9 Monograph* (pp. 891-901). Madison, Wisconsin, USA: Published by the ASA.

Chapman, P.J. (2012). "Soils, Biogeography and Ecology". In: J. Holden (Ed.), *An Introduction to Physical Geography and the Environment* (pp. 143-174) (3rd Edition). Essex, England: Pearson Educ. Ltd.

Chude, V.O. (1998). *Understanding Nigerian Soils and their Fertility Management for Sustainable Agriculture*. Inaugural Lecture delivered at Ahmadu Bello University (ABU), Zaria, Kaduna State on 26th November, 1998. 1998 Inaugural Lecture Series 13.

Chude, V.O., Daudu, C., Olayiwola, S.O. and Ekeoma, A. (2012). Fertilizer Use and Management Practices for Crops in Nigeria. In: *Federal Fertilizer Department (FFD), Federal Ministry of Agriculture and Rural Development (FMARD), Abuja* (4th Edition) (pp. 40-41). Published by the FMARD.

Chukwuemeka, I.A. (2018). Adoption of Integrated Soil Fertility Management in Nigeria: Challenges and Way Forward. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 354-359) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Cook, G.W. (1982). *Fertilizing for Maximum Yield – Granada Technical Books* (3rd Edition). London, United Kingdom: Granada Publishing Limited. 465 pp.

De Lannoy, G. (2001). *Crop Production in Tropical Africa*. Brussels, Belgium: Directorate General for International Cooperation.

Doran, J.W., Sarrantonio, M. and Liebig, M.A. (1996). Soil Health and Sustainability. *Advances in Agronomy*, 56, 42-45.

Edem, S.O. (2008). *Soils and their Potentials for Crop Production*. Uyo, Nigeria: Abaam Publishing Company.

Faniran, A. and Jeje, L.K. (2002). *Humid Tropical Geomorphology*. Ibadan, Nigeria: Heinemann Educational Books (Nigeria) Plc.

Faniran, A., Jeje, L.K. and Ebisemiju, F.S. (2006). *Essentials of Geomorphology: Earth in the Service of Humans*. Ibadan, Oyo State, Nigeria: Penthouse Publications (Nigeria).

Gee, G.W. and Or, D. (2002). Particle-size Analysis. In: In: J.H. Dane and G.C. Topp (Eds.), *Methods of Soil Analysis, Part 4: Physical Methods* (pp. 255-293). Madison, Wisconsin, USA: Published by the ASA.

Harpstead, M.T. (1973). Classification of Some Nigerian Soils. *Soil Science*, 116, 437-442.

Hausenbuiller, R.L. (1974). *Soil Science Principles and Practices* (3rd Printing of the 1st Edition). Dubuque, Iowa, USA: WM. C. Brown Company Publishers.

Havlin, J.L., Tisdale, S.L., Nelson, W.L. and Beaton, J.D. (2014). *Soil Fertility and Fertilizers: An Introduction to Nutrient Management* (8th Edition). Delhi, India: PHI Learning Private Limited.

Helmke, P.A. and Sparks, D.L. (1996). Exchangeable Potassium. In: D.L. Sparks, A.L. Page, P.A. Helmke and R.H. Leoppert (Eds.), *Methods of Soil Analysis, Part 3: Chemical Methods* (pp. 869-920). No. 5 in Soil Science Society of America (SSSA) Book Series. Madison, Wisconsin, USA: Soil Science Society of America (SSSA).

Ikeorgu, J.E.G., Wahua, T.A.T. and Ezumah, H.C. (1989). Effects of Melon (*Citrillus lanatus*) and Okra (*Abelmoschus esculentus* [L.] Moench) on the Soil Moisture and Leaf Water Status of Intercropped Cassava/Maize in Nigeria. *Tropical Agriculture*, 66, 78-82.

International Institute of Tropical Agriculture (IITA) (1979). *Selected Methods for Soil and Plant Analysis. Manual Series No. 1*. Ibadan, Nigeria: IITA.

Iyagba, A.G., Onuegbu, B.A. and Ibe, A.E. (2012). Growth and Yield Response of Okro Varieties to Weed Interference in South-eastern Nigeria. *Global Journal of Science. Frontier Research in Agriculture and Veterinary Sciences*, 12 (7), Version 1.

Kekong, M.A., Attoe, E.E. and Adiaha, M.S. (2018). Effect of Nitrogen-fortified Rice Mill Waste on Soil Chemical Properties and Yield of Maize in Nigerian Rain Forest. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 331-337) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Kochhar, S.L. (1986). *Tropical Crops: A Textbook of Economic Botany*. London, United Kingdom: Macmillan Publishers Limited.

Lombin, G. (1999). Soil Science. In: Youdeowei, A., Ezedinma, F.O.C. and Onazi, O.C. (1999), *Introduction to Tropical Agriculture* (pp. 34-87) (5th Impression of the 1st Edition). Harlow, England: Pearson Education Limited.

Lyam, A. (2005a). "The Benue Environment in the Twentieth Century". In: A. Lyam, Y.A. Ochefu, J.A. Sambe and A.M. Adejo (Eds.), *Benue State in Perspective* (pp. 93-122) (A Re-issuance of the First Edition). Makurdi, Nigeria: Aboki Publishers (A Division of Aboki Associates).

Makinde, E.A. (2013). Growth and Yield of Okra with Rock Phosphate-amended Organic Fertilizer. *Journal of Agricultural Science*, 5 (10), 221-226.

Mohammed, A., Mohammed, T., Zakari, S.I. and Ahmed, I. (2018). Evaluation of Mineralized Soil Nitrogen Contents as Influenced by Fertilizer N and Cowpea Residue Amendments in an Entisol of Sokoto Sudan Savanna Zone of Nigeria. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 344-353) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Moniruzzaman, M., Uddin, M.Z. and Choudhury, A.K. (2007). Response of Okra Seed Crop to Sowing Time and Plant Spacing in South-eastern Hilly Region of Bangladesh. *Bangladesh Agricultural Research*, 32 (3), 393-402.

Natschner, I. and Schwetmann, U. (1991). Proton Buffering in Organic Horizons of Acid Forest Soils. *Geoderma*, 48, 93-106.

Nelson, D.W. and Sommers, L.E. (1996). Total Carbon, Organic Carbon and Organic Matter. In: D.L. Sparks (Ed.), *Methods of Soil Analysis, Part 3* (pp. 961-1010). No. 5 in the 2nd Edition of Soil Science Society of America (SSSA) Book Series. Madison, Wisconsin, USA: Published by the ASA and SSSA.

Nyagba, J.L. (1995b). "Soils and Agriculture in Benue State". In: D.I. Denga (Ed.), *Benue State, the Land of Great Potentials: A Compendium* (pp. 98-110). Calabar, Cross River State, Nigeria: Rapid Educational Publishers Limited.

Odedina, O.G., Ojeniyi, S.O. and Awodun, M.A. (2007). Effects of Agroindmatrial Vaster on Nutrient Status and Performances of Tomato. *Global Journal of Environmental Research*, 1 (1), 18-20.

Odeyemi, R.T., Awodun, M.A. and Ojeniyi, S.O. (2013). Combined Effects of Poultry Manure and NPK Fertilizer on Soil Plant Nutrient Composition and Growth of Rubber. *Nigerian Journal of Soil Science (SSSN)*, 23 (2), 136-141.

Ojeniyi, S.O. (2000). Effects of Goat Manure on Soil Nutrients and Okra Yield in a Rain Forest Area of Nigeria. *Applied Tropical Agriculture*, 5, 20-23.

Ojeniyi, S.O. (2010). *Advances in Integrated Nutrient Management for Crop Production in Nigeria Monograph*. Ibadan, Nigeria: Dominion Publishers. pp. 1-7

Ojeniyi, S.O. and Adetoro, A.O. (1993). Use of Chromolaena Mulch to Improve Yield of Late Season Okra. *Nigerian Journal of Technical Education*, 10, 144-149.

Ojeniyi, S.O., Awodun, M.A. and Odedina, S.A. (2007). Effect of Animal Manure-amended Spent Grain and Cocoa Husks on Soil Nutrient Status, Growth and Yield of Tomato in the Middle East. *Journal of Sciences Research*, 2 (1), 33-36.

Ojeniyi, S.O., Owolabi, O., Akintola, O.M. and Odedina, S.A. (2009). Field Study of Effects of Organo-Mineral Fertilizers on Maize Growth in South-west Nigeria. *Nigerian Journal of Soil Science (NJSS)*, 19, 11-16.

Ojo-Atere, J.O., Ogunwale, J.A. and Oluwatosin, G.A. (2011). *Fundamentals of Tropical Soil Science*. Ibadan, Nigeria: Evans Brothers (Nigeria Publishers) Limited.

Okaro, E.U. (2006). *Intensive Agricultural Science for Junior Secondary Schools: Years 1, 2 and 3* (4th Reprint of the 1st Edition). Onitsha, Nigeria: Elites' Publishers.

Olasantan, F.O. (2001). Optimum Plant Populations for Okra (*Abelmoschus esculentus*) in a Mixture with Cassava (*Manihot esculenta*) and Its Relevance to Rainy Season-based Cropping Systems in South-western Nigeria. *Journal of Agricultural Science* (Cambridge), 136, 207-214.

Olasantan, F.O. and Bello, N.J. (2003). Optimum Sowing Dates for Okra (*Abelmoschus esculentus*) in Monoculture and Mixtures with Contrasting Cassava (*Manihot esculenta*) during the Rainy Season in South-western Nigeria. *Journal of Agricultural Science* (Cambridge), 142, 49-58.

Olasantan, F.O. and Salau, A.W. (2008). Effect of Pruning on Growth, Leaf Yield and Pod Yield of Okra (*Abelmoschus esculentus* [L.] Moench). *Journal of Agricultural Science* (Cambridge), 146, 93-102.

Olasupo, I.O., Muhammad, Z.Y., Muhammad, L., Maigatari, A.A., Muhammad, A. and Danladi, I. (2018). Effect of Decapitation and Soil Amendment on Growth, Cumulative Yield and Dry Biomass of Okra in Sudan Savannah of Nigeria. In: G.A. Oluwatosin, O.T. Ande, J.A. Adediran and M.A.N. Anikwe (Eds.), *Proceedings of the 42nd Annual Conference of the Soil Science Society of Nigeria (SSSN)* (pp. 308-313) held from 12th to 16th March, 2018 at the Institute of Agricultural Research and Training (IART), Obafemi Awolowo University (OAU), Moor Plantation, Ibadan, Nigeria. Published by the SSSN.

Olayinka, A. (1990). Effect of Poultry Manure, Corn Straw and Saw Dust on Plant Growth and Soil Chemical Properties. *Journal of Agriculture*, 12 (1), 36-44.

Olayinka, A., Adetunji, A. and Adebayo, A. (1998). Effect of Organic Amendments on Nodulation and Nitrogen Fixation by Cowpea. *Journal of Plant Nutrition*, 21 (11), 2455-2464.

Osundare, B. (2004). Effect of Different Companion Crops and Fertilizer Types on Soil Nutrient Dynamics and Performance of Cassava. *Nigerian Journal of Soil Science*, 14, 13-17.

Raji, B.A. and Mohammed, K. (2000). The Nature of Acidity in Nigerian Savanna Soils. *Samaru Journal of Agricultural Research (SJAR)*, 16, 15-24.

Salau, A.W. and Makinde, E.A. (2014). Okra Leaf Growth, Fruit Set and Harvest Duration as Affected by Cultivar and Sowing Date. *International Journal of Vegetable Science*. DOI: 10.1080/19315260.2013.873107

Salau, A.W. and Makinde, E.A. (2015). Effects of Planting Density and Variety on Okra Growth, Yield, and Yield Duration. *International Journal of Vegetable Science*, 21 (4), 363-372. DOI: 10.1080/19315260.2014.880770

Shamshuddin, J., Jamaila, I. and Ogunwale, J.A. (1995). Organic Carbon Determination in Acid Sulfate Soils. *Pertanika Journal of Tropical Agricultural Sc*ience, 17 (3), 197-200.

Thomas, G.W. (1982). Exchangeable Cations. In: A.L. Page, R.S. Miller and D.R. Keeney (Eds.), *Methods of Soil Analysis* (Eds.), *Methods of Soil Analysis, Part 2, 3rd Edition of Agronomy Monograph 9*. Madison, Wisconsin, USA: Published by the ASA and SSSA.

Thornbury, W.D. (2011). *Principles of Geomorphology* (2nd Edition). New Delhi, India: New Age International (P) Limited, Publishers.

Tyubee, B.T. (2003). Thermal Problem and Physiological Indoor Comfort in Makurdi, Nigeria. *Journal of Science and Technological Research*, 1 (1 & 2), 152-140.

Tyubee, B.T. (2005). *Influence of Extreme Climate on Communal Disputes in Tivland of Benue State*. Paper presented during the Conference on Conflicts in the Benue Valley held in Benue State University, Makurdi, Nigeria on 16th and 17th March, 2005.

Udo, E.J., Ibia, T.O., Ogunwale, J.A., Ano, A.O. and Esu, I.E. (2009). *Manual of Soil, Plant and Water Analyses*. Lagos, Nigeria: Sibon Books Limited.