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VARIETAL RESPONSE OF SOLE AND COMBINED APPLICATION OF NPK 15-15-15 FERTILIZER ON GROWTH YIELDS OF ROSELLE (*Tithonia diversifolia) VARIETIES* IN OGBOMOSO, NIGERIA.

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ABSTRACT

Roselle (*Hibiscus sabdariffa Linn*) is regarded as a vegetable, as the calyces are the economic parts commonly utilized for dietary, industrial, medicinal and socio-cultural purposes. However, despite the multipurpose nature of roselle, one of its major production limiting factors in Nigeria is soil fertility. As a result, local farmers opted for rapid nutrients-replenishing means of applying different chemical fertilizers, which had eventually worsened the tropical soil conditions, as manifested through accelerated nutrients depletion and poor general crop performance. Therefore, this research was conducted at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Oyo state, to evaluate the performance of two varieties of roselle (Green and Red) under percentile proportionate combinations of NPK 15-15-15 fertilizer and *Tithonia diversifolia* compost, and the control. The experiment involved six (6) treatments namely: F0 (Zero application- control), F1 (100% application of NPK 15-15-15 fertilizer), F2 (Tithonia compost), F3 (75% NPK 15-15-15 fertilizer + 25% Tithonia compost), F4 (50% NPK 15-15-15 fertilizer + 50% Tithonia compost) and F5 (25% NPK 15-15-15 fertilizer + 75% Tithonia compost) were arranged in Completely Randomized Design (CRD), replicated thrice. Data were collected on growth (plant height, number of leaves, number of branches and stem girth) and yield (fresh and dry weights of calyx, and dry biomass yields) parameters. Data collected were subjected to analysis of variance (ANOVA). Treatment means were separated using Duncan Multiple Range Test at 5% level of probability. The results of pre-cropping soil analyses showed that the soil sample used was texturally sandy loam and slightly acidic with pH (H_2O) value of 6.1. Also, the soil was grossly low in major nutrient concentrations N (0.09 %), P (0.42 mg/kg) and K (0.14 mg/kg). Application of different fertilizers significantly ($p \leq 0.05$) influenced growth and yield of the two varieties investigated compared to the control. All the treatments applied significantly improved growth and yield parameters of the two roselle varieties. The Green roselle variety significantly responded better to different fertilizer treatments tested, compared to red roselle variety (VIF4). Generally, the crop yields, irrespective of the variety was significantly enhanced with increasing levels of organic residues from 50 to 100%. However, application of 25% NPK 15-15-15 fertilizer and 75% Tithonia compost significantly improved the growth and yield parameters measured, as well as the nutrient uptakes of roselle.

In conclusion, although application of 25% NPK and 75% Tithonia compost significantly improved the performance of green roselle, their values were not significantly different from those obtained from 100% Tithonia compost, therefore application of 25% NPK and 75% Tithonia compost is recommended, in order to: supply adequate nutrients for optimum performance of the green roselle variety and ensure reduction of chemical loads on soils. In addition, application of 100% Tithonia compost is equally recommended for pure organic production of green roselle variety, in the study area.

INTRODUCTION

Roselle, or Jamaica sorrel (Hibiscus sabdariffa) is a unique species cultivated in many tropical regions for its leaves, seeds, stem and calyces which, the dried calyces are used to prepare tea, syrup, jams and jellies as beverages (Eslaminejad *et al*., 2011). Roselle is an annual plant which takes about six months to mature. Roselle is a short-day plant that is very sensitive to the photoperiod. In the first 4-5 months of its growth, Roselle requires a daily light phase of 13 hours (McClintock *et al.,* 2004). The flowers would not appear if there were more than 13 hours of sunlight in a day, flowering of roselle plants was excellent when daylight was shorter than 12 hours (McClintock et al., 2004). Roselle plants prefer well-drained humus and rich-fertile soils with a pH of 4.5 to 8.0. It tolerates floods and heavy winds. Roselle is commonly propagated by seeds, but it is also readily grown from cuttings (Duke 2009). Roselle tea is used to control high blood pressure and its leaves are used as a source of mucilage in pharmacy and cosmetics (McClintock *et al.,* 2004). Extractions from Roselle have been used medicinally to treat colds, toothaches, urinary tract infections and hangovers. Roselle is consumed as hot and cold drinks to its uses in folk medicine. The drinks are widely used as diuretic, for treating gastrointestinal disorders, liver diseases, fever, hypercholesterolemia and hypertension (Ojeda *et al.,* 2010).

Tithonia diversifolia, commonly referred to as "Mexican Sunflower" or "Tree Marigold," is believed to have its origins in Mexico and is now extensively dispersed throughout the humid and sub-humid tropics of Central and South America, Asia, and Africa (Babajide *et al.,* 2008). It is currently undergoing naturalization in various tropical regions of Asia and Africa. Its distribution has significantly expanded in Nigeria, where it is prevalent on abandoned wastelands, adjacent to highways, waterways, and cultivated agricultural lands (Olabode *et al.,* 2007). The green manure derived from Tithonia diversifolia has been confirmed to possess a high concentration of essential nutrients and is efficacious in enhancing soil fertility and crop yields (Jama *et al.,* 2000; Olabode *et al.,* 2007).

Literature Review

Hibiscus sabdariffa is commonly known as roselle, hibiscus, Jamaica sorrel or red sorrel (English) and in Arabic, karkadeh (Ali *et al*., 2005). Its native distribution is uncertain, some believe that it is from India or Saudi Arabia (Ismail, *et al*., 2008), while Murdock (Murdock, 1959) showed evidence that *Hibiscus sabdariffa* (Hs) was domesticated by the black populations of western Sudan (Africa) sometime before 4000 BC. Nowadays, it is widely cultivated in both tropical and subtropical regions including India, Saudi Arabia, China, Malaysia, Indonesia, The Philippines, Vietnam, Sudan, Egypt, Nigeria and México (Ismail, *et al.,* 2008; Yagoub *et al.,* 2004). There are two main varieties of Hs, the first being Hs var. altissima Wester, cultivated for its jute-like fiber and the second is Hs var. sabdariffa. The second variety includes shorter bushy forms, which have been described as races: bhagalpuriensi, intermedius, albusand ruber. The first variety has green, red-streaked, inedible calyces, while the second and third race have yellow-green edible calyces (var. ruber) and also yield fiber (Morton, 1987). Roselle is a species of Hibiscus native to West Africa, used for the production of best fiber and as an infusion, in which it may also be known as karkade. It is an annual or perennial herb or woody-based subshrub, growing to 2–2.5 m (7–8 ft) tall. The leaves are deeply three- to five-lobed, 8–15 cm (3–6 in) long, arranged alternately on the stems. The flowers are 8–10 cm (3–4 in) in diameter, white to pale yellow with a dark red spot at the base of each petal, and have a stout fleshy calyx at the base, 1–2 cm (0.39–0.79 in) wide, enlarging to 3–3.5 cm (1.2–1.4 in), fleshy and bright red as the fruit matures. It takes about six months to mature. Stalks and leaves range from dark green to reddish color; flowers are creamy white or pale yellow. For fiber crops, seeds are sown close together, producing plants 10 to 16 feet (3 to 5 meters) high, with little branching. The stalks, cut when buds appear, are subjected to a retting process, then stripped of bark or beaten, freeing the fiber. In some areas retting time is reduced by treating only the bark and its adhering fiber. Plants for fruit crops, more widely spaced, are shorter and many-branched, and their calyxes are picked when plump and fleshy. The fiber strands, 3 to 5 feet (1 to 1.5 meters) long, are composed of individual fiber cells. Roselle fiber is lustrous, with color ranging from creamy to silvery white, and is moderately strong. It is used, often combined with jute, for bagging fabrics and twines. India, Java, and the Philippines are major producers. Bamgboye and Adejumo (2009) determined the physical properties of roselle seeds at different moisture contents using ASAE standards. In many tropical areas, the red, somewhat acid calyxes of H. sabdariffa variety altissima are used locally for beverages, sauces, jellies, preserves and chutneys; the leaves and stalks are consumed as salads or cooked vegetables and used to season curries; and in Africa the oil-containing seeds are eaten (Olabode *et al*., 2007). Hibiscus sabdariffa L. Roselle is a versatile plant that is widely cultivated in tropical and subtropical regions because it has significant economic, medicinal, and industrial value prior to its rich bioactive compounds, fiber content, and various applications in food and beverages. The plant has been extensively studied for its phytochemical properties, health benefits, and agronomic potential (Akanbi *et al*., 2005). Roselle (*Hibiscus sabdariffa Linn.)* is regarded as a vegetable, as the calyces are the economic parts commonly utilized for dietary, industrial, medicinal and socio-cultural purposes. However, despite the multipurpose nature of roselle, one of its major production limiting factors in Nigeria is soil fertility. As a result, local farmers opted for rapid nutrients-replenishing means of applying different chemical fertilizers, which had eventually worsened the tropical soil conditions, as manifested through accelerated nutrients depletion and poor general crop performance (Babajide *et al.,* 2008).

Tithonia diversifolia is a quick growing shrub. A common weed of the family Pedaliaceae and its relatively high in nutrients concentrations. There is an increasing awareness about the importance of Tithonia biomass in soil fertility management (Olabode *et al.,* 2007). *Tithonia diversifolia (Hemsl. A. Gray)* which is often referred to as Mexican sunflower is a common weed and an annual shrub, which could be useful for compost making. It is relatively high in nutrient concentrations, particularly nitrogen (N) but little was known about its potentials for soil fertility enhancement, which make it a useful major ingredient in composting. Tithonia grows aggressively along road sides, abandoned farmlands and pastures, particularly in Nigeria (Olabode *et al.,* 2007). It had been reported to be successfully used for improving soil fertility and crop performance in Kenya (Jama *et al*., 2000). It's utilized as ornamental plants and animal feeds, insecticides (Akanbi *et al*., 2007) and nematicides (Jama *et al*, 2000). Other uses include mulching, fencing and medicines (Olabode *et al.,* 2007). Application of compost may favour rapid re-vegetation of degraded farmlands, erosion control, improvement of soil quality and health (Akanbi *et al.,* 2005). There are abundant evidences that inorganic fertilizers can improve yield of crop significantly (Ojeniyi, 2002). Fertilizers allow us to raise soil fertility so that the yield of crops need no longer be limited by the amounts of plant nutrients that the natural system can supply and factors other than nutrition then set the limit to productivity (Akanbi *et al*., 2007). The advent of inorganic fertilizer has thus revolutionized crop production through its provision of plant nutrients for improved crop productivity in Nigeria. Total dependence on inorganic fertilizers however does not provide the panacea to soil management and crop productivity problems in Nigeria. There are problems that arise with continuous use of inorganic fertilizers. Most farmers apply fertilizer without soil test, thus wrong amount and type may be applied. Deficiency of secondary and micronutrients occur in soil and crop, if the common NPK type is consistently used (Ojeniyi, 2002). Total dependence on inorganic fertilizers may be accompanied by fall in soil organic matter, increased soil acidity and degradation of soil physical properties and structured and increased erosion. Agricultural chemicals have contaminated ground and surface waters, harmed fish and wildlife and greatly increased agricultural dependence on fossil fuel resources (Akanbi *et al.*, 2007). The fore-going underscores the need to evolve alternative "reduced chemical" or "low-input" production systems involving a partial reduction in the use of chemicals. The use of organic materials is an important component for sustainable agricultural production as when such materials are applied to agricultural land they promote sustainability because of their long term position effects on soil chemical and physical properties. The possible substitution of readily available organic inputs for chemical fertilizer, and therefore a decreased dependence on external sources for costly fertilizer ((Ojeniyi, 2002). Plant wastes such as wood ash, spent grain, rice bran, and sawdust were effective as fertilizers (Olabode *et al.,* 2007). Effect was enhanced by amendment with pig, goat, cattle and poultry manure. The residue increased soil organic matter, N, P, Ca, Mg, and pH and reduced soil bulk density. Chemical analysis showed that the residues contained N, P, K, Ca, Mg, Fe, Mn, Cu, and Zn (Ogbalu, Obi and Ekperigin, 2001).

The problems associated with the single approach application of organic or inorganic fertilizers have made a combination of organic and inorganic fertilizers a viable option in improving crop productivity in the Nigeria. Total dependence on inorganic fertilizers which may be accompanied by fall in soil organic matter, increase in soil acidity, degradation of soil physical properties and structure and increase erosion has to be avoided while on the other hand total dependence on organic fertilizer may be restricted in use due to competing alternative uses, bulk i.e. the amount needed to achieve optimum crop productivity, slow release of nutrients and the quality of organic matter (Babajide *et al.*, 2008). However, the combined use of organic and inorganic fertilizers will ensure that the problems associated with the use of either organic or inorganic fertilizers are greatly reduced as the combination of organic and inorganic fertilizers complement each other. Nearly all attempts to maintain continuous crop production with chemical fertilizers alone in the tropics have failed (Akanbi *et al.*, 2007). However, organic and inorganic fertilizers supply nutrients to soil in different ways. Organic fertilizers create a healthy environment for the soil over a long period of time, while inorganic fertilizer work much more quickly (Olabode *et al.*, 2007). Use of inorganic fertilizers for crops is not so good for health because of residual effects but in the case of organic fertilizers such problems do not arise but rather increase the productivity of soil as well as crop quality and yield (Babajide *et al*., 2008). But when in use with organic inputs such as crop residues, manure and compost has great potential for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Olabode *et al*., 2007). It has been abundantly shown that combined use of organic and inorganic fertilizers is required for sustainable soil productivity under intensive continuous cultivation in Nigeria Ojeniyi (2002). The combined use of organic and chemical fertilizers has proved a sound soil fertility management strategy in many countries such as Tanzania, India and Central African (Ojeniyi, 2002). The tendency to supply all nutrients through chemical fertilizers has to be avoided as this has deleterious effect on soil productivity. The use of various organic manures alongside with inorganic fertilizer for crop production has helped to improve agricultural practices in West Africa Countries (Akanbi *et al*., 2005). Organic manure helps to improve the physical condition of the soil and provide adequate amount of necessary nutrients for the soil productivity. Organic fertilizer plays vital role as a major contributor of plant nutrients (Babajide *et al*., 2008). It also act as a store house for Cation exchange capacity (CEC) and as a buffering agent against undesirable pH flunctuation (Babajide *et al*., 2008; Olabode *et al.,* 2007 and Akanbi *et al.,* 2005). Although, N, P, and K uptakes were significantly higher in both organically and inorganically fertilized plants than their unfertilized counterparts but the role of nutrients is one of the paramount importance in boosting productivity and quality of crops especially heavy feeder of mineral elements (Babajide *et al.,* 2008). Application of organic manure improves economic yield and it is vital to apply organic fertilizer than inorganic to obtain financially viable yield of crops and lesser chemical load on soil (Jeyuathia *et al.,* 2006).

Combination of the two sources of fertilizer (NPK and Tithonia compost) will not only supply essential and micro nutrients for plant use, but can also have some positive interactions to increase their efficiency thereby reducing environmental hazards particularly soil pH (Jeyuathia *et al., 2006*). Therefore, there is need for more awareness about the importance of Tithonia biomass in soil fertility management (Olabode *et al.,* 2007). The yield per unit area can also be increased along with the improvement of its quality through the balanced application of organic and inorganic fertilizers in proper combination (Akanbi *et al.,* 2005).

Nitrogen is known as one of the most essential elements needed to be carefully managed under modern and sustainable crop production because of its important roles in crop production as well the high level of volatilization and leaching losses into the farmlands particularly in the tropics where rainfall is torrential and solar radiation is very high (Akanbi *et et.*, 2001). When N is insufficient, root systems and plant growth are stunted, older leaves turn yellow and the crop is low in crude protein. Nitrogen fertilizer is costly and losses can be harmful to the environment, making good use of N by meeting crop needs while avoiding excessive applications of goal. Nitrogen contributes up to 50% of all the nutrient input. This makes nitrogen a key determining factor for farmer crop yield (Akanbi, 2002). Phosphorus, is also one of the major plant nutrients an integral component of several important compounds in the plant cells including sugar-phosphate intermediates of respiration, photosynthesis and phospholipids that make up plant membrane helps in alleviating the yield and its attributes by supplying energy required for metabolic processes. It also enhances the quality and quantity of oil production as it plays important role in plant metabolism (Akanbi *et al.,* 2004). The fertilization with phosphorus helps unimproved the seed weight and also the development of deeper and poriferous root system it stimulates seed setting and hastens maturity. The pre-cropping soil analyses of the samples used shows that the soil sample used were inadequate in nutrient and therefore, application of fertilizer or artificial supply of nutrients to meet the nutrient require for optimum growth and yield of roselle is required. The results are in agreement with other earlier researcher (Babajide *et al.,* 2008; Olabode *et al*., 2007) who reported that the soil in the study area are slightly acidic and are grossly insufficient in nutrient to support completion of the vegetative and productive stages of tropical crops. Results from the study showed that the growth of roselle *(Hibiscus sabdariffa)* on the growth parameters such as plant height, stem girth, number of leaves, number of branches, and yield nutrient uptake from the two varieties tested responded positively to both organic and inorganic fertilizer materials except in the control (F0, zero application). The responses were higher in plants receiving NPK but not significantly different from other treatments with Tithonia compost including the control. Nutrient uptake particularly Nitrogen, Phosphorus and Potassium were all significantly enhanced with the application NPK fertilizer and Tithonia compost.

Experimental site

Pot experiments was conducted at the teaching and research farms, Ladoke Akintola University of Technology, Ogbomoso (LAUTECH), Nigeria, LAUTECH is located between latitude 8^0 10' N and 4^0 10' E and falls under southern guinea savanna vegetation zone of Nigeria. The temperature of the area ranges from 28^0 – 33^0C. The study area is located in the south-western Nigeria and characterized by bimodal rainfall distribution whereby the early rainy season starts in late March and ends in late July/early August, follow by a short dry spell in August and finally the late rainy season is from August to November. The annual mean rainfall is between 1150mm and 1250mm (Babajide *et al*., 2008).

Soil sampling and analysis

After land clearing and preparation, soil samples were collected randomly from the field, at the teaching and research farms, Ladoke Akintola University of Technology, Ogbomoso (LAUTECH), at a soil depth of between 0-15cm, using soil auger. Collected soil samples were bulked together to make a composite sample, for physical and chemical analyses. Similarly, after the termination of first experiment, post cropping soil sampling was carried out per plots/treatments and composited for laboratory analysis. The samples were air dried, crushed and sieved through 2 mm and 0.5 mm meshes for the determination of particle size, pH (H_2O), total nitrogen (N), organic carbon, available phosphorus (P), iron (Fe), copper (Cu), zinc (Zn), the exchangeable cation, (Ca, Na, Mg and K) and exchangeable acidity. The particle size were carried out according to the Bouyoucos (1951) hydrometer method using sodium hexametaphosphate as the dispersant. Total N was determined by the macro-Kjedahl method (Bremmer, 1965) and colorimetric determination by Technicon Autoanalyser (1951), while the cations exchangeable was determined using Atomic Absorption Spectrometer; (Model Buck 200A). Available P was determined by extraction with sodium bicarbonate (Olsen *et al.,* 1984). Organic carbon was determined by chromic acid digestion (Heanes, 1984).

Treatments and experimental design

Two varieties of *Hibiscus sabdariffa (VI, V2)* were grown under six fertilizer treatments:

F0 = No fertilizer application
F1 = 100% application of NPK 15-15-15 (300kg/ha),
F2 = 100% Tithonia compost (4tonnes/ha),
F3 = 75% NPK + 25% Tithonia compost,
F4 = 50% NPK + 50% Tithonia compost,
F5 = 25% NPK + 75% Tithonia compost.

V1F0, V1F1, V1F2, V1F3, V1F4, V1F5 and V2F0, V2F1, V2F2, V2F3, V2F4, V2F5. V1 = Green roselle variety and V2 = Red roselle variety.

The treatments were arranged in factorial experiment with 2 varieties and 6 fertilizer treatments as main pot and sub pot respectively in a Randomized Complete Block Design and replicated three times (2 x 3 x 6 Factorial experiment).

Data Collection and Analysis

Data were collected per pot. Data collected on growth parameters (plant height, stem girth, number of leaves) and yield parameters (number of capsule, shoot dry weight, root dry weight, shoot fresh weight, root fresh weight) with the aid of electronic weighing. Plant height was measured using measuring tape. Stem diameter was measured by using venial caliper, the value obtained was converted using a formula πD (where $\pi = 3.142$ and D = diameter (original value measured by the venial caliper) and was subjected to analysis of variance. Treatment means was separated using Duncan Multiple Range Test, at $p \leq 0.05$.

RESULTS

1. Pre-cropping soil characteristics and Physical analysis of soil properties

The pre-cropping chemical and physical parameter of the soil (Table 1.) showed that the soil was texturally sandy loam, slightly acidic with pH value of 6.12. The soil sample was gossly low in essential nutrients particularly N (0.09 gkg^{-1}), P (0.42 mkg^{-1}) and K (0.14 $Cmolkg^{-1}$) Table4.1. The result was in line with earlier findings of Babajide *et al*., (2008) which indicated that the soil samples in the study area were grossly low in essential nutrient concentrations and thereby require supplementary nutrient source/fertilizer to improve the performance of most arable crops in the area.

2. Effects of combined application of NPK 15-15-15 fertilizer and Tithonia compost on number of leaves of roselle varieties

Table 2 shows the effects of combined application of NPK 15-15-15 fertilizer and Tithonia compost on number of leaves of roselle varieties. At 8WAS, V2 that received 25% NPK 15-15-15 fertilizer + 75% Tithonia compost had the highest mean value 92.0 but not significantly different from other treatments except V1 that receive 100% NPK and 100% Tithonia compost with the least value (35.6) from the control. At 10 weeks, V2 that received 25% NPK + Tithonia compost) produced the highest number of mean value (99.7) which was not significantly different from other treatments applied except the control (zero application) with the least value of 49.5. At 12 weeks, V2 that received 50%NPK + 50% Tithonia compost produced the highest mean value of (148.2) which was not significantly different from other treatments except V1 and V2 that received 100% NPK and control with the least value of (62.5).

3. Effect of Tithonia diversifolia and NPK 15-15-15 combination on plant height (cm) of Roselle (*Hibiscus sabdariffa*) varieties

Table 3 shows the effect of *Tithonia diversifolia* and NPK combination on plant height (cm) of Roselle (*Hibiscus sabdariffa*) varieties. At 8 weeks, V1 that received 75% NPK and 25% Tithonia had the highest mean of (70.8) and is not significantly different from other treatments except V1 and V2 that received NPK with the least value of (27.6) from the control. At 10 weeks, V1 that receive 75% NPK and 25% Tithonia had the highest mean of (91.2) and is not significantly different from other treatments except V1 and V2 that received NPK with the least value of (49.0) from control. At 12 weeks, V1 that receive 75% NPK and 25% Tithonia had the highest mean of (101.5) and is not significantly different from other treatment except control with the least value of (56.7).

Table 1:Physical and chemical properties of the soil used

Soil characteristics	Values
pH (H_2O)	6.12
Organic Carbon (gkg^{-1})	3.26
Total N (gkg^{-1})	0.18
Available P ($mgkg^{-1}$)	5.20
Fe ($mgkg^{-1}$)	11.84
Cu ($mgkg^{-1}$)	2.86
Zn ($mgkg^{-1}$)	2.84
Exchangeable K ($cmolkg^{-1}$)	0.30
Exchangeable Na ($cmolkg^{-1}$)	0.24
Exchangeable Ca ($cmolkg^{-1}$)	24.10
Exchangeable Mg ($cmolkg^{-1}$)	3.25
Sand (gkg^{-1})	800.8
Silt (gkg^{-1})	90.2
Clay (gkg^{-1})	109
Textural class	Sandy loam

Table 2:Effects of combined application of NPK 15-15-15 fertilizer and Tithonia compost on number of leaves of roselle varieties

Treatment	8	10	12
V1T0	35.6c	48.2c	59.4c
V1T1	68.6b	84.4ab	108.5b
V1T2	67.6b	82.3ab	122.5ab
V1T3	85.5a	91.3a	135.3a
V1T4	88.4a	94.6a	140.0a
V1T5	90.2a	98.6a	142.0a
V2T0	42.0c	49.5c	62.5c
V2T1	58.3b	86.5a	112.5b
V2T2	78.4ab	88.6a	120.0ab
V2T3	88.4a	95.6a	142.1a
V2T4	89.0a	98.4a	148.2a
V2T5	92.0a	99.7a	148.0a

means followed by the same letter are not significantly different by DMRT (P≤0.05). F0 = zero application, F1= 100% NPK 15-15-15 fertilizer application, F2= 100% Tithonia compost application, F3 = 75% NPK 15-15-15 fertilizer + 25% Tithonia compost application, F4 = 50% NPK 15-15-15 fertilizer + 50% Tithonia compost application, F5 = 25% NPK 15-15-15 fertilizer + 75% Tithonia compost application; V1 = Green roselle variety and V2 = Red roselle variety. WAS = Weeks After Sowing.

Table 3: Effect of *Tithonia diversifolia* and NPK combination on plant height (cm) of Roselle (*Hibiscus sabdariffa*) varieties

Treatment	8	10	12
V1T0	27.6c	49.0b	58.9c
V1T1	46.2b	74.2a	100.3a
V1T2	52.5b	78.8a	90.6a
V1T3	62.5a	86.3a	101.5a
V1T4	70.8a	91.2a	99.1a
V1T5	64.1a	90.0a	93.5a
V2T0	30.7c	48.5b	56.7c
V2T1	50.1b	69.1b	80.3ab
V2T2	57.7b	77.1a	85.7ab
V2T3	64.9a	64.1b	79.3ab
V2T4	66.4a	75.3a	99.0a
V2T5	58.6b	72.3a	90.0a

Means followed by the same letter are not significantly different by DMRT (P≤0.05). F0 = zero application, F1= 100% NPK 15-15-15 fertilizer application, F2= 100% Tithonia compost application, F3 = 75% NPK 15-15-15 fertilizer + 25% Tithonia compost application, F4 = 50% NPK 15-15-15 fertilizer + 50% Tithonia compost application, F5 = 25% NPK 15-15-15 fertilizer + 75% Tithonia compost application; V1 = Green roselle variety and V2 = Red roselle variety. WAS = Weeks After Sowing.

4. Effect of Tithonia compost and NPK fertilizer on yield parameters of roselle (*Hibiscus sabdariffa*) varieties

From table 4. V2 that received 25 % NPK + 75% Tithonia compost had the highest mean value of 868.2 which is not significantly different from other treatment except V1 and V2 that receive 100% NPK and 100% Tithonia compost with the least value of 212.6 from the control. On dry biomass yield, V1 that receive 50% NPK and 50% Tithonia compost had the highest mean value of 469.1 which is not significantly different from other treatment except V1 and V2 that receive 100% Tithonia compost and control with the least value of 126.6.

Table 4. Effect of Tithonia compost and NPK fertilizer on yield parameters of roselle

(***Hibiscus sabdariffa***) **varieties.**

Treatments	Fresh Biomass yield (gplant^{-1})	Dry Biomass yield (gplant^{-1})
V1T0	212.6d	138.8d
V1T1	672.7b	340.8ab
V1T2	541.5c	298.0bc
V1T3	720.3ab	428.5a
V1T4	826.8a	469.1a
V1T5	868.2a	450.3a
V2T0	202.0d	126.6d
V2T1	660.8b	322.8ab
V2T2	532.4c	291.6bc
V2T3	698.2ab	358.5ab
V2T4	820.4a	436.4a
V2T5	784.5a	440.4a

Means followed by the same letter are not significantly different by DMRT ($P \leq 0.05$). F0 = zero application, F1= 100% NPK 15-15-15 fertilizer application, F2= 100% Tithonia compost application, F3 = 75% NPK 15-15-15 fertilizer + 25% Tithonia compost application, F4 = 50% NPK 15-15-15 fertilizer + 50% Tithonia compost application, F5 = 25% NPK 15-15-15 fertilizer + 75% Tithonia compost application; V1 = Green roselle variety and V2 = Red roselle variety. WAS = Weeks After Sowing.

DISCUSSION

Nitrogen is known as one of the most essential elements needed to be carefully managed under modern and sustainable crop production because of its important roles in crop production as well as the high level of volatilization and leaching losses into the farmlands particularly in the tropics where rainfall is torrential and solar radiation is very high. It is essential for the development of field crops. When N is insufficient, root systems and plant growth are stunted, older leaves turn yellow and the crop is low in crude protein. Nitrogen fertilizer is costly and losses can be harmful to the environment, making good use of N by meeting crop needs while avoiding excessive applications of goal. Nitrogen contributes up to 50% of all the nutrient input. This makes nitrogen a key determining factor for farmers crop yield (Akanbi 2012). Phosphorus, is also one of the major plant nutrients an integral component of several important compounds in the plant cells including sugar-phosphate intermediates of respiration, photosynthesis and phospholipids that make up plant membrane, helps in alleviating the yield and its attributes by supplying energy required for metabolic processes. It also enhances the quality and quantity of oil production as it plays important role in plant metabolism. The fertilization with phosphorus helps in improving the seed weight and also the development of deeper and poliferous root system, it stimulates seed setting and hastens maturity.

The pre-cropping soil analyses of the samples used shows that the soil sample used were inadequate in nutrient and therefore, application of fertilizer or artificial supply of nutrients to meet the nutrient required for optimum growth and yield of roselle is required. This results were in agreement with other earlier researcher (Babajide *et al.,* 2008; Olabode *et al*., 2007) who reported that the soil in the study area are slightly acidic and also grossly insufficient in nutrients to support completion of the vegetative and productive stages of tropical crops. Results from the study showed that the growth of roselle *(Hibiscus sabdariffa)* on the growth parameters such as plant height, stem girth, number of leaves, number of branches, and plant yields with nutrient uptake from the two varieties tested responded positively to both organic and inorganic fertilizer materials except in the control (F0, zero application). The responses were higher in plants receiving the NPK but not significantly different from other treatments in Tithonia compost including the control. Nutrient uptake particularly Nitrogen, Phosphorus and Potassium were all significantly enhanced with the application NPK fertilizer and Tithonia compost. The extent to which plant residues influence soil fertility is partly determined by their biochemical properties, decomposition and concurrent timing of nutrient release and crop demand, added that the rate of decomposition of organic material may be used as measure of biological activity in the soil and of the potential for the soil to provide adequate inorganic N to a crop. The improved performance of the plants receiving NPK and Tithonia compost treatments was probably due to continuous supply of nitrogen from increased activity of soil microbes resulting in increased mineralization of the inorganic based- NPK 15-15-15 fertilizer, and Tithonia compost treatments. It could be attributed to the availability of inorganic nitrogen for early development of leaves, improved soil structure resulting from microbial activity on the organic matter and later available of nitrogen after mineralization of the organic matter.

In conclusion, although application of 25% NPK and 75% Tithonia significantly improved the performance of green roselle, their values were not significantly different from those obtained from 100% Tithonia compost, therefore application of 25% NPK and 75% Tithonia compost is recommended, in order to: supply adequate nutrients for optimum performance of the green roselle variety and ensure reduction of chemical loads on soils. In addition, application of 100% Tithonia compost is equally recommended for pure organic production of green roselle variety, in the study area.

CONCLUSION

All treatments applied significantly improved growth and yield parameter of roselle varieties. Green roselle variety significantly responded better to the different fertilizer treatments compared to red roselle variety. Although, the application of 25% NPK and 75% Tithonia compost significantly improved growth and yield of roselle but the values obtained were not significantly different from those obtained from 100% Tithonia compost.

Recommendations

Therefore application of 25% NPK and 75% Tithonia compost is recommended, in order to: supply adequate nutrients for optimum performance of the green roselle variety and ensure reduction of chemical loads on soils. In addition, application of 100% Tithonia compost is equally recommended for pure organic production of green roselle variety, in the study area.

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