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Influence of Nutritional treatments on the Growth of Dwarf Gem Tomato Variety *(Solanum lycopersicum var dwarfgem L.)*

Eze Hope Nkiruka and Izundu Alexander Ikechukwu

Department of Botany, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
**Corresponding author: E-mail: hn.eze@unizik.edu.ng*

ABSTRACT

In Nigeria, crops are usually cultivated during the rainy season when there is high incidence of diseases such as damping-off. The tomato varieties that are high yielding with quality fruits are affected by this damping-off during the rains. To promote increased fruit supply, dwarfgem which has rare good quality of being resistant to damping-off serves as good alternative to ascertain the best nutritional treatment that will improve the growth qualities of dwarfgem tomato for maximum yield. The study was carried out at Nnamdi Azikiwe University, Awka. Seeds of dwarfgem were obtained from Agricultural Development Program (ADP) Awka. Seeds were raised in the nursery. Twenty pieces of 40cm plastic buckets were used to prepare two groups of media according to the treatments which comprised of 14 buckets each filled with mixture of organic manure and soil at the standard rate of 640g/60kg (32g/hectare). Organic manure was goat pellets while inorganic manure was NPK (15:15:15). Salinity, (NaCl), and Bicarbonate (H_3C0_3) were supplied at 2mM concentration in the irrigation water. The buckets were arranged according to treatments in a Randomized Completely Block Design (RCBD). Three plants were randomly selected and tagged. The parameters measured Weekly are height, stem girth, leaf area and number of branch es. Plant height was determined using meter rule, stem girth was measured using Venier caliper. Data were subjected to statistical analysis using Duncan T – test to separate the Means. The tomato plants treated with organic and inorganic fertilizers in combination with NaCl and BICA showed the highest height increase of (125.31±0.01cm), highest leave area and significantly highest tomato branching. This has shown that the treatment of dwarfgem tomato variety with organic and inorganic fertilizer in combination with salinity and bicarbonate fully improved the plant growth..

Keywords: Tomato, dwarfgem, vitamins, lycopene, bicabornate, organic manure, inorganic fertilizer

INTRODUCTION

Tomato (*Solanum lycopersicum*) belongs to Solanaceae family which includes over 3000 species with both the old (egg plant in China and India) and New world (pepper, potato and tomato) in Central South America [1]. It originated in Peru and Mexico, in the present day Central South America from where it spread to other parts of the world [2]. In the 16th Century, it reached Europe from Mexico. It was initially used as an ornamental plant, but its cultivation as an edible fruit started at the 18th Century. By the 19th, Century, it was introduced to West Africa and Nigeria in particular [3]. Tomatoes play a vital role in human diet and are a good source of vitamins such as folate and ascorbate acid and minerals such as Calcium and Potassium [4], [5], [6]. The fruits are eaten raw or cooked and can be processed into soup, juice, sauce, ketchup, puree, paste and powder [7]. They also serve as ingredient in stews and vegetable salads. In northern Nigeria, the fruits are sliced and dried for sale [8]. In the tropics, soil fertility is declining as a result of excessive rainfall and continuous cultivation; this has led to soils lacking essential nutrients [9]. This however is a major challenge in sustainable vegetable production as a result of nutrient deficiency. Proper usage of organic manure and inorganic fertilizers has positive impact on the availability of nutrients for the crop and nutrient status of the soil [10]. Therefore, soil improvement via

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integrated soil fertility management strategy through the use of organic manure and inorganic fertilizers is a major intervention component that has improved crop production worldwide [11].

Different management practices are adopted to increase and optimize tomato yields. The use of organic manure and inorganic fertilizers either solely or in combination enhanced yield and quality of crops. It also leads to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil biological activity [12]. Chemical fertilizers, although are important input to get higher crop productivity, over reliance on them however, is associated with declines in some properties and crop yields over time and causes serious land problems, such as soil degradation [13]. In plants, leaf formation, height increase as well as stem enlargement are aspects of plant growth which are manifestations of physiological processes. The above morphological expressions in a plant are responses to internal and external factors [14]. Application of plant waste and farmyard manure had also advanced in interest. Among them, animal wastes are rich in nutrients including micronutrients readily available and commonly used by farmers around the world [15]. The use of organic manure has been reported to improve biological, chemical and physical properties of the soil and invariably increase plant growth and because of its high organic matter content due to high microbial activity [16], [17]. Organic fertilizers have positive effect on root growth by improving the root rhizosphere conditions (structure, humidity etc) and also plant growth is encouraged by increasing the population of microorganisms [6]. Organic acid which occurs in decomposition increases the benefits of nutrients. Organic manures activate many species of living organisms which release many phytohormones and may stimulate plant growth and nutrients [18] and such organisms need nitrogen for multiplication [19].

The high cost of tomato in Nigeria market justifies the fact that the highest production capacity has not been reached and also goes to suggest that demand is still high. Utilizing the proper nutrient will therefore increase production to meet demand. Hence, the objective of this work is to find out the best production strategy that will bring about maximum growth and crop yield. This is based on the fact that better growth and establishment of a plant determines the yield with request to quantity and quality of the plant. This is therefore designed to ascertain the influence of nutritional treatments on the growth and development of tomato plant.

The size and number of leaves are reduced in a wide range of both herbaceous and perennial plants under conditions of nutrient deficiency [20], [21]. The application of fertilizer has been found to result in increases in leaf area, thickness and chlorophyll content and more resources being allocated to growth [20]. There is a tomato variety, dwarfgem, that is adapted to our local environment and is resistant to diseases like damping off fungus. But there are various poor developmental qualities of this tomato. There is need to try the application of nutrients for improved development of this tomato variety.

The integrated use of organic manure and inorganic fertilizers is a sustainable approach for efficient nutrient usage which enhances efficiency of chemical fertilizers while minimizing nutrient losses [22]. Synergistic effects of organic manures with inorganic fertilizers accumulate more total nitrogen in the soil [23].

MATERIALS AND METHOD

SOURCES OF MATERIALS

Tomato fruits of the variety dwarf gem used for this experiment were purchased from Agricultural Development Program (ADP) Awka, under special arrangement with an Extension officer. In selecting fruits for seed extraction, efforts were made to collect seeds from fruits of self-pollinated plants so as to maintain true to type. The seeds were selected and washed thoroughly with tap water. The washed seeds were air dried under room temperature and stored in air tight plastic containers prior to use. Plastic containers used in this experiment were purchased from a dealer in Eke market Awka. The plastic containers were perforated below for easy drainage. However, a mesh (0.2mm-0.5mm) was cut and placed inside (at the base) the bucket to reduce soil erosion. Prior to planting, the seeds were soaked in water for 3 hours to help imbibition. The different nutritional chemicals were purchased from Gepet Laboratory Chemicals and Equipment Ltd Onitsha while NPK fertilizer 15:15:15 was obtained from ADP Awka. Farm yard manure (goat pellets) was obtained from a goat rearer in Enugwu-Ukwu, Anambra State under special arrangement.

SOURCE OF SOIL

Soil was collected within abandoned farm land in Nnamdi Azikiwe University Awka.

PREPARATION OF NURSERY

Four plastic containers measuring 48cm×28cm×20cm (L × B × H) were perforated below and filled with loamy soil. The soil filled plastic containers were watered for two days before planting.

PLANTING AND GERMINATION

The seeds were planted by broadcast, the broadcasted seeds were then covered with light layer of soil to encourage germination. The set-up was watered every 2 days and continued till transplanting.

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TRANSPLANTING

Fourteen plastic buckets were filled with 30kg of soil/organic manure mixture prepared at the rate of 10.7g of organic manure per kg of soil. Six similar plastic buckets were also filled with 30kg of soil only. All the soil filled plastic buckets were watered daily for three days before transplanting. Following germination of the seeds in the nursery, the seedlings were transplanted after 28days of growth (28DAP). Three plants were transplanted into each bucket in the evening and watered day and night for 14days to encourage stabilization. In each bucket, a peg was inserted at the middle immediately after transplanting so that the tip of the peg was at the soil level. This served as the basement for all growth measurements. Following stabilization, the plants were thinned down to two plants per bucket and their respective treatments were applied as in the design.

EXPERIMENTAL DESIGN

Using randomized complete block design, the plastic buckets were separated into ten treatments including the control. Each treatment comprised of 2 plastic buckets.

The treatments were distributed as below;

1.Control
2.Organic
3.Inorganic
4.Organic + Inorganic
5.Organic + Salinity + Bicarbonate
6.Inorganic + Salinity + Bicarbonate
7.Organic +Inorganic+ Salinity + Bicarbonate
8.Organic + Nitrogen + Salinity + Bicarbonate
9.Organic + Phosphorus + Salinity + Bicarbonate
10.Organic + Potassium + Salinity + Bicarbonate

Plants which received inorganic fertilizer treatments were treated with the fertilizer NPK 15:15:15) fourteen days after transplanting (14 DAT). Measurements of growth of the whole plants started seven days later twenty-one days after transplanting (21 DAT).

FARM YARD MANURE (Goat pellets)

The 30kg of soil contained by each plastic bucket used for organic manure treatments was incorporate with 320g of organic manure at the rate of 10.7g organic manure per kg of soil. The manure was mixed with the soil and buckets were filled. Thereafter, the set-up was watered for 7 days to aid ammonification before plants were transplanted.

PREPARATION OF STOCK SOLUTIONS

The following compounds were used to access improvement in the nutritional content of the plants. For each nutrient, 2mM concentration was prepared

i. For Nitrogen source: Sodium nitrate ($NaNO_3$)
ii. Phosphorus source: Sodium biphosphate
iii. Bicarbonate source: Potassium hydrogen carbonates (K_2HCO_3)
iv. Salinity; Sodium Chloride (Nacl)
v. Potassium source: Potassium nitrate (KNO_3)

INORGANIC FERTILIZER

The inorganic fertilizer used was N.P.K 15:15:15. This was applied as a single dose. It was applied two weeks after transplanting when the plants were already stabilized

Control

Plastic buckets containing the control plants had only 30kg of soil.

Treatments

Application of various supplements (nutritional chemicals) also started 21DAP (Days After Planting). The plants were allowed to stabilize for 1week before various measurements started.

For each treatment having nine plastic buckets, three plants were randomly selected and tagged for continuous growth measurements. Growth parameters used were height, stem girth, leaf area and number of branches.

Data collection and Analysis

For the various growth characters studied, three plants were randomly selected and tagged. All measurements were taken and averaged over the three plants.

Growth parameters measured included height, leaf area, stem girth and number of branches. Collection of data commenced 21 days after transplanting. Data were collected at one-week interval (Weekly measurements).

Plant Height

This was determined by measuring the height attained weekly after transplanting. Plant height was measured starting from the base of the stem to the tip of the tip of the shoot. The pegs inserted in the soil served as the

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basement for all measurements by using ruler and measuring tape. The unit used for plant height measurement was centimeter (cm).

Leaf area

For all the measurements or analysis involving the leaves, the 3rd and 5th fully opened (unfolded) leaves were used (they are the most photosynthetic active leaves of the plant). The leaf area index of the leaf was determined by multiplying both the length and width by 0.75. The unit used for leaf area is cm^2.

Number of Branches

The number of branches per plant was done by direct counting of the branches as they emerge. The number of branches that emerged from the main stem of the tomato was counted and recorded weekly.

Stem girth

The stem girth of each of the stems was measured at the base using a venier calliper.

Data Analysis

The data collected were subjected to Analysis of Variance. The means were separated using least significant Difference. Test of significance was conducted at five percent level of probability.

RESULTS AND DISCUSSION

General Observations

Immediately after transplanting, the plants expressed signs of stress but recovered within 4 days. Such stress expression was also noticed within few hours of application of inorganic fertilizer. It was observed that the plants fruited in sets at intervals and in bunches. The number of fruits per bunch was high at the second harvest than in the first set and then smaller in subsequent sets. The results of the effects of treatments on the heights of tomato plants showed that all the treatments favoured the height of tomato plant. However, tomato plants treated with organic manure and inorganic fertilizer, showed the highest height increase (125.31±0.010cm). This was followed by the plants treated with organic and inorganic fertilizers in combination with NaCl and BICA (101.25±0.015cm). The least height increase was recorded in the control plant, (8.90±0.200cm). Significant differences in the tomato plant height among the treatments at P=0.05 existed clearly (Fig 1).

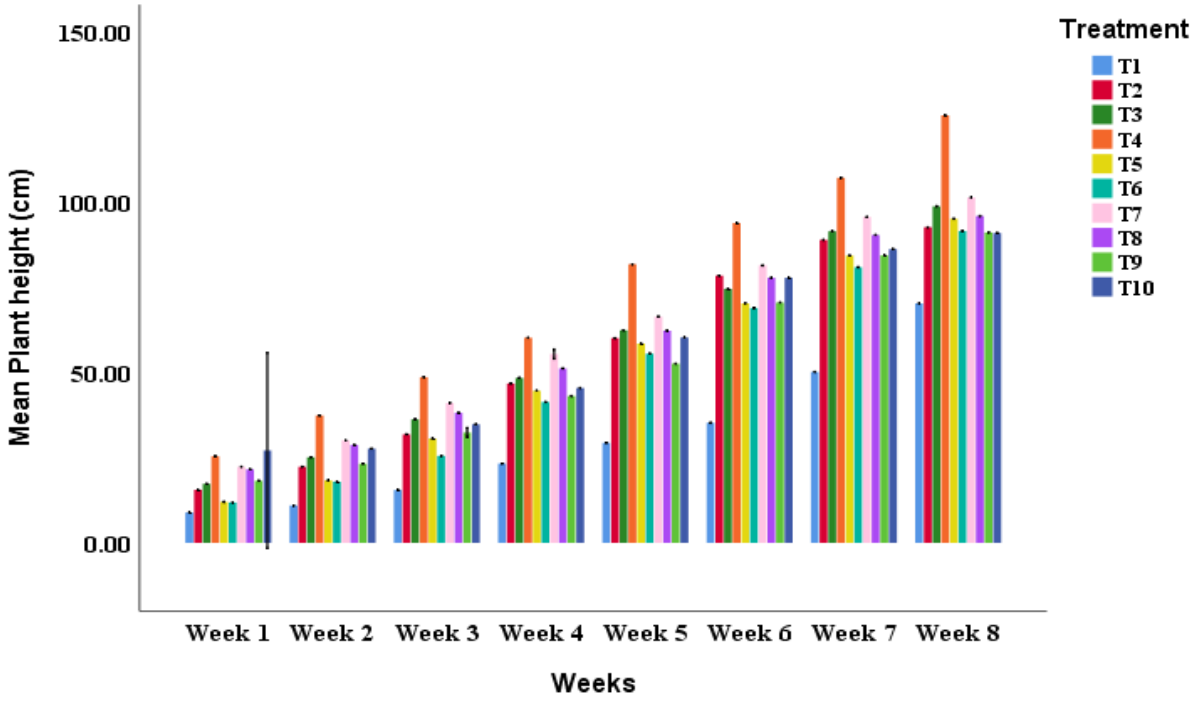

Figure 1: Tomato Plant height as influenced by treatment (cm)

Where;

T1=Control
T2 = organic
T3 = inorganic
T4= organic/inorganic
T5=organic/Nacl/BICA
T6=inorganic/Nacl/BICA
T7=organic/inorganic/Nacl/BICA
T8=organic/Nitrogen/Nacl/BICA
T9=organic/Phosphorus/Nacl/BICA
T10=organic/Potassium/Nacl/BICA

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Results of the effects of treatments on stem girth revealed that all treatments improved the stem girth of the tomato plant. The broadest tomato stem girth was recorded in the plant treated with organic and inorganic fertilizers, 9.25 ± 0.010cm. This was followed by the tomato plant treated with organic and inorganic fertilizers in combination with NaCl and BICA, 8.32±0.010cm. The least tomato stem girth was recorded in the control, 1.36 ± 0.010cm. The introduction of Nacl and Bicarbonate in the organic and inorganic fertilizers reduced the girth. There were significant differences in the mean tomato stem girth treatments (P<0.05) (Fig.2).

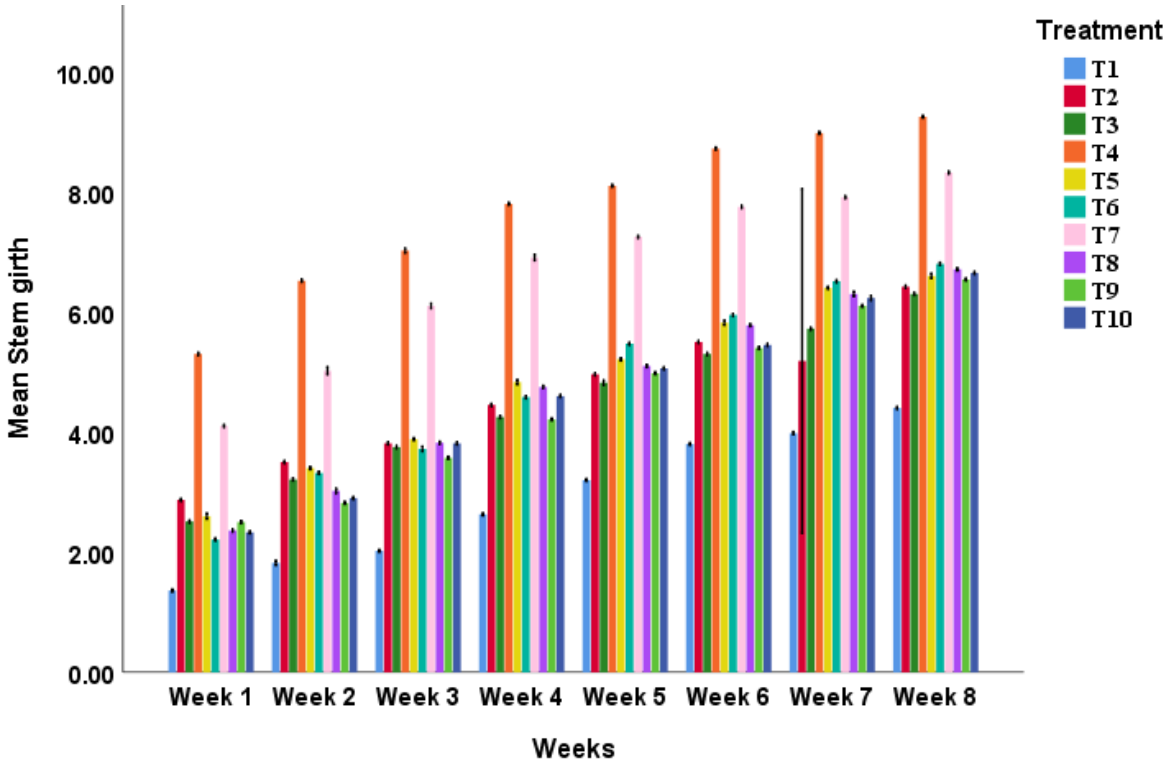

Fig.2: Effect of nutritional treatments on the girth of tomato plant (cm)

Where;

T1=Control	T2 = organic
T3 = inorganic	T4= organic/inorganic
T5=organic/Nacl/BICA	T6=inorganic/Nacl/BICA
T7=organic/inorganic/Nacl/BICA	T8=organic/Nitrogen/Nacl/BICA
T9=organic/Phosphorus/Nacl/BICA	T10=organic/Potassium/Nacl/BICA

The effects of treatment on leaf area revealed that all the treatments improved the leaf area of the plants. The highest tomato leaf area was recorded in the plant treated with organic and inorganic fertilizers with 40.28±0.010cm. This was followed by the tomato plant treated with organic fertilizer, 38.24±0.010cm. The least tomato leaf area was recorded from the tomato plant grown with inorganic fertilizer with 3.40±0.010cm. There was significant difference in the tomato leaf area (P<0.05) among treatments (Fig. 3).

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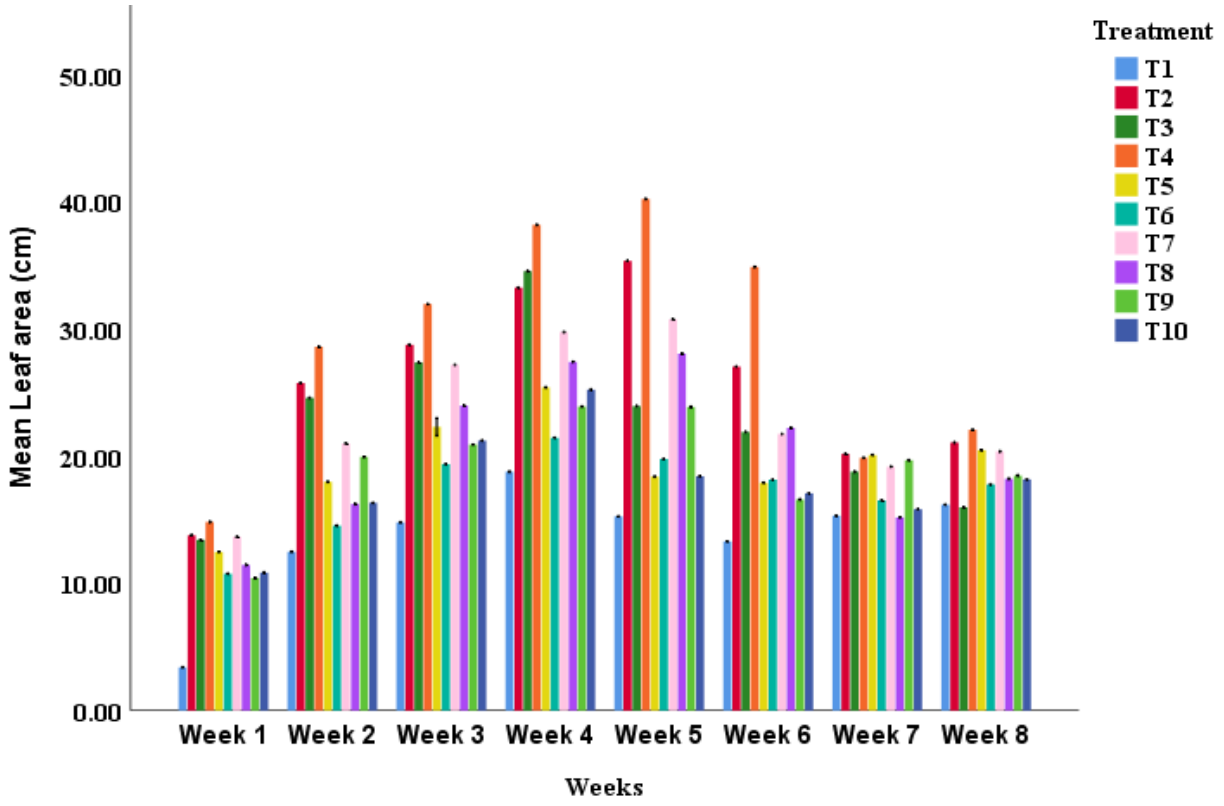

Fig 3: Influence of Nutritional treatments on the leaf area of tomato plants cm^2

Where;

T1=Control T2 = organic
T3 = inorganic T4= organic/inorganic
T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA
T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA
T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

Results showed that the highest number of branches was influenced by treatment with organic manure in combination with inorganic fertilizer (2.63±2.72), followed by plants treated with inorganic fertilizer (2.25±2.121) while the treatment that recorded the least value was organic manure, Potassium, NaCl and BICA, (1.50±1.512). The differences among these treatments were significant (P>0.05)(Table 1).

Table 1:Number of branches of tomato plants according to Treatments

Treatments	Branches (Mean numbers)
T1	1.75±1.753[a]
T2	1.75±1.581[a]
T3	2.00±2.268[a]
T4	2.63±2.722[a]
T5	2.00±1.604[a]
T6	1.50±1.690[a]
T7	2.25±2.121[a]
T8	1.50±1.690[a]
T9	1.75±1.832[a]
T10	1.50±1.512[a]

Values with same superscripts are not significantly different (P<0.975).

Where;

T1=Control T2 = organic
T3 = inorganic T4= organic/inorganic

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T5=organic/Nacl/BICA T6=inorganic/Nacl/BICA
T7=organic/inorganic/Nacl/BICA T8=organic/Nitrogen/Nacl/BICA
T9=organic/Phosphorus/Nacl/BICA T10=organic/Potassium/Nacl/BICA

DISCUSSION

The results on the growth parameters of the tomato plant showed that the application of organic and inorganic fertilizers was more effective in recording maximum plant height, thick stem girth, number of leaves per plant and leaf area. This is in agreement with the views of [24], who explained that in plants, earlier application of organic manure before planting brought about proper decomposition and immediate release of nutrients which caused rapid growth performance and led to increase in plant height. The results also confirmed the findings of [25], who reported that organic manure and chemical fertilier (NPK) which were supplied as essential nutrients at initial establishment stage of sweet corn recorded the best results for the measured variables like height of plant, width of stem. [26] and [27], stated that high and sustainable crop yield are possible with integrated use of mineral fertilizers and organic manure. The combined application of organic and inorganic fertilizers is considered a good option to enhance nutrient recovery and growth [28]. The application of organic fertilizer helped to significantly influence growth parameters. This may be due to improvement of soil physical condition for the plant growth along with increased availability of N, P, and K at early stage of crop growth. Nitrogen, Phosphorus and Potassium are necessary in plant growth and development. Plants need high concentration of these macro essential primary nutrients as any deficiency of these essential nutrients will prevent plant growth. Thus sufficient nitrogen, phosphorus and potassium, supplied by organic fertilizer, help in producing sturdy and taller tomato plants. Many research findings have shown that neither inorganic nor organic fertilizers alone can result in sustainable productivity [29]. These scenarios necessitated the use of integrated nutrient management since combined use of organic and inorganic fertilizers build ecologically sound and economically viable farming systems [30], [31]. Possible reasons for better influence by combined treatment include that of [32], who reported that reasonable application of combined inorganic and organic fertilizers decreased soil bulk density, increased moisture and soil fertility. Organic fertilizer apart from releasing nutrient elements to the soil has also been shown to improve either soil chemical and physical properties which enhance crop growth and development [33], [34], [35]. This may be responsible for the better performance recorded in plants that had combination of organic manure and inorganic fertilizer treatment. This agreed with the results obtained from other crops [36], [33], [26], [37]. These researches attributed this to increased efficiency in the utilization of inorganic fertilizers as a result of reduced leaching losses of nutrients. In addition, manure has also been reported to increase soil pH [38], hence the acidic soil of the experimental site which might have caused the unavailability of nutrient elements to the crop but was checked by the limiting potential of organic manure. The high increase in plant height with goat pellets together with inorganic fertilizers might be due to their synergistic effects of increasing nutrient use efficiencies and special effect of goat dung which acted as the store house of different plant nutrients, improved aeration, root penetration, water storage capacity of the soil as well as being host of different beneficial microbes. These results coincided with the findings of [39] and [40] who stated that organic fertilizer influenced significantly growth parameters. The finding that leaf area and other leaf components were promoted by organic and inorganic fertilizers is in line with the report of [40], who stated that leaf area increased with increase in nutrient content of organic fertilizer. They [40], explained that it was due to availability of organic dry matter in organic fertilizer that contain rich nutrients which was capable of higher light interception resulting in high photosynthetic activity and increased leaf area. This may later lead to an increased state of plant growth. The leaf may be the most important organ for plants to transfer solar energy to biological energy by means of photosynthesis. Leaf size, number, functional traits and photosynthetic capacity are closely related to plant size [41], [42], [43]. Leaf weight and area are different measures of leaf size [44], [45]. In general, under a constant investment of biomass to a leaf, a large surface will increase the contacting area to intercept the light that does undoubtedly enhance the photosynthetic potential [46]. Large leaves can improve the light utilization efficiency of foliar surface but they also need more input of biomass to increase leaf area.

CONCLUSION

In all, the ability of combined organic and inorganic fertilizer treatment in combination with salinity and bicarbonate in plant height, leaf area, girth and other growth parameters, positioned the plants for maximum yield. The treatments created the advantage that allowed the plants to trap radiant energy, increase uptake and enhance photosynthetic activities; Hence more accumulation of photosynthates. Eventually, the plants will grow more and increase its yield and quality.

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