Research Article

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# Growth, yield, fruit mineral and Vitamin C content of *Cucurbita pepo*. L as affected by Organic and NPK fertilizer

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**Abstract**: The nutrients requirement for *Cucurbita pepo* L. (summer squash) for optimal yield and quality fruits production can be achieved through adequate nutrient supply. A field experiment was carried out during the cropping season of 2015 and 2016 at Landmark University Teaching and Research Farm, Omu-Aran, Nigeria to investigate the impact of *Tithonia diversifolia*, poultry manure and NPK fertilizer on the growth, yield, mineral and vitamin C content in the fruit of *C. pepo*. The experiment consisted of *T. diversifolia* at 30 tons ha$^{-1}$, poultry manure at 10 tons ha$^{-1}$, *T. diversifolia* at 30 tons ha$^{-1}$ + Poultry manure 10 tons ha$^{-1}$, *T. diversifolia* at 30 tons ha$^{-1}$ + NPK (20:10:10), NPK (20:10:10) and control (no amendment of any kind) arranged in a randomized complete block design with four replications. The growth and fruit yield of *C. pepo using* the mean of the two years was increased by 68% and 2% respectively by *T. diversifolia* + poultry manure as compared to control due to an increase in nutrient availability in the soil with the amendment used. Also, Vitamin C content and Mg value of the fruit was increased by application of *T. diversifolia* as soil amendments as compared to the control. While the application of NPK fertilizer alone significantly increased the Ca, Mn and Fe contents of fruits. Fruit content of K was increased by 39 % by the application of *T. diversifolia* + NPK. Therefore, for the purpose of growing squash for the quality of fruits (vitamin C), the use of *T. diversifolia* at 30 tons ha$^{-1}$ as organic fertilizer is sufficient for the cultivation, while for growing the crop with interest in quantity, application of *T. diversifolia* at 30 tons ha$^{-1}$ + poultry manure at 10 tons ha$^{-1}$ is recommended.

**Keywords:** Summer squash, Poultry manure, *Tithonia diversifolia*, NPK fertilizer, and Quality.

## 1 Introduction

Vegetables are gradually acknowledged as crucial for food and nutrition security (Pepijn et. al. 2018). Today, the cheapest source of vitamins and minerals which are required for good health are vegetables. Vegetable production is now developing into a commercial enterprise favored by prescribed natural resources and other factors like the increasing consumption of vegetables and their products, transport facilities, development of research, extension and export services. Vegetables are in limited supply in Europe during winter months due to the unfavorable climatic conditions. This situation favours vegetables export to European markets where the winter is mild from Nigeria. (Daniel 2014)

*Cucurbita pepo* L. (summer squash) is a vegetable from the family of Cucurbitaceae and grown during the warmer season, in which the fruit can be harvested when they are physiologically immature (Kathiravan et.al. 2006). Summer squash is rich in vitamin C, beta-carotene, folate, and fiber, making it a health-benefiting food against diseases like cancers, heart disease, arthritis and asthma. (Mohammad et al. 2011). Most vegetables require fertilizer (organic and inorganic) for growth and optimum yield. The nutrient requirements of summer squash is generally high due to lots of biomass been produced by the plant (Oloyede et al. 2013). Organic fertilizers releases

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nutrients overtime thereby creating a healthy growing environment, while a fast release of nutrients is provided by inorganic fertilizers. Manures are a good source of fertilizer as they are natural products used to provide nutrients to plant by farmers. NPK fertilizer application tends to release fast nutrients to sustain soil fertility and crop production (Uyovbisere et al. 2000). It has been noted that the exorbitant price of fertilizer is a predicament to crop production in Nigeria (Akanbi et al. 2001). Likewise, using inorganic fertilizer has led to reduced crop yield, soil acidity and nutrient imbalance (Agbede et al. 2008).

Fertility and nutrient status of the soil is a major factor for improving crop yield and quality (Kolodziej 2006). The amount of fertilizer used as soil amendment, including organic and inorganic fertilizers has a positive impact on the availability of nutrients for the crop and nutrients status of the soil (Bijlsma et al. 2000). Thus, the use of different organic fertilizers solely or in combination with inorganic fertilizer enhanced yield and quality of crop (Zhang and Fana 2007). Soil amelioration and improvement via integrated soil fertility management strategy including organic and inorganic fertilizer is a major intervention component that has improved crop production worldwide (Chand et al. 2006). *Tithonian diversifolia,* a major annual weed found on uncultivated farm land, along roads and path in southwest Nigeria has aroused a lot of research interest due to its potentials as a green manure and high rates of nutrient accumulation found in its biomass and nutrient release (Gachimbi et al. 2004), its ability to mineralize fast provides an essential nutrients for crops (Jamal et al. 2000). Mulama (2001) reported that *T. diversifolia* as a soil amendment enhances the accessibility and imbibing of phosphorus by corn leading to an improvement of the straw and grain yield. Poultry manure, is another good soil amendment that offers nutrients for crop growth and improves the quality of soil when applied in right amount, because it is rich in organic matter content and other nutrient elements needed for plant growth (Van Ryssen et al. 1993). Egerszegi (1990) reported that soil bulk density was decreased while the water -soluble properties and carbon content were increased with the use of poultry manure.

A major challenge to sustainable vegetable production is nutrient deficiency from improper usage of fertilizer (Shaheen et al. 2010). Ideal nutrient supply is essential for plant development and yield (Liu et al. 2010). In the tropics, soils fertility declining from excessive rainfall and continuous cultivation have led to the soils lacking essential nutrients (Obalum et al. 2012). A combination of both organic and inorganic sources of nutrients for crops are becoming major aspects of environmentally smart agriculture. In view of this, this study aims at evaluating growth, yield, mineral and vitamin C content of fruit of summer squash (*Cucurbita pepo* L.) to organic and NPK fertilizers.

## 2 Materials and Methods

### 2.1 Description of the experimental site

The experiments were carried out at Landmark University Teaching and Research Farm, located in the transitional climatic zone of Nigeria with a mean annual rainfall of 1,600 mm and mean temperature of 27°C.

### 2.2 Soil sampling

Soil samples were collected randomly prior to the start of the experiments and bulked for laboratory analysis.

### 2.3 Source of material

Squash seeds were purchased from Premier Seed Nigeria limited, Zaria Kaduna-State. Poultry litters (chicken manure) were collected from the poultry units of the research farm where the experiments were conducted, while the leaves of *T. diversifolia* were harvested around the Farm area where the study was conducted. The NPK fertilizer (Add the NPK content and the manufacturer here) was acquired locally.

### 2.4 Experimental design, treatments and agronomic practices

Two summer squash seeds were planted at the commencement of the experiment in April 2015, which was later reduced to a seedling per stand two weeks after planting. The size of each plot was 10 × 12 m. Treatments were laid out in a randomized complete block design with three replicates. Treatments consisted of : No amendment of any kind-control (T1), *T. diversifolia* applied at 30 tons $ha^{-1}$ (T2) , *T. diversifolia* applied at 30 tons $ha^{-1}$ + poultry manure (PM) applied 10 tons $ha^{-1}$ (T3), *T. diversifolia* applied at 30 tons $ha^{-1}$ + NPK 20: 10:10 fertilizer applied at 150 kg $ha^{-1}$ (T4), NPK 20:10:10 fertilizer applied at 150 kg $ha^{-1}$ (T5), PM applied at 10 tons $ha^{-1}$(T6). Fresh leaves of *T. diversifolia* and poultry manure collected, were incorporated into the soil at a shallow depth (20 cm) using a hoe, two weeks before planting to allow mineralization. NPK fertilizer was applied 2 weeks after planting. Pesticides (Cypermethrin) were applied fortnightly 6 weeks after planting until the 10 weeks after planting. Emerging weeds were handpicked from each plot.

### 2.5 Data collection

Data was recorded from selected crop for the plant height, number of leaves, number of lateral branches and number of fruits, average fruit weight, fruit girth and length of fruit. Plant height, and fruit length were measured using meter rule. The fruit girth was measured using a Vernier caliper. Fully expanded leaves were counted to determine the leaf number. The fresh weight of the fruit was taken using a weighing balance. The fruit yield was determined from the fruit weight and number of fruits per plot.

### 2.6 Soil, manures and squash fruit analyses

Before the start of the experiment, soil samples from the surface were taken randomly. The soil particle-size was analysis as described by Gee and Or (2002). While the chemical analysis of the soil, *T. diversifolia* and poultry manure was analysed as described by Carter (1993). Mineral elements and vitamin C contents of squash fruits were determined according to methods recommended by the Association of Official Analytical Chemists (AOAC, 2003).

### 2.7 Statistical analysis

Statistical analysis was performed on collected data using analysis of variance (ANOVA) using SPSS 17, while Duncan's multiple range test (DMRT) was used to compare treatment means at $p < 0.05$.

## 3 Results

The result of the soil chemical and physical prior to the start of the experiment in both years are presented in Table 1. In both years, the soil chemical was found to be below the recommended levels to sustain production of crop according to Akinrinde and Obigbesan, (2000). The nutrient analysis of *T. diversifolia* and poultry manure shows that they contained sufficient nutrients for plant growth and development (Table 2).

Response of summer squash to organic and NPK fertilizer in both cropping seasons.

The average values of the effect of organic and NPK fertilizer on height, lateral branches and number of leaves of summer squash in both cropping seasons is presented in Table 3. Application of soil amendments significantly increased the plant height, lateral branches and leaf number of summer squash by 84.43%, 91.37%, and 89.15%, respectively, as compared the control. Treatment with *Tithonia* leaves + poultry manure produced the highest plant height (33.78 cm), but the difference was not significant for treatment with *Tithonia* alone. *Tithonia* +NPK fertilizer and PM alone had similar values of plant height (27.77 cm and 27.43 cm respectively) The number of leaves and lateral branches were significantly increased

**Table 1:** Physio-chemical properties of the soil prior to commencement of the experiment

| Parameter | 2015 | 2016 |
|---|---|---|
| Sand (%) | 76.1 | 76.00 |
| Silt (%) | 13.0 | 13.06 |
| Clay (%) | 10.9 | 11.13 |
| Textural class | Sandy loam | Sandy loam |
| pH (water) | 5.61 | 5.6 |
| Organic matter (%) | 2.24 | 2.28 |
| Total N (%) | 0.16 | 0.17 |
| Available P (mg $kg^1$) | 10.5 | 10.6 |
| Exchangeable K (cmol $kg^1$) | 0.14 | 0.13 |
| Exchangeable Ca (cmol $kg^1$) | 2.1 | 2.2 |
| Exchangeable Mg (cmol $kg^1$) | 0.36 | 0.37 |

**Table 2:** Chemical composition of poultry manure and *Tithonia diversifolia* leaves

| Amendment | pH | OC | N (%) | C:N | P (%) | K (%) | Ca (%) | Mg (%) |
|---|---|---|---|---|---|---|---|---|
| Poultry manure | 6.8a | 21.6b | 2.88b | 7.5b | 1.30a | 1.67b | 0.83b | 0.54a |
| *Tithonia diversifolia* leaves | 6.1b | 31.7a | 3.30a | 9.6a | 0.53b | 3.89a | 3.41a | 0.04b |

by 67%, and 58.6% with the application of *Tithonia* leaves + PM respectively, followed by *Tithonia*, and *Tithonia* + NPK fertilizer as compared with the treatment without amendments.

Yield and yeild parameter response of summer squash to organic and NPK fertilizer in both cropping seasons.

The yield parameters response of summer squash to organic and NPK fertilizer in 2015 and 2016 cropping seasons is presented in Table 4. Sole or combined use of soil amendments (organic and NPK fertilizer) was significant on the yield and yield components of summer squash, compared to treatment without amendments. The soil amendments influence on the yield parameters in table 4 showed that the application of *Tithonia* had the highest value for number of fruits $ha^{-1}$ (11938), fresh fruit weight (444.5 g), fruit dry weight (16.97 g) and fruit circumference (53.7 cm). A higher value was observed with the Treatments application of PM + Tithonia for the fruit length (17.2 cm), though the values were statistically similar with the values obtained from treatment with *Tithonia* and *Tithonia* + NPK (17.1 cm and 17.0 cm respectively). For the fruit circumference, treatment application with *Tithonia* had the highest value (53.7cm), but statistically similar to treatment application of PM + *Tithonia* (51.6 cm) and *Tithonia* + NPK (52.8 cm).

Fruit quality response of summer squash to organic and NPK fertilizer in 2015 and 2016 cropping season.

The mean effect of soil amendments on the mineral composition and Vit C. contents of summer squash is shown in Figure 1. The mineral content and vitamin C in the fruit was increased significantly by 87.13% and 93.3% respectively. The application of *Tithonia* alone significantly increased the values of Mg and Vit C. contents of summer squash fruit by 93.73% and 78.95% respectively. The application of NPK fertilizer alone significantly increased the values for Ca, Mn and Fe content in the

**Table 3:** Effect of thitonia diversifolia, poultry manure and NPK fertilizer the height (cm), lateral branches and leaves number of summer squash

| | Vegetative Growth | | |
|---|---|---|---|
| **Treatment** | **Plant height (cm)** | **Lateral branches (cm)** | **Leaves $plant^{-1}$** |
| CONTROL | $22.65^{e}$ | $13.00^{e}$ | $16.67^{d}$ |
| TITHONIA | $30.88^{b}$ | $37.67^{ab}$ | $40.00^{a}$ |
| PM+TIT | $33.78^{a}$ | $39.67^{a}$ | $40.33^{a}$ |
| TIT+NPK | $27.77^{c}$ | $25.33^{c}$ | $25.33^{b}$ |
| NPK | $25.70^{d}$ | $22.67^{d}$ | $22.33^{c}$ |
| PM | $27.43^{c}$ | $25.33^{c}$ | $25.66^{b}$ |

Mean with the same letters under same column are not significantly different at p=0.05 in line with DMRT. PM = poultry manure, TIT = Tithonia diversifolia

**Table 4:** Mean effect of application of organic and NPK fertilizer on yield of summer squash in 2015 and 2016 cropping seasons

| Treatment | Fruit $ha^{-1}$ | Fresh fruit weight (g) | Fruit dry weight (g) | Fruit length (cm) | Fruit circumference (cm) |
|---|---|---|---|---|---|
| CONTROL | $7094^{d}$ | $248.5^{d}$ | 9.13d | $8.3^{d}$ | $29.3^{d}$ |
| TITHONIA | $11738^{ab}$ | $444.5^{a}$ | $15.97^{a}$ | $17.1^{a}$ | $51.7^{a}$ |
| PM+TIT | $11929^{a}$ | $488.5^{a}$ | $16.97^{a}$ | $17.2^{a}$ | $53.6^{a}$ |
| TIT+NPK | $11492^{c}$ | $414.0^{b}$ | $14.67^{b}$ | $16.0^{b}$ | $48.8^{b}$ |
| NPK | $11219^{b}$ | $337.8^{c}$ | $13.85^{c}$ | $14.7^{c}$ | $46.5^{c}$ |
| PM | $114472^{c}$ | $412.4^{b}$ | $14.70^{b}$ | $16.0^{b}$ | $49.4^{b}$ |

Mean with the same letters under same column are not significantly different at p=0.05 in line with DMRT. PM = poultry manure, TIT = Tithonia diversifolia, fruit by 75.37%, 65.31% and 60.42% respectively as compared with the control. In a similar vein, the K content of summer squash fruit increased by 38.41% with the application of *Tithonia* + NPK fertilizer.

## 4 Discussion

The analysis of the initial physio-chemical properties of the experimental area used revealed that the soils used were low in fertility status, which is an attribute of the soil from this region as confirmed by Adekiya et al. (2018) that soils in the savannah region of Nigeria are low in nutrients from continuous cropping over the years.

The significant increase in the vegetative growth of summer squash to organic and NPK fertilizer as compared to the control could be adduced to the fact that the soil was low in nutrients, while organic and NPK fertilizer have provided essential nutrients for growth and yield of squash. The increase in growth and yield of summer squash under *Tithonia diversifolia* and PM alone could also be related to their low C: N ratios, and relatively high nutrient values of

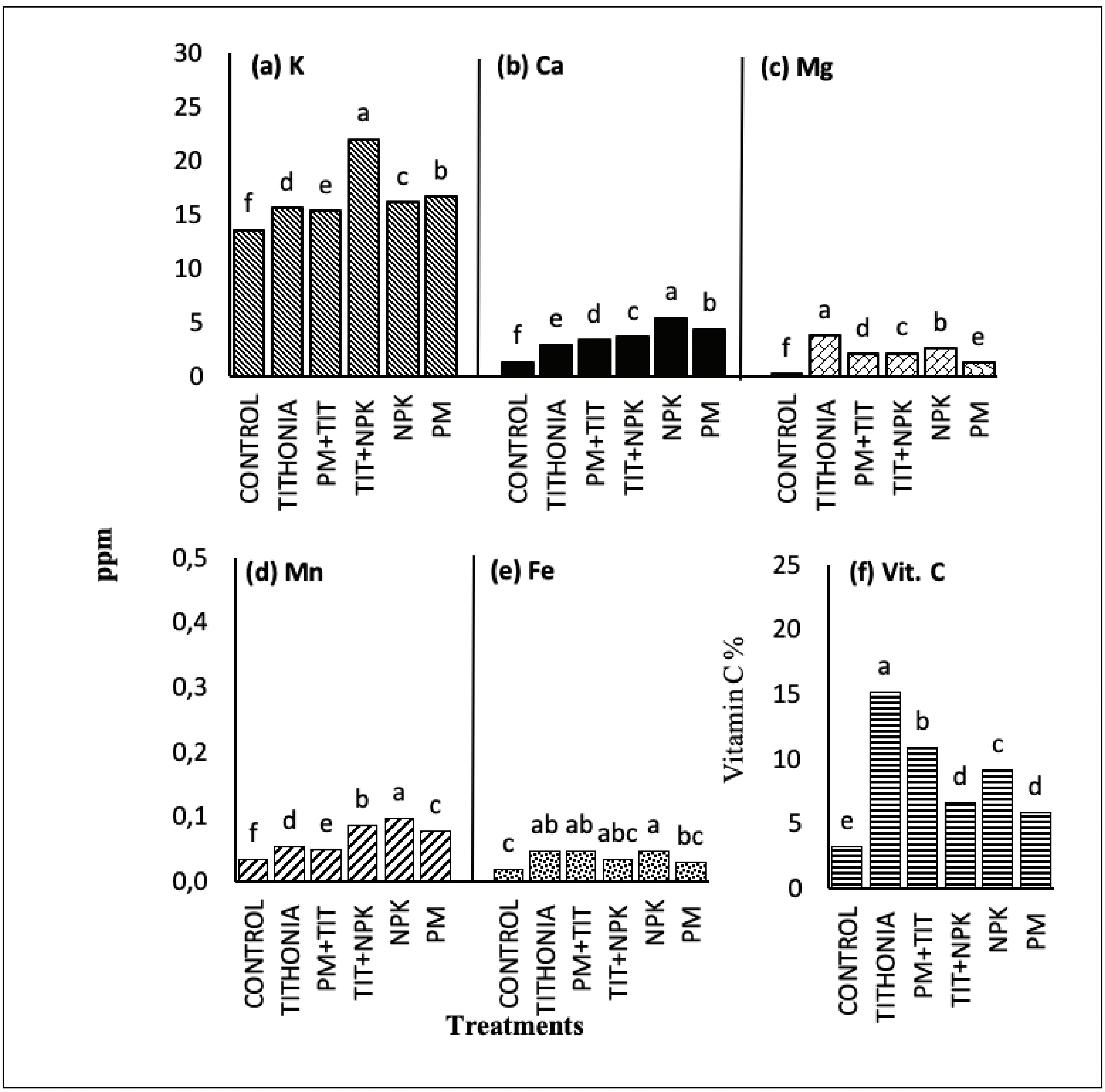


**Figure 1:** Effect of organic and inorganic amendment on the mineral composition and vitamin C of summer squash in 2015 and 2016 cropping season. Bars having same letter are not significantly different according to DMRT at p=0.05. *PM = poultry manure, TIT = Tithonia diversifolia*

both (Table 2). Chicken manure is an effectual source of nutrients for crops and had balanced nutritional and residual effects on crops and soil. The low C: N ratio will lead to fast mineralization and therefore release of nutrients into the soil. The better performance of the crop under Tithonia + PM treatment could be due to the fact that the humus of decaying leaves of *Tithonia diversifolia* may allow the retention of released nutrients from rapidly decomposing PM (with smaller C; N ratio) within the rooting zone fostering greater efficiency of nutrient management and uptake and increase in yield. Higher mineralization occurs where both organic amendments were combined, compared to their individual application, indicating a synergistic relationship. Adekiya (2018) also found a synergistic relationship between Acacia + PM in increasing nutrient release in increased tomato yield. Results also showed that the yield and yield components in summer squash were significantly affected by the *Tithonia diversifolia* + PM. The fruit length, fruit circumference, fruit fresh and dry weight of fruit were all increased with the application of *Tithonia diversifolia* + PM. The observed increase in these parameters could be adduced to the increase in vegetative growth and number of leaves enhancing the trapping of sunlight for photosynthesis and transportation processes leading to assimilation in the root (Aboyeji et al. 2017*)*. Likewise, organic manure increased accumulation of soil organic matter and lower soil bulk density giving improved aeration to soil and a more conducive environment for root growth and development in plants (Mandal et al. 2003). Apart from a greater volume of root, fresh and dry fruit weight recorded for summer squash plots treated with *Tithonia* +PM, *Tithonia* +PM accumulated large amounts of nitrogen and phosphorus from the soil and when incorporated into the soil, it released nearly all its nitrogen to the soil very quickly, making it an important source of nutrients (Gachengo et al. 1999) which was evidenced in a yield increase from 7.09 tons/ha in the control to 11.93 tons/ha in *tithonia* incorporated plot, this high yield was evidently due to the maximum fruit produced per hectare in the treatment as influenced positively by the application of organic and NPK fertilizer.

The positive response of summer squash fruit to organic and NPK fertilizer can be attributed to the increase in the nutrient availability in the soil from the amendment used. Plots treated with NPK fertilizer had the highest Ca, Mn and Fe concentration, which could be as a result of high levels of nitrogen (N) available from the NPK fertilizer that enhanced uptake of nutrients like Ca, Mn and Fe - this corroborates the results of Ilupeju et al. (2015) that at a higher rate of NPK, there is better utilization and availability of plant nutrients. Tisadale et al. (1995) reported that plant available Fe and its uptake is greatly influenced by nitrogen availability for root growth which in turn promoted the uptake and accumulation of Fe in plant tissues. It was also observed in this study that Ca and Mn content in summer squash fruits was significantly increased by NPK fertilizer, this is in line with the findings of Olaniyi and Ojetayo 2010 that the Ca content of *Capsicum* fruits were significantly influenced by the application of 250 kg of NPK fertilizer per hectare and Heidari and Mohammad 2012 who stated that an increase of N level from inorganic fertilizer from 75 kg to 225 kg N $ha^{-1}$ generated the highest value of Ca and Mn of *Momordica charantia* fruit.

Potassium (K) is an important nutrient that maintains the osmotic potential of cells, opening and closing of stomata and water relationships within a plant. K improves photosynthetic activity and helps better translocation of metabolites (Maity et al. 2006). K is often the nutrient absorbed at the highest rate by plant (Brunetto et al. 2015). The highest K content was recorded in the fruit of summer squash with plot treated with *Tithonia diversifolia* and NPK fertilizer in this experiments possibly due to the high K availability in the soil from the amendment used which the plant took up and accumulated in the fruits as a luxury consumption (Kaminski et al. 2007).

Higher levels of Vitamin C and Magnesium content recorded with the application of *T. diversifolia* as against plot treated with NPK fertilizer can be deduced from increased nutrients availability from mineralization as against easy loss of nutrients by leaching with NPK fertilizer. Increased Vitamin C content can be attributed to low foliage that hindered composition and intensity of light reaching plant tissues (fruits and leaves) which have reduced Vitamin C content in plant due to shade (Mozafar 1993). Increased in the usage of synthetic fertilizer have contributed to increase in $NH_4$ salt in plant tissues which negatively reduced the synthesis of Vitamin C. Hassan et al. (2012) noted that organic fertilizer significantly improved Vitamin C content in *Cosmos caudatus* plant compared to inorganic fertilizer.

## 5 Conclusion

The application of *T. diversifolia*, poultry manure and NPK fertilizer alone or in combination significantly improved the vegetative growth, yield, mineral and vitamin C content of the fruit of summer squash. The results showed that an application of *T. diversifolia* at 30 t $ha^{-1}$ + poultry manure at 10 t $ha^{-1}$ as an organic amendment had the best growth attributes for optimal yield as compared to the control. It was also observed that *T. diversifolia* alone as an organic amendment increased the vitamin C and magnesium contents of fruit. Therefore, the treatment with *T. diversifolia* at 30 t $ha^{-1}$ + poultry manure at 10 $ha^{-1}$ is recommended for sustainable production of *C. pepo,* while the utilization of *T. diversifolia* at 30 t $ha^{-1}$ as soil amendment is recommended for those that desire quality of fruit in terms of Vitamin C.

**Conflict of interest:** Authors declare no conflict of interest.

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