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INFLUENCE OF FERTILIZER COMBINATION AND TRAINING METHODS ON GROWTH AND PHYSIOLOGICAL TRAITS OF FLUTED PUMPKIN (*Telfairia occidentalis* Hook F.) SAMARU, NORTHERN GUINE SAVVAN, NIGERIA.

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ABSTRACT

A field experiment was conducted during the 2023 and 2024 wet seasons at the Institute for Agricultural Research Farm, Samaru, Ahmadu Bello University, Zaria, located in the Northern Guinea Savanna ecological zone of Nigeria (11°11′N, 07°38′E; 686 m above sea level)to evaluate the effects of fertilizer combinations and training methods on selected physiological growth parameters of fluted pumpkin. The treatments comprised seven combinations of poultry manure (PM) and NPK fertilizer (3 t PM + 250 kg NPK, 3 t PM + 0 kg NPK, 6 t PM + 0 kg NPK, 0 t PM + 250 kg NPK, 0 t PM + 500 kg NPK, 6 t PM + 500 kg NPK and 0 t PM + 0 kg NPK) and two training methods (Single-stake and no training). The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times**.** The study assessed leaf area index (LAI), chlorophyll content, crop growth rate (CGR), relative growth rate (RGR), and net assimilation rate (NAR) at different growth stages. Results showed that fertilizer combinations significantly influenced most physiological parameters measured. The integrated application of NPK fertilizer and poultry manure (NPK100 + PM100) generally produced the highest values for LAI, CGR, RGR, and NAR across several growth stages, while the control treatment (NPK0 + PM0) consistently recorded the lowest values. At 6 and 8 weeks after sowing (WAS), higher LAI and chlorophyll content were observed under treatments that combined mineral fertilizer with poultry manure, indicating improved nutrient availability and enhanced photosynthetic capacity. Similarly, CGR and RGR increased under fertilized treatments, reflecting improved biomass accumulation and growth efficiency, whereas unfertilized plots exhibited reduced growth due to nutrient limitations. Net assimilation rate followed a similar trend, with fertilized treatments showing higher photosynthetic efficiency compared with the control. Training methods also influenced some physiological parameters; trained plants generally recorded higher chlorophyll content, relative growth rate, and net assimilation rate, while non-trained plants exhibited higher crop growth rate at certain stages due to unrestricted vegetative growth. However, no significant interaction effects were observed between fertilizer combinations and training methods across the measured parameters. Conclusively the results indicate that integrated nutrient management, particularly the combined application of NPK fertilizer and poultry manure, enhances physiological growth performance and photosynthetic efficiency of fluted pumpkin.

Keywords: *Fertilizer combination, training method, physiological traints, fluted Pumpkin and Samaru*

INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis* Hook F.) is an indigenous vegetable consumed in Nigeria. It belongs to the family Cucurbitaceae. Fluted pumpkin has about 90 genera and more than 70 species distributed all over the warm parts of the world (Axtell, 1992). *Telfairia occidentalis* is a dioecious, creeping perennial vegetable shrub that spreads low across the ground and climbs and often coiled tendrils (Okoli and Mgbeogwu, 1983; Horsfall and Spiff, 2005; Udoh (*et al*; 2005). In Nigeria, the edible vegetable is commonly known as “Ugu” (Igbo), “Ubong, Nkong” (Efik/Ibibio), Agun (Hausa) and “Ireke” (Yoruba). Its succulent young shoots and tender leaves are used in preparing soups (Schippers, 2000) and sauce for garri and foofoo meals and it is usually cooked lightly with okro and fish or meat (Udoh (*et al*; 2005). It is an important vegetable crop that has high nutritional and commercial value (Schippers, 2000).

Fluted pumpkin is a plant of the lowland, humid tropics, where it is found at elevations up to 1,000 metres (world agroforestry center, eco crop). The crop prefers a loose, friable, ample, humus and shaded position. Nitrogen is essential for adequate vegetation and should ideally be given in the form of manure (Schippers, 2000). It grows best in areas where annual daytime temperatures are within the range 21 - 30°c, but can tolerate 19 - 38°c (eco crop). It prefers a mean annual rainfall in the range of 1,900 - 2,200mm, but tolerates 1,500 - 2,700mm. According to Ossom *et al* (1997), T. Occidentalis thrives well within the temperature range of 30 - 50°C while Udoh (*et al*, 2005) reported that the tropical vine crop thrives under a warm environment with plenty of sunshine and prolonged rainy season. Rainfall appears to be the major factor in its productivity with a requirement of 1000 - 2500mm per annum (Akoroda, (*et al*; 1990).

Fluted pumpkin is of local ethno-botanical importance in the folklore and the dietary and cropping systems of Igbos and their neighbors. The leaves and seeds are widely eaten as they are good sources of minerals (potassium, magnesium, sodium, phosphorus and iron), β-carotene, vitamins, fibres, fats (Schipper, 2000; (Nkang *et al.*, 2003); Christian, 2006; Ogbadoyi (*et al*, 2011). The oil seeds have lactating properties and are therefore in high demand by women with young babies. The sliced young leaves mixed with coconut water and salt can be stored in bottle and used for the treatment of convulsion.

Telfairia has long been important in the internal food trade of Igbos. Like other leaf vegetables, it is of low commercial value, but can in some cases provide an appreciable cash income to small farm families. Its leaves, succulent shoots, and seed kernels constitute the usual ingredients that are popular and regularly consumed in Igbo soups. Many good attributes account for the increasing importance of this chief vegetable among 30-35 million people in Nigeria. Fluted pumpkin leaves have high iron and protein contents, about 86% moisture, 11% crude protein, 25% carbohydrate, 3% oil, 11% ash as much of 700ppm of iron (Oyolu, 1978). According to FAO, (1998) and Udoh (*et a.l*, 2005), fluted pumpkin leaves have nutritional values of about 86ml water, 9g protein, 1.8g fat, 7.0g carbohydrate and 1.7g fibre. Its seed contains 13% oil which is used for cooking, manufacturing and cookies formulation (Okoli, 2012) and Nyanayo, 1998; Horsfall and Spliff,(2005). The oil in the seeds is non-drying and useful in soap making (Fasuyi, 2006).

Apart from the nutritional and agricultural importance, the plant is also medicinal, it possesses anti-inflammatory (Oluwole (*et al.*, 2003), anti-bacterial (Odoemena and Essien, 1995), erthropioeti, anti-cholesterolemic and anti-diabetic properties (Eseyin (*et al*, 2000; 2005).

Addressing the constraints to fluted pumpkin production requires targeted interventions. These include the development of Good Agronomic Practice Packages (GAPP), farmer training, breeding and dissemination of improved varieties, improved storage infrastructure, and stronger market linkages. While many farmers apply both organic and inorganic fertilizers, no scientifically validated recommendations exist regarding optimal rates or application time. The Nigerian Horticultural Research Institute (NIHORT) recommended 20 t/ha of poultry manure, with 20–25% of this rate suggested when sourcing or applying the full rate is impractical. This study evaluates various combinations of poultry manure and NPK fertilizer, using 20% of the recommended rate, which is 6 t/ha of poultry manure and 500 kg/ha of NPK 20:10:10. Poultry manure is rich in essential macro- and micro-nutrients, enhances soil fertility and structure, and increases soil carbon content. Likewise, NPK fertilizers are crucial for crop productivity, particularly in the nitrogen-deficient soils of the Nigerian savanna. In view of the above statement the following objectives were designed;

To determine the effect of combined poultry manure and NPK fertilizer for enhancing growth and fresh yield of fluted pumpkin

ii. To evaluate the effect of different training methods on the growth and fresh yield of fluted pumpkin.

MATERIALS AND METHODS

The experiment was conducted at the Artemisia Research Programme orchard of the Institute for Agricultural Research, Ahmadu Bello University, Samaru-Zaria, located in the Northern Guinea Savanna ecological zone of Nigeria (11°11′N, 07°38′E; 686 m above sea level) during the 2023 and 2024 rainy seasons. The experiment consisted of seven fertilizer combinations (T1–T7 0%PM(0 t/ha) 0%NPK (0 kg), 50% PM(3 t/ha) 50%NPK (250 kg), 100%PM (6 t/ha) 100% NPK(500 kg), 50% PM(3 t/ha) 0% NPK(0 kg), 0% PM(0 t/ha) 0%NPK (0 t/ha), 100%PM (6 t/ha) 0% NPK(0 kg), 0% PM(0 t/ha) 100% NPK(500 kg)) and two training methods (Stake and non-training). Treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Data on Leaf area, index, chlorophyll content, crop growth rate, relative growth rate and net assimilation rate were measured (CGR, NAR and RGR). Leaf area index (LAI) is the ratio of leaf surface area per unit land surface. Non-destructive LAI measurement for each treatment at 6, 8, 10 and 12 WAS done using ACCUPAR PAR/LAI Ceptometer (Model Li-3100C). Sensor of the Ceptometer was diagonally across the inner rows, such that the end of the sensor coincides with the line of the plants in each row. The displayed LAI for each plots was recorded accordingly. The chlorophyll contents of Pumpkin leaves were measure at 6, 8, 10 and 12 WAS from the five randomly tagged plants from each plot using Minolta chlorophyll meter SPAD (Soil-plant Analysis Development) Model SPAD-502, Minolta crop, Ramsey, NJ, Illinois U.S.A. The instrument measures transmission of red light at 650 nm, at which chlorophyll absorbs light, and transmission of infrared light at 940nm, at which no absorption occurs. On the basis of these two transmission values, the instrument calculates a SPAD value that was correlated with chlorophyll content. This was made non-destructive by sampling the leaves of radish from the plot. The reading was taken from a point one-half the distance from the leaf tip and halfway between the leaf margin and the mid-rib. Five measurements were averaged to give one chlorophyll value for radish leaf per plot. Relative growth rate is the dry weight increment per unit plant weight per unit time. This was determined at 6, 8, 10 and 12 WAS from the sampled plant stands after being oven dried to a constant weight using the formula described by Radford (1967).

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1} \ (gg^{-1}wk^{-1})$$

Where, W_2 and W_1 refers to total dry weight in g/plant at time T_2 and T_1 in weeks respectively and $\log_e$ represents the natural logarithm, and values obtained will be recorded.

This was determined by measuring dry matter per unit area of land per unit time. It was determined at 6, 8, 10 and 12 WAS using the formula as suggested by Radford (1967) as thus;

CGR = $\underline{W2-W_1}$ (gwk^{-1})

$t_2 - t_1$

Where, W_2 and W_1 are dry shoot weights taken at two respective time interval t_2 and t_1. This was determined at 6, 8, 10 and 12 WAS from the sampled plant stands after being oven dried to a constant weight and the values obtained were recorded.

Net assimilation rate (NAR); this expresses the photosynthetic efficiency of the assimilatory surface of the crop. This will be estimated 6, 8, 10 and 12 WAS as described by Watson (1985).

$$NAR = \frac{(W_2 - W_1)}{(T_2 - T_1)} \times \frac{(Log_e A_2 - Log_e A_1)}{(A_2 - A_1)s} \quad (g\ cm^2\ wk^{-1})$$

Where, W_1 and W_2 are dry weight of sample in g/plant, A_2 and A_1 are the corresponding leaf areas, while T_2 and T_1 represent the time interval, and $\log_e$ represents the natural logarithm. Data obtained from the estimates will be recorded. All data collected from the experiment was subjected to analysis of variance (ANOVA) using statistical software (SAS, 2018). The treatment means were compared using Duncan Multiple Range Test (DMRT).

RESULTS

Table 1 presents the effect of fertilizer combinations and training methods on the leaf area index (LAI) of fluted pumpkin (*Telfairia occidentalis*). Leaf area index is an important physiological parameter that reflects the photosynthetic capacity and vegetative growth of crops, as it represents the total leaf surface available for light interception and biomass production. At 6 weeks after sowing (WAS) in 2023, most fertilizer combinations were statistically similar in their effects on LAI, except the NPK100 + PM100 treatment which recorded the highest value. This suggests that early vegetative growth of fluted pumpkin responds positively to combine nutrient sources. The mixture of inorganic fertilizer (NPK) and poultry manure (PM) likely enhanced nutrient availability and improved soil physical and biological properties, resulting in increased leaf development. Similar findings have been reported in studies on fluted pumpkin where integrated nutrient management significantly improved vegetative growth parameters such as leaf area and vine length due to improved nutrient supply and soil fertility status (Falodun and Ogbeifun, 2022).

A similar pattern occurred during the 2024 wet season, where NPK100 + PM100**,** NPK100 + PM0, and NPK50 + PM50 produced the highest LAI values while other treatments recorded comparatively lower but statistically similar values. At 8 WAS in 2023, the treatment NPK100 + PM100 again produced the highest LAI, confirming the advantage of integrated nutrient supply. However, treatments NPK0 + PM100 and NPK0 + PM50 recorded lower LAI values, suggesting that sole application of poultry manure may release nutrients more slowly compared with mineral fertilizer. Organic manures generally require microbial decomposition before nutrients become available, which may delay nutrient release during early growth stages. Nonetheless, when combined with mineral fertilizers, poultry manure can enhance nutrient use efficiency and sustain crop growth (Nwite *et al*., 2014).

In 2024 at 8 WAS**,** NPK100 + PM100 still maintained the highest LAI, although NPK100 + PM0**,** NPK50 + PM50**,** and NPK50 + PM0 were statistically comparable. At 10 WAS in 2023**,** NPK100 + PM100 continued to record the highest LAI, though the differences among treatments were not statistically significant. This indicates that as the crop approached later vegetative stages, nutrient availability from different fertilizer combinations became relatively sufficient to support leaf expansion. However, during the 2024 wet season**,** all fertilized treatments recorded higher LAI compared with the control **(**NPK0 + PM0**)**, which consistently had the lowest value. The poor performance of the control treatment highlights the importance of fertilizer application in maintaining adequate soil nutrient levels for optimal crop growth.

Overall, the results demonstrate that integrated nutrient management particularly the combined application of NPK fertilizer and poultry manure (NPK100 + PM100) consistently improved leaf area index of fluted pumpkin across growth stages. This supports earlier findings that organo-mineral fertilizer combinations enhance crop growth by providing both readily available nutrients from inorganic sources and sustained nutrient release from organic amendments, thereby improving soil fertility and plant performance (Falodun and Ogbeifun, 2022; Nwite *et al*., 2014).

Table 2 presents the effect of fertilizer combinations and training methods on the chlorophyll content of fluted pumpkin (*Telfairia occidentalis*). Chlorophyll content is an important physiological indicator of plant nutritional status and photosynthetic capacity because chlorophyll molecules are directly involved in light absorption and energy conversion during photosynthesis. At 6 weeks after sowing (WAS) in 2023, the fertilizer combinations NPK100 + PM100**,** NPK100 + PM0, and NPK50 + PM0 produced the highest chlorophyll contents, with NPK50 + PM0 statistically similar to the first two treatments. This suggests that the availability of sufficient mineral nutrients especially nitrogen from NPK fertilizer enhanced chlorophyll formation in the early growth stage of the crop. It was indicated that increasing nitrogen supply significantly improves chlorophyll concentration and photosynthetic efficiency in leafy vegetables, including fluted pumpkin (Adekiya *et al*., 2020; Adekiya and Agbede, 2021).

During the 2024 wet season at 6 WAS, NPK100 + PM100, NPK100 + PM0, and NPK50 + PM50 produced the highest chlorophyll contents, while NPK50 + PM0 had slightly lower but statistically comparable values. The improved performance of integrated nutrient treatments indicates the importance of combining organic and inorganic fertilizers in enhancing plant physiological traits. Organic manures such as poultry manure improve soil structure, microbial activity, and nutrient retention, while inorganic fertilizers provide readily available nutrients that promote rapid plant growth (Adekiya *et al*., 2020).

At 8 WAS in 2023, NPK50 + PM50 recorded the highest chlorophyll content, while NPK100 + PM0 and NPK50 + PM0 were statistically comparable to it. Similarly, NPK0 + PM50 showed comparable performance, whereas the control (NPK0 + PM0) recorded the lowest chlorophyll content. This pattern suggests that moderate integration of organic and inorganic nutrient sources may provide a balanced nutrient supply for optimal chlorophyll synthesis during the mid-vegetative stage. The balanced release of nutrients from organo-mineral fertilizer combinations has been reported to enhance chlorophyll concentration and improve photosynthetic performance in vegetable crops (Ojeniyi *et al*., 2019).

A similar trend was observed in 2024 at 8 WAS, where NPK50 + PM50 produced the highest chlorophyll content, with NPK100 + PM100 and NPK100 + PM0 being statistically comparable. The superior performance of the combined fertilizer treatment may be attributed to improved nutrient availability and soil fertility conditions that support chlorophyll biosynthesis. However, NPK0 + PM50 was statistically comparable with NPK50 + PM0, NPK0 + PM100, and the control, indicating that organic manure alone may not always provide sufficient nutrients to sustain high chlorophyll levels during periods of rapid vegetative growth.

At 10 WAS in 2023, all fertilizer treatments were statistically similar and comparable to NPK50 + PM50 and NPK0 + PM50, both of which recorded the highest chlorophyll contents, except for the control which had a lower value. This suggests that as the crop approached later vegetative growth stages, nutrient mineralization from organic sources likely increased, thereby improving nutrient availability and supporting chlorophyll formation. In contrast, during the 2024 wet season at 10 WAS, the treatments NPK50 + PM50, NPK0 + PM100, and NPK0 + PM50 recorded the highest chlorophyll contents, although the control was statistically comparable to most treatments. Seasonal environmental factors such as rainfall, temperature, and soil moisture may influence nutrient mineralization and plant nutrient uptake, thereby affecting chlorophyll accumulation.

At 12 WAS in 2023, NPK50 + PM50 recorded the highest chlorophyll content, while NPK100 + PM100 had a slightly lower but statistically similar value. Treatments NPK50 + PM0, NPK0 + PM100, and NPK0 + PM50 were statistically comparable to NPK100 + PM0, whereas the control recorded the lowest chlorophyll content. Similarly, during the 2024 season at 12 WAS, NPK50 + PM50 again produced the highest chlorophyll content with NPK100 + PM100 being statistically comparable. The consistent superiority of NPK50 + PM50 at later growth stages suggests that moderate integrated fertilizer application may provide a balanced and sustained nutrient supply for chlorophyll synthesis and leaf development in fluted pumpkin.

Across both seasons, trained plants exhibited significantly higher chlorophyll content than non-trained plants, particularly at 12 WAS. Training likely improved canopy structure and light interception, thereby enhancing photosynthetic efficiency and chlorophyll accumulation. Proper vine management improves aeration and reduces mutual shading among leaves, which can increase chlorophyll stability and photosynthetic activity in climbing vegetables. Similar findings have been reported where improved canopy management practices enhanced photosynthetic performance and chlorophyll concentration in vegetable crops (Zhang *et al*., 2021).

Table 3 presents the effect of fertilizer combinations and training methods on the crop growth rate (CGR) of fluted pumpkin (*Telfairia occidentalis*). Crop growth rate is an important physiological index that reflects the rate of dry matter accumulation per unit area over time and provides insight into the overall vigor and productivity of a crop. CGR is influenced by factors such as nutrient availability, leaf area development, photosynthetic efficiency, and environmental conditions. At 8 weeks after sowing (WAS) in 2023, the fertilizer combination NPK100 + PM100 produced the highest crop growth rate, although it was statistically comparable with other treatments. At 10 and 12 WAS in 2023, all fertilizer treatments were statistically similar except for the control treatment (NPK0 + PM0), which recorded the lowest crop growth rate.

A similar trend was observed during the 2024 wet season, where NPK100 + PM100 recorded the highest crop growth rate at 8 and 10 WAS, although the differences among fertilized treatments were not statistically significant. This indicates that once sufficient nutrients were supplied, plants across the fertilized plots were able to maintain comparable growth rates. Organic manure mineralization over time may also have contributed to sustained nutrient availability during later growth stages, supporting biomass accumulation and crop development.

At 12 WAS in 2024, NPK100 + PM100 again recorded the highest crop growth rate, while other fertilized treatments remained statistically comparable except for the control, which consistently recorded the lowest values. The consistent inferiority of the control treatment confirms that nutrient supply is a key determinant of crop growth rate in fluted pumpkin. Adequate fertilization enhances leaf area development and photosynthetic capacity, which in turn increases the rate of assimilate production and plant biomass accumulation.

Regarding the effect of training methods, non-trained plants exhibited higher crop growth rates than trained plants at certain stages of growth. This may be attributed to differences in assimilate allocation and canopy structure. Non-trained plants may produce more vegetative biomass due to unrestricted vine growth, thereby increasing the rate of dry matter accumulation. However, training practices often improve canopy arrangement, light penetration, and aeration, which can enhance leaf efficiency and crop management rather than directly increasing biomass accumulation. In climbing vegetable crops, training systems are primarily used to improve canopy structure and facilitate harvesting rather than significantly altering physiological growth rates.

Furthermore, no significant interaction effects were observed between fertilizer combinations and training methods, indicating that both factors independently influenced crop growth rate. This suggests that fertilizer application primarily determines nutrient availability and vegetative growth, while training mainly affects canopy structure and plant architecture.

The consistently low crop growth rate recorded in the control treatment reflects the consequences of nutrient deficiency, which limits essential physiological processes such as cell division, leaf expansion, and photosynthesis. According to Agbede, T. M. (2009), soils lacking adequate nutrients often result in poor vegetative growth, reduced leaf area, and limited dry matter accumulation.

The similarity observed among fertilized treatments suggests that once a threshold level of nutrients is reached, additional increases may not significantly alter growth rate within a given growth stage. This finding aligns with the work of Ayoola, O. T. and Makinde, E. A. (2007), who reported that combined application of organic and inorganic fertilizers improves nutrient availability and supports optimal crop performance. Similarly, Eifediyi, E. K. and Remison, S. U. (2010) found that fluted pumpkin responds positively to both poultry manure and NPK fertilizer, with significant improvements in growth parameters compared to unfertilized controls.

Adequate nutrient supply enhances leaf area development and chlorophyll formation, thereby increasing photosynthetic efficiency and assimilates production. Adebayo, A. G. *et al.* (2011) reported that higher fertilizer application rates significantly improve vegetative growth and yield of fluted pumpkin, largely due to increased nutrient uptake and improved physiological activity.

With respect to training methods, the higher crop growth rate observed in non-trained plants at certain stages can be attributed to unrestricted vegetative growth and greater assimilate allocation to vine elongation and leaf production. However, training systems influence plant architecture rather than directly enhancing physiological growth rates. As noted by Norman, J. C. (1992), staking and training in climbing vegetables primarily improve canopy structure, light interception, and air circulation, which are beneficial for crop management and yield quality rather than biomass accumulation alone. Similarly, Ogunlela, V. B. *et al*. (2005) observed that training systems enhance canopy efficiency but may not always result in higher vegetative growth compared to non-trained plants.

Table 4 presents the effect of fertilizer combinations and training methods on the relative growth rate (RGR) of fluted pumpkin (*Telfairia occidentalis*). Relative growth rate is an important physiological parameter that measures the increase in plant biomass per unit of existing biomass over time, reflecting the efficiency with which plants convert assimilates into new growth. At 8 weeks after sowing (WAS) in 2023, the fertilizer combination NPK100 + PM100 recorded the highest relative growth rate. However, the control treatment (NPK0 + PM0) was statistically similar and comparable to other treatments. The superior performance of the NPK100 + PM100 treatment could be attributed to the synergistic effect of combining inorganic fertilizer with poultry manure, which improves nutrient availability and soil fertility. Integrated nutrient management has been reported to enhance vegetative growth and biomass accumulation in fluted pumpkin and other leafy vegetables by improving soil nutrient balance and promoting microbial activity (Adekiya *et al*., 2020; Olaniyi and Ajibola, 2021). Similarly, during the 2024 wet season at 8 WAS, NPK100 + PM100 and NPK100 + PM0 produced the highest relative growth rates, while other treatments were statistically comparable. The enhanced RGR under these treatments may be linked to increased nitrogen availability, which stimulates chlorophyll synthesis, photosynthetic activity, and protein formation. Similar research have indicated that adequate nitrogen supply significantly improves physiological growth parameters such as RGR, net assimilation rate, and crop growth rate in vegetable crops (Adekiya and Agbede, 2021).

At 10 WAS in 2023, all fertilizer treatments were statistically similar except for the control, which recorded a lower relative growth rate. The reduced RGR in the control treatment indicates that nutrient deficiency limited biomass accumulation and metabolic activities in the plants. Nutrient-poor soils often result in reduced leaf development, limited photosynthetic capacity, and lower dry matter production, ultimately affecting plant growth performance. Conversely, fertilized plots likely benefited from improved nutrient availability and uptake, which supported sustained vegetative growth. In 2024 at 10 WAS, the treatments NPK100 + PM100**,** NPK100 + PM0, and NPK50 + PM50 produced the highest relative growth rates, although other treatments remained statistically comparable. This finding further highlights the importance of balanced fertilization in promoting efficient biomass accumulation. The combination of organic and inorganic fertilizers provides both immediate and slow-release nutrient sources, ensuring continuous nutrient availability throughout the growth cycle. Similar results have been reported where organo-mineral fertilizer combinations improved growth parameters and biomass production in fluted pumpkin compared with sole fertilizer applications (Ojeniyi *et al*., 2019).

At 12 WAS in 2023**,** NPK100 + PM100 again produced the highest relative growth rate. Treatments NPK0 + PM100 and NPK0 + PM50 were statistically comparable to most fertilized treatments but differed from the control (NPK0 + PM0), which recorded the lowest RGR. Organic amendments such as poultry manure enhance soil organic matter, improve nutrient retention, and stimulate microbial activity, which collectively support plant growth over time. Similarly, during the 2024 wet season at 12 WAS**,** NPK100 + PM100 maintained the highest relative growth rate, while the remaining treatments were statistically comparable. The consistent performance of this treatment across growth stages indicates the effectiveness of integrated nutrient management in sustaining plant growth and biomass accumulation in fluted pumpkin production systems. Similar results have been reported where organo-mineral fertilizer combinations improved growth parameters and biomass production in fluted pumpkin compared with sole fertilizer applications (Ojeniyi *et al*., 2019).

With respect to training methods, trained plants recorded higher relative growth rates than non-trained plants at certain growth stages in both years. This may be attributed to improved canopy architecture and better light interception resulting from training practices. Proper vine training reduces leaf overlap and shading, allowing more efficient photosynthesis and assimilation of carbon for plant growth. Improved light penetration within the canopy can enhance physiological efficiency, leading to increased biomass accumulation and growth rates in climbing vegetables. Similar observations have been reported where canopy management practices improved photosynthetic efficiency and growth performance in vegetable crops (Zhang *et al*., 2021).

Furthermore, no significant interaction effects were observed between fertilizer combinations and training methods, indicating that both factors independently influenced the relative growth rate of fluted pumpkin. Fertilizer application mainly affected nutrient availability and physiological growth processes, while training influenced canopy structure and light interception.

Table 5 presents the effect of fertilizer combinations and training methods on the net assimilation rate (NAR**)** of fluted pumpkin (*Telfairia occidentalis*). Net assimilation rate is a physiological parameter that measures the rate of increase in plant dry matter per unit leaf area over time and reflects the efficiency of photosynthesis and assimilate production in plants. At 8 weeks after sowing (WAS) in 2023, all fertilizer treatments were statistically similar except for the control (NPK0 + PM0), which recorded the lowest net assimilation rate. Nutrient deficiency, particularly nitrogen deficiency, can significantly reduce chlorophyll synthesis and photosynthetic activity, ultimately affecting the assimilation of carbon in plant tissues. Similar sesearch have demonstrated that adequate nutrient supply significantly improves physiological growth indices such as NAR and relative growth rate in leafy vegetables (Adekiya *et al*., 2020; Adekiya and Agbede, 2021).

During the 2024 wet season, a clearer treatment response was observed. At 8 WAS, the fertilizer combination NPK100 + PM100 recorded the highest net assimilation rate. Treatments NPK0 + PM100 and NPK0 + PM50 were statistically similar and comparable to other fertilized treatments but differed from the control, which again recorded the lowest value. The superior performance of the NPK100 + PM100 treatment may be attributed to the synergistic effect of combining inorganic fertilizer with poultry manure. Inorganic fertilizers provide readily available nutrients required for rapid plant growth, while organic manures improve soil structure, enhance microbial activity, and supply nutrients gradually through mineralization. Such integrated nutrient management practices have been reported to improve plant physiological efficiency and biomass accumulation in fluted pumpkin and other leafy vegetables (Ojeniyi *et al*., 2019).

At 10 WAS in 2023**,** NPK100 + PM100 and NPK100 + PM0 recorded the highest net assimilation rates, while other treatments were statistically comparable except for the control, which again had the lowest value. The improved performance of treatments containing higher NPK levels indicates the importance of mineral nutrients, especially nitrogen, in supporting photosynthetic processes. Nitrogen is a key component of chlorophyll molecules and enzymes involved in photosynthesis, and its adequate supply enhances carbon assimilation and plant growth (Xu *et al*., 2022).

In contrast, during 10 WAS in 2024, all fertilizer treatments were statistically similar except for the control, which recorded a lower net assimilation rate. Environmental conditions such as rainfall and soil moisture during the wet season may also influence nutrient mineralization and uptake, thereby affecting plant physiological responses.

At 12 WAS in 2023, all treatments were again statistically similar except for the control, which recorded the lowest net assimilation rate. This result may be attributed to increased nutrient mineralization from organic sources as the season progressed, allowing plants in different fertilizer treatments to access sufficient nutrients for photosynthesis and biomass accumulation. However, during the 2024 wet season at 12 WAS**,** NPK100 + PM100 once again recorded the highest net assimilation rate, while NPK0 + PM100 and NPK0 + PM50 were statistically comparable with other treatments except the control. The consistent inferiority of the control treatment across growth stages highlights the importance of nutrient supplementation for sustaining plant physiological performance.

With respect to training methods, trained plants recorded slightly higher net assimilation rates than non-trained plants in both years**.** This improvement may be attributed to better canopy architecture and improved light interception resulting from plant training. Training systems in climbing crops such as fluted pumpkin help reduce leaf overlap and shading, thereby increasing light penetration within the canopy and enhancing photosynthetic efficiency. Improved canopy management has been reported to increase photosynthetic activity and assimilation rates in vegetable crops by optimizing leaf exposure to sunlight (Zhang *et al*., 2021).

Furthermore, no significant interaction effects were observed between fertilizer combinations and training methods, indicating that the effects of fertilizer application and training practices on net assimilation rate were largely independent. Fertilizer treatments mainly influenced nutrient availability and physiological processes, while training practices primarily affected canopy structure and light interception.

Conclusively, the results suggest that adequate fertilization particularly the combined application of NPK fertilizer and poultry manure (NPK100 + PM100) enhanced net assimilation rate in fluted pumpkin by improving nutrient availability and supporting efficient photosynthetic activity. Conversely, the absence of fertilizer application resulted in reduced assimilation efficiency due to nutrient limitations in the soil.

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Table 1: Effect of fertilizer combination and training method on leaf area index of fluted pumpkin at Samaru during the 2023 and 2024 wet season.

	Leave Area Index (LAI)							
	2023				**2024**			
Treatment	**6WAS**	**8WAS**	**10WAS**	**12WAS**	**6WAS**	**8WAS**	10WAS	12WAS
Nutrition (N)								
NPK100+PM100	3.72	4.19a	5.02	5.19a	3.33	4.28a	6.03a	6.72a
NPK100+PM0	3.54	4.02ab	4.95	4.99ab	3.02	4.03ab	6.43a	6.52a
NPK50+PM50	3.54	4.01ab	4.89	5.17a	3.01	4.02ab	5.87a	6.49a
NPK50+PM0	3.42	3.89ab	4.84	4.85ab	2.81	3.85ab	5.81a	5.82b
NPK0+PM100	3.36	3.64b	4.84	4.79ab	2.71	3.45b	6.30a	5.75b
NPK0+PM50	3.33	3.62b	4.82	4.76ab	2.66	3.43b	6.28a	5.72b
NPK0+PM0	3.32	3.56b	4.67	4.31b	2.64	3.34b	4.10b	4.15c
SE±	**0.140**	**0.153**	**0.162**	**0.138**	**0.238**	**0.231**	**0.194**	**0.166**
Training (T)								
Train	3.48	3.89	4.96	5.06a	2.91	3.83	5.96	6.07a
Non train	3.44	3.80	4.76	4.79b	2.86	3.70	5.71	5.75b
SE±	**0.075**	**0.082**	**0.087**	**0.074**	**0.127**	**0.123**	**0.104**	**0.088**
Interaction								
NxT	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means followed by same letter(s) within same column are not different statistically at *P=0.05* level of probability using DMRT, NS=
Not significant
WAS = Weeks after sowing

Table 2: Effect of fertilizer combination and training method on chlorophyll content of fluted pumpkin at Samaru during the 2023 and 2024 wet season.

	Chlorophyll Content							
	2023				2024			
Treatment	**6WAS**	**8WAS**	**10WAS**	**12WAS**	**6WAS**	**8WAS**	10WAS	12WAS
Nutrition (N)								
NPK100+PM100	12.81a	19.27ab	25.40ab	28.17ab	22.81a	19.27ab	19.40ab	22.17ab
NPK100+PM0	10.65a	18.40abc	23.92ab	25.86bc	22.65a	18.40ab	17.92ab	17.61cd
NPK50+PM50	12.65a	22.46a	26.30a	31.09a	20.65a	22.46a	20.30a	25.09a
NPK50+PM0	8.44ab	17.53abc	22.34ab	23.79b	18.44ab	16.53abc	16.34ab	17.79cd
NPK0+PM100	5.03bc	14.45bc	24.81ab	23.61b	14.67bc	13.45bcd	18.81a	19.86bc
NPK0+PM50	3.62c	13.25c	25.64a	22.54b	13.62bc	12.25cd	19.65a	16.54cd
NPK0+PM0	3.08c	7.35d	12.85c	13.30c	12.71c	10.35d	13.85b	14.30d
SE±	1.574	1.972	1.761	1.424	1.634	1.971	1.761	1.424
Training (T)								
Train	7.64	16.71	23.12	25.38a	17.43	16.71	18.12	20.38a
Non train	8.45	15.49	22.95	22.72b	18.45	15.49	17.95	17.72b
SE±	0.841	1.053	0.941	0.761	0.874	1.054	0.941	0.761
Interaction								
NxT	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means followed by same letter(s) within same column are not different statistically at *P=0.05* level of probability using DMRT. NS = Not significant

Table 3: Effect of fertilizer combination and training method on crop growth rate of fluted pumpkin at Samaru during the 2023 and 2024 wet season.

	Crop Growth Rate					
	2023			2024		
Treatment	**8WAS**	**10WAS**	**12WAS**	**8WAS**	**10WAS**	**12WAS**
Nutrition (N)						
NPK100+PM100	12.32a	22.65a	7.39a	4.92	19.15	24.89a
NPK100+PM0	10.56ab	21.90a	6.36a	4.70	18.40	23.86ab
NPK50+PM50	10.60ab	21.43a	6.39a	3.88	17.93	23.39ab
NPK50+PM0	10.06ab	21.19a	5.32a	3.31	17.69	22.82ab
NPK0+PM100	9.09ab	21.01a	5.24a	3.01	17.51	22.67ab
NPK0+PM50	8.10ab	20.99a	3.16a	2.98	17.49	19.94b
NPK0+PM0	3.83b	12.94b	2.54b	1.74	11.44	14.92c
SE±	**1.604**	**1.681**	**1.362**	**1.195**	**1.681**	**1.452**
Training (T)						
Train	7.22b	21.01	4.61	2.32b	21.97	21.97
Non train	11.23a	19.59	5.76	4.69a	23.02	23.02
SE±	**0.857**	**0.898**	**0.728**	**0.639**	**0.898**	**0.777**
Interaction						
NxT	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within same column are not different statistically at *P=0.05* level of probability using DMRT.
NS = Not significant
WAS = Weeks after sowing

Table 4: Effect of fertilizer combination and training method on relative growth rate of fluted pumpkin at Samaru during the 2023 and 2024 wet seasons.

	Relative Growth Rate					
	2023			2024		
Treatment	**8WAS**	**10WAS**	**12WAS**	**8WAS**	**10WAS**	**12WAS**

Nutrition (N)						
NPK100+PM100	2.14a	2.65a	2.77a	3.02a	4.56a	4.14a
NPK100+PM0	1.99ab	2.65a	2.61ab	3.01a	4.54a	3.98ab
NPK50+PM50	2.03ab	2.62a	2.61ab	2.86ab	4.02a	3.89ab
NPK50+PM0	1.91ab	2.62a	2.56ab	2.84ab	3.84ab	3.85ab
NPK0+PM100	1.98ab	2.56a	2.48b	2.69ab	3.77ab	3.79ab
NPK0+PM50	1.97ab	2.47a	2.43b	2.64b	3.67ab	3.66b
NPK0+PM0	1.39b	1.01b	1.00c	2.56b	2.66b	3.63b
SE±	**0.073**	**0.081**	**0.082**	**0.103**	**0.174**	**0.139**
Training (T)						
Train	1.94	2.42	2.35	2.92a	3.93	3.91
Non train	1.95	2.33	2.36	2.69b	3.80	3.79
SE±	**0.039**	**0.043**	**0.044**	**0.055**	**0.093**	**0.074**
Interaction						
NxT	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means followed by same letter(s) within same column are not different statistically at *P=0.05* level of probability using DMRT.
NS = Not significant
WAS = Weeks after sowing

Table 5: Effect of fertilizer combination and training method on net assimilation rate of fluted pumpkin at Samaru during the 2023 and 2024 wet season.

	Net Assimilation Rate (NAR)					
	2023			**2024**		
Treatment	**8WAS**	**10WAS**	**12WAS**	**8WAS**	**10WAS**	**12WAS**
Nutrition (N)						
NPK100+PM100	1.74a	1.61a	1.62a	2.21a	2.07a	3.22a
NPK100+PM0	1.72a	1.61a	1.61a	2.04ab	2.07a	3.01ab
NPK50+PM50	1.68a	1.54ab	1.61a	1.98ab	2.04a	3.01ab
NPK50+PM0	1.67a	1.54ab	1.54a	1.86ab	2.03a	2.96ab
NPK0+PM100	1.67a	1.48ab	1.52a	1.82b	1.96a	2.85b
NPK0+PM50	1.61a	1.46b	1.47a	1.79b	1.84a	2.79b
NPK0+PM0	0.45b	0.74c	0.77b	0.69c	0.76b	1.75c
SE±	**0.056**	**0.039**	**0.065**	**0.111**	**0.102**	**0.102**
Training (T)						
Train	1.48	1.47a	1.48	1.90	2.02	2.93
Non train	1.44	1.38b	1.43	1.92	1.91	2.95
SE±	**0.029**	**0.020**	**0.034**	**0.059**	**0.054**	**0.054**
Interaction						
NxT	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within same column are not different statistically at *P=0.05* level of probability using DMRT.
NS= Not significant
WAS = Weeks after sowing