Vol. 18(7), pp. 576-585, July, 2022
DOI: 10.5897/AJAR2022.15967
Article Number: BC507D669463
ISSN: 1991-637X

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African Journal of Agricultural Research

Full Length Research Paper

Growth and yield of carrots affected by integrated nutrient management of organic and inorganic fertilizers

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Received 7 February, 2022; Accepted 24 May, 2022

Two experiments were conducted at the Multipurpose Crop Nursery Research fields of the Akenten Appiah-Menka University of Skill Training and Entrepreneurial Development (AAMUSTED), Mampong-Ashanti during the 2018 major (March-July) and minor (September-December) seasons to assess the effect of organic and inorganic fertilizers and their combinations on the growth and yield of carrot. Four organic manures [cattle dung (CD), poultry manure (PM), *Gliricidia sepium* prunnings (GP) and *Leucaena leucocephala* prunnings (LP)] at 10 t/ha, NPK 15-15-15 at 300 kg/ha, their combinations (at ½ full) and no amendment (control) were arranged in a randomized complete block design with four replications. Combining organic manures and inorganic fertilizers increased the growth and yield of carrot greater than the control and sole fertilizers. Plant height and canopy width were greatest for the 5 t/ha CD + 5 t/ha PM and 5 t/ha PM + 5 t/ha GP in both seasons. Carrot root yields in both seasons for the organic and inorganic combinations ranged from 24.3-54.2 t/ha, which was 9-14% and 25-95% greater than the sole fertilizers (22.2-47.6 t/ha) and control (19.4-27.8 t/ha), respectively. Root yields in the major and minor seasons were highest for 5 t/ha CD + 5 t/ha GP and 5 t/ha CD + 5 t/ha PM, respectively.

Key words: Organic and inorganic fertilizer, growth, yield, carrot.

INTRODUCTION

Carrot (*Daucus carata* L.) is a biennial crop of the Apiaceae (Umbelliferae) family (Shaffer, 2000), and is globally ranked third in production among the root crops, after cassava and sweet potato. Carrot (*D. carota* L.) is one of the most preferred vegetables globally, due to its versatility in culinary uses and its enriched healthy

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Table 1. Initial physical and chemical characteristics of soils (0-20cm depth) at the sites during the two growing seasons.

Season	Physical properties			Chemical properties									
	Sand	Silt	Clay	pH	Org. C	Total N	Org. matter	P	K	Mg	Ca	Fe	Mn
	%			1:2.5	%			ppm	mg/kg			mg/kg	
Major season	84	8	8	5.06	0.23	0.2	0.40	21.21	90	850	2980	52.6	12.0
Minor season	82	9	9	4.72	0.45	0.06	0.72	18.26	220	930	1070	55.4	255

Source: Primary data from study

composition, such as phytonutrients, dietary fibre and minerals (Sharma et al., 2006). Carrot production in Ghana can be a lucrative enterprise, especially for most small scale, resource-poor farmers, since it is a short duration crop and can also produce higher yields per unit area (Ahmad et al., 2005). Success in vegetable culture in a temperate climate has been attributed to proper mineral nutrition because plant nutrition, among other agro-technical measures most influences yield, quality and storability (Biesiada et al., 2011).

In Ghana, small-holder farmers have resorted to amending soils with organic and inorganic fertilizers due to scarce land availability and inherently poor soil fertility. Combined use of organic and inorganic fertilizers provides synergistic effects for greater soil improvement and crop nutrients for crop growth, development and yields. While inorganic fertilizers supply readily available plant nutrients for greater plant growth and increased crop yields and productivity; organic fertilizers improve soil physical conditions by increasing soil porosity and decreasing bulk density allowing smooth root penetration and growth into the soil and also the gradual release of plant nutrients (Dauda et al., 2008; Subedi et al., 2018). *Gliricidia sepium, Leucaena leucocephala* and *Mucuna pruriens* are among a number of plant species readily available in the forest-savanna transition zones of Ghana (Gyamfi et al., 2001), but their green manure potentials have not been widely exploited in carrot production and storability.

The use of 20 t/ha of poultry manure produced higher carrot root yield than 250 kg of NPK/ha applied in the transitional zone of Ghana (Poku et al., 2014), while Atakora et al. (2014) reported higher carrot yield at 20 t/ha grasscutter manure than applying NPK. Dawuda et al. (2011) also observed that 15 to 20 t/ha of poultry manure increased carrot root length and yield. Mbatha (2008) recorded significant plant height and number of leaves of carrot at high rates of chicken and cattle manure. According to Daba et al. (2018), irrespective of the level of cattle manure applied, growth parameters of carrot plants were improved. They also indicated that 10 t/ha cattle manure increased the root weight by about half as compared to the control treatment.

Studying three different levels of urea (100, 150 and 200 kg N/ha) and three different levels of cattle dung (10, 15 and 20 t/ha), Mehedi et al. (2012) also recommended the combination of 150 kg N/ha + 15 t/ha of cattle dung for vigorous growth of carrot plants. A combination of 1/2 PM + 1/2 FYM gave the best yield and quality of carrots based on the pronounced effects of FYM, leaf manures (LF), poultry manure (PM) and chemical fertilizers on carrot growth and yield (Ahmad et al., 2014). The objective of the study was to assess the effect of organic and inorganic fertilizers and their combinations on the growth and yield of carrot.

MATERIALS AND METHODS

Two field experiments were conducted at the Multipurpose Crop Nursery Research site of the Akenten Appiah-Menka University of Skill Training and Entrepreneurial Development, Mampong Campus, in the Ashanti Region of Ghana during the major rainy season (March-July, 2018) and minor rainy seasons (September-December, 2018). Mampong-Ashanti (7', 8°N, 1', 24°W) is located in the forest-savanna transitional zone of Ghana at an altitude of 457.5 m above sea level. The soils at the experimental sites belong to the Bediesi series of the Savannah Ochrosol derived from Voltaian sandstone of the Afram Plains and are classified as Chromic Luvisol according to the FAO/UNESCO Soil classification (FAO, 1988). Table 1 shows some of the initial physical and chemical characteristics of the soil at the experimental sites.

The maximum average temperature recorded during the experiment was 31.3°C and the minimum temperature was 23°C in the major season, while in the minor season the average maximum and minimum temperatures were 30.9 and 22.2°C, respectively. Total rainfall recorded during the experimental period in the major season was 628.9 mm, with a maximum and minimum average relative humidity of 92.7 and 71.3%, respectively. In the minor season, total rainfall recorded was 561.4 mm and the maximum average relative humidity was 93.7% and the minimum was 60.3%.

Experimental design and treatments

A Randomized Complete Block Design (RCBD) with fifteen treatments consisting of five (5) organic manures and inorganic fertilizer rates and their combinations and the control (no fertilizer) with four replications was used. The treatments were: 10 t/ha cattle dung (CD) (Full CD); 10 t/ha poultry manure (PM) (Full PM); 300 kg/ha NPK (Full NPK); 10 t/ha *G. sepium* prunnings (GP) (Full GP); 10 t/ha *L. leucocephala* prunnings (LP) (Full LP); 5 t/ha cattle dung + 5 t/ha poultry manure (½ CD + ½ PM); 5 t/ha cattle dung + 150 kg/ha NPK (½ CD + ½ NPK); 5 t/ha cattle dung + 5 t/ha *G. sepium*

(½ CD + ½ GP); 5 t/ha cattle dung + 5 t/ha *L. leucocephala* (½ CD + ½ LP); 5 t/ha poultry manure + 5 t/ha *G. sepium* (½ PM + ½ GP); 5 t/ha poultry manure + 5 t/ha *L. leucocephala* (½ PM + ½ LP); 150 kg/ha NPK + 5 t/ha *G. sepium* (½ NPK + ½ GP); 150 kg/ha NPK + 5 t/ha *L. leucocephala* (½ NPK + ½ LP); 5 t/ha poultry manure + 150 kg/ha NPK (½ PM + ½ NPK); No fertilizer (control).

The improved Kuroda (TOKITA) carrot variety seeds were planted on bed sizes of 2 m long × 1 m wide, with planting distance of 25 cm between rows and 10 cm within rows. The cattle dung and poultry manure used were obtained from the kraal and deep litter system of housing, respectively in the livestock farm at the Akenten Appiah-Menka University of Skill Training and Entrepreneurial Development (AAMUSTED), Mampong campus. These were heaped under shade for one month to dry and further decompose before being applied. Leaves of *G. sepium* and *L. leucocephala* were harvested and pruned from the same farm. The organic manures and plant prunings were weighed, applied to the soil and allowed to further decompose in the soil for three weeks before planting. Beds were watered twice a week to help in the decomposition. The inorganic fertilizer (N.P.K. 15-15-15) was applied 3 weeks after planting. Other cultural practices carried out during the experiment were weeding, irrigation and earthening-up. Weeding was done when necessary and watering was done every three days during root development. The total experimental time (sowing to harvesting) was 90 days.

Data collected included plant height, canopy spread, leaf chlorophyll content, shoot dry matter, root fresh and dry matter and root yield.

Plant height

Five plants per plot were randomly selected from the middle rows and tagged for data collection. Data was taken at 2-week interval from 30 days after planting (DAP) to 86 DAP. A meter rule was placed at ground level to the top of the shoot and their values recorded in centimeters.

Canopy width

The canopy width was measured from the widest spread of canopy with the help of a meter rule and recorded in centimeters. The meter rule was used in taking the measurements, and their values recorded.

Chlorophyll content of leaves

The chlorophyll content of leaves was measured at 4 weeks interval from 58 to 86 DAP. Leaf chlorophyll content was measured using a chlorophyll meter (SPAD-502 plus). Reading was taken on the lower, middle and upper leaves from the five randomly selected and tagged plants and the average calculated.

Dry matter accumulation

Three (3) plants were destructively sampled from the border rows, separated into shoot and root and weighed using an electronic scale for shoot fresh weight and root fresh weight. The shoot and root samples were oven-dried at 75 to 80°C for 72 h to remove all moisture. Dried samples were also weighed using an electronic scale and the mean values per treatment estimated.

Root yield

At harvest, carrot roots harvested from the central rows were weighed in using the scale. The weight obtained in kilograms per hectare (kg/ha) was then converted to tons per hectare (t/h). Results were analyzed using Analysis of Variance with GenStat Version 11.1 Statistical package (Genstat, 2008). The Least Significant Difference (LSD) at 5% was used to separate treatment means.

RESULTS AND DISCUSSION

Plant height

There were significant differences in plant height among the treatments in both the major and minor seasons. Generally, in the major season, ½ CD + ½ PM, ½ PM + ½ GP, ½ CD + ½ LP and full PM gave the tallest plant height (Figure 1a). The full LP, control and ½ PM + ½ NPK gave the shortest plant height, while the remaining treatments produced intermediate plant heights (Figure 1a). Similarly, in the minor season ½ CD + ½ PM, ½ PM + ½ GP, ½ GP + ½ NPK and full PM gave the tallest plant height over the sampling periods (Figure 1b). The full LP, control and ½ PM + ½ NPK once again produced the shortest plant height in the minor season (Figure 1b). These findings are similar to that of Ahmad et al. (2014) who reported that integrated nutrient management practices where farm yard manure + poultry manure produced the tallest plant height. According to Dauda et al. (2008), poultry manure has the ability to supply essential plant nutrients required during the early and later stages of plant growth to promote plant growth.

Canopy width

There were also significant differences in canopy width among the treatments in both the major and minor seasons, and the trends were similar to that of the plant height. Generally, in the major season, ½ CD + ½ PM, ½ PM + ½ GP, ½ CD + ½ LP and full PM gave the widest canopy width, while full LP, control and ½ GP + ½ NPK gave the least canopy width (Figure 2a). The remaining treatments produced intermediate canopy widths (Figure 2a). Similarly, in the minor season ½ CD + ½ PM, ½ PM + ½ GP, ½ GP + ½ NPK, ½ PM + ½ NPK and full PM produced the widest canopies, while full LP, ½ PM + ½ LP, ½ GP + ½ NPK, control and full NPK had the least canopy widths over the sampling periods (Figure 2b). The improved canopy widths probably might be that cattle dung and poultry manure and their synergistic effects with *Gliricidia* and NPK had improved the soil physical property, increased the water holding capacity of the soil and readily made nutrients available, which increased plant growth and the canopy width of carrot plant. The increased plant height might have also supported greater canopy development. Daba et al. (2018) and Dawuda et al. (2011) had observed that cattle dung application improved carrot vegetative growth.

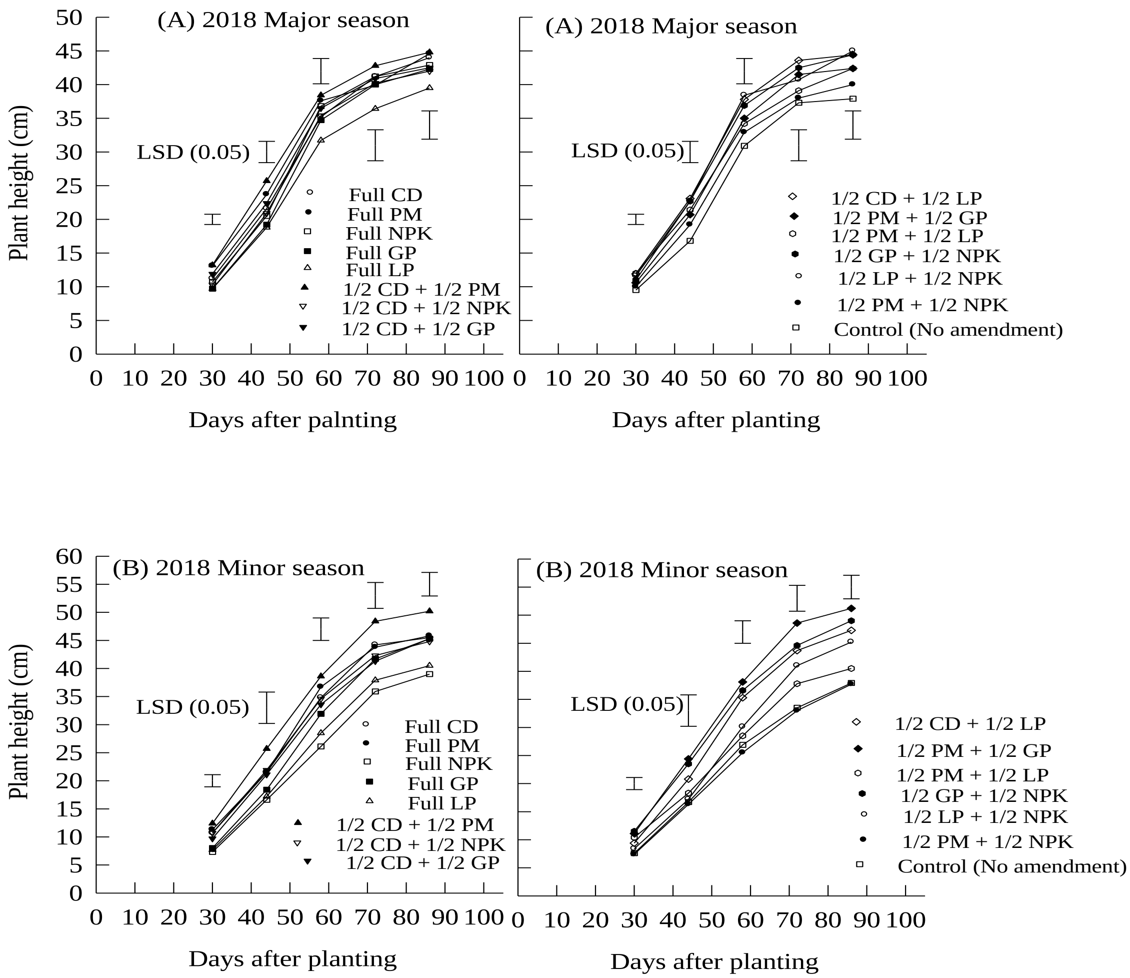

Figure 1. Plant height of carrots as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

Number of leaves per plant

Full GP and ½ CD + ½ LP produced the higher number of leaves for both seasons. Similarly, poultry manure combined with LP, NPK, CD and GP produced higher number of leaves in both seasons. In both seasons, full LP and the control had the least number of leaves. Full CD and full NPK also produced low number of leaves in the major and minor seasons, respectively. The readily available nutrients in PM and NPK combined with relatively slow release of nutrients from LP, CD and GP and the combined effects of organic fertilizers in improving soil physical properties probably accounted for the high number of leaves produced during both seasons.

The control treatment had the least number of leaves on all sampling occasions. Presumably, due to the slow releasing nature of organic manure and nutrients, *G. sepium* pruning produced greater number of leaves in the later samplings in the major season at Mampong in 2018. Agyeman et al. (2013) reported that the nutrient release pattern of decomposing *G. sepium* leaf litter increased with weeks with noticeable increase in all the nutrient elements during nutrient release. Also, studies by Makumba et al. (2006) reported high crop response to organic fertilizer application from agro forestry trees. Fahnirrozi et al. (2017) suggested the use of green biomass in combination with several other green biomasses in a study to develop organic liquid fertilizer from six potential biomasses including *L. leucocephala* and *G. sepium*.

Chlorophyll content of leaves

The chlorophyl content of leaves which also differed among the treatments in both the major and minor seasons, ranged from 12.34 to 17.52 mg/g at 8 WAP and 8.85 to 15.2 mg/g at 12 WAP during the major season.

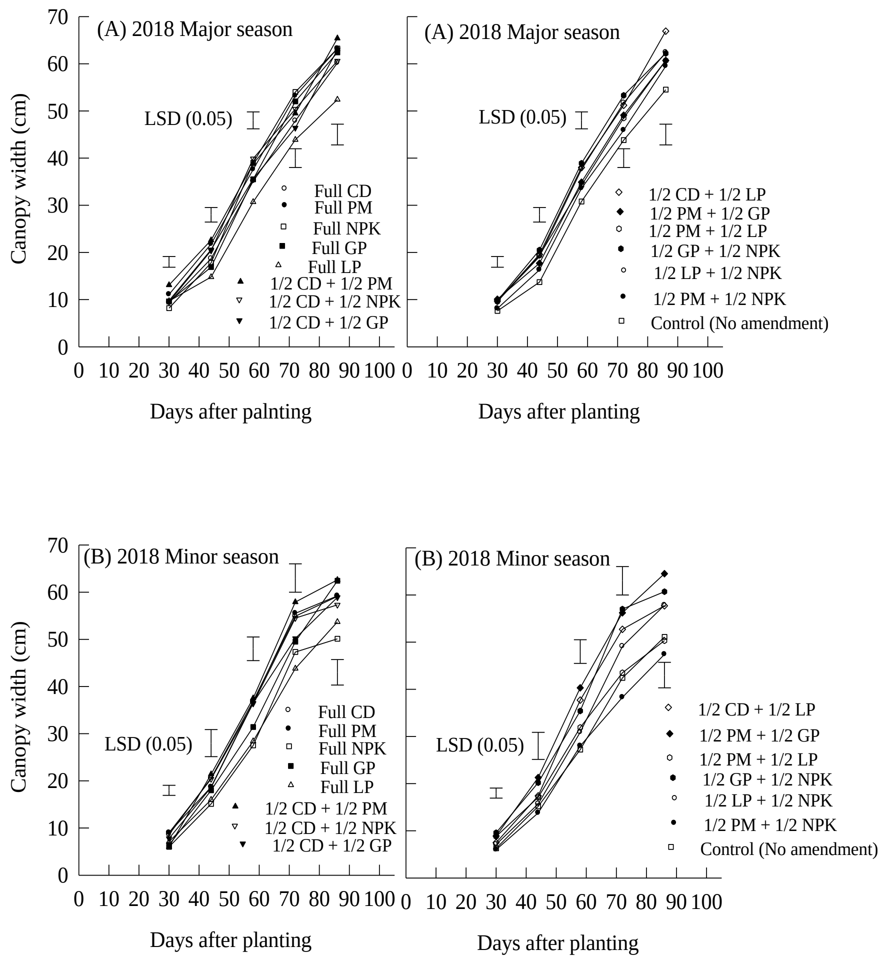

Figure 2. Canopy width of carrots as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

Chlorophyl content ranged from 14.11- to 17.88 mg/g at 8 WAP and 10.20 to 16.95 mg/g at 12 WAP during the minor season (Figure 3a and b). Generally, the chlorophyl content was slightly higher at 8 WAP than 12 WAP, by which period some amount of senescence had occurred. In the major season, ½ CD + ½ GP, ½ CD +1/2 NPK, ½ CD + ½ PM and ½ PM + ½ GP had higher leave chlorophyl contents at 8 and 12 WAP (Figure 3a). Full PM, full CD, full LP produced lower chlorophyl contents at 8 and 12 WAP, indicating generally that the organic and inorganic combinations produced higher chlorophyl content than straight applications. Poku et al. (2014) observed that chlorophyll content of leaves of the treatment combinations was high.

Similar trends were obtained in the minor season with ½ CD + ½ PM, ½ CD + ½ GP, ½ CD, ½ PM + ½ NPK and ½ CD + ½ LP treated plants with higher chlorophyl content at both 8 and 12 WAP (Figure 3b). Full PM, Full GP and control generally had lower chlorophyl content during the minor season at both sampling dates. Presumably, in both seasons, the higher plant height and wider canopy widths produced by the treatment combinations resulted in increased solar radiation interception, thus leading to higher chlorophyll content (Masclaux-Daubresse et al., 2010).

Shoot dry weight

There were no significant differences among the treatments for shoot dry weight at 8 WAP for both the major and minor seasons (Figure 4a and b). However, at 12WAP, ½ PM + ½ LP, ½ GP + ½ NPK, ½ CD + ½ NPK, ½ PM + ½ GP and full PM produced the highest shoot dry matter in both the major and minor seasons (Figure 4a and b). In the major and minor seasons, full CD, full GP, full LP and the control (no fertilizer) generally produced the least shoot dry matter (Figure 4a and b). The increased shoot dry weight following the amendments, especially with the organic and inorganic

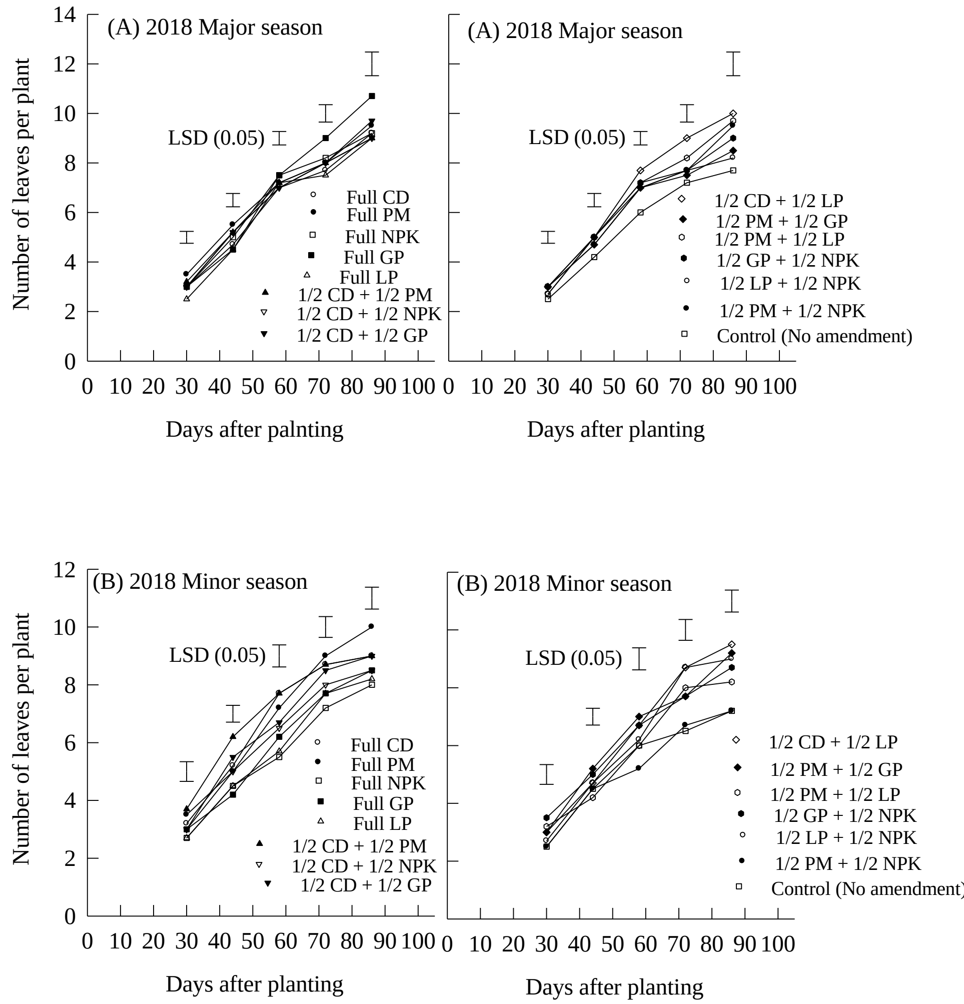

Figure 3. Number of leaves per plant of carrots as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

combinations, was most probably due to availability of nutrients, which increased the plant growth and development (Ahmad et al., 2014).

Root fresh and dry weights

There were no significant differences among the treatments for root fresh weight at 8 WAP for both the major and minor seasons (Figure 5a and b). However, in the major season, full PM, full LP, ½ CD + ½ LP, ½ PM + ½ NPK and ½ GP + ½ NPK produced greater root fresh weight than ½ CD + 1/2PM and ½ PM + ½ GP at 12 WAP (Figure 6a). The rest of the treatments produced intermediate root fresh weights. Similarly, in the minor season, full PM, full CD, ½ CD + ½ PM, ½ CD + ½ GP, ½ CD + ½ LP and ½ PM + ½ GP gave higher root fresh weight than full NPK, full GP, full LP and the control (Figure 6b). A review by Amanullah et al. (2007) showed that poultry manure application at 10 ton/ha improved the physical properties of soil. Results of increased fresh root weight by the application of sole poultry manure in this study agree with Agbede et al. (2017).

Root dry weight in the major season was higher for treatments full PM, full NPK, ½ CD + ½ GP, ½ PM + ½ NPK and ½ GP + ½ NPK than full GP and ½ CD + ½ PM at 12 WAP (Figure 7a). Similarly, in the minor season, root dry weight was higher in treatments full PM, full CD and the organic and inorganic combinations than full NPK and control (Figure 7b). Several studies have reported increased root dry weight from application of organic manure (Mbatha et al., 2014; Kumar et al., 2014; Agbede et al., 2017; Appiah, 2018). The greatest root dry weight observed in major season in the ½ GP + ½ NPK amended plot corroborates with the results obtained in a study by Appiah (2018). However, during the minor rainy

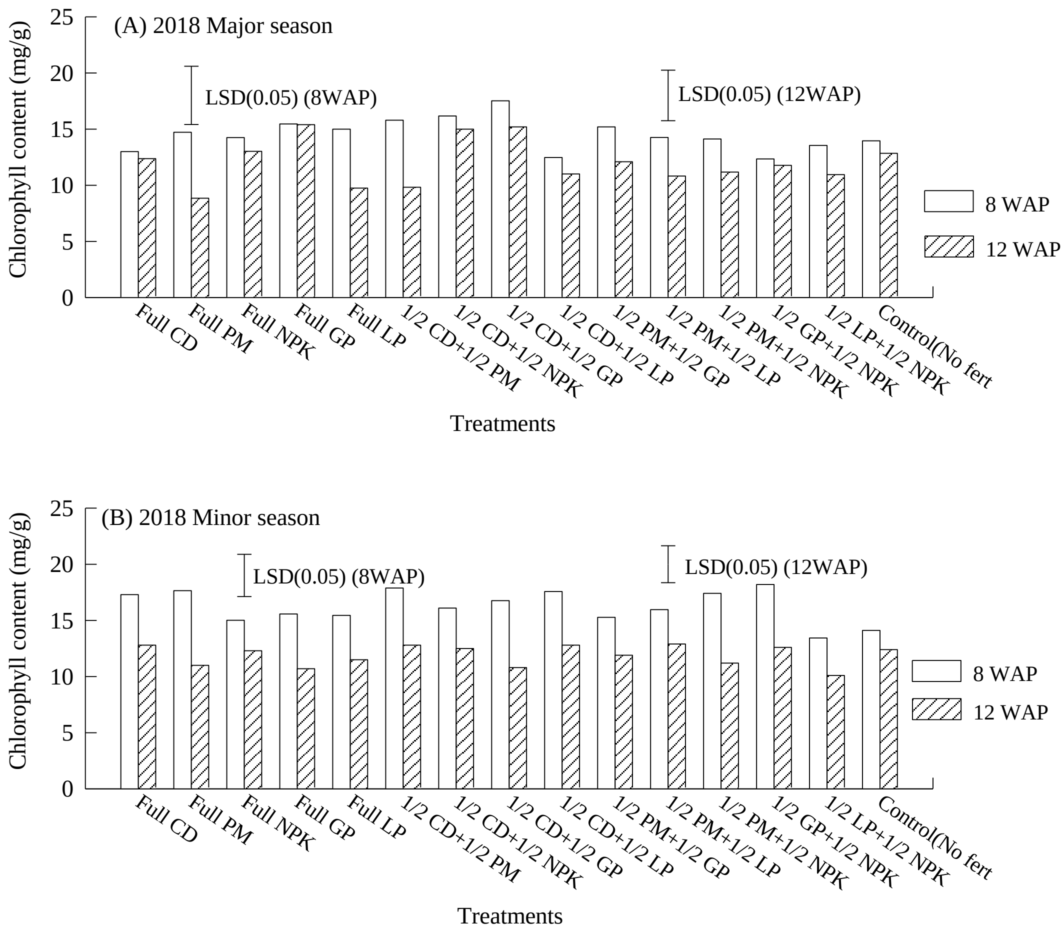

Figure 4. Chlorophyll content of carrot leaves as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

season the ½ CD + ½ PM treatment had the greatest root dry weight at 8 and 12 WAP. Somanath and Syeenivasmuthy (2005) also reported improved dry matter yield in *Coleus forskohlii* due to integrated use of farmyard manure with NPK than using NPK alone. This might explain why 300 kg/ha NPK produced lowest root dry weight in the minor season though it was at par with the control treatment effect.

Root yield

The carrots root yield ranged from 19.4 to 34.0 t/ha for the major season and 19.8 to 54.2 t/ha for the minor season. In the major season, the organic and inorganic fertilizer combinations (except ½ LP + ½ NPK) and the full PM, produced root yields of 29.8 to 34.0 t/ha, which were 34 to 40% higher than the sole applications and 54 to 75% higher than the control treatment (Figure 8a). Similarly, during the minor season, root yields ranged from 43.4 to 54.2 t/ha for all the organic and inorganic fertilizer combinations (except for ½ LP + ½ NPK and ½ PM +1/2 LP) and full PM, which were 119 to 125% higher than the sole application and 56 to 94% higher than the control (Figure 8b). The ½ CD + ½ GP and ½ CD + ½ PM produced highest root yields of 34.0 and 54.2 t/ha in the major and minor seasons, respectively (Figure 8a and b). According to Arora (2008), the use of integrated nutrient source provides balanced plant nutrient better than a single nutrient supply source. The synergistic effects of the integrated nutrient combinations in supplying readily available nutrients and improving soil physical and chemical characteristics resulted in greater plant height and canopy width, thus increasing solar radiation interception and utilization. This in turn resulted in greater dry matter production, root fresh and dry weights culminating into greater root yields. Tuber yield of potato was increased after using organic manures compared to the recommended dose of inorganic fertilizers only (Boke, 2014). The studies of Arora (2008) and Boke (2014) might explain why the effect of the combined fertilizers performed better than single doses of organic and

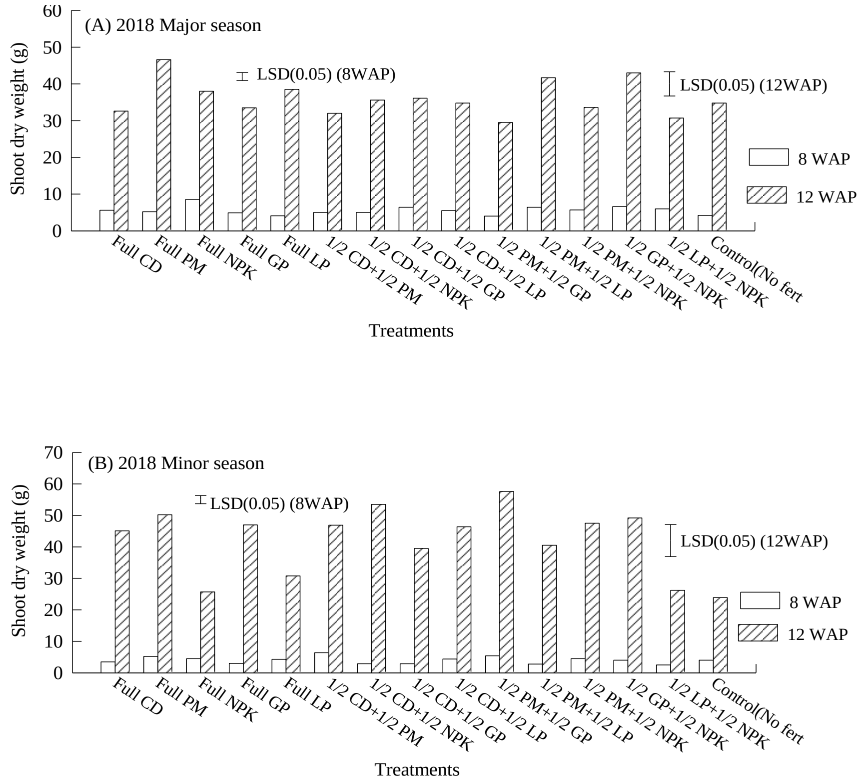

Figure 5. Shoot dry weight of carrot as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

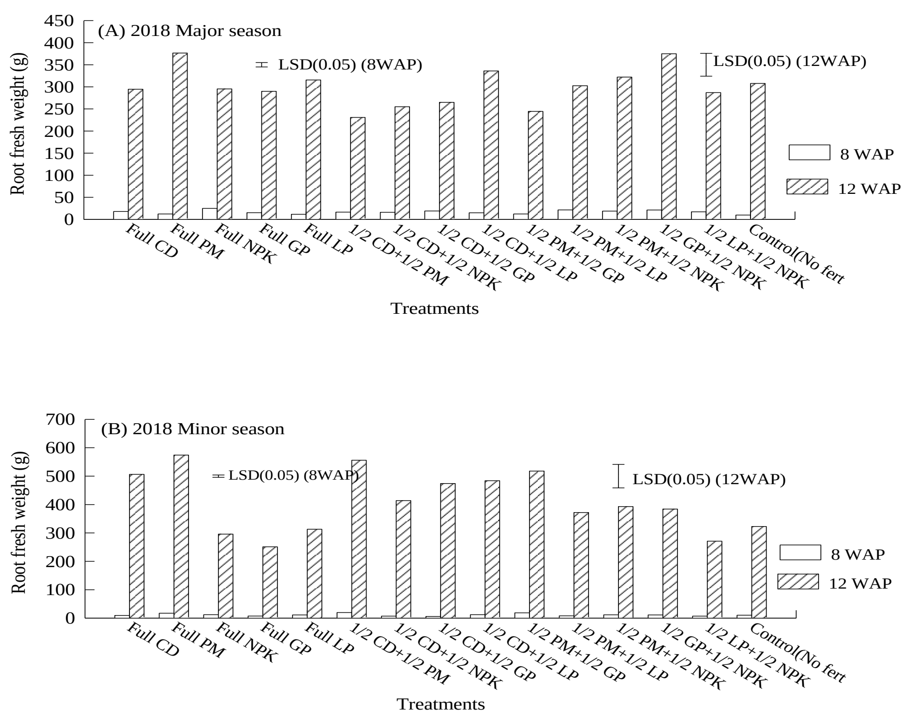

Figure 6. Root fresh weight of carrot as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

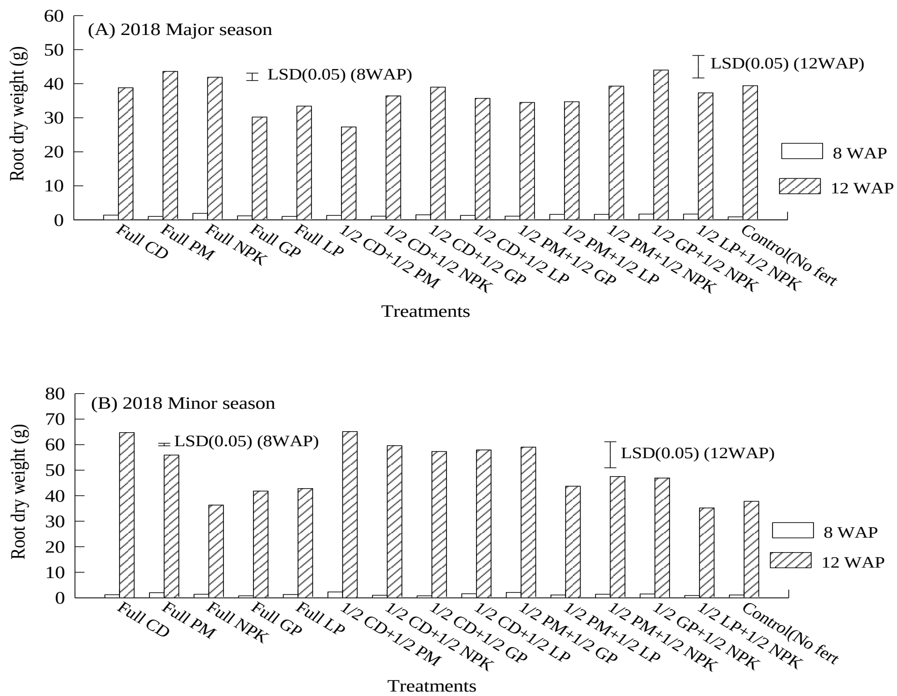

Figure 7. Root dry weight of carrot as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

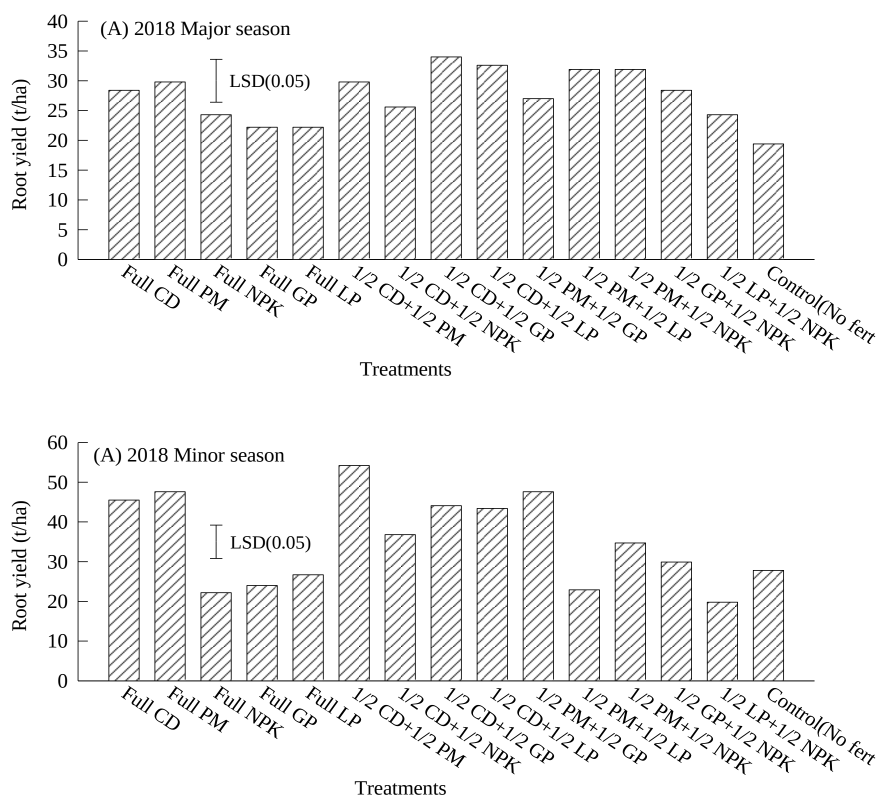

Figure 8. Root yield of carrots as influenced by organic and inorganic fertilizers during 2018 major and minor seasons.
Source: Primary data from study

inorganic fertilizers.

Conclusion

From the results presented, the integration of organic and inorganic fertilizers better enhanced the growth (plant height, canopy width and chlorophyll content) of carrot. Generally, carrots grown on amended plots treated with 5 t/ha CD + 5 t/ha PM (that is, ½ CD + ½ PM) and 5 t/ha PM + 5 t/ha GP (that is ½ PM + ½ GP) produced taller plants, wider canopy, while the 5 t/ha LP + 150 kg/ha NPK (that is ½ LP + ½ NPK) and the control treatment produced the least. The 5 ton/ha CD + 5 ton/ha GP (½ CD + ½ GP) produced the greatest root yield during the major season and 5 ton/ha CD + 5 ton/ha PM (½ CD + ½ PM) in the minor season. Therefore, application of 5 ton/ha CD + 5 ton/ha GP and 5 ton/ha CD + 5 ton/ha PM during the major season and minor season are recommended for optimum crop performance and to maximize yield productivity per unit area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Agbede TM, Adekiya AO, Eifediyi EK (2017). Impact of Poultry Manure and NPK Fertilizer On Soil Physical Properties and Growth and Yield of Carrot. Journal of Horticultural Research 25(1):81-88.

Agyeman K, Berchie JN, Gaisie E, Adomako J (2013). Synchronization of nutrient release from *Glyricidia sepium* with nutrient uptake by Maize through biomass decomposition. International Journal of Science and Advanced Technology 3:49-57.

Ahmad Z, Ali N, Ahmad M, Ulhag S, Ahmad S (2005). Yield and economics of carrot production in organic farming. Sarhad Journal of Agriculture 21(3):357-364.

Ahmad T, Amjad M, Iqbal Q, Nawaz A, Iqbal Z (2014). Integrated nutrient management practices improve growth and yield of carrot. Bulgarian Journal of Agricultural Science 20(6):1457-1465

Amanullah MM, Somasundaram E, Vaiyapuri K, Sathyamoorthi K (2007). Poultry manure to crops – A Review. Agricultural Reviews 28(3):216-222

Appiah FK (2018). Influence of green manures and NPK on the growth and yield response of carrot (*Daucus Carota* L) to different plant spacing. PhD. Thesis, Kwame Nkrumah University of Science and Technology, Ghana.

Arora S (2008). Balanced nutrition for sustainable crop production. Krishi World (Pulse of Indian Agriculture) pp. 1-5.

Atakora K, Agyarko K, Asiedu EK (2014). Influence of Grasscutter, Chicken Manure and NPK Fertilizer on the Physical Properties of a Chromic Luvisol, Growth and Yield of Carrot (*Daucus carota*). International Journal of Plant and Soil Science 3(2):197-204.

Biesiada A, Nawirska A, Kucharska A, Anna Sokół-Łętowska A (2011). The effect of nitrogen fertilization methods on yield and chemical composition of pumpkin (*Cucurbita maxima*) fruits before and after storage. Vegetable Crops Research Bulletin 70:203-211.

Boke S (2014). Effect of organic and inorganic fertilizer application and seedbed preparation on potato yield and soil properties on alisols of Chencha. International Journal of Natural Sciences Research 2(8):123-132.

Daba G, Mulugeta M, Ayana T (2018). Effect of cattle manure on growth and yield of carrot (*Daucus Carrota* L.) under Jimma condition Effect of cattle manure on growth and yield of carrot (*Daucus Carrota* L.) under Jimma condition. Available at: https://doi.org/10.18805/IJARe.A-285

Dauda SN, Ajayi FA, Ndor E (2008). Growth and yield of watermelon (*Citrullus lunatus*) as affected by poultry manure application. Journal of Agriculture and Social Sciences 4(3):121-124.

Dawuda MM, Boateng PY, Hemeng OB, Nyarko G (2011). Research Paper Growth and Yield Response of Carrot (*Daucus Carota* L.) To Different Rates of Soil Amendments and Spacing 31(2):11-20.

FAO/UNESCO (1988). FAO/UNESCO soil map of the world revised legend with corrections an updates. World Source Resources Report 60, FAO, Rome. Reprinted with updates as Technical Paper 20, ISRIC, Wageningen.

Fahrurrozi F, Sariasih Y, Muktamar Z, Setyowati N, Chozin M, Sudjatmiko S (2017). Identification of nutrients content in six potential green biomasses for developing liquid organic fertilizer in closed agricultural production system. International Journal on Advanced Science, Engineering, Information Technology 7(2):559-565.

Gyamfi E, Loos H, Anthofer J (2001). Farmers' perceptions of adoption of soil fertility technologies. Paper presented at the International Conference of the *Soil Science Society of Ghana* (26th February to 2nd March 2001) held at Tamale, Ghana

Kumar P, Meghwal PR, Painuli DK (2014). Effect of organic and inorganic nutrient sources on soil health and quality of carrot. Indian Journal of Horticulture 71(2):222-226.

Makumba W, Janssen B, Oenema O, Akinnifesi FK, Mweta D, Kwesiga F (2006). The long-term effects of a glyricidia–maize intercropping system in Southern Malawi, on glyricidia and maize yields, and soil properties. Agriculture, Ecosystems and Environment 116(1-2):85-92.

Masclaux-Daubresse C, Daniel-Vedele F, Dechorgnat J, Chardon F, Gaufichon L, Suzuki A (2010). Nitrogen uptake, assimilation and remobilization in plants: challenges for sustainable and productive agriculture. Annals of Botany 105(7):1141-1157. Avaialble at: https://doi:10.1093/aob/mcq028.

Mbatha AN (2008). Influence of organic fertilizers on the yield and quality of cabbage and carrots. MSc. Thesis, Department of Crop, Soil and Climate Sciences, University of the Free State Bloemfontein, South Africa.

Mbatha AN, Ceronio GM, Coetzer GM (2014). Response of carrot (*Daucus carota* L.) yield and quality to organic fertiliser. South African Journal of Plant and Soil 31(1):1-6.

Mehedi TA, Siddique MA, Shahid SB (2012). Effects of urea and cowdung on growth and yield of carrot. Journal of the Bangladesh Agricultural University 10(1):9-13.

Poku PA, Agyarko K, Dapaah HK, Dawuda MM (2014). Influence of *Mucuna pruriens* Green Manure, NPK and Chicken Manure Amendments on Soil Physico – Chemical Properties and Growth and Yield of Carrot (*Daucus carota* L.) The productivity of soils under long-term crop production in Ghana has been declining, Journal of Agriculture and Sustainability 5(1):26-44.

Shaffer E (2000). Produce availability and merchandising guide. The Packer, Vance Pub., Lenexa KS.

Sharma HK, Kaur J, Sarkar BC, Singh C, Singh B, Shitandi AA (2006). Optimization of pre-treatment Conditions of carrots to maximize juice recovery by response surface methodology. Journal of Engineering Science and Technology 1(3):158-165.

Somanath BS, Sreenivasmurthy CA (2005). Influence of FYM and inorganic fertilizer (NPK) and sources of potassium on the yield of *Coleus for-skohlii.* Journal of Medicinal and Aromatic Plant Sciences 27(1):16-19.

Subedi S, Srivastava A, Sharma MD, Shah SC (2018). Effect of Organic and Inorganic Nutrient Sources on Growth, Yield and Quality of Radish (*Raphanus sativus* L.) Varieties in Chitwan, Nepal. SAARC Journal of Agriculture 16(1):61-69.