RESEARCH ARTICLE

Growth and Yield Performance of Carrot (Daucus *carota L.*) as Influenced by Organic Manure under Open Field Conditions

Paye Deekermue[1*], Oluwatosin Mayowa Olajide[2], Abubakar Shehu Yaradua[2, 3], Aloysius H. Tye[1]

[1]Department of General Agriculture, College of Agriculture and Food Science, William V.S. Tubman University, Liberia
[2]Department of Agronomy, College of Agriculture and Food Science, William V.S. Tubman University, Liberia
[3]Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Nigeria

Corresponding Author: Paye, Deekermue: Email: payedeekermue92@gmail.com
Received: 28 August, 2024, Accepted: 28 November, 2024, Published: 29 November, 2024

Abstract

Carrot is an exotic vegetable in Liberia, commonly used in combination with other vegetables when making soups, stews, and salads. The study focused on assessing the growth and yield of carrots by combining NPK doses and organic manures in an open field at the Teaching and Research Farm, William V. S. Tubman University Campus, Harper City, Liberia. The randomized complete block design included soil amendments of 10 t/ha, 15 t/ha, and 20 t/ha of chicken manure, along with 300 kg/ha of NPK fertilizer (15:15:15), and a control for evaluation. The findings from the physical and chemical analysis of different macronutrients in the soil, such as soil carbon, phosphorus, potassium, calcium, magnesium, and sodium, were deemed to be moderate and satisfactory. The result of analysis of variance (ANOVA) showed that all growth and yield parameters were significantly affected ($P < 0.05$). Results indicated that the longest Plant height (19.10 cm) was recorded in the 20 ton ha-1 compost application, while the lowest plant height (6.84 cm) was measure in the control. The highest leaf number (15.15) was recorded in 20 t ha-1 while the lowest leaf number (10.22) was recorded in the control (0 t ha-1). The result revealed that the leaf area (39.76 cm^2) was recorded in the 20 ton ha-1, while the minimum (13.18cm^2) was recorded from the control. The next best results were seen with 20 t ha-1of chicken manure, which had root lengths of 19.31cm, while the lowest plant root length (6.84cm) was measure in the control. The highest root diameter of (7.87mm) was recorded in 20 t ha-1 while the lowest root diameter (2.16 mm) was recorded in the control (0 t ha-1). The result revealed that the maximum root weight (31.76 g) was recorded in the 20 ton ha-1, while the minimum (10.33 g) was recorded from the control. The study found that the carrot plants showed the best growth and highest yield when treated with 20 tons per hectare of chicken manure.

Keywords: Carrot; organic manures; root length; root weight, plant nutrients

Introduction

Carrots are highly esteemed exotic vegetables in Liberia, widely used in cooking alongside other vegetables (Ahmad et al., 2005). This versatile taproot vegetable is consumed in various ways, such as raw in salads or cooked in soups and other dishes (Rahman et al., 2020). However, carrot cultivation in Liberia faces challenges due to poor soil fertility, which significantly impacts farmers' productivity. Continuous cropping and the limited use of mineral and organic fertilizers have led to nutrient depletion in agricultural soils (Abuzar et al., 2011). Effective nutrient management is essential to improving soil fertility and enhancing crop yields, as highlighted by Silveria and Kohmann (2020). Plants primarily obtain essential minerals from the soil (Vijayprabhakar et al., 2020), and applying the right combination of nutrients is critical for achieving sustainable productivity. However, improper fertilizer application can adversely affect both soil health and crop production (Pandey et al., 2020). Although synthetic fertilizers are commonly used by carrot growers to boost yields, excessive reliance on these fertilizers has raised concerns about their negative impacts on human health and soil quality (Toor et al., 2020). Integrated nutrient management, which combines organic and mineral fertilizers, has shown promise in improving soil fertility and crop yields while minimizing environmental impacts (Singh et al., 2020). Natural soil amendments, such as chicken manure, cattle manure, and solid waste, can enhance soil quality by adding nutrients, improving water retention, and promoting microbial activity (Amjad, 2013; Goel et al., 2020). Organic manures not only improve soil structure but also serve as cost-effective alternatives to synthetic fertilizers, making them more accessible to farmers (Hafez et al., 2020). While organic fertilizers release nutrients more slowly than synthetic options, the combined use of organic and mineral fertilizers has been shown to boost crop productivity, enhance soil health, and reduce pollution risks (Hammad et al., 2020; Karmakar et al., 2020). Despite the potential benefits, limited research has been conducted on the effectiveness of integrated nutrient management in carrot cultivation. Therefore, this study aimed to evaluate the growth and yield response of carrots to combinations of NPK fertilizers and organic manures. This research is important for identifying sustainable nutrient management practices that balance productivity, soil fertility, and environmental protection. The aim of this study was to assess the effects of integrating NPK fertilizers with organic manures on the growth and yield of carrots. Specifically, the study sought to evaluate the yield response of carrots to various organic manure treatments, highlighting the potential benefits of integrated fertilizer application.

Materials and Methods

Descriptions of the study area

The experiment was carried out at the Teaching and Research Farm, William V. S. Tubman University, Harper City, Liberia from January to May 2023 cropping season under rain-fed conditions. The site is situated 4km from the capital of Harper City, in the southeastern region of the country. The study area is located at the coordinates 4°34′ N and 7°40′ W. It is located in the West African tropical rainforest, where the typical monthly temperatures range from a minimum of 25°C to a maximum of 30°C. The region experiences unpredictable, irregular annual rainfall totaling 1628 mm per year. The study area's natural vegetation consisted of a mix of savanna grasses and forested areas. The soil in the region consists of sandy loam.

Experimental design and treatments

The field trial included four different treatments of chicken manure: 10 tons per hectare, 15 tons per hectare, 20 tons per hectare, and no chicken manure (Control). Additionally, 300 kg per hectare of NPK (15:15:15) fertilizer was applied evenly to each bed at a rate of 0.5 kg per hectare. Each bed measured 2.5 meters in length and 1 meter in width. A distance of 0.4 meters was maintained between each bed. The study was set up using a random complete block design with three replications, as outlined in Gomez and Gomez's (2010) procedures. The experimental plots were randomly assigned treatments within a block.

Soil sample collections

The study obtained soil samples from the surface layer (0-25 cm deep) that were categorized as Latosol according to the USDA's soil classification system. Soil samples were collected from each block of the field using a stratified random sampling method. This was carried out in a randomized complete block design at various plot locations, utilizing core samplers and Dutch augers.

Laboratory Procedures

The soil samples gathered were dried at 105°C in the College of Agriculture and Food Science (CAFS) lab, then crushed in a mortar and pestle and sifted to eliminate debris such as roots and plant components.

Bulk density

The core method (Blake and Hartge, 1986) was used to measure the bulk density. The core samples were dried in an oven at 105^0C in the lab and periodically weighed until a consistent weight was reached. The bulk density is defined as the ratio of the dry mass of solid material to the total volume of soil, including both solid components and pore spaces.

Moisture content

The soil moisture level was measured using the oven-drying technique for a period of 24 hours. The sample was brought to the lab and 10g each of $CaCl_2$, H_2O, and KCl were added. The mixture was stirred for 5 minutes each and left to settle for 30 minutes to allow for ion exchange in order to determine the soil moisture content (Ahn et al., 2014). The weighing dishes were set on a balance scale and adjusted to read zero grams to eliminate the weight of the dishes. The wet soil samples gathered in the field were moved into the containers, weighed using a scale, and the weights of the wet soil samples were documented. The wet soil samples were dried in the oven at a temperature of 105 degrees Celsius. The soil was taken out of the oven and left to cool down. The soils that had been dried in the oven were weighed again, and the weights of the dried soils were noted down. Thus, the percent soil moisture content was calculated as:

$$\%\ \text{moisture content (MC)} = \frac{weight\ of\ moist\ soil - weight\ of\ oven{-}dried\ soil}{weight\ of\ oven{-}dried\ soil} \times 100$$

Soil pH

The pH of the soil was measured in both distilled water and 0.01 M $CaCl_2$ solution (with a ratio of 1 part soil to 2 parts solution) using a digital pH meter with a combined glass electrode. The measurement was taken after allowing the soil to equilibrate for 30 minutes, following the method described by Thomas (1996). The pH was measured twice to confirm the results. 10 grams of each soil sample was measured and placed into a plastic pH cup. In the initial group of cups, 10 ml of pure water was mixed, while in the second group, 20 ml of 0.01 M CaCl2 solution was added to achieve a soil solution ratio of 1:2. The mixture was stirred right away and left to settle for half an hour before measuring the pH with a digital meter. The delta pH (pH change) is calculated as the discrepancy between the pH levels in $CaCl_2$ and H2O. The above process was repeated for pH in 1 M KCl by adding 10 ml of KCl solution to 10 g of soil in a 1:1 ratio of soil to solution.

Electrical conductivity

The level of electrical conductivity determines the concentration of salt that is dissolved in the soil solution. The level of soluble salts in the liquid was assessed using the saturated paste technique as per the US Salinity Laboratory Staff's guidelines from 1954. A small quantity of de-ionized water was poured into the beaker before adding an approximately 2/3 full air-dried soil sample. De-ionized water was slowly poured into the beaker containing soil, all the while mixing it. Additional dry soil was incorporated when the mixture was too moist, while water was added when the mixture was too dry during the blending process. After blending, the sample was left to settle for one hour. The thick paste was moved to a Buchner funnel containing filter paper. A vacuum was used to extract and collect the saturated paste in a 250 ml vacuum flask. The extract's temperature was recorded and utilized for calibrating the conductivity meter. The electrical conductance of the saturated paste extract was measured using the JENWAY 4510 model conductivity meter.

Soil organic carbon determination

The soil organic carbon was analyzed using the Walkley and Black modified technique, as described by Nelson and Sommers (1982). An Erlenmeyer flask was filled with one gram of soil that had been dried. Blank samples were also provided for comparison. The samples and empty flasks were each given ten milliliters of 1 N (0.1667 M) potassium dichromate solution. Two milliliters of concentrated sulfuric acid were poured onto the soil slowly and carefully using a measuring cylinder. The mixture was then stirred and allowed to sit for 30 minutes in a fume cupboard. Next, 250ml of distilled water was mixed with 10ml of concentrated ortho-phosphoric acid. After adding 1 ml of diphenylamine indicator, the reaction mixture was titrated with a 1.0 M solution of ferrous sulphate.

Calcium and magnesium determination

The analysis of calcium and magnesium was conducted by adding 25 ml of the extract into an Erlenmeyer flask, along with 2% potassium cyanide, 2% potassium ferrocyanide, hydroxylamine hydrochloride, 10 ml ethanolamine buffer, and 0.2 ml Eriochrome Black T solution. In order to achieve a pure turquoise hue, a solution was titrated using 0.01 M EDTA (Ethylene Diamine Tetraacetic Acid).

Soil particle size distribution

The hydrometer method by Boyoucos (1962) was used to analyze soil texture. To do this, 50 grams of soil that has been dried in air were placed into a measuring cylinder, followed by the addition of 50 milliliters of sodium hexamethaphosphate. The treatment was agitated and allowed to settle. Hydrometer readings were taken and corrected at the 40-second and 5-hour marks.

Experimental materials and procedures

Orange carrot seeds were utilized as the experimental crop for this study. The soil was meticulously cultivated to a depth of 30 cm using traditional tillage methods, creating optimal conditions for planting. Following this, a field layout was created, and each treatment was allocated randomly to the experimental plots. Seeds were planted in raised beds that were 20 cm tall, with spacing determined by the treatment assigned to the plot. Carrot seeds were planted by making drilled rows that were 1 meter by 1 meter in length in every plot. Two weeks before planting, different amounts of chicken manure were applied all at once, while NPK fertilizers in granular form were applied in two stages: half during sowing and the other half during the mid-tillering crop stage at 35 days after emergence, in between the rows. All plots received the same level of watering and other necessary cultural practices. Weeds were handpicked and gathered from the fields where crops were grown, and harvesting was done when the crops were fully mature using a manual hand tool.

Data collection

The growth indicators of plant height, number of leaves, and leaf area (length x width) were accurately measured by selecting five plants at random. The root length and diameter were determined by measuring parameters from five selected plants with a vernier caliper. The weight of the roots of each plant was measured by weighing five randomly chosen plants with a precise balance, and the average weight was then calculated and utilized for further analysis.

Statistical analysis

The data gathered was analyzed using Analysis of Variance (ANOVA) in SAS 9.1 to test any significant differences among the selected treatments. Mean comparisons were made using the Least Significant Difference (LSD) at 0.05 significant levels.

Results and Discussion

Table 4.1 displays the physical and chemical characteristics of the soil that were examined prior to and throughout the study. The soil bulk density measured at 1.43 g/cm³ indicates the soil's texture and structure. Typically, soils with low bulk densities are linked to increased total porosity, but root penetration and seed emergence may prove challenging when bulk density exceeds 1.6 g cm-3 (Russell, 1976). The results fall within the acceptable range for the majority of agricultural practices (Wild, 1993). Additionally, the average soil moisture level was recorded at 14.3%, which falls within the ideal range for cultivating most crops. The moisture content of soil plays a crucial role in regulating the various processes within the soil system, including its physical, chemical, and biological aspects (Buss et al., 2010). Sandy soil accounted for 83.0%, while clay made up 11.0% and fine silt accounted for 6.0% of the soil composition. Additionally, sandy soils typically have greater bulk densities than fine silts and clays due to their larger yet less numerous pore spaces. Clay soils with well-maintained soil structure have more pore space due to the small particle size, allowing for numerous small pore spaces to exist between them. The levels of different macronutrients in the soil samples, including carbon, phosphorus, potassium, calcium, magnesium, and sodium, were found to be moderate and adequate. The nitrogen levels were at a low 0.16%. The presence of Ca, Mg, Na, and K as exchangeable cations suggests a significant capacity for cation exchange. Overall, the soil had a low pH of 3.61, with its acidity likely due to factors such as high rainfall causing leaching of bases from the soil, acid rain, and crop harvesting. The soil pH falls within the highly acidic range of 4.0 - 5.5 according to Adepetu et al. (2014). The soil's pH was lower than the ideal range of 6.0 to 7.0 for most crops like cabbage. The electrical conductivity (EC) measurement was recorded at 0.032 dS m-1. The recorded value fell below the acceptable salinity level of 4 dS m-1 according to Adepetu et al. (2014). The soil EC levels were found to be low, with no concerns about salinity anticipated. Electrical conductivity (EC) indicates the level of soluble salts in the soil solution. The results also show that the levels of iron and copper in soil are optimal for crop growth, with most plants thriving when the copper level is at 0.6 parts per million or higher. The appropriate level of manganese in the soil for crops may differ depending on the type of crop being grown. Soil test results ranging from 1 to 5 parts per million (ppm) are generally considered satisfactory. Manganese deficiencies tend to be found primarily in soil with a pH of 8.0 or higher. The findings indicate that manganese levels are significantly low across all the sites where samples were taken. A zinc soil test level of 1.5 ppm or higher is adequate for the majority of crops.

Table 1: Physical and chemical properties of topsoil analyzed before planting from the study area

Soil physical and chemical properties	Constituent units
pH (1:1)	3.61
N (%)	0.16
OC (%)	1.05
Sand (%)	83.0
Clay (%)	11.0
Silt (%)	6.0
Ca (cmol Kg-1)	2.26
Mg (cmol Kg-1)	1.41
K (cmol Kg-1)	0.63
Na (cmol Kg-1)	0.27
EC (dS m^{-1})	0.032
P (cmol Kg-1)	5.83
Mn (ppm)	0.18
Fe (ppm)	0.34
Cu (ppm)	0.91
Zn (ppm)	4.80
Bulk Density (g cm^{-3})	1.42
Moisture Content (%)	14.6

Growth parameters of carrot variety among the selected treatments under an open field system

The mean growth analysis (number of leaves, leaf area and plant height) of carrot evaluated in an open field system is shown on table 4.2. The higher values of plant height (19.10cm), leaf number (15.15) and leaf area (39.76 cm^2) were observed at the 20 ton ha-1 chicken manure application, while the lowest values of plant height (6.84cm), leaf number (10.22) and leaf area (13.18cm^2) were recorded in the control (0 t ha-1) chicken manure. When crops have to compete with their neighboring plants for soil nutrients and sunlight, their health and growth can be negatively impacted. Poorly functioning plants will not attain their desired height or leaf area and their roots will have to compete not only for nutrients and water but also for space. According to Kiran *et al.*, (2016) found a significant increase in plant growth of carrots with the application of higher dose of compost than its lower dose. Moreover, leaf weight can be affected by the accumulation and the partitioning of synthesized food to non-photosynthetic parts Osorio (*et al*., 2014). Leaf area size is likely to enhance photosynthesis, leading to the production of more leaves, which has been supported by the findings of Appiah *et al.*, (2017) in other plants.

Table 2. Mean plant height (cm), mean leaf number, and Leaf Area (cm^2) of carrot

Treatment	Plant height (cm)	Leaf number	Leaf area (cm^2)
10 ton/ha Chicken Manure	$(11.67)^c$	$(11.23^c$	$(27.89)^a$
15 ton/ha Chicken Manure	$(13.52)^b$	$(12.51)^b$	$(33.82)^b$
20 ton/ha Chicken Manure	$(19.10)^a$	$(15.15)^a$	$(39.76)^a$
Control	$(6.84)^d$	$(10.22\ )^d$	$(13.18)^d$

Mean values followed by different letter(s) are significantly different at 5% probability.

Yield evaluation of carrot variety among the selected treatments under an open field system

The study showed that the highest root length (19.31cm), root diameter (7.87mm), and root weight (31.76g) were observed with the application of 20 tons per hectare of chicken manure. The next best results were seen with 15 tons per hectare of chicken manure, with values of 17.03 cm for root length, 5.37mm for root diameter, and 22.01g for root weight. In contrast, the control treatment (0 t ha-1) showed the lowest values for root length (6.84cm), root diameter (2.16mm), and root weight (10.33g) (Table 4.3). The research clearly demonstrated that using more chicken manure led to longer roots with a greater diameter, ultimately resulting in higher plant yield. This could be because the roots had enough resources to grow and develop without facing as much competition for soil nutrients. According to the research conducted by Kiran et al., (2016), compost is highly effective in enhancing soil fertility, especially when used for the cultivation of vegetable crops. Adelaide (2011) also discovered that compost is an effective fertilizer that can help sustain soil fertility levels and enhance agricultural output. The results align with the observations made by Asante et al. (2019), who noted notable differences in carrot root thickness due to the use of chemical fertilizers and organic compost.

Table 3. Root length, root diameter, and root weight comparisons among the selected treatments

Treatment	Root length (cm)	Root diameter (mm)	Root weight (g)
10 ton/ha Chicken Manure	(15.51) [c]	(3.97)[c]	(15.10)[c]
15 ton/ha Chicken Manure	(17.03) [b]	(5.37)[b]	(22.01)[b]
20 ton/ha Chicken Manure	(19.31)[a]	(7.87)[a]	(31.76)[a]
Control	(6.84)[d]	(2.16)[d]	(10.33)[d]

Note: Mean values followed by different letter(s) are significantly different at 5% probability

Conclusions

Effective agronomic practices greatly impact the growth and productivity of carrots, with soil fertility playing a crucial role in management. The experiment results indicated that the growth and yield traits, such as plant height, leaf number, leaf area, root length, root diameter, and root weight, were most favorable when using the highest rates of chicken manure. The average of these parameters was found to be greater with the highest chicken manure application rate of 20 tons per hectare. The differences observed were statistically significant ($p \leq 0.05$), probably because of variations in nutrient levels that support the plant's root length, diameter, and weight during growth and development. The minimal metrics may be due to the insufficient amount of chicken manure being used on the soil. The study results suggest that the soils at the site do not exhibit significant characteristics that could interfere with the study parameters. Hence, it is essential to work together to enhance soil fertility by utilizing a combination of organic and inorganic fertilizers as an integrated approach.

Declaration

Acknowledgment: The authors thanks the College of Agriculture and Food Science for providing research laboratory environment and facilities

Funding: This study received no external funding

Conflict of interest: The authors of this research work declare they have no conflict of interest regarding the publication of this paper

Ethics approval/declaration: N/A

Consent to participate: Participants were informed about their right to ask questions relating to the research.

Consent for publication: Informed consent was obtained from all subjects involved in the study.

Data availability: Data used to support the findings of this study are available from the corresponding author upon request.

Authors contribution: Paye Deekermue and Aloysius H. Tye conceived the study idea, co-wrote the paper, andInvestigated data collection and analysis; Oluwatosin Mayowa Olajide conducted the soil laboratory analysis and Abubakar Shehu Yaradua revised the paper.

References

Abuzar M.R., Sadozai G.U., Baloch M.S., Baloch A.A., Shah I.H., Javaid T., Hussain N., 2011 Effect of plant population densities on yield of maize. J. Animal Plant Sci., 21(4): 692 695.

Adelaide, M. (2011). Influence of temperature on yield and quality of carrots (Daucus carota var. sativa). November, 1–84.

Adepetu, J. A., Adetunji, M. T. and Ige, D. V. (2014). Soil Fertility and Crop Nutrition by J. A. Adepetu (2014). Printed by Jumak Nig. Ltd. Jumak Publishers, Ringroad, Ibadan. pp. 1 – 560.

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

Ahn, J. Y., Kil, D. Y., Kong, C., & Kim, B. G. (2014). Comparison of oven-drying methods for determination of moisture content in feed ingredients. *Asian-Australasian Journal of Animal Sciences*, 27(11), 1615-1622. http://doi.org/10.5713/ajas.2014.14305

Almendro-Candel, María Belén, Ignacio Gómez Lucas, Jose Navarro-Pedreño, Antonis A. Zorpas. Physical properties of soils affected by the use of agricultural waste. Agricultural waste and residues. 2008; 2(1):77- 99

Appiah E.A., Kugbe J.X., Rufai A.M., 2021. Maize growth and yield response to incremental rates of phosphorus in p-depleted lixisols of Nothern Ghana. Inter. J. Agric. Envir. Biores., 6(3): 257275.

Asante, K., Manu-Aduening, J., & Essilfie, M. E. (2019). Nutritional Quality Response of Carrot (Daucus carota) to Different Rates of Inorganic Fertilizer and Biochar. *Asian Journal of Soil Science and Plant Nutrition*, *5*(2), 1–14.

Black CA. Methods of soil analysis, Part I. Physical and mineralogical properties, including statistics of measurement and sampling. Part II. Chemical and microbiological properties. (M. ASA, Ed.) Agronomy Journal. 1986; 54:464-465

Bouyoucos GJ. Hydrometer method improved for making particle size analysis of soils. Journal of Experimental Botany. 1962; 57.

Busse, M. D., Shestak, C. J.,Hubbert, K. R. and Knapp, E. (2010). Soil physical properties regulate lethal heating during burning of woody residue. *Soil Science Society of America Journal* 74: 947-955.

Fallah, S., Mouguee, S., Rostaei, M., Adavi, Z., Lorigooini, Z. and Shahbazi, E.2020.Productivity and essential oil quality of Dracocephalum kotschyi under organic and chemical fertilization conditions. Journal of Cleaner Production, 255: 120189.

Goel, R., Debbarma, P., Kumari, P., Suyal, D.C., Kumar, S. and Mahapatra, B.S., 2021. Assessment of soil chemical quality, soil microbial population and plant growth parameters under organic and conventional rice–wheat cropping system. Agricultural Research, 10(2), pp.193-204

GOMEZ K.A., GOMEZ A.A., 2010 Statistical procedures for agricultural research. Wiley and Sons Inc., New York, USA, pp. 680.

Hafez,M., Popov, A.I. and Rashad, M.2020.Integrated use of bio-organic fertilizers for enhancing soil fertility–plant nutrition, germination status and initial growth of corn (Zea mays L.). Environmental Technology & Innovation, 21: 101329.

Hammad, H.M., Khaliq, A., Abbas, F., Farhad, W., Fahad, S., Aslam, M., Shah, G.M., Nasim, W., Mubeen, M. and Bakhat,H.F.2020. Comparative effects of organic and inorganic fertilizers on soil organic carbon and wheat productivity under arid region. Communications in Soil Science and Plant Analysis , 51(10): 1406-1422

Karmakar, S., Bhattacharyya, A., Ghosh, B., Roy, R., Kumar, S., Kar, B. and Saha, G. 2020.Suitability of coupling application of organic and inorganic fertilizers for crop cultivation. Ecological and Practical Applications for Sustainable Agriculture, Springer, pp. 149-177.

Kiran, M., Jilani, M. S., Waseem, K., & Marwat, S. K. (2016). Response of Carrot (Daucus carota L.) Growth and Yields to Organic Manure and Inorganic Fertilizers. American-Eurasian J. Agric. & Environ. Sci, 16(6), 1211–1218.

Nelson DW, Sommers LW. Total carbon, organic carbon and organic matter. In: Page, A.L., Miller, R.H and Keeney, D.R. (eds.). Methods of soil analysis. Part 2. Second edition. Chemical and microbiological properties. Wisconsin USA. American Society of Agronomy and Soil Science Society of America, 1982, 301-312

OSORIO S., RUAN Y.L., FERNIE A.R., 2014 An update on source-to-sink carbon partitioning in tomato. Frontiers Plant Sci., 5: 516.

Pandey, M., Shrestha, J., Subedi, S. and Shah, K.K. 2020. Role of nutrients in wheat: A review, Tropical Agrobiodiversity, 1(1):18-23.

Rahman, N., Uddin, M.B., Quader, M.F.B and Bakar, M.A. 2020.Optimization of mixed peels from banana, carrot and apple to develop high fiber biscuit. International Journal of Natural and Social Sciences, 7(1): 21-5.

Russell, E. W. (1976). Soil condition and plant growth. Longman publications Limited London.10th Edition. 80pp.

Silveira, M.L. and Kohmann, M.M. 2020. Maintaining soil fertility and health for sustainable pastures. In: Management Strategies for Sustainable Cattle Production in Southern Pastures, Elsevier, pp. 35-58

Singh, B., Singh, A., Singh, T. and Singh, N. 2007. Integrated nutrient management in carrot (Daucus carota L.). Progressive Agriculture, 7(1&2): 84-86.

Thomas, G. W. (1996). Soil pH and soil acidity. *In: Sparks, D. L. (ed.), Methods of Soil Analysis Part 3: SSSA Book Series No. 5* Soil Science Society of America Inc., American Society of Agronomy Inc, Madison, Wisconsin, pp. 363 – 376.

Toor, M.D., Amin, M.M., Khan, B.A., Nadeem, M.A.,Usman, M., Faizan, M., Arshad, A., and Zafar, K. 2020. Consequence of surplus fertilizers and nutrients: a review on effect on plants and humans, International Journal of Botany Studies 5(3): 360-364.

US Salinity Laboratory Staff, (1954). Diagnosis and improvement of saline and alkali soils. US Department of Agriculture Handbook, Washington, DC,60.

Vijayaprabhakar, A., Hemalatha, M. and Joseph, M. 2020. Utilization of paddy straw as a source of nutrients for succeeding paddy and its effect on soil available nutrients, nutrient uptake and crop yield. International Journal of Farm Sciences, 10(1): 53-58.

Wild A. (1993). Soils and environment, An introduction. Great Britain: *University of Cambridge.*