EFFECT OF MEDIA COMPOSITION ON GROWTH AND YIELD OF KALE (*Brassica oleracea var sabellica*).

BY

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CERTIFICATION

This is to certify that this research work was carried out by Nnaemeka Paschal Uchechukwu with Registration number 2014824098 in the Department of Crop Science and Horticulture, Faculty of Agriculture.

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DEDICATION

This work is dedicated firstly to the Almighty God for His love and Mercies that has made it possible for me to experience this beautiful moment, and also to Engr, John Nosike Nnaemeka for his wonderful support to me spiritually, morally and financially.

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ABSTRACT

A field experiment was carried out at the Research and Teaching Farm of the Department of Crop Science and Horticulture, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria to study the effect of media composition on the growth and yield of kale. The experiment was laid out in a Completely Randomised Design (CRD) and the treatments include, A (mixture of top soil, poultry manure, and river sand), B (mixture of rice husk, poultry manure, and river sand), and C (mixture of rice husk, and poultry manure), with each treatments replicated three (3) times. Mean separation was done using Least Significant Difference (LSD) at 5% probability level. The results obtained showed that the leaf area, number of leaves, number of branches, leaf weight and vine length from kale plants grown on treatment B and A were significantly (P< 0.05) higher than those grown on treatment C, in most weeks after transplanting. The results showed that the use of treatment B (mixture of rice husk, poultry manure, and river sand) and treatment A (mixture of top soil, and poultry manure) enhanced production of kale compared to treatment C (mixture of rice husk and poultry manure), with treatment B(mixture of rice husk, poultry manure, and river sand) being the best.

CHAPTER ONE

INTRODUCTION

1.1.0 Kale

Kale (*Brassica oleracea var sabellica*) belongs to the family *Brassicaceae*. It is closely related to vegetables such as cabbage (*Brassica oleracea var. Capitata*), cauliflower *(Brassica oleracea var. Botrytis*), broccoli (*Brassica oleracea var. Italica*) and rape (*Brassica napus L.*) (Kelly *et al*., 2005). The exact history of this vegetable is more difficult to trace but it has also been referred to as borecole or non-heading cabbage or broccoli that grows native in regions of the eastern Mediterranean and Asia. It has also been cultivated as a vegetable for more than 2500 years (Kelly *et al*., 2005). Kale, (Brassica oleracea) variant is a leafy herbaceous biennial or perennial plant in the family Brassicaceae grown as a leafy green vegetable. It is usually grouped into the "cooking greens" category with collards, mustard, and Swiss chard, but it is actually more of a non-heading cabbage, although much easier to grow than cabbage (Marie, 2018). According to Anderson, (2014); kale plant is a non-heading, cabbage-like plant that is either curly or straight, with blue-green or purple leaves. The leaves grow from a central stem that elongates as it grows. Though, a biennial crop, Kale is usually grown as an annual plant, harvested after one growing season and can reach a height of 1 m (3.3 ft). It produces abundant leaves in the first year and flowers in the second year. Kale is a cool season vegetable that prefers a sunny location, a fertile and well-drained soil (Drost and Johnson, 2005).

The plant will grow best at temperatures between 4 and 21°C (40–50°F) allowing it to be grown in both Spring and Fall (Anderson, 2014). Kale is a hardy plant, tolerating frost, and will grow optimally in a rich, moist, well-drained soil with a pH of 6.5. Kale requires at least six hours of direct sunlight every day. The crop is mainly used for winter supplies when other green leafy vegetables may be in short supply. Cultivation of the crop is similar to that for cabbage (Manchali *etal*., 2012). Shoots and leaves of kale are cooked by boiling in a similar manner to cabbage. They provide a valuable source of minerals and vitamins. In growing vegetables for commercial purposes, the grower must always use a medium with more desirable properties to produce good quality vegetables. Growing media have different properties such as texture, pH and water holding capacities that usually vary from one to the other (Kuhar *et al*., 2016). The looseness of the medium allows root growth and hence proper growth of the plant.

All the basic life sustaining conditions especially at germination should be readily available or plants will be affected for life and hence may not perform to the best of their genetic potential (Bhardwaj, 2014). A number of commercial media are available for growing vegetables. These growing media consist of either single component or a mixture of components that provide water, air, nutrients and support to plants. They vary greatly in composition, particle size, pH, aeration, nutrient retention and water holding capacity. However, the growing medium used must have good nutrient and water-holding characteristics, and provide good aeration to the root system (Biondo *et al*., 2000). Weight is another important property to be considered so that filled containers can be easily handled. The growing medium should also be free of pathogenic organisms and substances that are toxic to plants. The pore spaces of the medium should be able to provide water and air to avoid poor aeration which can lead to water logging (Rahimi *et al*., 2013). Use of very good planting media is critical for the growth and development of the crop after transplanting. Nurseryman and to some extent farmers compost their own media, but the choice of the medium to use is largely determined by the cost that may not be an appropriate assessment tool to use. The use of poor media composition has resulted in poor yield of vegetables which have mostly been attributed to the medium used. Therefore, the aim of the work reported here was to evaluate the suitability of some of the locally available commercial media for production of kale plants (Rahimi *et al*., 2013).

Growing media have different properties such as texture, pH and water holding capacities that usually vary from one to the other (Kuhar *et al*., 2016), so the grower must always use a medium with more desirable properties to produce good quality vegetables.

Therefore, the objective of this study was:

- To evaluate the effect of different media in growing kale.
- To ascertain the best media for planting kale.

CHAPTER TWO

LITERATURE REVIEW

2.0.0 Kale

2.2.0 **Varieties, distribution and classification**

The three types of kale that we have become popular in the produce section of today's grocery stores are actually domesticated versions of wild plants that took farmers hundreds of years to develop (The World’s Healthiest Foods, 2018). These three types include

(1) flatter, wider-leafed kale,

(2) darker Lacinato-type kale, and

(3) more tightly formed curly leafed kale.

The list below shows some common kale varieties belonging to each of these three types, according to Kelly *et al*., (2005).

(1) Flatter, Wider-Leafed Kale

- Smooth German
- Red Russian
- Beria
- Black Magic
- Tronchuda

(2) Darker, Lacinato-Type Kale (also sometimes called Napus or Siberian type kale)

- Tuscan Black
- Dinosaur Kale
- Toscano

(3) More Tightly Formed, Curly-Leafed Kale (also sometimes called Scotch or Scotch-curled kale)

- Dwarf Blue Curled
- Starbor
- Darkibor
- Winterbor

There are not always sharp dividing lines between these three types of kale, and you can expect to find varieties that blend different features. Kelly, (2018); described kale under three main types;

a. Curly kale has bright green leaves that are very curly; it's also known as Scotch or green kale and is probably familiar to most eaters as a garnish, though it's much more than that.
b. Black kale has elongated, flat, bluish-green leaves with a crinkled texture; it's also called Tuscan or dinosaur kale, and Lacinato is a specific Italian heirloom variety of this type.
c. Red kale has frilly leaves with red or purple stems.

However, there is another variety known as the ornamental kale. It is a more recently cultivated species that is considered as salad savoy. Its leaves can be green, white or purple. Its stalks coalesce to form a loosely knit head. It has a more mellow flavour and tender texture (The World Healthiest Foods 2018). Regardless of variety, however, all versions of kale are considered cruciferous vegetables and belong to the Brassica genus of plants that also includes broccoli, Brussels sprouts, cabbage, cauliflower, collards, mustard greens, and turnip greens.

The botanical family to which kale belongs is the *Brassicaceae*, also known as the Mustard family. The *Brassicaceae* is a large family comprised of approximately 3,000 described species apportioned among 350-380 genera. The precise number of genera will vary depending on the authority (Korus and Lisiewska, 2009). The classification scheme for kale and indeed all of the other brassicas is clear and straightforward until one reaches the species level. At that point the addition of numerous subspecies, varieties, and cultivars results in a rather complex and confusing arrangement of-the taxa in question. For example, the scientific name for kale, *Brassica olceracea* var. *Acephala*, is also shared by cabbage, Chinese cabbage, cauliflower, collards, brussels sprouts, brocolli, kohlrabi, and tronchuda kale, to name a few (Korus and Lisiewska, 2009). Despite the fact that all of the aforementioned varieties are similar to one another and to kale, and are therefore referred to as *B. oleracea*, they are nevertheless separate entities (Korus and Lisiewska, 2009). Brassica vegetables, such as kale and collard greens (*Brassica olceracea* var. *Acephala*), are very important to many agricultural systems around the world (WHO, 2015). The estimated annual value of brassica vegetables in the USA is approximately $1 billion. Broccoli, cabbage, cauliflower, and Brussels sprouts are the most valuable brassica crops; however, no production statistics are currently available for leafy green brassicas in the USA (Korus and Lisiewska, 2009).

Kale, traditionally a less recognized crop, is becoming a significant specialty crop in the Southern US as a result of its suitability to southern fall and winter growing conditions (Hertog *et al*., 1999). Kale is a traditional leafy green brassica used as a garnish on plates and salad bars but is gaining popularity as a primary ingredient in either raw or cooked form. Georgia, North Carolina, and South Carolina have emerged over the last five years as the leading kale producing states (Hertog *et al*., 1999). From some 500 acres producing only 15% of US kale in 2001, the Carolinas have emerged as kale leaders, currently producing more than two-thirds of America's annual kale output (Hertog *et al*., 1999). Most of the kale produced in this region is sold in a variety of fresh and processed forms that are nationally distributed. Carolina kale is marketed by market class (curly, dinosaur, red Russian, ornamental), stage of maturity, and packed fresh ready to eat or cook (Agte *et al*., 2000).

Kale is also a popular leafy green vegetable in northern regions of Asia, and Europe. Between 1993 and 2013, about 72.3% of the world's brassica vegetables were produced in Asia. The production rate of brassica vegetables for human consumption was 270 million metric tons as of 2012 but is small in comparison with sugarcane, soybean, and maize, for which about one billion tons were produced (WHO, 2015). Also, representatives of the *Brassicaceae* exhibit a cosmopolitan distribution although certain regions of the world have a greater concentration of genera than others. Members of this family are found in most parts of the world but are mainly concentrated in the north temperate region and more especially in the countries surrounding the Mediterranean basin and in southwestern and central Asia, where more genera occur than anywhere else in the world (Heywood, 1978). In the Mediterranean area 113 genera occur of which 21 (17%) are endemic, and 625 species of which 284 (45%) are endemic. The Irano-Turanian region has 147 genera of which 62 (42%) are endemic and 874 species of which 524 (60%) are endemic, while in the Saharan-Sindian region there are 65 genera, 19 (30%) being endemic and 180 species, 62 (34%) of which are endemic (Korus and Lisiewska, 2009).

2.2.0 Uses

2.2.1 Nutritional

There is a general belief among nutritionists and health professionals that the health benefit of vegetables should not be linked to only one compound or one type of vegetable, but rather a balanced diet that includes more than one type of vegetable is likely to provide better protection (Nielsen *et al*., 1999). All the vegetables may offer protection to humans against chronic diseases. With the exception of glucosinolates and thiosulfides, which are unique to the kale, the phytonutriceuticals content of a number of other vegetables consist primarily of vitamin C, fiber, selenium, folate and polyphenolics (carotenoids and flavonoids) (Crosby *et al*., 2006). The main difference is that each kale group contains a unique combination and amount of these phytonutriceuticals, which distinguishes them from other groups and vegetables within their own group. For example the *Apiaceae* family (e.g. celery, parsley, carrot) is rich in flavonoids, carotenoids, vitamin C, and vitamin E. Celery and parsley for example are among the best vegetables sources for the flavonoid apigenin and vitamin E (Nielsen *et al*., 1999), and carrots have an unique combination of three flavonoids: kaempferol, quercetin, and luteolin (Ching *et al*., 2001). In carrot, overall carotenoid levels have increased dramaticaly in the past four decades through traditional breeding to reach levels of 1000 ppm carotenoids, on a fresh weight basis (Simon and Goldman, 2007). The *Asteraceae* or *Compositae* family (e.g. lettuce, chicory) is rich in conjugated quercetin, flavonoids, and tocopherols.

Crozier *et al*. (Crozier *et al*., 2000) observed sizeable variations in flavonol content were also observed with lettuce cultivars by these authors. The commonly consumed small "round" lettuce contained only 11 μg/g fresh weight of quercetin, and the levels in "iceberg" lettuce were even lower. In contrast, the outer leaves of "Lollo Rosso", a red cultivar of lettuce, contained 911 μg/g. The red color of this lettuce is due to high levels of anthocyanins, which like quercetin, are products of the phenylpropanoid pathway. As one end- product of the pathway has been elevated, it may well be that other related compounds, including the flavonols, are also found in higher concentrations. Roman lettuce is richer in lutein than head lettuces; and leafy and roman lettuces are richer in quercetin (Almeida, 2006). The *Cucurbitaceae* family (e.g. pumpkin, squash, melon, cucumber) is rich in vitamin C, carotenoids, and tocopherols (Dhillon *et al*., 2012). Burger *et al.* (Burger *et al*., 2004) in a survey of 350 melon accessions from different horticultural groups of *Cucurbita melo* observed a 50-fold variation in ascorbic acid content, ranging from 0.7 mg to 35.3 mg/100g of fresh fruit weight (Crosby *et al*., 2006). Ascorbic acid and *β*-carotene content ranged from 7.0 to 32.0 mg/100g and 4.7 to 62.2 μg/100g, respectively in sweet melons (Crosby *et al*., 2006). Bitter gourd (*Momordica charantia*) has anti-diabetic properties and can be used to ameliorate the effects of type-2 diabetes. Diet is the primary therapy for this type of diabetes and bitter gourd is particularly critical when pharmaceuticals are not available, as happens in a great part of the developing world (Dias and Ryder, 2011).

The *Chenopodiaceae* family (e.g. spinach, Swiss chard, beet greens) is an excellent source of folate and have been shown to inhibit DNA synthesis in proliferating human gastric adenocarcinoma cells (T.He *et al*., 1999). The *Chenopodiaceae* vegetables are also among the most oxalate dense vegetables (Sienera, 2006). When oxalates become too concentrated in body fluids, they can crystallize and cause health problems such as kidney calcium oxalate stones. All the legumes (*Fabaceae* or *Leguminosae* family; e.g. bean, pea, soy-bean, chickpea, lentils), mature and imature seeds are good sources of dietary fiber and isoflavonoids (S. K. Misra, 2012). Mallillin *et al.,2008* determined the total, soluble and in-soluble fibre and fermentability characteristics of ten legumes mature seeds (mungbean, soyabean peanut, pole sitao, cowpea, chickpea, green pea, lima bean, kid-ney bean and pigeon pea) and concluded that the dietary fibre content ranged from 20.9 to 46.9 g/100g and that the best sources after *in vitro* fermentation using human faecal inoculum stimulating conditions in the human collon (as mmol/g/fibre isolate of acetate, propinate, bu-tyrate produced after fibre fermentation measured by HPLC) were pole sitao and mungbean (acetate), kidney bean and pigeon pea, (propinate), and peanut and cowpea (butyrate). High-flavonol legumes include sugar snap peas and mange-tout, which were found to contain 98 and 145 μg quercetin/g respectively. Some legumes are also rich in iron.

Trinidad *et al., 20*10 determined the mineral availability *in vitro* of iron, zinc and calcium in ten local legumes (cowpeas, mung beans, pole sitao, chickpeas, green peas, groundnuts, pigeon peas, kidney beans, lima beans and soyabeans). They found that the highest iron availability among legumes was for lima beans (9.5 (sem 0.1)) and mung bean while for zinc and calcium, the highest availability was for kidney beans (49.3 (sem 4.5)) and pigeon peas (75.1 (sem 7.1)), respectively. Groundnuts have the lowest Fe (1.3 (sem 1.1)), Zn (7.9 (sem 1.3)) and Ca (14.6 (sem 2.8)) availability. They concluded that mineral availability of Fe, Zn, and Ca from legumes dif-fers and may be attributed to their mineral content, min- eral-mineral interaction and from their phytic and tannic acid content. For example mungbean (*Vigna radiata*) either eaten as whole pod grains or grown to produce bean sprouts, is an important source of iron for women and children throughout South Asia (J. S. Dias and E. Ryder, 2011).

2.2.2 Medicinal

Brassica vegetables contain numerous micronutrients, such as antioxidants, carotenoids, glucosinolates, polyphenols, vitamins, and minerals important to human health (Aires, 2015). Available data indicate that kale is rich in several vitamins (A, K, C, and probably folate), essential minerals (potassium, calcium, magnesium), and dietary fiber. It is likely that kale can also provide other nutrients including carotenoids, folate, and prebiotic carbohydrates, although these have not been characterized [Emebu *et al*,. 2011]. Brassica greens are also known to contain phytochemicals such as folic acid, ascorbic acid, riboflavin, and carotenes [Agte *et al*., 2000]. Flavonoids act in the body as antioxidants and capture free radicals. This means that they may have a lessening effect on the likelihood of developing chronic diseases such as cancer. Other phytochemicals found in vegetables such as brassicas are categorized as antinutrients. These chemical compounds are known to disrupt many physiological pathways and lessen the absorption of beneficial nutrients. Included in this group are oxalates, phytate, and tannins. Cruciferous vegetables (*Brassicacea* or *Cruciferae family*) which include, cabbage, brocolli, cauliflower, Brussels sprouts, kales, kailan, chinese cabbage, turnip, rutabaga, radish, horseradish, rocket, watercress, mustards, among other vegetables, provide the richest sources of glucosenolates in the human diet (World Cancer Research Fund, 1997). Most consumers associate cruciferous vegetable consumption with health.

They have reasons for that because based on one of the largest and most detailed reviews of diet and cancer, the World Cancer Research Fund in USA concluded that a diet rich in crucifers is likely to protect humans against colon, rectum, and thyroid cancers, and when consumed with vegetables rich in other phytonutriceuticals, can protect against cancer in other organs (World Cancer Research Fund, 1997). Crucifers rich in glucosenolates including broccoli, cabbage, Brussels sprouts, and kale have been shown to protect against lung, prostate cancer, breast cancer, and chemically induced cancers (Ambrosone *et al*., 2004). Epidemiological data show that a diet rich in crucifers can reduce the risk from several types of cancers and that the risk can be significantly reduced by an intake of at least 10 g per day (Kirsh *et al*., 2007). Epidemiological studies have suggested that diets rich in broccoli, may reduce the risk of prostate cancer, and consumption of one or more portions of broccoli per week can reduce the incidence and the progression from localized to aggressive forms of prostate cancer (Traka, 2010).

The overwhelming evidence concerning the anticarcinogenic effect of phytonutriceuticals in crucifers were from *in vivo* studies, mainly with brocolli, using animal models and human Volunteers (Juge *et al*., 2007). In order to establish the relationship between whole brocolli and cancer prevention. Farnham *et al., 2000* examined the di- versity of induction of the phase II detoxification enzyme quinone reductase, in murine hepatoma cells, by 71 in- bred and 5 hybrid lines of broccoli. They found that the rate of induction of quinone reductase in hepa 1c1c7 by the broccoli inbred lines ranged from 0 to 15,000 units and that the rate of induction was highly correlated (average r = 0.85, P = 0.0001) to the concentration of glucoraphanin in each broccoli inbred. These results suggest that there are significant differences in the health benefits among crucifers, which is important not only from a health point of view, but also as a marketing tool to pro- mote a certain cultivar. Comparative studies of glucosenolate profiles indicate significant quantitative and quailtative differences among accessions within each crucifer, between plant parts, developmental stage, agronomic management, and climatic conditions (J. W. Fahey *et al*., 2001).

Kushad *et al.,* 1999 observed in 65 cultivars of brocolli, that glucoraphanin was the major glucosinolate and that there was more than 27-fold difference between the highest concentration in cultivar "Brigadier" and the lowest con- centration in cultivar "EV6-1".

Hansen *et al., 20*10 also observed in their study with 21 cultivars of red cabbage and 6 white cabbages, that there was a considerable variation in the concentration of the individual glucosenolates between the cultivars examined. Red cabbage cultivars were found to contain significantly higher concentrations of glucoraphanin compared to white cabbage cultivars. There were also significant differences within the red cabbage cultivars. Of the red cultivars examined "Rodima" had the highest concentration with 7.4 mg/g DW glucoraphanin whereas "Primero" has the lowest concentration containing only 0.6 mg/g DW. The white cabbage cultivars contained significantly higher levels of glucoiberin compared to red cultivars. The white cabbage cultivar "Bartolo" contained the highest level of 7.4 mg/g dry weight, whereas the cultivar "Candela" had the low- est level of 1.7 mg/g dry weight. The red cultivars ranged from approximately 3 mg/g dry weight to 0.3 mg/g dry weight. The red cabbages were also found to contain significantly higher concentration of gluconasturtiin compared to white cabbage cultivars. The cultivar "Amager Garo" had the highest concentration whereas "Primero" had the lowest, 1 and 0.1 mg/g dry weight, respectively. Similar differences were also observed in turnip and rutabagas (Korus and Lisiewska, 2009).

Fahey *et al*., 1997evaluated glucosinolate content of broccoli sprouts and found that they contain nearly 20- to 50-fold higher glucosinolates than tissue from mature plants. In broccoli heads, the most significant glucosinolates are glucoraphanin, glucobrassicin, progoitrin, and gluconasturtiin. In cabbage, Brussel sprouts, cauliflower, kale, tronchuda and collard the predominant glucosinolates are sinigrin, progoitrin, and glucobrassicin (B. Kusznierewics etal., 2008). In turnip and rutabagas, the predominant glucosenolates are glu-coerucin, glucoraphanin, and glucobrassicin. In radish, the predominant glucosinolates are glucoerucin, glucoraphanin, and glucobrassicin (E. Ciska *et al*., 2000). Each of these crucifers also contains smaller amounts of other glucosinolates. The bulk of the differences in the aliphatic glucosinolates are genetically regulated (Hertog *et al*., 1999) Differences in the indol glucosinolates, in contrast to aliphatic glucosinolates, have been attributed to environmental factors. Even though the glucosinolate content is influenced by environmental conditions the effect of genotype is found to be greater than that of environ- mental factors (M. W. Farnham *et al*., 2000).

Crucifer vegetables are also rich in vitamins, with kale rated as the second highest among 22 vegetables tested (Cao *et al*., 1996). Evaluation of α- and *β*-, *α*-, and *γ*-tocopherols, and vitamin C in broccoli, Brussels sprouts, cabbage, cauliflower, tronchuda, and kale, showed significant variations between and within these crucifers [53,68]. Vitamin C is the most abundant vitamin in all five crucifers tested (Kurilich *et al*., 1999). Kale had the highest amount of these vitamins, followed by broccoli, Brussels sprouts, cabbage and cauliflower. Analysis in- dicated that 79% of *β*-carotene, 82% of *α*-tocopherol, and 55% of vitamin C variability in broccoli were associated with genetic factors (Kurilich *et al*., 1999). Crucifers are also excellent source of folate. Brussels sprouts and broccoli were ranked among the highest vegetable sources for folate, contributing about 110 to 135 and 70 to 90 μg/100 g, re- spectively(Scott *et al*., 2000). Crucifers also contain significant amounts of dietary fiber. Dietary fiber content of kale was estimated to be about 5% of the total fresh weight or about 50% of the total dry weight, consisting of about 40% nonstarch polysaccharides (Fermenian *et al*., 1999).

There are plenty of crucifers (e.g. kales, tronchuda cabbages, packchoy, kailan, rutabaga, turnip, Brussels sprouts, etc.) that are good sources of calcium. Kale contains a high content of protein, fiber, calcium, and sulfur when compared to broccoli, the reference within *Brassica* vegetables. Crucifers are capable of accumulating substantial amounts of selenium when grown on high-selenium soil (Hertog *et al*., 1999). Other antioxidants in crucifers include flavonoids. Miean and Mohamed, 2001 examined the flavonoid content of 62 vegetables and found that broccoli, cauliflower, cabbage, chinese cabbage, and kale contained between 148 and 219 mg/kg of flavonoids. Broccoli contained myricetin, quercetin, and luteolin; in a similar study, Hertog *et al., 1999* evaluated the methanol- extracted flavonoids from 28 vegetables and found that quercetin levels, in the edible part of most vegetables, were below 10 mg/kg, except in kale (110 mg/kg), broccoli (30 mg/kg), and onion (486 mg/kg). Kale, broccoli and turnip contained 211, 72, and 48 mg/kg of kaempferol, respectively.

In summary, Farnham *etal.*, 2000 also briefly outlined six health benefits of kale

- **Detoxification and Weight loss:** The fiber (5 grams in one cup) and sulfur in kale aid with digestion and liver health. The Vitamin C it contains hydrates your body and increases your metabolism, leading to weight loss and healthy blood sugar levels. The fiber in kale also lowers cholesterol.
- **Strengthen Your Immune System:** Kale's impressive concentration of nutrients strengthens the immune system and fights viruses and bacteria. Kale has more iron than beef, making it a great source of this valuable mineral for vegans and vegetarians. It helps more oxygen get to your blood and greatly helps those who are anemic.
- **Healthier Hair, Skin & Nails:** The healthy balance of omega-3 and omega-6 fatty acids keep your body strong, healthy and beautiful from the inside out. Kale's concentration of major nutrients gives your skin's health and appearance a boost.
- **See Clearly and Stand Strong:** Kale's Vitamin A content helps keep the eyes from optical disorders that come with age. It also helps store vitamins in the retina. The calcium and vitamin K keep your bones strong.
- **Anti-inflammatory:** The omega-3 fatty acids in kale help fight and alleviate arthritis, autoimmune disorders and asthma. The vitamin C content helps relieve stiff joints.
- **Fighting Disease:** Kale, like other dark green veggies, may be helpful in preventing various cancers such as colon, prostate and ovarian. Its abundant vitamin K content is important for bone health, forestalling the effects of osteoporosis. And the folic acid and B6 provide cardiovascular support and prevent heart disease.

2.2.3 Aesthetic

Kale (*Brassica oleracea*) is an important landscape plant for fall, winter and spring gardens and parks. This attractive plant is resistant to the cold. Due to excessive stem elongation of ornamental cabbage and kale in the fall and early winter, there is a challenge for maintaining a short, yet robust plant that will look proportional to the proper size (Treder, 2008). Shorter plants are more attractive and easier to handle during marketing and planting.

Commercial value of ornamental cabbage and kale depends on its height. Plant growth regulators are commonly applied to limit stem elongation and produce a more compact plant (Treder, 2008).

2.3.0 **Media composition for healthy plant production**

Successful cultivation of plants is largely dependent on the chemical and physical properties of the growing media. One of the most important reasons for the poor quality of the plants produced in many farms cross the world is the poor quality of the potting mixture (Vikas Kumar *et al*., 2014).

Much more attention needs to be paid to its selection and preparation. It is necessary to find out what kinds of soil, sand and compost are available locally. An ideal planting medium should be free of weeds and diseases, heavy enough to avoid frequent tipping over and yet light enough to facilitate handling and shipping (Vikas Kumar *et al*., 2014). The texture of the mixture is most important. It determines whether the plant get air, moisture and nutrients or not in the right amount. The media should also be well drained and yet retain sufficient water to reduce the frequency of watering (Dias and Ryder, 2011). A sandy loam or loamy sand, which contains between 40 and 70 per cent sand is needed. For nursery use, the C: N ratio of matured compost must be less than 15. Other parameters to consider include cost, availability, consistency between batches and stability in the media over time (Manchali *et al*., 2012). Selection of the proper media components is critical to the successful production of plants. On the other hand, the purpose of a good planting medium is to enable vigorous and healthy growth of the plant and to prepare seedling for successfully transplanting in the field (Manchali *et al*., 2012). The planting medium will be physically support for growing seedling, and stores and supplies nutrients, water and air to the root system. Porosity is one of the most important physical properties of the growing medium because it determines the space available in a container for air (aeration), water and root growth (Rahimi *et al*., 2013). Aeration is important because the root system ―breathes‖ in the large, air filled pores (macropores). Poor aeration affects adversely the root formation (morphology) and structure (physiology) and it also leads to decrease seedling vigor (Rahimi *et al*., 2013).

2.4.0 **Characteristics of a composted medi**a

According to Dias and Ryder, 2011, the following points should be considered for healthy composition of planting media:

1. It should be in light weight, easier to handle, friable and easily blended.
2. It should have good porosity with well drainage as well as good water holding capacity.
3. It should be store longer period without changes in physical, chemical and biological properties.
4. The potting medium should be 4.5 to 6.0 pH and good cation exchange capacity.
5. The medium should be free from pest and disease as well as free from weeds.
6. It mixtures of low silt, clay and ash content.

7. It should be maintained a constant volume either wet or dry condition.
8. It should be promotion of firm root plug formation and dimensional stability.
9. It should be low inherent fertility and bulk density.

The better the medium, the better will be the development of a healthy, fibrous root system and the quality of seedling produced. Any nutrient deficiency can be compensated foe with additions of chemical fertilizers and other amendment (Dias and Ryder, 2011)

2.4.1 Soil mixture

This is the most commonly employed medium for pot plants. It usually consists of top soil, well decomposed cattle manure, leaf mold, river sand and also charcoal in some cases (Rahimi *et al*., 2013). It must be pass it through by sieving (1-2 cm) to remove roots, stones, and lumps, before filling it to any containers (Rahimi *et al*., 2013). Soil mixture commonly used for propagation is:

- Top soil = 3parts.
- FYM or Poultry mnure = 2parts.
- River sand - 1 part.

2.4.2 Good drainage

The growing medium must allow adequate drainage from macro pores, so that water does not remain at the bottom of the container where it would inhibit root respiration (Rahimi *et al*., 2013). The presence of macro pores is a function of particle size, particle arrangement and the degree of compaction. The presence of small pores helps to retain water concentration (Rahimi *et al*., 2013).The organic provides a large number of micro pores.

2.4.3 Porosity

The porosity (percentage of air space divided by total container volume) of a good growing medium for container tree seedlings should exceed fifty percent (50 %) and the aeration porosity (the percentage of air space remaining after saturation when water has freely drained) should range from 20 to 35 percent depending on the medium (Rahimi *et al*., 2013).

Overall balance of both macro and micro pores is necessary for a high quality container medium. Porosity is depends on particle size, size class mixture, texture and their changes overtime. There is direct proportional relation between particle size and aeration pores but inversely proportional to water holding capacity (Rahimi *et al*., 2013).

2.4.4 Cation exchange capacity

It is a measure of the ability of soil or planting medium to hold nutrients. The cation exchange capacity means that nutrients will not be retained (Rahimi *et al*., 2013). They will be washed out (leached) from the mix during irrigation. The high cation exchange capacity results in nutrients being held to the mix and available to the seedlings (Rahimi *et al*., 2013).

As a result, high cation exchange capacity medium is able to continually provide nutrients to the plants (Rahimi *et al*., 2013). As generally, the greater the addition of organic matter or compost, the higher the cation exchange capacity of the mixture.

2.5.0 Components of a planting media

Planting media are either composed of a single substrate (unmixed material from a single source) or more likely are mixtures of various organic and organic or mineral components. Mixtures of various components with complementary physical and chemical properties will produce superior potting media (Dekreij and Leeuven, 2001). Composting improves their physical properties and balances the ratio of carbon to nitrogen in the material (Dekreij and Leeuven, 2001).

Components of properties of individual planting medium are mentioned below:

MEDIA COMPONENTS – ORGANIC AMENDMENTS

2.5.1 Compost and animal manures

A large variety of compost or animal manure products is available in the marketplace. This section will highlight several considerations when evaluating these materials as a media amendment.

Acording to Dekreij and Leeuven, 2001.

Manures: disadvantages include possible high salts, fine particle size and weed seeds. The advantages include the nutrient contribution and potential improvement in media physical properties.

Sludge: a primary consideration when evaluating sludge is the potential for elevated heavy metals including cadmium, lead, zinc, copper and mercury. Plant-based composts: in some areas compost products provide a low-cost media amendment (Dekreij and Leeuven, 2001).
Critical issues to consider are the availability and consistency of the product and the particle size. Particle sizes for plant-based compost can be either too large or too fine depending on the source material and composting process (Dekreij and Leeuven, 2001).

2.5.2 Rice husks

Crop growers are fortunate in that this organic component is readily available as a result of the sizeable rice industry at Achala, Anambra state. Rice husks are available in a variety of forms including fresh, aged, carbonized, composted and parboiled (Dekreij and Leeuven, 2001). Fresh rice husks are typically avoided as container substrates because of residual rice and/or weed seed (Dekreij and Leeuven, 2001).

Parboiled rice hulls (PRH) are produced by steaming and drying rice hulls after the milling process, which results in a product that is free of viable weed and/or rice seed (Dekreij and Leeuven, 2001). Despite being an organic compound, rice husks consist mainly of lignin, cutin and insoluble silica, providing a slow breakdown of particles and therefore making them an appropriate substrate for long-term crop production (Dekreij and Leeuven, 2001). Recent research conducted at the University of Arkansas indicates that amending pine bark with up to 40% PRH will not significantly decrease plant growth or increase the volume or frequency of irrigation for container grown plants after one and two growing seasons (Dekreij C and Leeuven G, 2001). According to Dekreij and Leeuven, 2001, a number of researchers have demonstrated that PRH is a suitable alternative to perlite in greenhouse substrates. In bedding plant trials at the University of Arkansas, the highest shoot and root growth occurred for plants grown in substrates containing 20% to 30% PRH. The pH of composted rice and parboiled rice husks ranges from 5.7 to 6.2, and 6.2 to 6.5, respectively.

Fresh rice hulls are light in weight (bulk density 6 to 7 lbs/ft3) and are useful to increase drainage and aeration (Dekreij and Leeuven, 2001). Fully composted rice husks will hold more water than unprocessed husks. Either fresh or composted rice husks have a high Mn content (Dekreij and Leeuven, 2001).

2.6.0 General mixing and handling recommendations

According to Khayyat *et al*., 2007:

1. Test the media pH, total soluble salts (electrical conductivity) and wettability before use.
2. Do not make changes to your current growing media without experimenting first to see if changes may affect your cultural practices.
3. Thoroughly mix components, but don‘t over mix, especially if a medium contains vermiculite or plastic-coated slow-release fertilizer.
4. Do not store media that contains fertilizer for long periods of time, especially if the media is moist.
5. Avoid contamination of components or finished media by keeping amendments in closed bags or by covering outdoor piles.
6. Do not allow mixes containing a significant amount of peat moss to dry out.

2.7.0 A review on the science of growing crops without soil (soilless media)

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for plant growth (Polycarpou *et al*., 2005). However, soils do pose serious limitations for plant growth too, at times. Some of them are presence of disease causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion etc. (Polycarpou *et al*., 2005). In addition, Open Field Agriculture is difficult as it involves large space, lot of labour and large volume of water (Polycarpou *et al*., 2005). In most urban and industrial areas, soil is less available for crop growing, or in some areas, there is scarcity of fertile cultivable arable lands due to their unfavorable geographical or topographical conditions (Polycarpou *et al*., 2005). Other serious problem experienced is to hire labour at regular times for conventional open field agriculture (Butler and Oebker, 2006). Under such circumstances, soilless media can be introduced successfully (Butler and Oebker, 2006).Soilless media is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution (Maharana and Koul, 2011). Soilless media systems of cultivation can be classified according to the techniques employed. It supplies fresh vegetables in countries with limited arable land as well as in small countries with large populations (Maharana and Koul, 2011). It could be useful to provide sufficient fresh vegetables for the indigenous population as well as for tourists in countries where tourism plays a vital role in their economy. Typical examples of such regions are the West Indies and Hawaii, which each have a large tourist industry and very little farmland for vegetable production (Pual, 2000).

In soilless media some cultural practices like soil cultivation and weed control are avoided, and land not suitable for soil cultivation can be used (Polycarpou *et al*., 2005). Plants grown by hydroponics had consistently superior quality, high yield, rapid harvest, and high nutrient content. Soilless media could be applied to growing some popular local crops with the application of food safety standards and at a reasonable price (Pual, 2000). This system will also help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition (Butler and Oebker, 2006). Soilless media can provide important requirements for plant growth with equal growth and yield results compared to field soil (Polycarpou *et al*., 2005). Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium. When the mineral nutrients in the soil dissolve in water, plant roots are able to absorb them. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive (Polycarpou *et al*., 2005). The simplest and oldest method for soilless culture is a vessel of water in which inorganic chemicals are dissolved to supply the nutrients that plants require (Pual, 2000). Various modifications of pure-solution culture have occurred in the past. The retention of nutrients and water can be further improved through the use of spaghnum peat, vermiculite, or bark chips. These are the most commonly used materials, but others such as rice hulls, bagasse (sugarcane refuse), sedge peat, and sawdust are used sometimes as constituents in soilless mixes (Pual, 2000).

2.7.1 Advantage of soilless media

There are many advantages of growing plants under soilless media over soil-based media (Savvas, 2002). Soilless culture offers opportunities to provide optimal conditions for plant growth and therefore, higher yields can be obtained compared to open field agriculture; gardening is clean and extremely easy, requiring very little effort (Silberbush and Ben-Asher, 2001). Soil less media offers a means of control over soil-borne diseases and pests, which is especially desirable in the tropics where the life cycles of these organisms continues uninterrupted and so does the threat of infestation (Savvas, 2002). It is also effective for the regions of the World having scarcity of arable or fertile land for agriculture (Sonneveld, 2000). It reduces the cost and time taken for various tasks which are avoided in soilless culture of cultivation. It offers a clean working environment and thus hiring labour is easy (Savvas, 2002).

2.7.2 Limitation of soilless media

Despite of many advantages, soilless media has some limitations (Sonneveld, 2000). Application on commercial scale requires technical knowledge and higher initial capital expenditure (Savvas, 2004). This will be further high if the soilless media is combined with controlled environment agriculture (Sonneveld, 2000). High degree of management skills is necessary for solution preparation, maintenance of pH and Ec, nutrient deficiency judgment and correction, ensuring aeration; maintenance of favourable condition inside protected structures, etc (Savvas, 2004). Great care is required with respect to plant health control. Finally energy inputs are necessary to run the system (Van *et al*., 2002). Considering the significantly high cost, the soil-less media is limited to high value crops of the area of cultivation.

CHPTER THREE

MATERIALS AND METHODS

3.0.0 Materials and methods

3.1.0 Experimental site

The experiment was conducted at the Department of Crop science and horticulture Research Farm, Nnamdi Azikiwe University Awka, Anambra State Nigeria. Awka is characterized by tropical rain forest with temperature of 27^0C - 30^0C. The area is located between latitude 06^0 15^l N and longitude 07^0 08^l E, with an average rainfall of 1810.3 mm per annum. The experiment was carried out in the raining season (June, 2019 to October, 2019).The nursery was carried out in a high tunnel of height 2.5 m which was made of bamboo sticks and palm fronds roofing and seedlings nurtured to maturity in open field inside a polythene bag.

3.2.0 Sources of planting material

The planting material was a batch of kale seeds procured from Sansui Agro farm Jos, Plateau state, Nigeria. The seeds were developed by Johnny selected seeds company located in USA.

3.3.0 Cultural practices

3.3.1 Media Preparation

Top soil, poultry manure and river sand was compounded in the ratio of 3:2:1. The mixture was composted for three weeks and for the period, in one week interval was turned and mix with little water to aid the decomposition of the medium. The cured media was incorporated into a local basket.

Plate 1: Baskets used at the nursery for cultivation of Kale

3.3.2 Nursery

The seeds were evenly spread in a local basket and kept under the shade. The nursery was carried out in a high tunnel of height 2.5 m which was made of bamboo sticks and palm fronds for roofing.

Plate 2: Nursery raised for Kale cultivation

3.3.3 Managements

Proper management was given by watering twice a day prior and after seedling emergence and hardening of seedling was done at one week to transplanting.

Plate 3: Management practices like watering of the Kale seedlings undertaken by me

3.3.4 Land Preparation

The land was cleared of existing vegetation and properly prepared for the experimental layout with nylon bags which was filled to ¾ with the prepared media.

3.3.5 Transplanting

Kale seedlings were transplanted to the nylon bags at 3 weeks from planting in the nursery. The nylon was kept in an open field.

3.4.0 Treatments and experimental layout

The kale seedling received three treatments of varying media composition replicated four times. The media composition used includes A (mixture of top soil + poultry manure + river sand), B (mixture of rice husk + poultry manure + river sand) and C (mixture of rice husk + poultry manure). The distance between the nylon bags is 0.1m, each plot had eight bags with two seedling in each. Each block had a spacing of 0.5m for pathway. The experiment was laid out in a Complete Randomised Design (CRD)

3.5.0 Sources of media composition

The top soil used, was collected at a depth 0cm – 5cm at the department of Forestry and Wildlife Teaching and Research Farm, the poultry manure used, was poultry droppings from battery cage system gotten from Aroma farms Awka, Anambra state, while the rice husk was gotten from 'Onu' Rice Mill located at Achalla, in Awka North Local Government Area of Anambra state, Nigeria.

3.6.0 Media preparation and treatment allocation

On 1st July 2019, the media was moistened with water respectively. Then, it was separately covered with a cellophane material to initiate curing. It was left under cover for 1month without allowing air to penetrate each composited media.

The treatment were packed into the nylon bags and placed according to the treatments:

A = top soil + poultry manure + river sand.

B = rice husk + poultry manure + river sand.

C = rice husk + poultry manure.

3.7.0 Data collection

Data were collected from 3weeks after transplanting and at 1week interval. The data collected during the experiment included the following parameters:

- Leaf length.
- Leaf width.
- Number of leaves per plant.
- Vine or stem length.
- Number of branches per plant.
- Leaf weight.

Leaf length was measured with a transparent meter rule. Leaf width was also measured with a meter rule. Vine or stem length was measured from base of plant to the shoot tip. Number of branches and leaves was determined by counting the branches and leaves of each kale stand. At the end of the experiment, leaf weight was determined immediately after harvest using an electronic balance - PGW 4502e (Adam®, Smith-Hamilton, Inc., Miami Florida, US; www.adamequipment.com).

All the data collected were subjected to analysis of variance in completely randomized design(CRD) using GENSTAT (2012).

CHAPTER FOUR

RESULTS.

Table 4.1: Effect of different growing media on the leaf area of Kale

Table 4.1: Effect of different growing media on the leaf area of Kale

Growing media	3WAT	6WAT	7WAT	8WAT	9WAT	10WAT
A	-5.9	30.7	13.9	14.7	17.8	24.2
B	10.8	28.5	33.7	37.6	44.7	55.6
C	21.7	15.4	35.8	33.4	37.9	43.1
LSD(0.05)	23.95	NS	NS	NS	NS	NS

WAT = weeks after transplanting.

A = mixture of top soil + poultry manure + river sand.

B = mixture of rice husk + poultry manure + river sand.

C = mixture of rice husk + poultry manure.

NS = non-significant.

Table (4.1) showed that the different growing media significantly ($P<0.05$) influenced the leaf area at only 3WAT. There were however, no significant ($P>0.05$) difference at 6, 7, 8, 9, and 10WAT. Growing media C gave significantly ($P<0.05$) higher leaf area at 3WAT, there were drop on the leaf area at 6WAT for the growing media C. Growing media A and B had similar result in all the weeks after transplanting.

The result also showed that at 10WAT, treatment B had the highest leaf area, while treatment A at 3WAT had the lowest leaf area.

Table 4.2: Effect of different growing media on the number of leaves of Kale

Table 4.2: Effect of different growing media on the number of leaves of Kale

Growing media	**3WAT**	**6WAT**	**7WAT**	**8WAT**	**9WAT**	**10WAT**
A	1.84	8.56	7.54	7.53	8.35	9.83
B	5.75	7.79	7.50	8.13	8.83	9.46
C	6.58	5.83	6.25	6.25	6.54	6.87
LSD(0.05)	1.949	NS	NS	NS	2.233	2.337

WAT = weeks after transplanting.

A = mixture of top soil + poultry manure + river sand.

B = mixture of rice husk + poultry manure + river sand.

C = mixture of rice husk + poultry manure.

NS = non-significant.

The table (4.2) showed that the different growing media significantly ($P<0.05$) influenced the number of leaves at 3, 9, and 10WAT. There were however, no significant ($p> 0.05$) difference at 6, 7, and 8WAT. Growing media C gave significantly ($P<0.05$) higher number of leaves at 3, and 10WAT, there were drop at the number of leaves at 6, 7, 8, and 9WAT for the growing media C. Growing media A and B had statistically similar result at 3, 9, and 10WAT.

The result also showed that at 10WAT, treatment B had the highest number of leaves, while treatment A at 3WAT had the lowest number of leaves.

Table 4.3**:** Effect of different growing media on the vine length of Kale

Table 4.3: Effect of different growing media on the vine length of Kale

Growing media	**3WAT**	**6WAT**	**7WAT**	**8WAT**	**9WAT**	**10WAT**
A	2.32	4.288	3.79	3.39	3.81	4.18
B	3.24	4.200	3.19	3.64	4.10	4.53
C	4.02	3.312	3.40	3.52	3.87	4.18
LSD(0.05)	1.223	0.6668	NS	NS	NS	NS

WAT = weeks after transplanting.

A = mixture of top soil + poultry manure + river sand.

B = mixture of rice husk + poultry manure + river sand.

C = mixture of rice husk + poultry manure.

NS = non-significant.

Table (4.3) showed that the different growing media significantly ($P<0.05$) influenced the vine length at 3 and 6WAT.There were however, no significant ($p> 0.05$) difference at 7, 8, 9, and 10WAT. Growing media C gave significantly ($P<0.05$) higher vine length at 3WAT, there were drop at the vine length at 7, 8, and 9WAT for the growing media C. Growing media A gave significantly ($P<0.05$) higher vine length at 6WAT, although it is statistically similar to the growing media B.

The result also showed that at 10WAT, treatment B had the highest vine length, while treatment A at 3WAP had the lowest vine length.

Table 4.4**:** Effect of different growing media on the number of branches of Kale

Table 4.4: Effect of different growing media on the number of branches of Kale

Growing media	**3WAT**	**6WAT**	**7WAT**	**8WAT**	**9WAT**	**10WAT**
A	1.84	8.56	7.54	7.53	8.35	9.83
B	5.75	7.79	7.50	8.13	8.83	9.46
C	6.58	5.83	6.25	6.25	6.54	6.87
LSD(0.05)	1.949	NS	NS	NS	NS	2.337

WAT = weeks after transplanting.

A = mixture of top soil + poultry manure + river sand.

B = mixture of rice husk + poultry manure + river sand.

C = mixture of rice husk + poultry manure.

NS = non-significant.

Table (4.4) showed that the different growing media significantly ($P<0.05$) influenced the number of branches at 3, and 10WAT. There were however, no significant ($p> 0.05$) difference at 6, 7, 8, and 9WAT, but growing media C gave the highest number of branches at 6 and 7WAT and growing media B had the highest number of branches at 8 and 9WAT.

The result also showed that at 10WAT, media A had the highest number of branches, although it is statistically similar to growing media B at 10WAT, while treatment A at 3WAT had the lowest significant number of branches.

Table 4.5: Effects of different growing media on the leaf weight of kale

Table 4.5: Effects of different growing media on the leaf weight of kale

Growing media	**10WAT**
A	0.00016tonnes/hectare
B	0.00017tonnes/hectare
C	0.00012tonnes/hectare
LSD(0.05)	NS

WAT = weeks after transplanting.

A = mixture of top soil + poultry manure + river sand.

B = mixture of rice husk + poultry manure + river sand.

C = mixture of rice husk + poultry manure.

NS = non-significant.

The table (4.5) showed that there were no significant differences (P>0.05) on the leaf weight of kale. Treatment B gave the highest weight of 0.00017tonnes/hectare, while treatment C had the lowest weight 0.00012tonnes/hectare.

CHAPTER FIVE

DISCUSSION

5.1 Leaf area of kale

Leaf area is a crucial growth indices determining the capacity of plant to trap solar energy for photosynthesis and has marked effect on growth and yield of plant (Detpiratmongkol *et al.*, 2014). Table 4.1 showed the effect of different growing media on leaf area was highly significant ($p<0.05$).

Plate 4: Kale plants from media B

The highest leaf area (55.6) was obtained under media B (mixture of rice husk, poultry manure and river sand) which was statistically similar to media C (mixture of rice husk and poultry manure) with 52.19g. Manure provided nutrients for soil micro-organisms and increases the activities, which in turn convert unavailable plant nutrients into available form to promote plant growth (Umesha *et al*., 2014).

Plate 5: Kale plants from media C

The higher leaf area in treatment B and C could also be attributed to the solubility, absorption and translocation of the absorbable nutrients by the plant for leaf synthesis as a result of decomposed poultry manure (Madisa *et al*., 2013 and Masarirambi., *et al* 2012). The leaf area of plants grown media A was significantly ($p<0.05$) lower than in media B probably due to poor drainage. The higher leaf area in media B could be attributed to the media's desirable properties to continuously supply growth factors (nutrients, water and oxygen) throughout the period of seedling development. Kakoei and Hassan reported that the highest number of leaves per cutting observed in cole crops was due to medium characteristics like porosity and water holding capacity (Kakoei and Salehi, 2013). media B and C are formulations made from different components to achieve a substrate with desirable properties. However, media A was noted to be retaining water because of its caked nature, and this does not support good crop growth.

According to Awang *et al*., 2009, media A is considered a good growing media component with acceptable pH, electrical conductivity and other chemical attributes but it has been recognized to have high water holding capacity which causes poor air-water relationship, leading to low aeration within the medium, thus affecting the oxygen diffusion to the roots (Awang *et al*., 2009). Seeds of kale grown in media A emerged and some eventually died while the struggling seedlings were stunted.

5.2 Number of Leaves of kale

Results in Table (4.2) showed that the effect of growing media on the number of kale leaves was highly significant ($p<0.05$). The media A had the highest number of leaves (9.83) which were statistically similar to media B (9.46). This could be attributed to the solubility, absorption and translocation of the absorbable nutrients by the plant for leaf synthesis as a result of amending growing media with decomposed chicken manure. In addition, organic manure increases carbon, nitrogen, pH, cation exchange capacity and exchangeable Ca, Mg and K which invariably enhance crop yield and improves productivity which occurred in kale plants grown in media A and media B (Ayoola and Makinde 2008). The application of chicken manure has been found to increase growth in vegetables and the good performance observed in media A could be attributed to increased nitrogen levels derived from chicken mature amendment(Ayoola and Makinde 2008).). The number of leaves in plants grown in media C were significant fewer ($p<0.05$) than those grown in other two growth media.

Plate 6: Kale plant from media A

The highest leaf area (55.6 cm^2) was obtained under treatment B medium which was significantly ($P<0.05$) higher than treatment C (43.1 cm^2). Leaves are the main source of food synthesized for the plant and thus their absence affects plant growth and development. Leaf area is recognized as a crucial growth index determining the capacity of plants to trap solar energy for photosynthesis and has marked effect on growth and yield of plant (Mathowa *et al*., 2014).

5.3 Number of Branches of kale

The effect of growing media on the number of kale branches was highly significant ($p<0.05$). More branches per plant (9.83) were observed in media A followed by media B with statistically similar number of branches per plant (9.46). Organic manure improves cation exchange capacity (CEC) and its application can also result in higher water holding capacity especially in media A (Murwira,1999).

5.4 Leaf Weight of kale

Leaf weight was not significantly affected ($p<0.05$) by growing media. This could be attributed to the non-stimulating effect of decomposed poultry manure that supplies plant with nutrients required for better yield (Abdelrazzag, 2002.). The poor performance observed in media C could be probably be attributed poor aeration as a result of poor drainage or delayed decomposition of organic matter by microbial action due to small number of microbes in pots. This is supported by Hassink 1999, who reported that the influence of soil texture on organic matter decomposition and net mineralization depend, on the accessibility of organic substrate to soil organism (Hassink, 1999). Leaf weight was significantly ($P<0.05$) different between treatment B and C, but treatment A has a reasonable amount of leaf weight even though it did not support any reasonable seedling growth. Treatment B exhibited higher leaf weight (0.00017tonnes/hectare) treatment A followed with 0.00016tonnes/hectare. According to Khayyat *et al*., 2007, reduced porosity in a medium is a factor which may restrict root formation hence slower plant growth.

CONCLUSION AND RECOMMENDATION

Land should not be a limiting factor to kale production. It could be grown as a potted plant using the recommended media composition for efficient production and maximum yield production. It could be deduced from this study that growing medium influenced the growth and yield of kale. Growing media B had highest yield of 0.00017tonnes/hectare, while treatment A had a nearer weight of 0.00016tonnes/hectare.

So in the absence of growing media B, growing media A could be used since they all supported the growth and development of kale seedling.

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APPENDIX

Appendix 1: statistical results

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GenStat Release 7.2 DE  (PC/Windows)             23 October 2019 11:12:18
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Variate: LeafArea_3WAP

Source of variation     d.f.(m.v.)      s.s.       m.s.    v.r.  F pr.

Block stratum               3           754.5      251.5    2.22
Media                       2          1541.8      770.9    6.81  0.077
Residual                    3(3)        339.9      113.3
Total                       8(3)       1143.1

Grand mean  8.9

    Media        A        B        C
              -5.9     10.8     21.7


*** Least significant differences of means (5% level) ***

Table                Media
rep.                     4
d.f.                     3
l.s.d.               23.95


Variate: No_lvs_3WAP

Source of variation     d.f.(m.v.)      s.s.       m.s.    v.r.  F pr.

Block stratum               3          7.8659     2.6220    3.50
Media                       2         51.3844    25.6922   34.26  0.009
Residual                    3(3)       2.2500     0.7500
Total                       8(3)      18.7654

Grand mean  4.72

    Media        A        B        C
              1.84     5.75     6.58


*** Least significant differences of means (5% level) ***

Table                Media
rep.                     4
d.f.                     3
l.s.d.               1.949


Variate: VineLe_3WAP

Source of variation     d.f.(m.v.)      s.s.       m.s.    v.r.  F pr.
```

Block stratum	3	2.1165	0.7055	2.39	
Media	2	5.8209	2.9104	9.85	0.048
Residual	3(3)	0.8865	0.2955		
Total	8(3)	4.1780			

Grand mean 3.19

Media	A	B	C
	2.32	3.24	4.02

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	1.223

Variate: NoBran_3WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	7.8659	2.6220	3.50	
Media	2	51.3844	25.6922	34.26	0.009
Residual	3(3)	2.2500	0.7500		
Total	8(3)	18.7654			

Grand mean 4.72

Media	A	B	C
	1.84	5.75	6.58

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	1.949

Variate: LeafArea_6WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	567.5	189.2	1.35	
Media	2	545.8	272.9	1.95	0.287
Residual	3(3)	420.5	140.2		
Total	8(3)	1300.0			

Grand mean 24.9

Media	A	B	C
	30.7	28.5	15.4

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	26.64

Variate: No_lvs_6WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	8.237	2.746	1.09	
Media	2	15.777	7.888	3.14	0.184
Residual	3(3)	7.538	2.513		
Total	8(3)	26.340			

Grand mean 7.39

Media	A	B	C
	8.56	7.79	5.83

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	3.567

Variate: NoBran_6WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	8.237	2.746	1.09	
Media	2	15.777	7.888	3.14	0.184
Residual	3(3)	7.538	2.513		
Total	8(3)	26.340			

Grand mean 7.39

Media	A	B	C
	8.56	7.79	5.83

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	3.567

Variate: VineLe_6WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.

Block stratum	3	0.08235	0.02745	0.31	
Media	2	2.33021	1.16510	13.27	0.032
Residual	3(3)	0.26344	0.08781		
Total	8(3)	2.06889			

Grand mean 3.934

Media	A	B	C
	4.288	4.200	3.312

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	0.6668

Variate: LeafArea_7WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	2959.5	986.5	2.12	
Media	2	1171.8	585.9	1.26	0.401
Residual	3(3)	1398.4	466.1		
Total	8(3)	3398.7			

Grand mean 27.8

Media	A	B	C
	13.9	33.7	35.8

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	48.58

Variate: No_lvs_7WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	23.688	7.896	4.89	
Media	2	4.305	2.153	1.33	0.385
Residual	3(3)	4.847	1.616		
Total	8(3)	27.173			

Grand mean 7.10

Media	A	B	C
	7.54	7.50	6.25

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.860

Variate: NoBran_7WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	23.688	7.896	4.89	
Media	2	4.305	2.153	1.33	0.385
Residual	3(3)	4.847	1.616		
Total	8(3)	27.173			

Grand mean 7.10

Media	A	B	C
	7.54	7.50	6.25

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.860

Variate: VineLe_7WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	1.8876	0.6292	2.18	
Media	2	0.7477	0.3739	1.30	0.393
Residual	3(3)	0.8646	0.2882		
Total	8(3)	2.8889			

Grand mean 3.46

Media	A	B	C
	3.79	3.19	3.40

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	1.208

Variate: LeafArea_8WAP

Source of variation d.f.(m.v.) s.s. m.s. v.r. F pr.

Block stratum	3	2338.7	779.6	1.05	
Media	2	1189.1	594.5	0.80	0.527
Residual	3(3)	2236.1	745.4		
Total	8(3)	3839.3			

Grand mean 28.6

Media	A	B	C
	14.7	37.6	33.4

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	61.44

Variate: No_lvs_8WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	17.541	5.847	5.52	
Media	2	7.336	3.668	3.46	0.166
Residual	3(3)	3.177	1.059		
Total	8(3)	24.321			

Grand mean 7.30

Media	A	B	C
	7.53	8.13	6.25

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.316

Variate: VineLe_8WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	1.3790	0.4597	1.59	
Media	2	0.1208	0.0604	0.21	0.822
Residual	3(3)	0.8676	0.2892		
Total	8(3)	1.8261			

Grand mean 3.52

Media	A	B	C
	3.39	3.64	3.52

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	1.210

Variate: NoBran_8WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	17.541	5.847	5.52	
Media	2	7.336	3.668	3.46	0.166
Residual	3(3)	3.177	1.059		
Total	8(3)	24.321			

Grand mean 7.30

Media	A	B	C
	7.53	8.13	6.25

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.316

Variate: LeafArea_9WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	2706.3	902.1	1.07	
Media	2	1561.0	780.5	0.93	0.486
Residual	3(3)	2525.4	841.8		
Total	8(3)	4444.6			

Grand mean 33.4

Media	A	B	C
	17.8	44.7	37.9

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	65.29

Variate: No_lvs_9WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	12.6906	4.2302	4.29	
Media	2	11.6750	5.8375	5.93	0.091
Residual	3(3)	2.9549	0.9850		
Total	8(3)	23.8580			

Grand mean 7.91

Media	A	B	C
	8.35	8.83	6.54

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.233

Variate: VineLe_9WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	1.1621	0.3874	1.55	
Media	2	0.1886	0.0943	0.38	0.714
Residual	3(3)	0.7475	0.2492		
Total	8(3)	1.6377			

Grand mean 3.93

Media	A	B	C
	3.81	4.10	3.87

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	1.123

Variate: NoBran_9WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	12.6906	4.2302	4.29	
Media	2	11.6750	5.8375	5.93	0.091
Residual	3(3)	2.9549	0.9850		
Total	8(3)	23.8580			

Grand mean 7.91

Media	A	B	C
	8.35	8.83	6.54

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.233

Variate: LeafArea_10WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	3170.	1057.	1.05	
Media	2	1987.	994.	0.99	0.468
Residual	3(3)	3021.	1007.		
Total	8(3)	5481.			

Grand mean 41.0

Media	A	B	C
	24.2	55.6	43.1

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	71.41

Variate: No_lvs_10WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	9.884	3.295	3.05	
Media	2	20.719	10.359	9.60	0.050
Residual	3(3)	3.236	1.079		
Total	8(3)	28.722			

Grand mean 8.72

Media	A	B	C
	9.83	9.46	6.87

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.337

Variate: VineLe_10WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	0.9443	0.3148	1.98	
Media	2	0.3307	0.1653	1.04	0.454
Residual	3(3)	0.4765	0.1588		
Total	8(3)	1.3610			

Grand mean 4.30

Media	A	B	C
	4.18	4.53	4.18

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	0.897

Variate: NoBran_10WAP

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	9.884	3.295	3.05	
Media	2	20.719	10.359	9.60	0.050
Residual	3(3)	3.236	1.079		
Total	8(3)	28.722			

Grand mean 8.72

Media	A	B	C
	9.83	9.46	6.87

*** Least significant differences of means (5% level) ***

Table	Media
rep.	4
d.f.	3
l.s.d.	2.337

Variate: Plant_weight

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Block stratum	3	4289.8	1429.9	6.05	
Media	2	5348.3	2674.1	11.31	0.040
Residual	3(3)	709.4	236.5		
Total	8(3)	8655.6			

```
Grand mean  145.6

    Media        A        B        C
             155.6    165.0    116.3

*** Least significant differences of means (5% level) ***

Table                Media
rep.                     4
d.f.                     3
l.s.d.               34.60
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