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Effect of soil amendments on the nutritional quality of three commonly cultivated lettuce varieties in Ghana

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Effect of soil amended with poultry manure and NPK fertilizer on the quality of three cultivars of lettuce; Great Lake, Eden and Trinity cultivated in KNUST, were assessed and analysed. The cultivars were raised, harvested and stored at the Department of Horticulture of the Kwame Nkrumah University of Science and Technology, Kumasi. The harvested leaves were assessed for calcium, iron, vitamin C, chlorophyll, carotenoid level, weight loss and dry matter content. The treatments showed a significant effect (p≤0.05) on the quality parameters except weight loss and dry matter content. The cultivars also varied (p≤0.05) with regards to the quality indicators assessed. Similarly, the interaction of the treatments and cultivars showed significant differences.

Key words: Organic fertilizer, Inorganic fertilizer, quality, shelf life *Lactuca sativa*.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a native of Europe, Asia and Northern Africa and has been cultivated for over 5,000 years. Lettuce is a rich source of antioxidants, Vitamin A and C and phytochemicals which are anti-carcinogenic. It also provides some dietary fibre, carbohydrates, protein and a small amount of fat. Lettuce also provides calcium, iron and copper, with vitamins and minerals largely found in the leaf. Lettuce is usually consumed as a salad or shredded in a salad mix of onion, tomato, cheese and basil. In the market gardens of tropical regions including Ghana, early maturing iceberg type lettuce with three prominent cultivars (Eden, Trinity and Great lakes) are mostly cultivated. The productivity and quality of these lettuces depend on the growing conditions and soil amendments. Also, the difference in minerals and vitamins of the various cultivars of lettuce might also be due to the genotypic difference since they are grown under the same environment (Ojetayo et al., 2011).

In Ghana, commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing vegetable crops (Lampkin, 1990). This is because they are easy to use, quickly absorbed and utilized by crops. The widespread adoption of synthetic fertilizer and associated agricultural practices had a host of unintended consequences to our environment, the quality of our foods and health, and the sustainability of our food system. Organic manure can serve as alternative practice to inorganic fertilizers (Gupta et al., 1988; Wong et al., 1999; Naeem et al., 2006) for improving soil structure (Bin, 1983; Dauda et al., 2008). Organic fertilizers can be used to reduce the amount of

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toxic substances such as nitrates produced by conventional fertilizers in vegetables like lettuce, hence, improving the quality of leafy vegetables as well as human health. However, poultry manure has long been recognized as the most desirable of these organic fertilizers because of its high nitrogen content and availability in most part of the country. It decomposes in the soil releasing nutrients for crop uptake. In a research conducted to find the effects of animal manure on different crops, it was reported that poultry manure was appreciably richer in plant nutrients than other animal manures (FAO, 2008).

Public concern about food quality and safety is steadily increasing. The judgment of fresh vegetables depends on visual characteristics as well as on nutritional quality. The idea of nutritional quality includes beneficial and harmful ingredients, taste, fragrance, freshness and shelf-life as well as the risk of toxic pathogens (Sagoo et al., 2001). Regarding lettuce, the marketable and nutritional quality depends heavily on the agronomic strategy used. Fast release of nitrogen (N) from fertilizers or a surplus of N can lead to an increase in nitrate content of plant tissues, synthesis of N-containing compounds and a decrease in beneficial phytochemicals.

The productivity and quality of vegetable crops especially lettuce therefore depends on the growing conditions and fertilizer application. Despite many investigations in the area of the effect of fertilizers on growth and yield of lettuce, there is little information on the postharvest quality of the crop using various fertilizers to assess its nutritional components. With these ideas in view, it called for an experiment to be conducted to determine the effect of soil amendments on the nutritional on the nutritional quality of three commonly cultivated lettuce cultivars in Ghana. Specifically to determine the effect of soil amendments on the nutritional composition of lettuce.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at Department of Horticulture experimental field, Kwame Nkrumah University of Science and Technology. The area is located between latitude 6°40”26’ North and longitude 1°35” West and lies approximately 260 m above sea level. The climate of the area is tropical maritime, which is characterized by a wet and dry season with a double maxima rainfall regime. The major rainfall season occurs between March and September, peaking in June and August. November to March is the main dry season making rainfall weakly bimodal. The mean annual rainfall is 1,300 mm and the mean temperature is 28°C.The experiment was carried out in the dry season (October to December 2012).

Soil and manure analysis

Soil and manure analysis was performed before the commencement of field experiments and after cultivation. Total nitrogen was determined using Kjeldahl method. Available phosphorus was determined calorimetrically using Spectrophotometer. Potassium, calcium and Iron from soil, manure and plant tissues were determined by the use of Atomic Absorption Spectrophotometer (AAS). The soil pH was measured using pH meter. All tests were performed at Crop Science Laboratory-KNUST.

Fertilizers

Organic and inorganic fertilizers were used. The organic fertilizer specifically used was decomposed poultry manure and its application rate was 20 t ha^{-1} reported to 3.6 kg $plot^{-1}$ of 1.80 m^2. A rate of 300 kg ha^{-1} of inorganic fertilizer (N: P: K-15-15-15) equivalent to 0.054 kg per 1.80 m^2 was also applied. There was also a control plot with no treatment.

Lettuce cultivars

The cultivars of lettuce used in this experiment included Eden, Trinity and Great lakes and all belonging to the Crisp/Iceberg family. The choice of these cultivars was due to their prominence among most vegetable growers and consumers in the country. The seeds of the plant were purchased from Chinese woman’s certified agrochemical shop in Kumasi. The lettuce plants were harvested after a normal growth period of 9 weeks.

Experimental design

The experimental design used was a 3×3 factorial in a Randomized Completely Block Design (RCBD) with three (3) replications. Total plots were 27 plots. Plot size was 1.5×1.2 m. Thus the experimental field was 48.60 m^2. The plots were separated with paths of 0.5 m, between replications and 0.5 m between treatments. The gross experimental area was 81.1 m^2 and 1m of borders was provided around the experimental field on which lettuce plants were grown.

Planting pattern

Seeds of lettuce were sown in a nursery and transplanted onto the field after three weeks. Healthy and vigorous seedlings were selected and transplanted to the field at a spacing of 30 × 30 cm with a total of 20 plants per plot. Periodic watering and all other cultural practices were carried out regularly on the field.

Lettuce sampling

The lettuce plants were harvested after a normal growth period of 9 weeks including period in nursery. Six lettuce heads from each plot were collected with sterile disposable gloves just before harvesting and were put into separate sterile polythene bags and transported on ice to the laboratory for nutritional analysis.

Chlorophyll and carotenoids

Chlorophylls and carotenoids were extracted using methanol 99.9% as solvent. Samples were kept overnight in a dark cold room at 4°C. Leaf pigments were immediately determined after extraction. Absorbance readings were taken at 665.2, 652.4 and 470 nm. Total chlorophyll and carotenoids levels were calculated by using Lichtenthaler’s formula.

Calcium (Ca) determination

Calcium was determined by ashing accurately weighed 1 g of dried and ground sample into glazed, high-form porcelain crucible for 2 h in a muffle furnace at 500°C. The ashed sample was left to cool and 10 drops of deionised water followed by 3 to 4 ml of nitric acid were added to the sample. Excess nitric acid was evaporated by placing the sample on a hot plate set at 100 to 120°C. The sample was returned to furnace and ashed for additional 1 h and after being cooled, the ash was dissolved in 10 ml hydrochloric acid and transferred quantitatively to 50 ml volumetric acid. In order to counteract chemical interferences, which have been fairly documented to depress calcium absorbance, a releasing agent in form of lanthanum (10,000 µg mL^{-1}) was added in all replicates and standards to obviate combined interference effects.

Iron (Fe) Determination

Washed samples were fragmented and dried in an exhaust drier at 55°C. The dried material was ground in a laboratory mill. From each sample, 2.5 g of dry plant matter was weighed out and mineralized in a muffle furnace at 450°C. After complete mineralization, combusted samples were dissolved in 10% HCl and transferred to flasks of 50 cm^3 capacity. The concentration of iron was determined by the atomic flame absorption method using an AAS 3 Zeiss apparatus.

Vitamin C (ascorbic acid) determination

Ascorbic acid (AA) was extracted by homogenizing 7 g of tissue in 6% metaphosphoric acid. Ascorbic acid content was determined by using a column Inertsil 3 (5 µm, 4.6×250 mm) (Rizzolo et al., 2002).

Weight loss

This parameter was determined by observing the daily changes in weights of the sampled plants in the plastic bottles until their shelf-life were completed. This was carried out with the use of an electric sensitive balance.

Dry matter

Weight of oven-dry mass of edible leaves was taken after drying the harvested leaves at 65°C for 48 h. The dry matter after shelf- life was also done using the same procedure.

Shelf - life process

Lettuce plants were placed in plastic bottles filled with 100 ml of water and stored in a room of 30°C and atmospheric humidity of 71%. The weights of samples in the plastic bottles and the appearance of the leaves were observed each day and notices were made on leaf drooping, browning, and yellowing as these affects the products marketability quality. The produce shelf-life was determined by the number of days they were stored up to marketable or acceptable quality.

Data collection

Data were collected on nutritional composition, dry matter and weight loss. Nutritional parameters involved parameters such as Ca, Fe, Carotenoid, Chlorophyll and Vitamin C. Data was collected from the three central rows of each plot comprising six sample plants.

Data analysis

Data collected were subjected to statistical analysis, using Statistix Analytical Software version 9. Means differences were separated at 5% using LSD.

RESULTS

Soil and manure analysis for soil nutrients

The analysis for nutrient compositions in the soil and manure before planting as well as after harvest are shown in Tables 1 and 2. The result showed that, the soil was deficient in organic content, total nitrogen, calcium and potassium. It was slightly acidic while the manure, an alkaline. Soil analysis of the amended plots after the experiment showed that, plots amended with poultry manure performed the highest in all the parameters than the other amendments except with minimal level of total nitrogen due to the fact that, it was greatly used by the leafy vegetable for growth. This therefore suggests that poultry manure amended plots have greater chance of influencing the quality of the plant.

Quality parameters of lettuce after harvest

Interaction effect of treatments and cultivars on quality parameters assessed on lettuce after harvest

Calcium: There was a significant interaction effect ($p \leq 0.05$) of the treatments and cultivars on the calcium content of the lettuces. Great Lakes grown on soil amended with poultry manure recorded the highest calcium level (44.22) and was significantly different from N.P.K.-Eden (42.78), Control-Great Lakes (42.11), N.P.K.-Trinity (42.00), Control-Eden (41.67) and Trinity (41.11) in the decreasing order. These were statistically not different from each other. Likewise, Eden (43.56) and Trinity (42.89) cultivars grown on soil amended with poultry manure were significant not different and similar to the Great Lakes lettuce on the same soil (Table 3).

Iron: The interactions showed a significant difference ($p \leq 0.05$) on the iron content. Trinity (1.94) and Eden (1.90) grown on plots treated with poultry manure and Trinity (1.89) cultivated on plots treated with N.P.K. had a similar iron content. They were significantly different from the rest except Great Lakes lettuce (1.84) grown on plots treated with poultry manure. The three cultivars grown on the control plots and Great Lakes on N.P.K. treated plots were not different (Table 3).

Vitamin C: Likewise, the interactions showed a

Table 1. Soil and manure analysis before experiment.

Sample	Organic content (%)	Organic matter (%)	Total N (%)	Ca^{2+} cmol kg^{-1}	K^{+} cmol kg^{-1}	Fe mg kg^{-1}	Available P mg kg^{-1}	pH
Soil	0.72	1.24	0.11	5.2	0.14	20	154	6.1
Manure	15.96	-	2.29	11.84	4.47	11	2.46	8.12

Table 2. Soil analysis after harvest.

Sample	Organic content (%)	Organic matter (%)	Total N (%)	Ca^{2+} cmol kg^{-1}	K^{+} cmol kg^{-1}	Fe mg kg^{-1}	Available P mg kg^{-1}	pH
Control	0.83	1.43	0.05	8.73	0.11	23.33	255.08	6.78
P. manure	0.89	1.53	0.07	8.93	0.16	25.33	330.20	6.78
N.P.K	0.83	1.44	0.07	8.80	0.15	30.00	238.84	6.67

significant difference (p≤0.05) on the Vitamin C content of the harvested lettuces. Eden grown on plots treated with poultry manure recorded the highest vitamin C content, followed by Great Lakes and Trinity on poultry manure treated plots, Eden, Trinity and Great Lakes on N.P.K. treated plots and the least, by Eden, Trinity and Great Lake on the control plots in the decreasing order (Table 3).

Carotenoid: A significant interaction effect (p≤0.05) was recorded between the treatments and cultivars. Trinity (2.49), Eden (2.45) and Great Lakes (2.44) grown on poultry manure treated plots had a similar carotenoid level and were different from Trinity (2.34), Eden (2.28) and Great Lakes (2.23) harvested from plots treated with N.P.K. as well as Eden (2.12), Great Lakes (2.08) and Trinity (2.04) on the control plots in the decreasing order. The highest carotenoid level was recorded by the three lettuce cultivars grown on plots treated with poultry manure and the least, by the lettuce cultivars grown on control plots (Table 3).

Chlorophyll: Trinity (4.56) lettuce grown on plots treated with poultry manure contained the highest chlorophyll content and was significantly different (p≤0.05) from the rest except Great Lakes (4.25) grown on the same plots. Trinity (4.16) harvested from the control plots had the least chlorophyll content and this was significantly not different from N.P.K.-Eden (4.18), N.P.K.-Trinity (4.19) and Great Lakes (4.19) and Eden (4.18) on the control plots (Table 3).

Dry matter: The interaction of the soil amendments and the cultivars showed a significant difference (p≤0.05) on dry matter content. N.P.K.-Eden and Control-Trinity had 5.08 dry matter content which was the highest and different compared to the least, 4.91 recorded by Trinity grown on poultry manure treated plots. The highest was significantly not different compared to the rest except 4.97, 4.94 and 4.91 in the decreasing order recorded by Control-Eden, N.P.K.-Great Lakes and poultry manure-trinity, respectively (Table 3).

Interaction effect of soil amendment and cultivars on quality parameters assessed on lettuce after storage

Calcium: Eden cultivar grown on plots treated with poultry manure retained the highest level of calcium (42.67). It was significantly different (p≤0.05) from Trinity harvested from N.P.K. (40.89) treated plots as well as Eden (40.44) and Trinity (40.22) from the control plots in the decreasing order. Except for these, the rest of the interactions were not significant when compared against one another (Table 4).

Iron: Trinity harvested from poultry manure treated plots at storage end retained and recorded the highest level of iron of 1.90 mg g^{-1}. It was significantly different (p≤0.05) from all of the interactions except iron retained by the same cultivar grown on N.P.K. treated plots (1.86). Eden harvested from control plots had the least iron of 1.71 mg g^{-1} This was statistically not different Great Lakes from both N.P.K. treated (1.76) and control (1.75) plots as well as Eden from N.P.K. (1.76) treated plots (Table 4).

Vitamin C: Again, Eden harvested from plots treated with poultry manure recorded the highest level of vitamin C (20.78) at the end of shelf life. It was significantly different (p≤0.05) from all except Great Lakes (19.89) from the same plots. Great Lakes, Trinity and Eden grown on the control plots recorded the least vitamin C content of 15.44, 16.00 and 16.11 in the increasing order. They were significantly equal to Trinity and Great Lakes grown of N.P.K. treated plots (Table 4).

Carotenoid: Trinity grown on plots treated with poultry manure (2.48) at the end of storage maintained a significantly high level of carotenoid against the rest of

Table 3. Interaction effect of soil amendment and cultivars on some quality parameters of lettuces after harvest.

Treatment*Cultivars		Calcium	Iron	Vitamin C	Carotenoid	Chlorophyll	Dry matter
P. Manure	Gt Lakes	44.22^{a}	1.84^{bc}	20.89^{ab}	2.44^{ab}	4.25^{ab}	5.06^{ab}
P. Manure	Eden	43.56^{ab}	1.90^{a}	21.89^{a}	2.45^{a}	4.22^{bc}	5.01^{abcd}
P. Manure	Trinity	42.89^{abc}	1.94^{a}	20.22^{bc}	2.49^{a}	4.56^{a}	4.91^{d}
N.P.K.	Gt Lakes	43.89^{ab}	1.79^{cd}	17.56^{de}	2.23^{c}	4.21^{cd}	4.94^{cd}
N.P.K.	Eden	42.78^{bc}	1.83^{c}	19.11^{cd}	2.28^{c}	4.18^{de}	5.08^{a}
N.P.K.	Trinity	42.00^{cd}	1.89^{ab}	18.11^{d}	2.34^{bc}	4.19^{cde}	4.99^{abcd}
Control	Gt Lakes	42.11^{cd}	1.75^{d}	16.00^{e}	2.08^{d}	4.19^{cde}	5.02^{abc}
Control	Eden	41.67^{cd}	1.76^{d}	16.44^{e}	2.12^{d}	4.18^{de}	4.97^{bcd}
Control	Trinity	41.11^{d}	1.79^{cd}	16.44^{e}	2.04^{d}	4.16^{e}	5.08^{a}
LSD (5%)		1.41	0.06	1.57	0.11	0.04	0.10
CV (%)		3.52	3.47	9.00	5.04	0.96	2.10

Table 4. Interaction effect of soil amendment and cultivars on some quality parameters of lettuce after storage.

Treatment*cultivars		Calcium	Iron	Chlorophyl	Vitamin C	Carotenoid	Dry matter	Weight Loss
P. Manure	Gt Lakes	42.33^{abc}	1.80^{cd}	4.21^{a}	19.89^{ab}	2.34^{bc}	5.02^{d}	25.68^{b}
P. Manure	Eden	42.67^{a}	1.83^{bc}	4.20^{ab}	20.78^{a}	2.37^{b}	5.26^{abc}	28.68^{ab}
P. Manure	Trinity	41.67^{abcd}	1.90^{a}	4.24^{a}	19.00^{bc}	2.48^{a}	5.42^{a}	27.92^{ab}
N.P.K.	Gt Lakes	42.44^{ab}	1.76^{de}	4.17^{bc}	16.56^{de}	2.26^{cd}	5.11^{cd}	25.84^{b}
N.P.K.	Eden	41.67^{abcd}	1.76^{de}	4.15^{c}	18.00^{cd}	2.20^{d}e	5.30^{abc}	32.92^{a}
N.P.K.	Trinity	40.89^{cd}	1.86^{ab}	4.16^{c}	16.89^{de}	2.33^{bc}	5.22^{abcd}	27.53^{ab}
Control	Gt Lakes	41.11^{bcd}	1.75^{ef}	4.16^{c}	15.44^{e}	2.03fg	5.14^{bcd}	27.27^{ab}
Control	Eden	40.44^{d}	1.71f	4.16^{c}	16.11^{e}	2.11ef	5.36^{ab}	27.77^{ab}
Control	Trinity	40.22^{d}	1.78^{de}	4.14^{c}	16.00^{e}	1.96g	5.16^{bcd}	33.17^{a}
LSD (5%)		1.54	0.04	0.03	1.58	0.1	0.22	6.79
CV (%)		3.96	2.6	0.87	9.51	4.89	4.45	25.31

the interactions. It was significantly different from all of the interaction means. Eden (2.37) subjected to the same treatment was second to the highest. It was also different from the rest except Great Lakes (2.34) and Trinity (2.33) subjected to poultry and N.P.K. treatments respectively on the field. Trinity cultivar grown on control plots had the least carotenoid content (1.96). It was not different from Great Lakes (2.03) grown on the same control plots (Table 4).

Chlorophyll: Great Lakes and Trinity subjected to poultry manure treatment on the field recorded the highest chlorophyll content at the end of storage. They were significantly different from all of the cultivars subject to the N.P.K. treatment and the control that had the least, except Eden, the second highest subjected to the same treatment as shown in (Table 4).

Dry matter: Trinity subjected to poultry manure treatment on the field had the highest dry matter content (5.42) and was significantly different ($p \leq 0.05$) from Great Lakes grown on plots subjected to N.P.K. (5.11) and poultry manure (5.02) respectively in the decreasing order. The rest of the interaction means were significantly not different from one another (Table 4).

Weight loss: Trinity (33.17) and Eden (32.92) grown on the control and N.P.K. treated plots respectively suffered the highest weight loss while Great Lakes subjected to N.P.K. (25.84) and poultry manure (25.68) treatments suffered the least. Both categories were significantly different from each other. The rest of the interactions statistically recorded the same weight loss (Table 4).

DISCUSSION

Minerals and vitamin composition of lettuce

Lettuce like other leafy vegetable is an important source of minerals and vitamins needed in our diets for good functionality and repairs of the human body. Fresh

vegetables like lettuce is judged on visual characteristics as well as nutritional quality (Rattler et al., 2006) such minerals and vitamins composition. Results of the experiment showed a significant impact of the soil amendment, varietal difference on the level of minerals and vitamin composition of lettuces studied and analysed. The three lettuce cultivars, Great Lakes, Eden and Trinity were rich in calcium, vitamin C and had a considerable good amount of iron in a significant different quantities. The difference in the minerals and vitamin level might also be due to the genotypic difference since they are grown under the same environment (Ojetayo et al*.,* 2011).

Calcium composition of lettuce

The interaction of the soil amendments and the cultivars explains that, fresh Great Lakes with the highest calcium content was harvested from plots for which the soil was treated with poultry manure (organic fertilizer).The high calcium content from the plot treated with poultry manure can be attributed to relatively ample amounts of calcium in the chemical composition of chicken manure (Bokhtiar and Sakurai, 2005).

There was a significant drop in the level of calcium in the lettuce after shelf life. Yet, the nutritional lost was minimal to cause a drastic change in the level of significance. Regardless of the lost, Great Lakes cultivar maintained the highest calcium and the least, by Trinity. The results also show that Great Lakes performed well with either poultry manure or N.P.K. fertilization and even the control. The difference might also be due to the genotypic difference since they are grown under the same environment (Ojetayo et al., 2011).

Also reduction in calcium content of lettuce after storage shows that vegetables deteriorate immediately after harvest irrespective of the storage method adopted (Babarinsa, 2000). Again, temperature and relative humidity are critical factors in the maintenance of quality during storage, which reconfirms the inconsistency of the mineral quality of lettuce irrespective of the fertilizer type used. This agrees with the findings of Babatola and Olaniyi (1997) and Olaniyi et al. (2010).

Iron composition of lettuce

Freshly harvested Trinity had the highest iron content followed by Eden and the least, in Great Lakes. This is completely a reverse occurrence seen with calcium content in lettuce. It would be right to say based on the result that, cultivar of lettuce which contains significant higher calcium has a considerable low iron content. The poultry manure released a significant higher iron to the lettuce in the soil compared to N.P.K. and the least, by the control. The effect could be due to the fact that organic carbon acts as a source of energy for soil microorganism, which upon mineralization releases organic acids that decreased soil pH and improves availability of Fe (Bokhtiar and Sakurai, 2005). The effect of Fe on the cultivars as seen in the interaction showed Trinity had the highest iron content along with Eden. This outcome might have had a significant impact on the level of the iron in the three lettuce cultivars studied though much is influenced naturally by genetic makeup.

The analysis after shelf life however showed a slight change in the iron content. Trinity retained significantly a higher iron content compared to Eden and Great Lakes which had a significant equal iron. The effect of fertilization with the poultry manure and N.P.K. remained unchanged. The marginal losses in iron content incurred by the cultivars could mainly be due to external factors which triggers high water loss in the lettuce as well as the living produce falling back on the reserved nutrients to survive. Also reduction in Fe content of lettuce after storage shows that vegetables deteriorate immediately after harvest irrespective of the storage method adopted (Babarinsa, 2000).

Vitamin C

Vitamin C is known to serve as antioxidant that offers protection against some form of cancer. This along with some other phytochemicals and antioxidants reduce the risk of cancer of the respiratory system and intestinal tract (Wolford and Banks, 2013). Vitamin C may vary in concentration depending on the cultivar type. The results of the study showed varying concentration of vitamin C in the cultivars. Eden was richer in ascorbic content, followed by Trinity and the least in Great Lakes.The significant difference in vitamin C obtained among the cultivars might also be due to the genotypic difference since they are grown under the same environment (Ojetayo et al., 2011).

The poultry manure (organic fertilizer) and control acted differently from each other with poultry manure contributing to a significant higher amount of the vitamin especially on Eden while the control performing poorly. Schuphan (1974) found that spinach and lettuce grown organically were higher in ascorbic acid compared to those grown conventionally, using composted manure over organic fertilizers .The three cultivars also performed poorly on the control soil as they had the least vitamin C content.

The storage period and light had a significant impact on the lettuce by causing the three cultivars to suffer a loss in vitamin C though it is said that cut vegetables normally retain vitamin C content longer. Vitamin C like any antioxidants is susceptible to degradation when exposed to oxygen or light (Gil et al*.,* 2006) after harvest. These could be a reason to why the lettuces; Great Lake and

Trinity different from Eden suffered a lost in vitamin C increasingly. According to Kader (2002) and Lee and Kader (2000), postharvest losses in nutritional quality, particularly vitamin C content, can be substantial and the losses are enhanced by physical damage, extended storage duration, high temperatures and low relative humidity.

Phytochemicals

Carotenoid

The three lettuce cultivars showed no significant difference in the carotenoid level in terms of varietal effect. This could mean that they all have similar genetic traits responsible for carotenoids concentration. This is contrary to carotenoid concentration in some wild accessions of lettuce due to genetic variation reported by Mou (2005). Soil nutrients made available to the vegetable from different sources, that is organic and inorganic significantly had an impact on carotenoid level in the lettuces after harvest and shelf life. This effect was seen in the interaction of the cultivars and soil amendment materials. And numerous factors such as maturation stage (Rodriguez -Amaya, 2000), difference in the plant cultivars (Olson, 1999), soil type, effect of agrochemicals and cultivation conditions (Amaya-Farfan, 1999) may have interfered with the carotenoid content (Cardoso et al*.,* 2009) after harvest. The analysis after harvest showed that Great Lakes, Eden and Trinity when subjected to poultry manure application, recorded the highest level of carotenoids. This is similar to the outcome of Rattler et al. (2006) where they had increased in β-carotene content in lettuce, a form of carotenoid as result of using and increasing compost manure (organic fertilizer). The lettuce cultivars responded well to the inorganic fertilizer (N.P.K.) producing carotenoid levels close but different to the organic source. Rattler et al. (2006) also had a lower level of carotenoids (β-carotene) with application of mineral fertilizer. It thus means that, different fertilizer type (organic and inorganic) had a significant impact on the level of carotenoids. The least carotenoids level was produced by the lettuces when grown on the control soil as a result of limited nutrients in Table 4. That is, lettuce grown on soil lacking much nutrients and the effectiveness of a cultivar to respond to the soil nutrients from different nutrient source may affect the content of carotenoids.

A lost in the carotenoid levels in the three cultivars occurred and hence caused a slight difference in the quantities remained in them after shelf life. The results showed that, Trinity had the capability of retaining significantly, the highest carotenoid level with poultry manure fertilization, followed by Eden and Great Lakes with the same treatment. Meanwhile, Trinity without any fertilizer treatment performed poorly in retaining the lowest level of carotenoids. This outcome could mean that, type of fertilizer application can affect the rate at which lettuce loses carotenoids in storage. It is also possible that genetic makeup may slightly have an effect on carotenoids lost caused by damage through injuries, temperature and humidity variation at storage. Amaya-Farfan (1999), attributed carotenoids difference in plants to several factors but the most relevant to the study after shelf life is the presence of damage to plant structure, exposure to light and storage condition which might have been a responsible cause. And According to Azevedo and Rodriguez-Amaya (2005), carotenoids content is affected by climate alterations, with exposure to sunlight and higher temperatures, increasing the biosynthesis of carotenoids but, at the same time, inducing photo-degradation, thus reducing their levels in plants. This phenomenon could have taken place before end of shelf life.

Chlorophyll content

Chlorophyll is a plant pigment which appears green and gives the green colour of plants. The treatments had a significant effect on the chlorophyll content of the harvested lettuces. The lettuce cultivar that had poultry manure treatment as fertilizer recorded significantly, a higher chlorophyll content than those with N.P.K. and no treatment application. This is in support of the argument by Kempraj (2012) that, the presence of nitrogen in soil and chlorophyll in plants are directly related. He further stated that, chlorophyll could be used as an indirect indicator of nitrogen levels in fertilizer management. Based on this claim, it is possible that the poultry manure released more nitrogen to the lettuces than N.P.K.

Trinity cultivar responded well to the poultry manure fertilization by producing the highest chlorophyll content and was not significantly different from Great Lakes when subjected to the same treatment. Trinity cultivar however performed poorly when subjected to N.P.K. and the control treatment to produce the lowest chlorophyll contents. This is due to inadequate nutrients especially nitrogen to be made available to crops for absorption.

There was a significant drop in chlorophyll due to the interaction of the treatments and cultivars at the end of shelf life. Trinity together with Great Lakes retained the highest chlorophyll content different from the chlorophyll recorded by the other interactions except with Eden, subjected to poultry manure application. Also, all cultivars retained very low chlorophyll content when subjected to N.P.K. and the control except Great Lakes subjected to N.P.K., which did fairly good by retaining second highest amount of chlorophyll. It is as result of the organic fertilizer (poultry manure) releasing enough nutrients to the various cultivars.

Also, the drop in the chlorophyll level at the end of shelf life might be due to decomposition. It is claimed by

Webexhibits (2013) that, chlorophyll decomposed in presence of sunlight and hence plants replenish by producing more. This claim could therefore support this outcome as the three cultivars of lettuce maintained their chlorophyll level immediately after harvest and had a fall due to the fact that, they were taken of their growth medium and parent stalk which helped in the replenishing process. Also, storage period and adverse condition within the storage area might have affected the lettuce and aided in the decomposition of the chlorophyll.

Dry matter content

The soil amendment materials and the cultivars showed no significant individual effect after harvest. This could mean that, the different cultivars show no genetic variation in terms of dry matter and thus have similar moisture composition. And probably, the fertilizer type does not contribute to the dry matter content of the lettuce and any variations may be due to other factors. The analysis of dry matter content after shelf life was similar to that recorded after harvest except that, Great Lakes cultivar recorded a significant low dry matter that differed from Eden and Trinity which were similar. It is possible that the formation of the crisp head by Great Lakes reduced the surface areas of the leaves and hence, interfered with rate of respiration which results in moisture loss.

The interaction between the cultivars and treatments had a significant impact on the dry matter of lettuce both after harvest and end of shelf life. Eden and Trinity subjected to NPK and no treatment respectively had the highest dry matter content after harvest whiles Trinity grown with poultry manure fertilization recorded the least dry matter. It is generally reported that, leafy vegetables as well as root vegetables and tubers have the trend for higher dry matter contents when organically grown (Woëse et al*.,* 1997; Bourn and Prescott, 2002; AFSSA, 2003). The study revealed that, difference may occur in vegetables that have similar or same genetic traits if organically grown. That is, after storage, Trinity and Great Lakes fertilized with poultry manure, recorded the highest and lowest dry matter content respectively. The result also shows that, Great Lakes have the tendency to retain enough or probably have a high moisture content compared to Trinity. It also explains that, moisture content and dry matter content relate in the opposite direction.

Weight loss

The three cultivars of lettuce recorded no significant difference in terms of weight loss. It could be attributed to the fact they have similarities in moisture (water) composition regardless with difference in other characteristics as well. Likewise, type of fertilizer as a treatment also did not singly caused any significant effect. The absorption of water from the soil to other parts of the crop depends on the roots and basically, the three cultivars might have the same rooting system.

Contrary to the above, the interaction between the cultivars and the soil treatment slightly showed a significant impact on the weight loss of lettuce. That is, Eden together with Trinity suffered the highest weight loss fertilized with N.P.K. and the control compared to Great Lakes subjected also to N.P.K. and poultry manure which suffered the least weight loss under such circumstances. They were not different when compared against the rest.

CONCLUSION AND RECOMMENDATION

The soil treatment had a significant impact on the mineral composition, vitamin C content and chlorophyll concentration but not the carotenoids. The cultivars varied in the levels of calcium, iron, vitamin C and chlorophyll content due to variation in the expression of inherent genes with the cultivars and amount of nutrients made available to the lettuces. These minerals, vitamin C as well as the chlorophyll and carotenoids were relatively in high quantities. However, there was a significant drop in the mineral composition, chlorophyll, carotenoid and vitamin C.

Based on the results of the experiment, highly decomposed and treated poultry manure could be encouraged for use as an alternative for other sources of fertilizers for the cultivation of lettuce as it records higher levels of minerals, vitamin C as well chlorophyll irrespective of the cultivar type.

Also, in homes of no refrigerators, freshly harvested lettuce plants should be kept in vessels of considerable amount of water as the process prolongs the produce shelf life for three to four days.

Conflict of Interest

The authors have not declared any conflict of interest.

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