GROWTH AND YIELD OF LETTUCE (*Lactuca sativa* L.) AS INFLUENCED BY COMPOST AND INTRA-ROW SPACING

BY

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Being a Dissertation Submitted to the Department of Agronomy, Faculty of Agriculture, Bayero University Kano, in Partial Fulfillment of the Requirements for the Award of Masters Degree in Agronomy

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DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Professor A. A. Manga and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up titled GROWTH AND YIELD OF LETTUCE (*Lactuca sativa* L.) AS INFLUENCED BY COMPOST AND INTRA ROW SPACING was carried out by **Musbahu Jibrin Abdullahi** (**SPS/13/MAG/ 00001)** under our supervision and meets the regulations governing the award of Masters Degree in Agronomy at Bayero University Kano and it is approved for its contribution to scientific knowledge and literary presentation.

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APPROVAL PAGE

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DEDICATION

This research work has been dedicated to my parents Alhaji Jibrin Abdullahi and Hajiya Ramlat Babayyo and entire members of my family.

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ABSTRACT

A field experiment was conducted at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano and National Horticultural Research Institute, Bagauda Sub- station, Kano during 2015 rainy season under field condition to investigate the growth and yield of lettuce as influenced by compost and intra row spacing. The treatments consisted of factorial combinations of five levels of compost (0, 5, 10, 15 and 20 t ha^{-1}) and three levels of intra row spacing (20, 25and 30 cm) which were arranged in a Randomized Complete Block Design with three replications. The objectives of the study were to determine the effect of compost and best intra row spacing for the growth and yield of lettuce. Vegetative growth characters and yield were measured and data were analyzed using SAS (Statistical Application Software). Compost application significantly affected plant height, number of leaves, leaf area, and fresh weight per plant, dry weight per plant, crop growth rate, relative growth rate, leaf area ratio and yield. Intra row spacing significantly affected some of the vegetative growth characters particularly plant height, number of leaves and leaf area. Significant interaction between compost and intra row spacing on plant height, number of leaves and leaf area were observed. In conclusion, the result obtained in the study indicated that application of 20 t ha^{-1} of compost along with 20 cm intra row spacing appeared to be optimal for good yield of lettuce at Bagauda and 15 t ha^{-1} of compost along with 20 cm intra row spacing in BUK.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Lettuce (*Lactuca sativa* L.) is an annual plant of the daisy family Asteraceae. It is most often grown as a leafy vegetable but sometimes for its stem and seed (Hugh Fearnly, 2013). The origin of lettuce is Turkey and the Caucasus or the Middle East. The ancestor is probably the European prickly lettuce (*Lactuca serriola* L.), that crosses easily with the cultivated forms. Lettuce was known as vegetable in the Mediterranean as early as 4500 BC; it was depicted in Egyptian tombs in 2500 BC; and cultivated by the Greeks and Romans as a popular vegetable. In Western Europe, headed types have been known since the 14th century but leafy types have been known much longer. At present lettuce, especially the headed types, is the world's most important salad crop. Salads are traditionally more popular in temperate areas than in the tropics, but lettuce is increasingly important in Africa as an exotic vegetables, European type of vegetable, grown for the city markets, super markets, restaurants and hotels. It can be found in all African countries, most frequently at higher elevations and in the cooler season and more often in Francophone than in the Anglophone countries (Grubben *et al.,*1993). Lettuce is most often used for salads, although, it is also seen in other kinds of food, such as soups, sandwiches and wrap; it can also be grilled (Hugh Fearnly, 2013). One variety, the Woju or Asparagus lettuce, is grown for its stems, which are eaten either raw or cooked. Lettuce is a good source of vitamin A and potassium as well as a minor source for several other vitamins and nutrients. Despite its beneficial properties, contaminated lettuce is often a source of bacterial, viral and parasitic disease outbreaks in humans, including *E.coli* and *Salmonella*. In addition to its main use as leafy green, it has also gathered religious and medicinal significance over centuries of human consumption (Hugh Fearnly, 2013).

The use of inorganic fertilizers has, however, been associated with human health problems and environment degradation (Arisha and Bardisi, 1999). Moreover, the increasing costs of inorganic fertilizers have rendered them unaffordable to most resource-poor small scale growers. Organic manure can serve as a substitute to mineral fertilizers. Manures supply the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce (Wong *et al*., 1999; Nehra *et al*., 2001; Suresh *et al*., 2004; Dauda *et al*., 2008).

Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity (Sanwal *et al*., 2007). Several authors have reported the importance of organic manure as a source of nutrients and a means of soil rejuvenation (Adeleye *et al*., 2010).

Moniruz-zaman (2006) indicated that plant population or density is among the factors that affect yield and quality of lettuce. An increase in plant spacing was found to increase plant height, canopy width, leaf number, leaf length, and leaf fresh and dry mass per plant. Ideal plant density can lead to optimum yield, whereas too high or too low plant densities can result in relatively lower yield and quality.

1.2 PROBLEM STATEMENT

Lettuce (*Lactuca sativa* L.) is one of the most important leafy vegetable in human diet. The plant is full of vitamins and minerals with lots of fiber. Despite its usefulness and nutritional values, lettuce production is still very low in Nigeria. This is due to inadequate of organic manure (compost) in the soil, low rate and wrong timing of their application, use of low yielding varieties, improper spacing, pest and disease prevalence, soil and climatic condition, technical know how of crop production by farmers, and above all market for the sales of the crop. Many researchers have shown that lettuce grow best in loose, fertile, sandy loam soils, well supplied with organic matter than the use of inorganic fertilizer.

1.3 JUSTIFICATION

Lettuce is one of the most important leafy vegetable crops worldwide, which has a wide range of adaptability. But inadequate soil fertility more especially nitrogen can hinder the production of lettuce leading to low yield and total failure. It was also reported that the use of organic manure in the production of lettuce is better than the use of inorganic fertilizer. This is because the use of inorganic fertilizers has been associated with human health problems and environment degradation (Arisha and Bardisi, 1999). As such the use of organic manure in the production of lettuce is better when appropriate or optimum rate of compost are used because it increases the fertility of the soil thereby increasing production of lettuce. Inadequate application of compost in the production of lettuce leads to low growth and yield of lettuce. Also best intra row spacing which indicates plant population per unit area is among the factors that affect yield and quality of lettuce (Moniruz-zaman, 2006). This study was carried out to determine optimum rates of compost and intra-raw spacing for efficient lettuce production.

1.4 OBJECTIVES OF THE RESEARCH

i) To determine the effect of compost on the growth and yield of lettuce

ii) To determine the appropriate intra-row spacing for the growth and yield of lettuce.

iii) To obtain optimum compost rate for the growth and yield of lettuce

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 EFFECT OF COMPOST ON GROWTH AND YIELD OF LETTUCE

Compost is organic matter that has been decomposed and recycled as a fertilizer and soil amendment. Compost is a key ingredient in organic farming. Compost manure can serve as a substitute to mineral fertilizers. Compost supplies the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce (Wong *et al.,* 1999; Nehra *et al.,* 2001; Dauda *et al.,* 2008). Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity (Sanwal *et al.,* 2007). The effectiveness of adding compost household waste to crops has been clearly demonstrated in the experiment. This impact on growth was also observed with other types of composts (Alvarez *et al*; 1995, Wong *et al*., 1999). El Hanafi (2006) showed that the addition of compost made from Waste tea has had positive effects on yield of tomato plant biomass, fruit number and weight of roots were increased compared to control. In addition, Lee and Park (2004) and Sétémé (2007) studied the growth of lettuce (*Lactuca sativa*) in the presence of compost at different concentrations, in the best case they got a plant growth 2 to 3 times greater in the presence of compost compared to control after 6 weeks of experiment. The positive effect of compost on plant growth was due mainly to the improvement of the physicochemical and biological properties of soil, the rate of diffusion of nutrients and water holding capacity (Huot *et al*, 2009). Plants planted in a growth medium containing compost are stronger and have better performance. Compost not only adds organic matter to the soil but also trace elements such as iron, manganese, copper, zinc and boron, necessary for plant growth (Duplessis, 2002;

Fagnano *et al*., 2011). Masarirambi *et al.* (2010) studied an effect of organic fertilizer (bounce back compost, cattle manure and chicken manure) and inorganic fertilizer on lettuce yield and quality. They found that the type of fertilizer significantly affected growth, yield and mean leaf dry mass. The application of organic fertilizer had a significant effect on stem length as well as stem diameter, head weight and bud number (Iraj khazaei *et al*., 2013). Another research conducted at Faculty of Sciences and Technology University of Algarve, Portugal showed that the average values of the studied growth parameters, from the six treatments. Plant height was greater when the compost concentration increased in the soil; the compost application to the soil is environmentally sustainable, particularly in the poor soils, characteristic of southern Portugal, increasing soil fertility and improving crop production in the experiment. The results showed an increase in plant height with the increase of the compost amount applied. There were differences in the growth parameters, of red lettuce at 2, 3, 4, 5 and 6 weeks after transplanting. This depended on the type of fertilizer used. Plants which had been fertilized with chicken manure had the highest growth parameters and marketable yield. Similar results have been reported (Uddin *et al*., 2009). This could be attributed to the nutrient content of the fertilizer used. Cantaloupe (*Cucumis melo*) plants receiving chicken litter exhibit relatively higher marketable yield than those receiving no chicken litter (Ghanbarian, *et al*., 2008). Similar results were obtained with broccoli (Ouda and Mahadeen, 2008) and cattle manure was found to increase pod yield of okra (Ogunlela *et al*., 2005). This could also be attributed to the large quantities of available phosphorus and available potassium contained in the chicken manure. Studies by Rao (1991) indicated that the soil could be enriched with the application of organic material which tends to decompose and release relatively large amounts of nitrogen into the soil before planting each fresh crop to boost yield. The method of application and the quantity of organic fertilizers have effects on crop yield and nutrient uptake. In a study conducted by Xu *et al*. (2005) on quality of leafy vegetables, and yield grown with the chicken manure he found that chicken manure exhibited relatively higher values on number of leaves, plant height, marketable yield and mean leaf dry mass. The application of organic fertilizer had a significant effect on stem length as well as stem diameter, head weight, bud number (Iraj khazaei *et al*; 2013).

A study by Magkos *et al*. (2003) evaluated the dry matter content of several vegetables and found that organically cultivated crops had higher dry matter content than those grown conventionally. These findings, however, are evident only for the plants that grow above the ground (leaf vegetables) such as spinach, lettuce, chard, savoy cabbage and white cabbage (Magkos *et al*., 2003). There was relatively higher zinc (Zn), iron (Fe) and calcium (Ca) contents in plants produced by bounce back compost. This can be attributed to the balanced quantity of nutrients in the bounce back compost. Magkos *et al*. (2003) reported that although a small number of studies have been published, slightly higher contents of minerals such as Fe, Ca, phosphorus (P), manganese (Mn), magnesium (Mg), zinc (Zn), copper (Cu), and potassium (K) have been obtained in organic vegetables; the majority of evidence, however, has revealed no significant differences between organic and conventional vegetables. There was no significant difference in the sensory and organoleptic evaluation of lettuce grown with both organic and inorganic fertilizers. Similar result was reported by FAO (2005). Another research conducted by Dawuda (2011) on the growth and yield response of carrot to different rates of soil amendments and spacing he found that the application of 15 and 20 t ha^{-1} decomposed chicken improved vegetative growth, increased root yield and gave more income.

2.2 EFFECT OF INTRA ROW SPACING ON GROWTH AND YIELD OF LETTUCE

Plant spacing is one of the factors that can affect vegetative quality and quantity. Optimum plant density ensures that the plants grow uniformly and properly through efficient utilization of moisture, nutrients, light and thus produce maximum yield of lettuce (Firoz *et al*. 2009). Moniruzzaman (2006) indicated that plant population or density is among the factors that affect yield and quality of lettuce. An increase in plant spacing was found to increase plant height, canopy width, leaf number, leaf length and leaf fresh weight and dry weight per plant. Ideal plant density can also lead to optimum yield and quality. A field experiment was conducted by Moniruzzaman (2006) with three levels of spacing (40 × 20 cm, 40 × 30 cm and 40 × 40 cm) and two levels of mulching (mulch and non-mulch) to find out the effect of plant spacing and mulching on yield and profitability of lettuce cv. He found that The highest fresh matter yield of lettuce was obtained from the closest spacing (40 × 20 cm) that was statistically similar to that recorded of medium spacing (40 × 30 cm) during both the years. The highest yield (25.9 t ha^{-1} in 1999-'00 and 28.3 t ha^{-1} in 2000-'01 with an average of 27.10 t ha^{-1}) was observed in the spacing of 40 × 20 cm with mulch, which was statistically at par with the spacing of 40 × 30 cm with mulch.

2.3 INTERACTION BETWEEN COMPOST AND INTRA ROW SPACING ON GROWTH AND YIELD OF LETTUCE

Akinfasoye *et al.,* 2008 conducted a field experiment to findout the effects of organic fertilizer and spacing on growth and yield of lagos spinach (c*elosia argentea* L.). The results showed that the interaction between compost application rate and spacing on vegetative growth of the plant was definite in that 15x15cm x 6 t ha^{-1} produced taller plant owing to the enhanced soil fertility in the crop ecology. Wider stem girth, higher number of leaves per plants and higher number of off-shoots per plant as well as larger LA were produced with 25 x 25cm x 6 t ha^{-1} because the soil was more fertile and the space wider thus there was less competition among crops. Competition was also responsible for resulting status of shoot growth and number at 15 cm x 15 cm and 20 cm x 20 cm. Compost singly enhanced shoot yield from the first to the last harvest. Shoot yield ranged from 3.70-34.7 kg ha^{-1} this is within the range as observed by Tindall (1984); Olufolaji and Ayodele (1988); Schippers (2000). Increase in harvest with compost was also expected as more compost rate was expected to release more nutrients. Though spacing had little effect, it still produced highest shoots weight at 20 x 20cm. Compost at adequate spacing consistently increased shoot weight but the increase in weight was more prominent at 20 x 20cm under respective compost weight. Also within the 20 x 20cm, higher rate of 4 and 6 t ha^{-1} compost had greater effect. 20 x 20 cm x 4 t $ha^{-1}$was better still when one considers the time, cost and ease of transportation and application manure, this agreed with Schippers (2000) that the optimum rate of poultry manure for the large-leaved cultivars is 0.4 t ha^{-1}.

Also field experiment was conducted by Iraj khazaei *et al* 2013 to find out the effects of spacing, mulch and organic fertilizer on the growth and yield of lettuce. Four levels of spacing (40×40 cm, 40×35 cm, 40×30 cm and 40×25 cm),two cultivation systems(mulch and non mulch) and two different types of organic fertilizers (humic acid and vitamint). The results obtain showed that the interaction between spacing and organic fertilizer was significant for the head diameter, leaf number and NO3 %.Interaction effect of spacing and mulching on P and K contents of lettuce leaf were significant. Also, head diameter, NO3 % and K % were affected significantly by interaction effect of mulching and Organic fertilizer. Finally, interaction between spacing, mulching and Organic fertilizer was significant only for NO3 %. Another research was also conducted by Maroof (2010) to test the effect of nitrogen and spacing on growth and yield of lettuce (*Lactuca sativa* L.) The experiment consisted of two factors. FactorA: Nitrogen (4 levels) N0: 0 (Control); N1: 50; N2: 100 and N3: 150 kg/ha respectively; and Factor B: Plant spacing (3 levels), S1: 40 cm × 20 cm, S2: 40 cm × 25 cm; S3: 40 cm × 30 cm. The results showed that the Interaction effect of nitrogen and plant spacing showed significant difference among the treatments in terms of number of leaves per plant of lettuce at 30, 40, 50 and 60 Days after transplanting. The maximum number of leaves/plant (19.16, 27.1, 31.77 and 29.71 at 30, 40, 50 and 60 DAT, respectively) was found from N3S2. The treatment combination of N3S3 also showed higher number of leaves/plant but significantly different from N3S2. Again, the minimum number of leaves/plant (11.54, 15.44, 21.34 and 20.51 at 30, 40, 50 and 60 DAT respectively) was attained from P0S1. It was revealed that optimum level of nitrogen and plant spacing ensured maximum number of leaves/plant.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The experiment was conducted during 2015 rainy season, at Bayero University, Kano Teaching and Research Farm (latitude 11^0 58'N and longitude 8^o 25'E) and National Horticultural Research Institute, Bagauda sub-station Kano, (Latitude 11^o 33'N and Longitude 8^o 25'E). Both locations are situated in Sudan Savanna zone of Nigeria, characterized by mean annual rainfall range of 800mm - 1000mm per annum.

3.2 SOIL ANALYSIS

Soil of the experimental fields was collected at 0-15cm depth prior to planting. These were bulked and analyzed for physico-chemical properties as described by Black (1965).

3.3 COMPOST ANALYSIS

The sample of the Compost used in the experiment was collected prior to planting. This was bulked and analyzed for physico-chemical properties as described by Black (1965).

3.4 SEED VARIETY/SOURCES/DESCRIPTION

Loose leaf, cutting or branching Lettuce variety (Maikunnen kura) was the most widely planted, it was used in the experiment and was obtained from Seed Project

Company Hadejia Road, Kano. Loose leaf Lettuces are colorful, easy, and fast-growing lettuce variety.

3.5 COMPOST MAKING

The compost was prepared in the Department of Soil Science Bayero University, Kano using their rotating compost bins as a container. The materials used were; grass cuttings, soft pruning's, annual plants and weed remains before they set seed ,fruits and vegetables scraps, cow dung, poultry litter, straw, root pruning and water. A woody material was placed at the bottom of the compost bin to help with air circulation. Different compost materials were arranged into layers at least 30cm deep with a ratio of 50:50. Larger materials were shredded so they decompose more easily. Water was sprayed whenever the layers of the material are drying out in order to moisten the pile without soaking it. The bin was filled; it started to heat up as the decomposition process gets underway. After four weeks it began to cool down, the bin was turned with a fork, mixing up the contents thoroughly and water was added or sprayed if it is drying out. The layer of the material was turned regularly whenever the temperature is low. Thermometer was used in measuring the temperature of the compost in the compost bin. The compost was ready in three months (Gaur, 1992).

3.6 TREATMENTS AND EXPERIMENTAL DESIGN

The treatments consisted of five levels of compost (0, 5, 10, 15 and 20 t ha^{-1}) factorially combined with three intra-row spacing (20, 25 and 30 cm). The treatments were laid out in a randomized complete block design (RCBD) with three replications.

3.6.1 Field Layout

Each replicate contains 15 plots and each plot was measured 2m×2m ($4m^2$), and the net plot was 2×0.8m ($1.6\ m^2$) comprised of 4 inner rows. This gives a total of 45 plots in each location. The discard between the plots was 50 cm (0.5 m) spacing. While between the replicates was 1m spacing.

3.7 CULTURAL PRACTICES

3.7.1 Nursery Practices

The soil of the nursery area was cultivated to a fine tilth. The weed free nursery beds of 2 m × 1 m ($2\ m^2$) were prepared. Two nursery seedbeds (raised) were prepared, one for each location. The lettuce seed was broadcast on the seed bed and lightly covered with soil (Ashworth and Suzanen, 2002). Mulch materials (straw) were used to cover the seed bed and irrigated immediately.

3.7.2 Land Preparation

The land was cleared, ploughed and harrowed and was divided into plots. The field was laid out into fourty five (45) plots; each plot was measured 2 m× 2 m ($4\ m^2$). The replication was demarcated by 1 m discard while the plots were demarcated by 0.5 m each.

3.7.3 Compost Application

The compost was incorporated to the soil two weeks before transplanting to allow for mineralization/decomposition to take place. The compost was applied as per treatment combination.

3.7.4 Transplanting

The seedlings raised in the nurseries were transplanted to the field 3WAS at a spacing of 20 cm×20 cm, 25 cm×20 cm and 30 cm×20 cm (i.e the spacing between the plants and between the rows). When the rainfall was fully established, missing stands were supplied within a week of transplanting.

3.7.5 Weeding

Hoe weeding was done at 2^{nd} and 4^{th} week after transplanting.

3.7.6 Pest and Disease Control

The plots were sprayed fortnightly with Dimethionate (75ml/15litre of water) using knapsack sprayer to control pest and diseases. The spray was done at 2 and 4WAT.

3.7.7 Harvesting

The entire plant was uprooted after the leaves become greenish and developed. This was washed, and lower leaves that are discoloured with spot or yellow coloration were discarded.

3.8 METEOROLOGICAL DATA

Records of rainfall, minimum and maximum temperature, relative humidity, wind speed and sunshine hours of the growing season in the study area were collected from the Meteorological Station of Bayero University, Kano and National Horticultural Research Institute, Bagauda. (Appendix I)

3.9 DATA COLLECTION

Data were taken on five randomly selected tagged plants from the net plot to avoid border row effect at 2weeks interval. Data was collected on the following parameters:

3.9.1 Plant Height (cm)

Height of the plant was measured from the five randomly selected tagged plants from the base to the tip of the plant using a meter rule at 2, 4 and 6WAT. Mean values for each plot were recorded.

3.9.2 Number of Leaves per Plants

The number of leaves per plant was counted from the five randomly tagged plants and recorded at 2, 4, and 6 WAT and the mean values were also be recorded.

3.9.3 Leaf Area per Plant (cm^2)

This was measured using portable leaf area meter (model: YMJ-A) at 2, 4, and 6 WAT.

3.9.4 Fresh Weight per Plant (g)

Fresh sample of lettuce was collected from each plot from the border rows at 2, 4 and 6 weeks after transplanting and this was measured using digital weighing balance (Model: METLAR MT-2000).

3.9.5 Dry Weight per Plant (g)

After weighing the fresh weight of lettuce collected from each plot (treatment) the samples were ovun dried at 75^0C. Each sample was measured and recorded using digital weighing balance (Model: METLAR MT-2000).

3.9.6 Crop Growth Rate (g m^2week^{-1})

Crop growth rate was computed as suggested by Watson (1958) at 2, 4 and 6 weeks after transplanting (WAT) using the formular:

$$CGR=\frac{W2-W1}{t_2-t_1} \text{ g/plant/wk.}$$

Where; W_1 and W_2 = total dry weights in gram/plant at time t_1 and t_2 respectively.

3.9.7 Relative Growth Rate (g g^{-1}week^{-1})

This was calculated at 2, 4 and 6 weeks after transplanting using the formular described by Blackman (1919):

$$RGR=\frac{Logew_2-Logew_1}{t_2-t_1}$$

3.9.8 Leaf Area Ratio (g cm^{-2}week^{-1})

This was calculated at 2, 4 and 6 weeks after transplanting using the formular described by Blackman (1919):

$$LAR=\frac{W_2-W_1}{A_2-A_1}\times\frac{LogA_2-LogA_1}{t2-t_1}$$

Where W_2 and W_1, A_2 and A_1 are dry weights and leaf area at times t_2 and t_1.

3.9.9 Crop Yield (t ha^{-1})

The whole plants in the net plot were harvested and weighed using digital weighing balance (Model: METLAR MT-2000). The total weight of lettuce in the net plot was multiplied by the conversion factor 2500 to get the yield of lettuce in kilogram per hectare (2500 was obtained by dividing 10,000 m^2 by the plot size which is $4m^2$)

3.10 DATA ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967). Duncan Multiple Range Test (DMRT) (Duncan, 1955) was used to compare treatment means. Simple correlation analysis was also done to assess the type of relationship among the variables. Yield against compost rates was regressed to know the optimum compost rates.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Physical and Chemical Properties of the Soil of the Experimental Sites

The result in Table 1 indicated that the soil in the experimental sites was characterized as sandy-loam. The particle size distribution of sand, clay and silt at BUK is 77, 9 and 14% respectively and at Bagauda the particle size distribution was recorded as 72 sand, 9 clay and 19% silt. The chemical analysis of the soil samples of the experimental sites taken prior to transplanting indicated that soil contains low amount of organic carbon in both location. Also the amount of nitrogen (total nitrogen) and available phosphorous were low in both location, but the amount of nitrogen in BUK was a little higher than at Bagauda. The pH of the soils were near neutral, the amount of calcium for both soils were moderate, magnesium was moderate at BUK while high at Bagauda, potassium was moderate at BUK while high at Bagauda, sodium was moderate at Bagauda while high at BUK, CEC was low at BUK while moderate at Bagauda.

4.1.2 Chemical Properties of the Compost used in the Experiment

Table 2 shows the chemical and physical properties (pH, EC, total organic carbon, total nitrogen, total organic carbon, total nitrogen, total phosphorous, available phosphorous, total potassium and C/N ratio) of compost used in the experiment. It could be seen that the pH (H_2O) and pH (KCl) values was 7.24 and 7.34. This pH range is in the optimum range for growing media as mentioned by (Bunt, 1998) who stated that the optimum range is from 5.2-7.3. The EC value was 1.70 dsm^{-1} of compost. This EC value

Table 1. Physical and Chemical Properties of the soil (0-30cm) at BUK and Bagauda

Soil Properties	BUK	BAGAUDA
Physical (%)		
Sand	77	72
Clay	9	9
Silt	14	19
Textural Class	Sandy-loam	Sandy-loam
Chemical		
Ph	7.2	7.34
Organic Carbon (g kg^{-1})	0.20	0.39
Total Nitrogen (g kg^{-1})	0.11	0.07
Available P (g kg^{-1})	9.42	6.16
Total Phosphorous(mg kg^{-1})	148.33	96.67
Exchangeable base (cmol/kg)		
Ca	4.25	3.50
Mg	0.81	1.25
K	0.29	0.54
Na	0.48	0.13
CEC	6.05	10.6

Table 2. Chemical Properties of the Compost Prepared at BUK

Compost Properties	Analytical Value
pH (H_2O)	7.74
pH (KCl)	7.34
EC (ds $^{m-1}$)	3.10
OC (%)	28.53
Total N (gkg^{-1})	1.75
Total P (gkg^{-1})	1.35
Available P (mg kg^{-1})	42.34
Total K (ppm)	1.42
C/N ratio	16.3:1

is in the optimum range (2.0-4.0) for growing media as mentioned by (Hanlon, 2012). Regarding the total organic carbon results it was 28.53% was in the optimum range. The total nitrogen value was 1.75% of the compost. This result was in agreement with the one obtained by (Benito *et al*., 2006) whose found that the total nitrogen rate ranged from 0.99 to 2.01%. The phosphorous and potassium values were 1.35 and 1.42 respectively. Regarding the C/N ratio, it was 16.3:1 of the compost. This result was in agreement with the result obtained by (Rosen *et al*., 1993) who's found that the C/N ratio ranged from 15:1 to 20:1 is ideal for ready-to-use compost.

4.1.3 Plant Height (cm)

Table 3 shows the effect of compost rates and intra row spacing on plant height of lettuce. The result indicated that compost rates significantly affected plant height throughout the sampling periods at both BUK and Bagauda. Application of 20 t ha^{-1} produced significantly taller plants than all the other compost rates at BUK, but 5 and 10 t ha^{-1} were statistically similar at 2 and 4WAT. At Bagauda application of 20 t ha^{-1} produced significantly taller than all the other compost rates, but the control was at par with 5 t ha^{-1} at 4 and 6WAT.

Significant effect of spacing on plant height was observed at 6WAT in BUK. At 6WAT in BUK 20 cm intra row spacing was significantly taller than 30 cm intra row spacing but at par with 25 cm spacing, however no significant effect was observed at Bagauda. There was significant effect on interaction between compost and spacing at 6 and 4 WAT at BUK and Bagauda respectively.

Table 3. Effect of Compost Rates and Intra Row Spacing on Plant Height (cm) of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	5.22d	9.91d	20.97d	6.37e	13.71d	21.62d
5	6.27c	12.11cd	27.16cd	7.73d	14.55d	24.95d
10	6.66c	13.37c	28.76bc	9.50c	17.46c	32.04c
15	7.80b	15.83b	35.68ab	11.22a	20.46b	40.02b
20	9.51a	18.20a	40.38a	12.52a	22.95a	51.64a
SE±	0.323	0.812	2.418	0.428	0.816	1.888
Spacing(cm)						
20	7.47	14.44	33.86a	9.50	17.94	34.43
25	7.25	14.28	30.27ab	9.79	18.27	34.89
30	6.56	12.92	27.65b	9.11	17.28	32.84
SE±	0.249	0.629	1.873	0.332	0.633	1.463
Interaction						
C*S	NS	NS	*	NS	*	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT. NS= not significant, WAT= weeks after transplant, C= compost, S= spacing, *= Significance

Table 4 shows the interaction between compost and intra row spacing at 6WAT in BUK. Looking at the spacing under 0, 10 and 15 t ha^{-1} there was no significance differences among the spacing. Under 5 t ha^{-1} 20 cm intra row spacing was significantly higher than 25 and 30 cm, but 25 and 30cm were statistically the same.

Looking at compost rates under 20 cm intra row spacing there was no significant effect. Under 25 cm 0, 5 and 10 t ha^{-1} were similar but 15 and 20 t ha^{-1} were significantly higher than all the other compost rates. However under 30 cm intra rows spacing 15 and 20 t ha^{-1} were significantly higher than the other compost rates, but 0, 5 and10 t ha^{-1} were statistically similar. At Bagauda at 4WAT the interaction between compost rates and intra row spacing is shown in Table 5. Looking at the spacing under 0, 5, 10 and 15t ha^{-1} there was no significant difference among the spacing. Under 20t ha^{-1} 25 cm intra row spacing was significantly higher than 30 cm spacing, but 20 and 25 cm spacing were statistically similar. Looking at compost rates under 20 cm intra row spacing 15 and 20 t ha^{-1} were similar but significantly higher than 0, 5 and 10 t ha^{-1}. Under 25 cm 20 t ha^{-1} was significantly higher than all the compost rates. However, under 30 cm there were no significant difference among the compost rates.

4.1.4 Number of Leaves per Plant

Table 6 shows the effect of compost rates and intra row spacing on number of leaves per plant. The results obtained shows that compost rates had significant effect on number of leaves of lettuce per plant throughout the sampling period at both BUK and Bagauda.

Table 4. Interaction between Compost Rates and Intra Row Spacing on Plant Height of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing(cm)	0	5	10	15	20
20	26.76b-e	38.20b	33.60bcd	37.06b	33.70bcd
25	19.96d-e	22.56cde	25.80b-e	31.50bcd	51.5a
30	16.20e	20.73de	26.90b-e	38.50b	35.93bc
SE±	4.188				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 5. Interaction between Compost Rates and Intra Row Spacing on Plant Height (cm) of Lettuce at 4WAT at BAGAUDA in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	12.30f	13.03f	18.73cde	21.53abc	24.10ab
25	12.97f	14.97ef	16.83def	20.93bcd	25.67a
30	15.87ef	15.67ef	16.83def	18.93cde	19.10cde
SE±	1.415				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 6. Effect of Compost Rates and Intra Row Spacing on Number of Leaves of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	4.88b	9.04b	22.66b	4.62c	7.11c	15.47e
5	4.96b	9.62b	28.72b	5.18b	10.37b	21.41d
10	5.40b	10.77b	30.13b	5.18b	10.10bc	27.67c
15	5.47b	13.77a	42.00a	5.70b	11.77b	35.55b
20	6.67a	15.88a	45.81a	6.77a	16.07a	46.92a
SE±	0.188	0.902	3.012	0.217	1.054	1.826
Spacing(cm)						
20	5.61	12.62	40.20a	5.58	11.19	30.59
25	5.47	11.84	32.21b	5.59	11.94	28.04
30	5.36	11.00	29.18b	5.31	10.13	29.58
SE±	0.146	0.699	2.333	0.168	0.816	1.414
Interaction						
C*S	NS	NS	NS	NS	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT.
NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

At BUK application of 20 t ha^{-1} produced significantly more leaves than all the other compost rates but 0, 5.10 and 15 were statistically similar. But 20 t ha^{-1} had more leaves than at 0, 5 and10tha-1. At Bagauda increase in application of compost from 0-20 t ha^{-1} at all sampling periods produced singnificantly more leaves.

Intra row spacing shows no significant at BUK and Bagauda in all the sampling periods, except at 6WAT at BUK where narrow spacing (20cm) significantly produced more leaves than wider spacing (25 and30cm) which were statistically at par.

4.1.5 Leaf Area (cm^2)

The effect of compost and intra row spacing on leaf area of lettuce is shown in Table 7. The results obtained show that application of compost significantly affected leaf area of lettuce. Application of 20 t ha^{-1} gave the wider leaf which was significantly higher than all the other compost ^{rates} at 2WAT, However at 4 and 6WAT 15 and 20 t ha^{-1} were similar but significantly higher than 0, 5 and 10 t ha^{-1}. At Bagauda 20 t ha^{-1} gave the wider leaf which was higher than all the other compost rates but was at par with 15 t ha^{-1} at 6WAT.

Intra row spacing shows no significant at BUK all the sampling periods, However intra row spacing shows significant at Bagauda at4 and 6WAT where narrow spacing (20cm) significantly produced wider leaf than (25 and30cm) which were statistically at par.

Table 7. Effect of Compost Rates and Intra Row Spacing on Leaf Area (cm^2) of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	5.51d	22.61c	43.12c	10.30e	30.52c	36.48c
5	7.52cd	27.27bc	50.98bc	18.61d	38.35c	50.86b
10	10.54bc	35.68b	51.53bc	25.45c	53.00b	49.75b
15	14.44b	45.73a	64.85ab	36.38b	52.08b	61.00a
20	22.02a	52.87a	66.53a	45.90a	70.97a	67.35a
SE±	1.414	3.387	4.658	2.094	4.243	3.048
Spacing(cm)						
20	13.98	38.79	54.94	26.79	55.61a	56.52a
25	11.28	36.98	59.36	28.68	45.92a	47.96b
30	10.75	34.73	51.92	26.52	45.42b	54.78ab
SE±	1.095	2.623	3.607	1.622	3.287	2.361
Interaction						
C*S	NS	NS	NS	NS	NS	NS

Means followed by different letter(s) differ significantly at $P \leq 0.05$ using DMRT.
NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

4.1.6 Fresh Weight (g)

The fresh weight of lettuce per plant as influenced by compost and intra row spacing at both BUK and Bagauda is shown in Table 8. The results obtained showed that compost rates had significant effect on fresh weight of lettuce per plant. Application of 20 t ha^{-1} was significantly higher than all the other compost rates but 10 and 15 t ha^{-1} at 4WAT, 15 and 20 t ha^{-1} at 6WAT were the same at BUK. The trend was almost similar at Bagauda with 20 t ha^{-1} being significantly higher than all the other rates except at 2WAT where it was at par with 25 t ha^{-1}.

There was no significant effect of spacing throughout the sampling periods in the two locations. Significant effect of interaction between compost and spacing on fresh weight was observed.

Table 9 shows the interaction effect between compost and intra row spacing on fresh weight of lettuce per plant in BUK was highly significant at 6WAT. Looking at the spacing under 0, 5 and 10 t ha^{-1} there was no significant effect among the spacing. Under 15 t ha^{-1} 30 cm intra row spacing was similar with 20 cm spacing but significantly higher than 25cm spacing. Under 20 t ha^{-1} 25 cm was significantly higher than 20 cm spacing but at par with 30 cm spacing. Looking at the compost rates under the various spacing 15t ha^{-1} was significantly higher than all the other spacings when 20 cm is considered. However under 25 cm spacing 20 t ha^{-1} gave significantly higher fresh weight than all the other compost rates, the trend was the same with 30 cm spacing. Table 10 shows the interaction between compost and intra row spacing on fresh weight of lettuce per plant in Bagauda at 2WAT. Looking at the spacing under 5, 10 and 15t ha^{-1} there was no

Table 8. Effect of Compost Rates and Intra Row Spacing on Fresh Weight (g) of Lettuce per Plant at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	0.81d	5.03b	19.56c	2.13c	3.02c	11.06c
5	1.16c	5.43b	39.83b	2.47c	4.81bc	20.35c
10	1.63b	9.15a	50.01b	2.86bc	6.50bc	40.55b
15	1.94b	12.61a	108.43a	3.66ab	8.71b	41.06b
20	2.75a	14.41a	113.75a	4.37a	14.56a	73.92a
SE±	0.117	2.208	6.894	0.361	1.601	3.681
Spacing(cm)						
20	1.70	8.30	60.31	2.93	9.10	37.80
25	1.76	11.44	64.19	3.25	6.18	38.04
30	1.51	8.24	74.45	3.12	7.28	36.32
SE±	0.090	1.711	5.339	0.280	1.240	2.852
Interaction						
C*S	NS	NS	**	*	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing,*= significant, **=highly significant

Table 9. Interaction between Compost Rates and Intra Row Spacing on Fresh Weight (g) of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	20.36c	41.40bc	44.30bc	123.40a	72.10b
25	21.13c	41.76bc	55.63bc	56.46bc	145.96a
30	17.20c	36.33bc	50.10bc	145.43a	123.20a
SE±	11.939				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 10. Interaction between Compost Rates and Intra Row Spacing on Fresh Weight (g) of Lettuce at 2WAT at BAGAUDA in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	1.40de	2.03cde	3.10b-e	3.70abc	4.43ab
25	1.06e	2.77b-e	3.20bcd	3.70abc	5.53a
30	3.93abc	2.63b-e	2.30cde	3.60abc	3.16bcd
SE±	0.626				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

significant effect among the spacing. Under the control 30 cm spacing was significantly higher than 20 and 25 cm intra row spacing, but 20 and 25cm spacing were statistically similar. Under 20 t ha^{-1} 25 cm intra row spacing was significantly higher than 30 cm spacing. Looking at compost rates under 20cm 20 t ha^{-1} was significantly higher than 0 and 5tha-1. However under 25cm spacing, 20 t ha^{-1} was significantly higher than all the other compost rates except 15 t ha^{-1} but under 30 cm spacing the trend was not consistent.

4.1.7 Dry Weight (g)

Data on dry weight of lettuce per plant as influenced by compost and intra row spacing at both BUK and Bagauda was shown in Table 11.

The results obtained indicated that compost rates significantly affected dry weight of lettuce per plant throughout the sampling period at BUK and Bagauda. At BUK application of 20 t ha^{-1} were recorded significantly higher compared to other compost rates at 2WAT, but 10 and15tha-1, 0 and 5t ha-1 were statistically similar. At 4WAT 20 t ha^{-1} and 15 t ha^{-1} were similar but significantly higher than 0 and 5 t ha^{-1}. The trend was almost similar at 6WAT. At Bagauda, at 2WAT 20t ha-1 was also significantly higher than all the other compost rates except 15 t ha^{-1} but 15 and 20 t ha^{-1} were similar, however the trend was almost similar at 4 WAT. At 6 WAT 20 t ha^{-1} was significantly higher than all the other compost rates.

Significant effect of intra row spacing on dry weight was observed at 4WAT at Bagauda, where 20 cm intra row spacing was significantly higher than 25 cm intra row spacing but at par with 30 cm spacing. However no significant effect was observed

Table 11. Effect of Compost Rates and Intra Row Spacing on Dry Weight (g) per Plant of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	0.17c	0.80b	3.05c	0.31bc	0.53c	1.84c
5	0.24c	0.96b	5.95bc	0.27c	0.76c	3.07c
10	0.32b	1.41ab	6.65b	0.42bc	0.98bc	6.00b
15	0.36b	1.98a	13.14a	0.48ab	1.43ab	6.20b
20	0.53a	2.07a	13.63a	0.65a	1.81a	9.34a
SE±	0.025	0.259	1.123	0.064	0.189	0.537
Spacing(cm)						
20	0.34	1.33	7.44	0.43	1.37a	5.20
25	0.34	1.65	8.86	0.46	0.89b	5.46
30	0.30	1.36	9.16	0.40	1.05ab	5.20
SE±	0.019	0.201	0.870	0.049	0.147	0.416
Interaction						
C*S	NS	NS	*	NS	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing,*=significant during the sampling periods at BUK. However, significant interaction was observed at 6WAT in BUK.

Interaction between compost rates and intra row spacing on dry weight of lettuce per plant is shown in Table 12. Looking at the spacing under 0, 5, and 10t ha-1 of compost there was no significant effect among the spacing. Under 15 t ha^{-1} 20 and 30 cm intra row spacing were similar but significantly higher than 25 cm spacing, however under 20 t ha^{-1} 25 and 30cm were similar but 25 cm significantly higher than 20 cm intra row spacing.

Looking at compost rates under 20 cm 15 t ha^{-1} was significantly higher than all the compost rates which were the same. Under 25 cm 20 t ha^{-1} was significantly higher than all the other compost rates which were also the same. However, under 30 cm 15 and 20 t ha^{-1} were at par but significantly higher than the remaining compost rates.

4.1.8 Crop Growth Rate (g /week)

The mean value for crop growth rate as influenced by compost and intra row spacing in BUK and Bagauda is presented in Table 13. Compost rates significantly affected crop growth rate of lettuce throughout the sampling periods at BUK and Bagauda Application of 20 t ha^{-1} was significantly higher than 0 and 5 t ha^{-1} compost rates, but 5, 10 and 15 t ha^{-1} were similar at 2WAT in BUK. At 4WAT 15 and 20 t ha^{-1} were similar but significantly higher than other compost rates, however the trend was almost similar at 6WAT.

Table 12. Interaction Effect between Compost Rates and Intra Row Spacing on Dry Weight (g) of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	3.20c	5.86c	5.80c	14.66a	7.70bc
25	3.16c	6.30c	7.46bc	8.66bc	18.70a
30	2.80c	5.70c	6.70c	17.56a	13.03ab
SE±	1.946				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 13. Effect of Compost Rates and intra row Spacing on Crop Growth (g /week) Rate of Lettuce at BUK and BAGAUDA during 2015 rainy season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	0.27c	1.04b	0.72c	0.16c	0.65c	0.38c
5	0.38bc	2.57b	1.43bc	0.24bc	1.15c	0.70c
10	0.56ab	2.62b	1.58b	0.28bc	2.50b	1.39b
15	0.72ab	5.36a	3.26a	0.47ab	2.38b	1.43b
20	0.85a	5.77a	3.31a	0.57a	3.76a	2.17a
SE±	0.132	0.555	0.282	0.088	0.289	0.134
Spacing(cm)						
20	0.49	2.93	1.84	0.50a	1.91	1.19
25	0.66	3.60	2.13	0.21b	2.28	1.25
30	0.53	3.90	2.21	0.32ab	2.07	1.20
SE±	0.103	0.429	0.219	0.069	0.224	0.104
Interaction						
C*S	NS	**	*	NS	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing,*=significant, **=highly significant

At Bagauda at 2WAT 20 t ha^{-1} was significantly higher than the other compost rates except 15 t ha^{-1}. In the other hand at 4 and 6 WAT 20 t ha^{-1} was significantly higher than all the compost rates but 10 and15tha-1, 0 and 5t ha-1 were statistically the same.

Significant effect of spacing on crop growth rate was observed only at 2WAT at Bagauda, where 20cm intra row spacing was significantly higher than 25 cm spacing but at par with 30 cm spacing. However no significant effect of intra row spacing was observed throughout the sampling periods at BUK. However, significant interaction was observed at 4and 6WAT in BUK.

The interaction between compost rates and intra row spacing at 4WAT at Bagauda is shown in Table 14. Looking at the spacing under 0, 5 and 10 t ha^{-1} there was no significant effect among the spacing. Under 15 and 20t ha^{-1} 30 cm intra row spacing was statistically similar to 20 cm but significantly higher than 25 cm spacing. However under 20tha-1, 25 cm intra row spacing was significantly higher than 20 cm but at par with 30cm intra row spacing. Looking at compost rates under 20 cm, 15 t ha^{-1} was significantly higher than all the compost. Under 25 cm, 20 t ha^{-1} was significantly higher than all the other compost rates. However under 30 cm 15 t ha^{-1} was significantly higher than 5 and 10 t ha^{-1} but similar to 0 and 20tha-1. At 6WAT at BUK the interaction of compost and intra row spacing is shown in Table 15. Looking at the spacing under 0, 5 and 10 t ha^{-1} there was no significant effect among the spacing. Under 15 t ha^{-1} 30 cm intra row spacing was significantly higher than 20 cm but similar to 25 cm spacing. However, under 20 t ha^{-1}, 25 cm was significantly higher than 20 cm but similar to 30 cm. Looking at compost rates under 20 cm 15 t ha^{-1} was significantly higher than 0, 5 and

Table 14. Interaction between Compost Rates and Intra Row Spacing on Crop Growth Rate of Lettuce at 4WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	1.25d	2.48bc	2.18c	6.25a	2.48bc
25	0.93cd	2.81bc	3.15bc	3.15bc	7.96a
30	0.95a-d	2.43c	2.53bc	7.93a	5.65ab
SE±	0.961				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT. NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 15. Interaction between Compost Rates and Intra Row Spacing on Crop Growth Rate of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	0.74	1.39	1.37d	3.58ab	2.11bcd
25	0.74	1.51	1.77cd	2.06bcd	4.55a
30	0.68	1.37	1.60cd	4.31a	3.12abc
SE±	0.489				

Means followed by different letter(s) in a column differ significantly at P≤0.05 using DMRT. NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

10 t ha^{-1} but was statistically the same with 20 t ha^{-1}. Under 25 cm 20 t ha^{-1} was significantly higher than all the other compost rates, but under 30 cm spacing it was 15 t ha^{-1} that was significantly higher than all the other compost rates.

4.1.9 Relative Growth Rate

Table 16 shows the effect of compost rates and intra row spacing on relative growth rate of lettuce at BUK and Bagauda. Compost rates significantly affected relative growth rate of lettuce. At 2WAT at BUK 15 t ha^{-1} was significantly higher than 5 and 20 t ha^{-1}, but statistically similar to 0 and 10 t ha^{-1}. At 4WAT 5, 10, 15 and 20 t ha^{-1} were similar but significantly higher than the control. At 6WAT 15 t ha^{-1} was significantly higher than all the compost rates. At Bagauda at 2WAT 5 t ha^{-1} was significantly higher than all the other compost rates. But at 4 and6WAT 20 t ha^{-1} was significantly higher than all the other compost rates.

Significant effect of spacing was observed only at 6 WAT where 20 and 30 cm were statistically the same but significantly higher than 25 cm intra row spacing. There was no significant difference observed at Bagauda throughout the sampling periods.

The interaction effect between compost rates and intra row spacing on relative growth rate at 6WAT is shown in Table 17. Looking at the spacing there was no significant effect under 0, 5 and 10 t ha^{-1} among the spacing. Under 15 t ha^{-1}, 20 and 30 cm intra row spacing were similar but significantly higher than 25cm intra row spacing, however under 20 t ha^{-1} 25 cm was significantly higher than 20 cm, but 20 and 30 cm were similar. Looking at compost rates under 20 cm, 15 t ha^{-1} was significantly higher

Table 16. Effect of Compost Rates and Intra Row Spacing on Relative Growth Rate (g/week) of Lettuce Productivity at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	0.32ab	0.28b	0.31d	0.22	0.26	0.21b
5	0.22b	0.45a	0.34b	0.25	0.30	0.26a
10	0.30ab	0.36a	0.32b	0.19	0.43	0.28a
15	0.38a	0.40a	0.38a	0.22	0.32	0.27a
20	0.25b	0.42a	0.34b	0.20	0.78	0.29a
SE±	0.037	0.032	0.012	0.047	0.175	0.018
Spacing(cm)						
20	0.27	0.37	0.32a	0.26	0.53	0.26
25	0.30	0.38	0.33ab	0.17	0.41	0.27
30	0.31	0.39	0.36a	0.22	0.32	0.26
SE±	0.029	0.028	0.009	0.036	0.136	0.014
Interaction						
C*S	NS	NS	*	NS	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT. NS= notsignificant, WAT= weeks after transplant, C= compost, S= spacing,*=significant

Table 17. Interaction between Compost Rates and Intra Row Spacing on Relative Growth Rate (g/g/week) of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	0.28d	0.32bcd	0.31cd	0.41a	0.29cd
25	0.29cd	0.36abc	0.32bcd	0.32bcd	0.39ab
30	0.35a-d	0.36abc	0.33b	0.42a	0.34bcd
SE±	0.021				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

than all the other compost rates but all the other compost rates were statistically similar. Under 25 cm, 20 t ha^{-1} was significantly higher than the control which was at par with 5, 10 and 15 t ha^{-1}. However under 30 cm, 15t ha^{-1} was significantly higher than 10 and 20t ha^{-1} but at par with 0 and 5 t ha^{-1}.

4.1.10 Leaf Area Ratio

Table 18 shows the effect of compost rates and intra row spacing on leaf area ratio of lettuce. The results indicated that application of compost rates significantly affected leaf area ration of lettuce. There was no significant effect observed at 2 and 6WAT in BUK. But at 4WAT 5t/ha was significantly higher than 15 t ha^{-1} but at par with 0, 10 and 20 t ha^{-1}. At Bagauda there was no significant effect at 2 and 4WAT. But at 6WAT 20 t ha^{-1} was significantly higher than all the other compost rates. Significant effect of spacing was not observed throughout the sampling periods at both locations. The interaction was also not significant throughout the sampling periods at both locations.

4.1.11 Yield

Table 19 shows the effect of compost rates and intra row spacing on yield of lettuce at 6WAT at BUK and Bagauda. Compost rates significantly affected lettuce yield at BUK. Application of 15 t ha^{-1} was significantly higher than all other compost rates. But in Bagauda it was the application of 20 t ha^{-1} that was significantly higher than all the other compost rates.

Significant effect of spacing on yield was observed at BUK, and that 20 cm intra row spacing was significantly higher than 25 cm and 30 cm spacing. However, no

Table 18. Effect of Compost Rates and Intra Row Spacing on Leaf Area Ratio (g $cm^{-2}week^{-1}$) of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

	BUK			BAGAUDA		
Treatments	2WAT	4WAT	6WAT	2WAT	4WAT	6WAT
Compost(t ha^{-1})						
0	35.23	22.87ab	25.52	57.39	36.30	4.83e
5	35.64	25.29a	20.18	64.74	47.01	7.44d
10	33.04	21.09ab	21.08	62.11	35.54	10.28c
15	34.12	15.08b	24.28	59.16	44.93	10.94b
20	38.17	21.68ab	23.70	59.29	41.11	12.46a
SE±	3.787	2.935	2.425	6.221	3.547	4.567
Spacing(cm)						
20	40.24	22.98	24.66	60.43	32.64	42.32
25	32.89	22.31	21.09	62.14	32.24	39.77
30	32.59	18.31	23.10	59.04	32.44	40.85
SE±	3.003	2.273	1.878	4.819	2.748	3.538
Interaction						
C*S	NS	NS	NS	NS	NS	NS

Means followed by different letter(s) differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 19. Effect of Compost Rates and Intra row Spacing on Yield (t ha^{-1}) of Lettuce at BUK and BAGAUDA during 2015 Rainy Season.

Treatment	BUK	BAGAUDA
Compost(t ha^{-1})		
0	3.41e	4.83e
5	4.68d	7.44d
10	5.98c	10.28c
15	8.02a	10.94b
20	7.24b	12.46a
SE±	0.089	0.050
Spacing(cm)		
20	7.85a	10.28
25	5.40b	10.36
30	4.35c	6.94
SE±	0.069	0.039
Interaction		
C*S	**	**

Means followed by different letter(s) significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing, **=highly significant

significant effect was observed at Bagauda. There was significant interaction between compost and spacing on yield at both locations

Interaction effect between compost rates and intra row spacing at BUK is shown in Table 20. Looking at the spacing under all the compost rates 20 cm spacing was significantly higher than 25 and 30 cm spacing, it was also noted that 25cm spacing was significantly higher than 30 cm spacing except under 15tha-1. Looking at compost rates under spacing and at 20 cm, 15 t ha^{-1} was significantly higher than all the compost rates, but under 25 cm, 15 and 20 t ha^{-1} were similar but significantly higher than 0, 5 and 10 t ha^{-1}. At 30cm spacing 15 t ha^{-1} was significantly higher than all the compost rates. Table 21 shows the interaction of compost rates and spacing at 6WAT at Bagauda.

Looking at the spacing under compost rates and at 15 and 20 t ha^{-1}, 20 cm spacing was significantly higher than 25 and 30 cm spacing, however under 10 t ha^{-1} 20 and 25 cm spacing were similar but significantly higher than 30 cm spacing. At 0 and 5 t ha^{-1} the trend was not consistent. Comparing the compost rates under spacing and at 20 cm spacing, 20 t ha^{-1} gave significantly higher yield than all the other compost rates but under 25cm, it was10 and 20 t ha^{-1} that gave the highest yield in comparison to other compost rates. Finally, under 30 cm spacing the trend was almost the same with that of 25 cm spacing.

4.1.12 Correlation

The matrices of correlation coefficients showing the association between measured characters and yield is shown in tables 22 and 23. Highly significant positive

Table 20. Interaction between Compost Rates and Intra Row Spacing on Yield of Lettuce at 6WAT at BUK in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	4.60gh	7.03c	8.26b	11.26a	8.10b
25	3.86i	4.93fg	5.36ef	5.76e	7.10c
30	1.76j	2.10j	4.33h	7.03c	6.53d
SE±	0.155				

Means followed by different letter(s) in a column and row differ significantly at P≤0.05 using DMRT.NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

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Table 21. Interaction between Compost Rates and Intra Row Spacing on Yield of Lettuce at 6WAT at BAGAUDA in 2015 Rainy Season.

Treatments	Compost rates(t ha^{-1})				
Spacing	0	5	10	15	20
20	5.43k	8.00h	9.27e	13.03b	15.70a
25	5.70j	8.53g	12.67c	12.20d	12.70c
30	3.36l	5.80j	8.93f	7.60i	9.00f
SE±	0.088				

Means followed by different letter(s) in a column and differ significantly at P≤0.05 using DMRT. NS= not significant, WAT= weeks after transplant, C= compost, S= spacing

Table 22. Correlation matrix table showing association between growth and yield characters of Lettuce at Bagauda.

	PH	NL	LA	FWP	DWP	CGR	RGR	LAR	YLD
PH	1.00								
NL	0.900**	1.00							
LA	0.611**	0.792**	1.00						
FWP	0.864**	0.884**	0.634**	1.00					
DWP	0.809**	0.862**	0.624**	0.981**	1.00				
CGR	0.798**	0.854**	0.626**	0.973**	0.966**	1.00			
RGR	0.245	0.370**	0.211	0.519**	0.560**	0.596**	1.00		
LAR	0.057	0.187	0.237	0.055	0.076	0.108	0.596**	1.00	
YLD	0.766**	0.713**	0.492**	0.779**	0.743**	0.741**	0.317**	0.087	1.00

PH=Plant Height, NL=Number of Leaves, LA=Leaf Area, FWP=Fresh weight per plant, DWP=dry weight per plant, CGR=crop growth rate, RGR=relative growth rate, LAR=leaf area ratio, YLD=yield

Table 23. Correlation matrix table showing association between growth and yield characters of Lettuce at BUK

	PH	NL	LA	FWP	DWP	CGR	RGR	LAR	YLD
PH	1.00								
NL	0.803**	1.00							
LA	0.235	0.459**	1.00						
FWP	0.623**	0.615**	0.445**	1.00					
DWP	0.601**	0.584**	0.388**	0.921**	1.00				
CGR	0.601**	0.584**	0.396**	0.921**	0.995**	1.00			
RGR	0.228	0.208	0.166	0.660**	0.702**	0.694**	1.00		
LAR	0.206	0.257	-0.032	-0.032	-0.090	-0.102	0.155	1.00	
YLD	0.617**	0.720**	0.442**	0.596**	0.527**	0.538**	0.236	0.116	1.00

. PH=Plant Height, NL=Number of Leaves, LA=Leaf Area, FWP=Fresh weight per plant, DWP=dry weight per plant, CGR=crop growth rate, RGR=relative growth rate, LAR=leaf area ratio, YLD=yield correlation between yield and the measured characters was observed in the two locations except that of the yield and leaf area ratio which was observed to be non significant.

4.1.13 Regression

The result of the regression (Figure I and II) analysis has shown that there was a linear relationship between the yield and the compost rates. Although there was a better fit of linear regression at Bagauda than of Bayero University, Kano was also linear. As such the highest rate of 20 t ha^{-1} is seems to be better than the other rates, since the optimum was not reached.

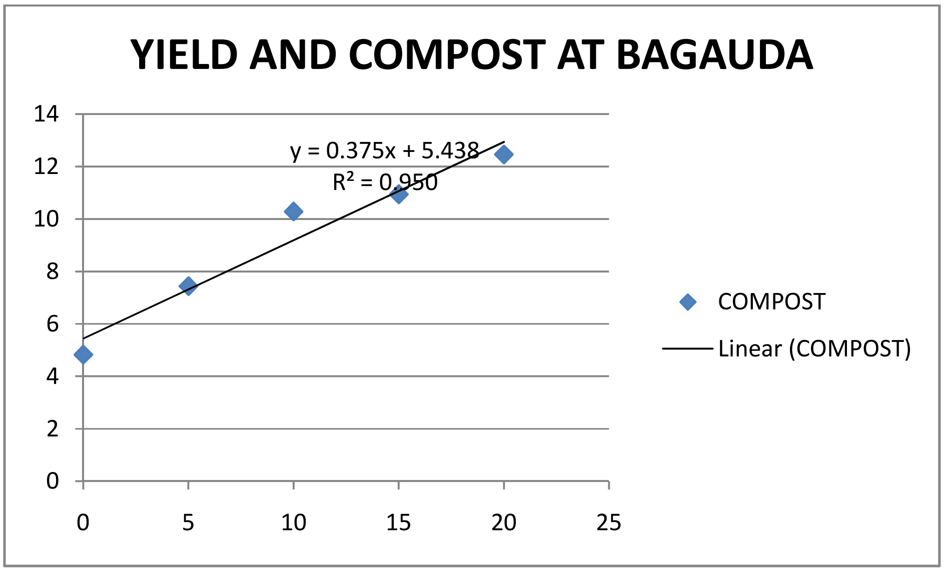

Figure I: Linear Relationship between Yield and compost rates at Bagauda

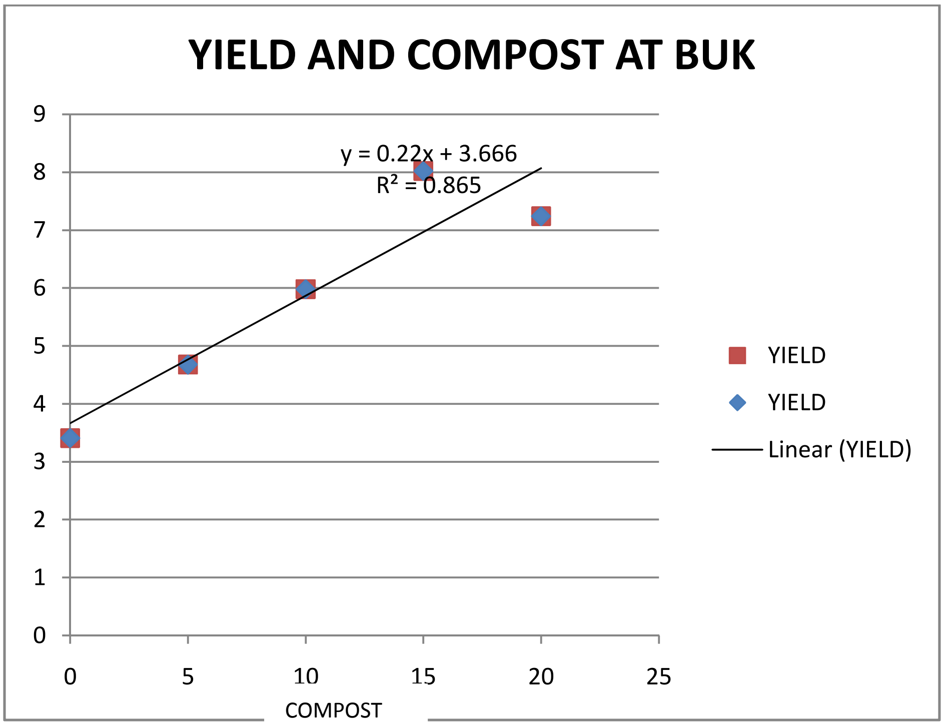

Figure II: Linear Relationship between Yield and compost rates at BUK

4.2 DISCUSSION

4.2.1 Effect of Compost on the Growth and Yield of Lettuce

Compost rates significantly affected growth and yield of lettuce. This impact of growth was also observed with other types of compost (Alvarez *et al*. 1995). Lettuce treated with 20 t ha^{-1} of compost gave a significant increase in plant height, number of leaves, leaf area and fresh weight of lettuce per plant compared to the other compost rates and the minimum were recorded in 0 and 5 t ha^{-1} of compost. This is similar to the findings of (Lee and Park, 2004; Seteme, 2007 and Dawud M.M., 2011). The positive effect of compost on plant growth is due to improvement of the physico-chemical properties of soil, the rate of diffusion of nutrients and water holding capacity (Huot *et al*. 2009) and (Seteme, 2007). Dry weight per plant of lettuce was differed significantly higher with the application of 20 t ha^{-1} followed by 15 t ha^{-1} of compost than the other compost rates this is in conformity with the findings of (Magkos *et al*., 2003). There was also a significant effect on crop growth rate (CGR), Relative growth rate (RGR) and Leaf Area Ratio (LAR). Application of 20 t ha^{-1} of compost gave a wider leaf area of lettuce followed by 15 t ha^{-1} compared with the other compost rates this was agreed with the findings of (Mrabet, 2005). Similarly, relative growth rate and leaf area ratio was significantly higher with the application of 20 t ha^{-1} of compost, but all the remaining compost rates significantly affected relative growth rate and leaf area ratio of lettuce. Lettuce treated with 20 t ha^{-1} of compost gave higher yield of 12.46 t ha^{-1} at Bagauda than the other compost rates. This is in agreement with the study of Xu *et al*. 2005 in his study of yield and quality of leafy vegetables grown with organic fertilizer showed that vegetable grown with organic fertilizers (compost) grew better and resulted in a higher total yield than those grown with chemical fertilizers. On the other hand the lettuce treated with 15 t ha^{-1} of compost gave a yield of 8.02 t ha^{-1} at BUK. This was lower than that of Bagauda. Increase in yield might be due to improvement of soil physical and chemical properties thereby making nutrients more available to lettuce.

4.2.2 Effect of Intra Row Spacing on the Growth and Yield of Lettuce

The results of the present study showed that the effects of different intra row spacing on plant height, number of leaves per plant, and yield were greatest at a spacing of 20 cm intra row spacing. Because an increase in plant density increases plant height (Tehio Kaho and gardner, 1988). The increase in plant height can be attributed to competition for photosynthetically active radiation. The results also agree with those of Badi *et al*. (2004) where the closer spacing produced a significant increase in leaf area and leaf number. This is also in agreement with the findings of (Silver *et al*., 2000) and (Moniruzzaman, 2006) where the fresh weight per plant, dry weight per plant, crop growth rate, and relative growth rate were greatest at a spacing of 25 cm spacing. But 25 and 30 cm were statistically similar. This is in compliance with the study of (Echer *et al* 2001) and (Maboko, 2009).

4.2.3 Interaction Between Compost and Intra Row Spacing on the Growth and Yield of Lettuce

Application of 20 t ha^{-1} of compost along with 20 cm intra row spacing was significant for plant height, number of leaves, leaf area, fresh weight of lettuce per plant and yield. Interaction of 20 t ha^{-1} of compost along with the 25cm was significant for dry weight per plant, crop growth rate, relative growth rate, leaf area ratio. Therefore the results indicated that 20 t ha^{-1} along with 20 cm intra row spacing to be optimum for maximum growth and yield in lettuce BUK and 20 t ha^{-1} of compost along with 20cm intra row spacing at Bagauda. Similar results were reported by (Dawuda, *et al*. 2011).

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Field experiment was conducted at Bayero University, Kano Research Farm and National Horticultural Research Institute, Bagauda Sub- station, Kano during 2015 Rainy Season under Field Condition to Investigate the Growth and Yield of Lettuce as influenced by Compost and Intra row spacing. The treatments consisted of factorial combinations of five levels of compost rates (0, 5, 10, 15 and 20 t ha^{-1}) and three levels of intra row spacing (20, 25and 30 cm) which were arranged in a Randomized Complete Block Design with three replication. The objective of the study was to determine the optimum level of compost rate and best intra row spacing for the growth and yield of lettuce. Vegetative growth characters and yield were measured and the data were analyzed using ANOVA. Compost application significantly affected plant height, number of leaves, leaf area, and fresh weight per plant, dry weight per plant, crop growth rate, relative growth rate, leaf area ratio and yield. Intra row spacing significantly affected plant height, number of leaves and leaf area. Significant interactions between compost and intra row spacing on plant height, number of leaves and leaf area were observed. In conclusion, the result obtained in the study indicated that application of 20 t ha^{-1} of compost along with 20 cm intra row spacing appeared to be optimum for good yield of lettuce.

5.2 CONCLUSION

Loose leaf lettuce can be grown better on soil with compost fertilizers applied. The results obtained showed that the compost can be considered as an organic fertilizer and soil amendment which improves the physical and chemical properties of soil and consequently improve in crop yield. Similarly, the incorporation of 20 t ha^{-1} of compost along with 20 cm intra row spacing at Bagauda and 15 t ha^{-1} of compost along with 20cm intra row spacing at BUK seems to be the best alternative for achieving higher yield. Therefore it could be concluded that application of compost at the rate of 20 t ha^{-1} along with 20 cm intra row spacing at Bagauda and 15 t ha^{-1} of compost along with 20cm intra row spacing at BUK appeared to be optimum for good yield of loose leaf lettuce.

5.3 RECOMMENDATION

The present results revealed that 20 t ha^{-1} of compost with intra row spacing of 20 cm may be recommended at Bagauda and 15 t ha^{-1} with intra row spacing of 20 cm in BUK for the production of loose leaf lettuce during the rainy season. Also based on the regression analysis 20 t ha^{-1} and above may be recommended at both location, since the optimum was not reached.

Further studies on the following can be conducted

- To test the effect of higher levels of compost on growth and yield of lettuce
- To test the effect of both inter and intra row spacing for the growth and yield of lettuce.
- To test the effect of different organic manure on the growth and yield of lettuce

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Appendix I

Meteorological Data Record of the Experimental Sites at BUK and Bagauda During 2015 Rainy Season.

		BAGAUDA			**BUK**	
Month	Rainfall (mm)	Relative Humidity (%)	Temperature (^{0}c)	Rainfall (mm)	Relative Humidity (%)	Temperature (^{0}c)
June	124	27.53	25.03	75.00	78.10	35.02
July	213.9	28.11	23.52	160.00	92.05	32.53
August	505.72	27.5	24.00	292.79	97.27	30.58
September	235.75	26.43	22.88	103.29	64.90	31.86
October	28	26.79	27.56	31.20	95.15	35.59
November	25	21.78	15.96	0.00	75.52	33.46

SOURCE: Meteorological unit of NIHORT, Kano sub-station and Department of geography, Bayero University, Kano