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# Comparative effects of organic and inorganic fertilizer treatment on growth, yield, and quality of lettuce (*Lactuca sativa* L.)

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**Abstract**

Lettuce (*Lactuca sativa* L.) is a very important exotic vegetable that can increase the income of farmers if high yield is obtained. However, high yield in *Lactuca sativa* is limited due to low soil fertility. The aim of this experiment is to evaluate the effect of organic and inorganic fertilizers on the growth, yield and quality parameters of lettuce. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five treatments in three replications. The organic fertilizers used were poultry manure and cow dung applied at 40 ton/ha, while the inorganic fertilizer was NPK applied at 700 kg/ha and Urea applied at 200kg/ha. Data were recorded on five competitive plants for plant height (cm), leaf area ($cm^2$). The data collected were subjected to analysis of variance (ANOVA). Comparison of means of yield parameters, its related characters and proximate analysis was also done using the same statistical package. The leaf yield (ton/ha) was also recorded. The results showed a high level of significance among the treatments, implying that the fertilizer used in this work affected the yield of *Lactuca sativa* and its related characteristics. Furthermore, high yield of *Lactuca sativa* were obtained from poultry manure (13.53 t/ha, 11.33 t/ha), cow dung (12.02 t/ha, 10.07 t/ha) and NPK (11.21 t/ha, 10.73 t/ha) in Igbon and Ejigbo, respectfully, while the least yield in both locations were obtained from control. The quality parameters showed that the treatments had no effect on the quality of *Lactuca sativa*. It is therefore concluded that poultry manure should be applied to lettuce to achieve higher yield while organic fertilizer should be applied to improve the quality. Also, lettuce should be harvested at 8 weeks after planting to avoid bitter taste. 

**Keywords**: Fertilizer, Growth, Lettuce, Proximate analysis, Yield

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## Introduction

Lettuce is majorly cultivated in Northern Africa, Europe and Asia since over 500 years ago (Vernon, 2005). In recent times, new varieties have been developed which can favourably adapt to various biotic and abiotic conditions (Owen, 2008). These adaptations can be modified by the use of modern technology. Several scientists have done many works on the climate requirement of this crop that will best suit their environmental conditions (Norman, 2000; Rhodes, 2004; Owen 2008). Leaves of lettuce are very good antioxidants, Vitamins A and C. Its leaves are also rich in antioxidants and anti-carcinogenic properties (Nicoli et al., 1999; Wissemeier & Zuhlke, 2002). It can be used in the cure of many heart related illnesses, thereby preventing terrible diseases of man such as cancer, cardiovascular disease, neural disorders, oxidative stress, diabetes and arthritis (Yoshikawa et al., 2000; Devasagayam et al., 2001). It is consumed as salad when mixed or shredded with other ingredients such as onion, cheese and tomato. Its production is now popular among vegetable farmers (Owen, 2008).

Lettuce plays an important role in food security and in poverty eradication (Muller & Krawinkel, 2005). It is a commonly grown vegetable in Vom, Plateau State of Nigeria. It is cultivated in Nigeria and consumed by humans but produced at the National Veterinary Research Institute (NVRI), Vom for feeding micro-livestock such as rabbit guinea pig, mice etc. Lettuce is rich in vitamin A (carotene), vitamin C (ascorbic acid), calcium and iron (Ananda & Ahundeniya, 2012) including protein and carbohydrate (Tindall, 1986). Lettuce may be grown under rain-fed conditions or with an irrigation facility and also with a hydroponic system in a controlled environment (Valenzuela et al., 1996; Ananda & Ahundeniya, 2012). Organic fertilizers play a major function in plant growth to supply major and minor nutrients to the plant (Chaterjee et al., 2005). It also improves soil physic-chemical properties of the soil. Similarly, Anant-Bahadur et al. (2006) reported that mineralization of organic materials improves chemical composition of the soil. Incorporation of organic fertilizer improves the vegetative growth of lettuce (Abdel-El-Moez et al., 2001; Ewulo et al., 2007; Wei Lan et al., 2010) and its total yield (Salama & Zake, 2000; Shehata et al., 2004; Awodun et al., 2007; Dass et al., 2008; Huez-Lopez et al., 2011).

However, addition of organic fertilizers alone will not supply nutrients needed by plants in adequate proportion when compared with the inorganic fertilizers. Application of inorganic fertilizers to lettuce improves vegetative growth (Badr & Fekry, 1998; Arisha & Bardisi, 1999; Stewart et al., 2005). Inorganic fertilizer is applied to supply major nutrients needed by plants for optimum growth (Adediran et al., 2004; Naeem et al., 2006). However, where inorganic fertilizers are not available, organic fertilizers can be used as replacement (Naeem et al., 2006) to supply plant nutrients, improvement of soil structure (Dauda et al., 2008) as well as activities of microorganisms in the soil (Suresh et al., 2004).

Most farmers prefer inorganic fertilizers to organic fertilizers due to the fact that it is less bulky and easily absorbed by plants (Eliot, 2005). Reports from several experiments in south west Nigeria showed that farmers use urea in the production of lettuce to facilitate the growth to maturity. Soils in the tropics are low in phosphorus, necessitating the need to add fertilizer to meet the requirements of plants (Zapata & Axman, 1995). Epidemiological studies show that high intake of vegetables reduces the risk of cardiovascular diseases (Joshipura et al., 2001; Liu et al., 2010, Lin et al., 2021) where attempts were made to investigate the response of organic and inorganic fertilizers on the growth and yield of Lettuce (*Lactuca sativa* L). Therefore, this study was conducted to examine the effect of poultry manure, cow dung, urea and NPK on the growth, nutrient quality and yield of lettuce.

## Materials and Methods

This study was carried out at the Teaching and Research Farm of the College of Agriculture, Osun State University, Ejigbo (Latitude 7$^o$, 52’28.37”N and Longitude 4$^o$, 18’13.76”E) Campus and at the premises of Osun State Mini Water Scheme, Igbon. Forty (40) tonnes per hectare each of well cured poultry manure and cow dung was used. This organic manure was sorted out for stone and other materials, air-dried, grounded, packed into a bag and sampled for chemical analysis. Urea (46% nitrogen) (30kg N/ha) and NPK fertilizer (15: 15: 15) (30kgN/ha) were used for the study.

### Planting material

Seeds of Eden cultivar of iceberg variety of lettuce (*lactuca sativa)* were collected from Agro-Tropic Company, Ibadan, Oyo State for this experiment.

### Land preparation

The experimental area was carefully mapped out and cleared of vegetation. Soil auger was used to collect composite soil samples at 12 random spots on the experimental site at a depth of 0-15 cm.The sample was mixed in a bowl, air-dried, sieved (2 mm) and bagged for laboratory analysis. The soil samples were analyzed at the Department of Agronomy Laboratory at Landmark University, Omu Aran, Kwara State for the physical and chemical properties of the soil.

### Nursery transplanting and crop management

The nursery was done with the use of polythene bags, bamboo sticks and palm fronts. Loamy soil was gotten and sieved with a 2 mm sieve to remove stones and was packed into the polythene bags with the use of a hand trowel. The polythene bags were closely packed and arranged in 10 rows and columns under the palm fronts for shed, irrigation was done to moisten the soil, and then the Eden seeds were planted. Emergence of seedlings began on the third day after planting, irrigation of the nursery was done in the morning and evening every day. The seedlings were transplanted three weeks after planting with the arrival of true leaves. The experimental plots were slashed and cleared manually of any debris before beds were made. Each bed in the experimental field was numbered for easy identification of the treatments.

The seedlings were transplanted at a rate of one per hole, a spacing of 30 by 30 cm was used between and within seedlings on the beds. Twelve seedlings were planted per bed, bringing the total number of seedlings for this experiment to one hundred and eighty. The transplanting was done in the evening so as to prevent heat stress and allow the plants to recover from transplanting shock. The seeds were raised in the nursery with polythene bags and were later transplanted at 4 weeks after planting.

### Experimental design and treatment

The experimental design used was the Randomized Complete Block Design (RCBD), with five treatments and three replicates. Each replicate consists of three beds, giving a total of fifteen beds.

### Cultural practices

Weeding: weed was controlled manually with the use of hoe as the need arises to keep the plot weed-free. Fertilizer Application: Poultry manure and cow dung were applied one week before transplanting while NPK and Urea were applied by side placement two weeks after transplanting to avoid burning the plant. Pest and Disease Control: Pest and diseases were controlled with the use of cypermethrin; the major pests encountered on this project are the aphids which were due to planting of lettuce during dry season. Irrigation: Irrigation was done very early in the morning and late in the evening with the use of a watering can. Harvesting: Harvesting was done with the use of a shovel which was dipped to the lowest level of the bed to manually remove the root from the soil to prevent contaminating the plant. Harvesting was carried out at eight weeks after planting after which samples of each treatment of the leaves were taken for proximate analysis at the Department of Agronomy Laboratory, Landmark University, Omu-Aran, Kwara State.

**Data collection**

Data that were collected at 8 weeks after transplanting are:

**Number of leaves (NOL)**

The number of leaves on each plant were counted and recorded.

**Plant height (cm)**

This was determined by placing a tape rule vertically from the base of each plant along its height to the apical region.

**Leaf area index ($cm^2$)**

This was calculated as the mean of the product of the length and breadth of 5 different leaves per plant.

**Leaf yield (tons/ha)**

The weight of the leaves was taken in tons/ha and recorded.

**Proximate analysis**

This was done to test the nutrient composition present in the leaf per treatment.

**Data analysis**

The data collected were subjected to the analysis of variance (ANOVA) using SAS-GLM procedures (SAS Institute, 1990). The treatment means were separated by the least significant difference (LSD). Comparison of means of yield parameters, its related characters and proximate analysis was also done using the same statistical package.

## Results and Discussion

The properties of soils in the experimental sites in the first cropping season of 2017 are shown in Table 1. The soil at Ejigbo was acidic (pH = 5.65) sandy loam and slightly acidic sandy loam at Igbon (pH = 6.32). Light soil texture is a characteristic feature of soils developed on basement complex rock parent materials even as the soil reaction is within acceptable range for nutrient availability needed for optimum growth and yield of maize (Aduloju et al., 2014). The total N was 0.9 and 0.7 g $kg^{-1}$ at Ejigbo and Igbon while soil organic matter content was 14.0 and 17.0 g $kg^{-1}$ respectively. These values are low compared to the 1.5-2.0 g $kg^{-1}$ and 25-30 g $kg^{-1}$ critical levels of total N and organic matter respectively established for soils in Nigeria (Bello et al, 2011). Soil available P was 7.8 and 8.8 mg $kg^{-1}$ at Ado and Ejigbo. These values are below the critical level of 10-15 mg $kg^{-1}$ established for soils in Nigeria. The mean performance for growth parameters of lettuce with organic and inorganic fertilizer treatment follows a similar trend in both Ejigbo and Igbon (Table 2). The leaves yield (13.53, 11.33 t/ha) (Igbon and Ejigbo, respectively) for lettuce with poultry manure was significantly higher at ($P \leq 0.05$) than other values in both locations but not significantly different from the lettuce with NPK fertilizer. The plant height of lettuce without fertilizer was significantly lower than the rest of the treatments in both locations. For plant height, lettuce fertilized with poultry manure and cow dung application was significantly different but significantly higher than the rest of the fertilizer treatments in Igbon and Ejigbo. The plant height of lettuce with NPK, Urea and control are not significantly different but significantly lower. Leaf area showed that Poultry manure and NPK treatment are not significantly different but are significantly higher than the rest of the fertilizer applied. Table 3 shows the yield (ton/ha) of lettuce treated with organic and inorganic fertilizer in two locations. The yield in Igbon was significantly higher than that of Ejigbo. Also, the yield of lettuce treated with poultry manure was significantly higher than the other treatments while the yield of lettuce without application of either organic or inorganic fertilizer was significantly low.

The results of the proximate analysis are represented in Table 4. The highest percentage moisture content from lettuce was from inorganic fertilizer treated plots while the least was recorded from control plots. The mean moisture content of the analysed vegetables as presented showed that lettuce treated with Urea, NPK, poultry manure, cow dung and control 30.90, 28.70, 24.70, 26.60, and 27.70% respectively. These values are lower than those reported earlier for some Nigeria green vegetables (Akindahunsi & Salawu, 2005), and a significant difference in the moisture contents was observed in lettuce treated with different fertilizers. The ash content of lettuce treated with poultry manure (32.90%) is much higher than all the other ash content of lettuce treated with other sources of fertilizers. Dietary fibre of lettuce treated with poultry manure (11.70%) is greater than other treatments. The ash content of lettuce treated with poultry manure and cow dung (11.70 and 10.70% respectively) is higher than Amaranthus hybridus (8.61%) reported by Akubugwo et al. (2007). For percent ash content, the highest was from inorganic fertilizer plots (32.4 and 30.9% poultry manure and cow dung, respectively) while the least came from control plots (21.00%). For calcium content, the highest was from inorganic fertilizer plots [27.90 and 27.8 (mg/g)] poultry manure and cow dung respectively] while the least came from control plots (19.3 mg/g). In Phosphorus production, the highest content was realized from organic fertilizer treated plots, followed by the inorganic plots with lowest phosphorus content recorded from the control plots. In crude protein production, the highest percentage was realized from organic fertilizer treated plots, followed by the control plots with lowest percentage recorded from the inorganic fertilizer treated plots.

It is evident from the results that the use of organic fertilizer types could be used in increasing the quality parameters of lettuce measured in the present work (moisture content, crude fat, crude protein, Calcium, Phosphorus and ash). Organic foods are generally considered healthier than conventionally-grown products. Nevertheless, an improved nutritional profile of organic vs. conventional crops has not been ascertained (Bourn, 2002), meaning that the use of organic fertilizer could be further encouraged. This goes in line with the present clamour for organic farming that is currently gaining the acceptance of all and sundry in agricultural production. The results obtained from this experiment shows that there are significant differences in the growth and yield parameters with respect to organic and inorganic fertilizer applications (Paudel et al., 2004; Masarirambi et al., 2012). The result also confirmed that plant height, number of leaves, leaf area, and yield were significantly increased with fertilizer. Fertilizer provides nitrogen, phosphorus and potassium which plants require for vegetative growth, energy transformations and enzymatic activities, respectively (Jones, 2003). The result shows significant ($P \leq 0.05$) differences in the number of leaves per plant. Lettuce plants fertilized with poultry manure showed a relatively high number of leaves per plant followed by cow dung, NPK, Urea and control. Jenni et al. (2008) reported that heavy application of poultry manure and cow dung would result in an increase in the vegetative growth of crops, thereby increasing the yield and also the income of farmers. Lettuce that received poultry manure had significantly higher growth performance compared with other treatments. This result corroborates the result of Uddin et al. (2009). This could be as a result of the mineral composition of poultry manure.

Increase in the average number of leaves per plant of lettuce plant fertilized with organic and inorganic fertilizers shows that heavy application of poultry manure and cow dung can be used to increase the growth and yield of lettuce, corroborating the findings of Jin et al. (1996) that addition of manure can influence the proximate analysis of horticultural crops (Almante et al., 2006). A possible reason behind this result is that organic manures added higher potassium content in soil than inorganic farming systems. The nutrient composition in terms of moisture content, protein, fat, ash, calcium, phosphorus and fibre obtained in this experiment shows that addition of fertilizers reacts differently to the growth and yield characteristics as they were revealed by the significant differences in the nutrient composition; however, moisture content value obtained in this experiment were significantly different. Differences between each moisture content are slightly different from one another with urea having the highest moisture content of 32.32%. Urea having the highest value for moisture content indicated that inorganic farming conserves more water than organic farming in lettuce. This was in line with Rosen et al. (1999) who investigated the increasing trend of exchangeable P, Ca, Na, Cu, Zn, Mo, and Pb in organic crops and discovered that the possible factors behind the lower moisture content in organic lettuce was that the additional minerals occupied more space in plant than the inorganic farming system.

The calcium content in lettuce obtained in this experiment varies slightly, with differences ranging from 0.51 – 0.69%. The values obtained are not significantly different. Poultry manure having the lowest, followed by cow dung, with the inorganic fertilizer having the highest value. The result obtained antagonised the work of Islam (2004) who reported that the application of poultry manure recorded the highest value for Ca content in spinach. This can be attributed to the fact that organic and inorganic fertilizer has no effect on lettuce due to the season it was planted. Values obtained for protein, fat, Ash, phosphorus and fibre are not significantly ($p \leq 0.05$) different. Cow dung has the highest protein content followed by urea and poultry manure; N.P.K and control recorded the lowest. This implies that organic fertilizer also contributes to the protein content of plants compared to inorganic fertilizer. Fat value obtained ranges from 3.07 – 3.61% in which the values are not significantly ($p \leq 0.05$) different. Urea recorded the highest fat content while cow dung recorded the lowest. The accumulation of fat content in an inorganic fertilizer plant may result due to the content of the materials used to produce the inorganic fertilizer (Akubugwo et al. (2007). Ash and phosphorus obtained for the treatment (organic and inorganic) are not significantly different ($p \leq 0.05$). This shows that fertilizer application has no effect on the plant's ash and phosphorous content.

Poultry manure and NPK recorded the highest value for fibre; this resulted in increased rate of growth of plants cultivated on the poultry manure and NPK plots. The more the lignification of the plant, the more the fibre content. The control plot has the lowest yield which may be due to less fertility of the soil compared to the plots in which fertilizers have been added. However, there were significant differences in the parameter of growth for lettuce at 8 weeks after planting, which depends on the type of fertilizer used. The plant with poultry manure fertilizer showed significantly higher growth and yield parameters. This is due to the attribute of the nutrient composition in the fertilizer, corroborating the results reported by Uddin et al. (2009). The result shows that poultry manure has the highest yield followed by NPK and cow dung because poultry manure has large quantities of phosphorus and potassium. Mineralization of organic materials is faster and releases nitrogen to the soil to enhance crop yield (Rao, 1991). The method of application and quantity of organic fertilizer had an effect on both crop yield and nutrient uptake. Owen (2003) reported that inorganic fertilizers do not help in aggregating soil structure; consequently, crops produced from organic fertilizer have more yield than crops produce from inorganic fertilizer. The low performance of the plant in the control plot is a reflection of nutrient deficiency in the soil. This is in line with the works of Xu et al. (2005); Okpara et al. (2007).

**Table 1** Physical and chemical properties of soil in the experimental sites

| Properties | Value | |
|---|---|---|
| | Ejigbo | Igbon |
| Sand % | 67.00 | 65.00 |
| Clay % | 16.00 | 14.88 |
| Silt % | 20.00 | 17.00 |
| Textural class | Sandy loam | Sandy loam |
| pH ($H_20$) | 5.65 | 6.32 |
| Carbon % | 0.80 | 0.70 |
| Organic matter % | 1.40 | 1.70 |
| Nitrogen % | 0.09 | 0.07 |
| Phosphorus (mg/kg) | 7.80 | 8.80 |
| $Ca^{2+}$ (cmol/kg) | 1.65 | 1.72 |
| $Mg^{2+}$ (cmol/kg | 0.65 | 0.50 |
| $K^+$ (cmol/kg) | 0.20 | 0.19 |
| $Na^+$ (cmol/kg) | 0.16 | 0.09 |

**Table 2** Means of organic and inorganic fertilizer on the growth parameter of lettuce at 8 weeks after planting (WAP)

| Treatment | Weight of leaf (Yield t/ha) | | Plant height (cm) | | Leaf area ($cm^2$) | |
|---|---|---|---|---|---|---|
| | Ejigbo | Igbon | Ejigbo | Igbon | Ejigbo | Igbon |
| Poultry manure | $11.33^a$ | 13.53a | $15.89^a$ | 16.21a | $206.33^a$ | 250.21a |
| Cow dung | $10.07^b$ | 12.02b | $15.03^a$ | 16,23a | $153.13^b$ | 160.21b |
| N. P. K | $10.73^{ab}$ | 11. 21ab | $13.49^b$ | 13.73b | $194.33^a$ | 237.33a |
| Urea | $9.00^c$ | 10.08c | $13.29^b$ | 13.51b | $139.93^{bc}$ | 159.23bc |
| Control | $8.25^c$ | 8.73c | $13.23^b$ | 13.42b | $132.13^c$ | 137.23c |
| LSD | 1.50 | 1.25 | 2.33 | 2.01 | 13.23 | 20.01 |

Superscript letters in the same column indicate significant difference ($p<0.05$)

**Table 3** Effect of organic and inorganic fertilizer on proximate analysis of lettuce

| Treatment | Moisture content (%) | Protein (mg/g) | Fat (mg/g) | Ash (%) |
|---|---|---|---|---|
| Cow dung (Mean ± S.D) | 25.60 ± 1.00 | 11.40 ± 0.90 | 0.32 ± 0.01 | 30.90 ±4.10 |
| Poultry manure (Mean ± S.D) | 24.70 ±1.70 | 12.70 ± 1.40 | 0.45 ± 0.03 | 32.40 ±1.60 |
| NPK (Mean ± S.D) | 28.60 ± 4.10 | 9.20 ± 0.30 | 0.21 ± 0.01 | 26.30 ±4.20 |
| Urea (Mean ± S.D) | 30.90 ± 1.30 | 8.80 ± 0.40 | 0.02 ± 0.01 | 22.40 ±0.80 |
| Control (Mean ± S.D) | 27.70 ±1.70 | 10.80 ± 0.40 | 0.010 ± 0.01 | 21.00 ±1.40 |

The values after ± indicate standard deviation (S.D.)

**Table 3** continue

| Treatment | Calcium (mg/g) | Phosphorus (mg/g) | Crude fibre (mg/g) |
|---|---|---|---|
| Cow dung (Mean ± S.D) | 27.80 ± 1.30 | 0.02 ± 0.01 | 10.70 ± 1.40 |
| Poultry manure (Mean ± S.D) | 27.90 ± 5.00 | 0.04 ± 0.03 | 11.70 ± 0.80 |
| NPK (Mean ± S.D) | 24.94 ± 33.70 | 0.01 ± 0.01 | 6.70 ± 1.40 |
| Urea (Mean ± S.D) | 23.40 ± 6.70 | 0.02 ± 0.01 | 5.70 ± 1.34 |
| Control (Mean ± S.D) | 19.30 ±1.00 | 0.01 ± 0.01 | 5.70 ± 1.24 |

The values after ± indicate standard deviation (S.D.)

## Conclusion and Recommendation

It is evident from this work that organic fertilizer and, to a lesser extent, inorganic fertilizer (NPK 15: 15:15 and urea) could be conveniently used to increase Lettuce yield. Organic fertilizer was seen to have the highest growth parameters followed by inorganic fertilizer during this experiment. Inorganic fertilizer showed the highest nutrient content for the proximate analysis of lettuce. Both organic and inorganic fertilizers have different functions and those functions are vital to sustaining crop production. Lettuce does well in Ejigbo, Osun State with minimum agronomic practices. There is potential for an added benefit when organic and inorganic fertilizers are both used in combination to give better and higher yield of lettuce. To improve the quality of lettuce, it is best to add organic fertilizer in order to improve its nutrient value. Finally, production of lettuce will be better with organic fertilizer since it is more advantageous than the inorganic one and that inorganic fertilizer did not produce higher than it.

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