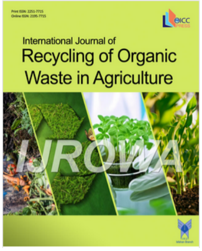


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# Response of cauliflower (*Brassica oleracea* var. *botrytis*) grown in the field to organic waste fortification and cropping seasons

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**Original Research**

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**Abstract:**

**Purpose**: To evaluate cauliflower (*Brassica oleracea* var *botrytis*) field performance in response to season, organic waste types, and rates; a cultivar (ATRIA 153F1) was grown for two years (2019 and 2020) under two dif-ferent seasons (Rainy and Dry). This is to ascertain the effective season, type, and rate of organic waste for the promotion of sustainable agriculture and organic farming practices for cauliflower.
**Method**: The experiment was $2 \times 4$ factorial in a randomized complete block design with four replications. Factor A was the two different organic wastes (poultry and pig slurry) while factor B was the four rates (0, 10, 20, and 30 t/ha) of the organic wastes. The growth and yield parameters monitored were plant height, number of leaves, curd diameter, and curd fresh weight. Data on nutrient assessment of the fortified plots were also collected.
**Results**:The study reveals that Season played a significant role in the growth and yield of cauliflower on average for the two years studied. Dry seasons produced taller plants (30.40 cm), and a higher number of leaves (15.90), while rainy seasons produced larger curd diameter (10.28 cm) and higher curd weights (71.39 t/ha). Soil fertility significantly improved with the application of the organic wastes. Plant height and number of leaves showed responses to manure type (MT) and manure rates (MR) suggesting that both assist in the growth and development of cauliflower in the field.
**Conclusion**: The responses of yield components tended towards the positive side and the parameters responded to MT and varying MR. This study recommends the use of organic waste and emphasizes the need to consider cropping seasons in optimizing benefits. Optimization of organic waste management practices for cauliflower farming could lead to a significant increase in yield and sustainability in large-scale commercial agriculture.

**Keywords:** Brassicas; Rainy season; Poultry manure; Pig slurry; Curd weight

## 1. Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is among the most popular cruciferous vegetable crops cultivated for their succulent curds as edible parts. Other crucifers include cabbage, kale, Brussels sprouts, collards, kohlrabi, mustard, and broccoli. Crucifers have been ranked by the Food and Agriculture Organization among the top twenty vegetable crops grown worldwide, establishing them as an important food source globally (Avato and Argentieri, 2015). It is a good source of vitamins, minerals, and chemoprotective phytochemicals (Manchali et al., 2012; Satheesh and Fanta, 2020; Raiola et al., 2018; Favela-González et al., 2020). Cauliflower is a productive vegetable based on biomass per area of cultivation. They are grown all through the year for their tender curds and vegetables but thrive best in a cool, moist climate and do not withstand extreme temperatures (Din et al., 2007). Cropping season plays a vital role in vegetable production as rainfed production reduces evapotranspiration during the rainy season which leads to adequate water use efficiency (Tesfaye and Walker, 2004; Li and Troy, 2018). It is known to promote soil improvements and agricultural productivity. Poultry and pig slurry are good sources of N, P, K, and S which is responsible for the higher yield of cauliflower. An increase in the application of this manure sometimes leads to an increase in yield but sometimes becomes toxic to the plants and also saturates the soil, therefore adequate rate of manure should be considered in this vegetable production. Information on the influence of cropping season, organic manure type, and rates on the growth and yield of cauliflower is lacking in the study area. Therefore, it is necessary to identify suitable growing seasons, manure types, and rates that will increase yield and income for resource-poor farmers this study aimed to evaluate the response of cauliflower grown in the field to cropping season, organic manure type, and rates.

## 2. Materials and methods

### Collection of climatic data

The meteorological data on temperature, rainfall distribution, and relative humidity were collected from the Department of Crop Science Meteorological unit, University of Nigeria, Nsukka during the period of the experiments.

### Soil sample collection

Soil samples were collected (using a soil auger at 15 cm depth) and taken to the Department of Soil Science laboratory for routine analysis including particle sizes, textural classes, soil pH and the Cation exchange capacity, organic matter component, total Nitrogen, phosphorus and potassium. The nutrient content of the organic waste utilized was also determined.

### Field experiment

ATRIA 153F1 cauliflower seeds were sourced from East-west seeds in Kaduna State, Nigeria and seedlings were raised in the nursery for six weeks and were transplanted to an already made bed measuring 1 m × 1 m, 0.5 m between beds and 1 m between blocks. This study was laid out as a $2 \times 4$ factorial experiment in a randomized complete block design replicated three times. The main factor is the manure type (MT) while the manure rates MR (0 tonnes, 10 tonnes, 20 tonnes, and 30 tonnes per hectare) is the sub-factor. Beds were prepared 2 weeks before transplanting and well-cured manure was applied on the already-made bed. Seedlings were transplanted with a spacing of 25 cm in between plants. These experiments were performed in rainy and dry seasons (May to August 2019 and November 2019 to February 2020). It was repeated in (May to August 2020 and November 2020 to February 2021). The following parameters were collected: Plant height, number of leaves, number of days to curd formation, curd diameter, and total curd weight.

## 3. Results and discussion

### Meteorological data for the 2019 and 2020 planting seasons

The meteorological data from the experimental sites shows that there is a marked variation in the weather elements being considered (Table 1). The rainfall distribution shows that during the rainy season, it ranges between 220.73 – 264.38 mm, whereas the dry season ranges between 4.57 – 10.67 mm of rainfalls in the 2019 season. During the 2020 rainy season, rainfall ranged between 198.63 – 219.18 mm while in the 2020 dry season, the distribution ranged between (15.75 – 41.91 mm). Moreover, the temperature ranged between 20.29 – 38.00 °C for both sea-sons in 2019 and 19.39 – 35 °C. The data also revealed that the mean relative humidity for rainy and dry seasons ranged between 56.06 – 76.15% and 24 – 77% respectively.

### Physicochemical properties of soil of the experimental site and organic wastes used for the study

The physicochemical properties of the soil from the experimental sites before planting revealed that the soil was not fertile (Table 2). The percentage of Nitrogen (2.44%), Phosphorus (30.28%), and Potassium (2.00%) was low. Cation exchange capacity (13.60 meq/100g) and base saturation (19.93) were relatively low. Organic matter (2.44%) and

**Table 1.** Weather conditions at the experimental site during the 2019 and 2020 growing seasons.

| Month | Rainfall | Min temp (°C) | Max temp (°C) | Relative humidity (%) |
|---|---|---|---|---|
| | | 2019 season | | |
| **May** | 220.73 | 21.77 | 31.55 | 56.06 |
| June | 328.67 | 20.47 | 30.30 | 59.60 |
| July | 145.28 | 20.29 | 28.65 | 62.52 |
| August | 264.38 | 21.16 | 27.38 | 62.45 |
| **November** | 4.57 | 33.0 | 22.0 | 54 |
| December | - | 34.0 | 18.0 | 30 |
| January (2020) | 0.51 | 19.43 | 32.07 | 37.07 |
| February (2002) | 10.67 | 21.71 | 33.93 | 38.36 |
| | | 2020 season | | |
| **May** | 198.63 | 21.61 | 29.52 | 72.32 |
| June | 168.60 | 21.17 | 28.67 | 74.19 |
| July | 283.96 | 20.71 | 27.35 | 74.26 |
| August | 219.18 | 20.26 | 26.61 | 76.15 |
| **November** | 41.91 | 21.7 | 30.37 | 77.00 |
| December | 15.75 | 19.39 | 29.35 | 66.40 |
| January (2021) | - | 20.00 | 35.00 | 44 |
| February (2021) | - | 21.00 | 34.00 | 24 |
| **Total** | **1902.84** | **385.67** | **436.75** | **908.38** |
| **Mean** | **146.37** | **24.10** | **27.29** | **56.77** |

Source: Meteorological station, Department of Crop Science, University of Nigeria Nsukka.

**Table 2.** Physico-chemical properties of the experimental sites and manure (poultry and pig slurry) utilized.

| **Mechanical properties** | Soil particle size | Poultry manure | Pig slurry |
|---|---|---|---|
| Textural class | SL | - | - |
| Clay (%) | 19 | - | - |
| Silt (%) | 4 | - | - |
| Coarse sand (%) | 35 | - | - |
| Fine sand (%) | 41 | - | - |
| **Chemical properties** | | | |
| pH in water | 5.8 | - | - |
| pH in Kcl | 4.9 | - | - |
| Organic carbon (%) | 1.420 | - | - |
| Organic matter (%) | 2.440 | 77.98 | 52.69 |
| Total Nitrogen (%) | 0.098 | 2.17 | 1.68 |
| Phosphorus (ppm) | 30.28 | 0.41 | 0.36 |
| **Exchangeable base in meq/100 g soil** | | | |
| Sodium ($Na^+$) | 0.04 | 0.93 | 0.63 |
| Calcium ($Ca^{2+}$) | 0.07 | 0.80 | 0.32 |
| Potassium ($K^+$) | 2.00 | 0.13 | 1.09 |
| Magnesium ($Mg^{2+}$) | 0.60 | 2.35 | 0.22 |
| CEC meq/100gsoil | 13.60 | - | - |
| Base saturation % | 19.93 | - | - |
| **Exchangeable acidity in 100 meq/100 g soil** | | | |
| Aluminum ($Al^{2+}$) | 0.20 | - | - |
| Hydrogen ($H^+$) | 1.40 | - | - |

Source: Department of Soil science laboratory, University of Nigeria, Nsukka.

organic carbon (1.42%) depict the low fertility of the soil of the study area. The pH was slightly acidic. The soil was classified as Sandy loam.

Poultry and pig manure utilized during the experiments were relatively high in percentage organic matter content (77.98 and 52.69%) and organic carbon (22.70 and 18.96%). Percentages of Nitrogen (2.17 and 1.68%), Potassium (0.13 and 1.09%), and Phosphorus (0.41 and 0.36%) were low.

### Effect of season, manure type, and rates on the growth of cauliflower

Season significantly ($p \leq 0.05$) influenced the plant height at 2, 4, 6, and 8 weeks after transplanting (WAT) (Table 3). The dry season produced taller cauliflower (31.66 cm) at 8 WAT while the rainy season had shorter plants (26.61 cm) in 2019. It followed the same trend in 2020 where the dry season had taller plants (29.14 cm) and the rainy season gave shorter plants (23.32 cm). The season also had a significant effect ($p \leq 0.05$) on the number of leaves at 2, 4, and 6 WAT in 2019 and 2020. The dry season recorded more leaves (15.92) while the rainy season had fewer leaves (13.48) in 2019. The trend was the same in 2020 where the dry season recorded 15.92 numbers of leaves whereas the rainy season recorded fewer leaves (9.79).

MT significantly ($p \leq 0.05$) influenced the plant height at 2, 4, 6, and 8 WAT (Table 3). Poultry manure produced taller plants (29.82 cm) at 8 WAT while pig manure had shorter plants (28.45) in 2019. It followed the same trend in 2020 where poultry manure had taller plants (28.41 cm) and dry season had shorter plants (25.99 cm). MT significantly ($p \leq 0.05$) influenced the number of leaves at 2, 4, and 6 WAT. Poultry manure had a higher number of leaves (15.56) at 10 WAT while pig manure had lesser leaf numbers (13.83) in 2019. During the 2020 planting, poultry manure had 14.22 while in the dry season; it recorded 13.53 numbers of leaves.

MR significantly ($p \leq 0.05$) influenced the plant height at 2, 4, 6, and 8 WAT (Table 3). 20 t/ha produced taller kales (30.60 cm) at 8 WAT while 0 t/ha had shorter plants (18.80 cm) in 2019. It followed the same trend in 2020 where 20 t/ha had taller plants (34.72 cm) and 0 t/ha had shorter plants (15.81 cm). MR significantly ($p \leq 0.05$) influenced the number of leaves at 2, 4, and 6 WAT. The number of leaves recorded for 0, 10, 20, and 30 t/ha in 2019 was 11.25, 14.38, 17.04 and 16.02 respectively. In 2020, it followed the same trend and recorded 10.39, 12.29, 16.50, and 15.67 numbers of leaves for 0, 10, 20, and 30 t/ha respectively. 20 t/ha had more leaves while 0 t/ha had the least number of leaves.

The interaction between season and MT (Table 4) was significant ($p \leq 0.05$) at 4, 6, and 8 WAT in 2019. At 8 WAT, the interaction between dry season and pig manure had taller plants (31.58 cm) while rainy season and poultry manure had shorter cauliflower (22.40 cm). The interaction between season and manure was not significant in 2020. The interaction between season and manure type did not significantly ($p > 0.05$) influence the number of leaves at 2, 4, and 6 WAT in both 2019 and 2020.

The interaction of season and MR was statistically significant ($p \leq 0.05$) at 4, 6, 8, and 10 WAT. The dry season with 20 t/ha recorded taller plants (39.47 cm) whereas the dry season and 0 t/ha gave the least height of 19.38 cm in 2019. It was not significant in 2020. The interaction of season and manure rates did vary across different weeks after transplanting for the number of leaves during the two-year studies.

The interaction of MT and MR was not statistically significant ($p \leq 0.05$) at 8 WAT in both 2019 and 2020 for plant height. The interaction significantly ($p \leq 0.05$) influenced the number of leaves at 6 WAT. In 2019, poultry manure in combination with 0, 10, 20, and 30 t/ha recorded 9.52, 13.27, 15.98, and 15.48 numbers of leaves respectively while that of pig manure and 0, 10, 20, and 30 t/ha recorded 9.75, 11.17, 12.42 and 11.67 numbers of leaves respectively. It was not significant in 2020.

**Table 3.** Main effect of season, manure type and manure rates on growth parameters of cauliflower for 2019 & 2020.

| | 2019 | | | | | | | 2020 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant Height (cm) | | | | Number of Leaves | | | Plant Height (cm) | | | | Number of Leaves | | |
| Season | 2WAT | 4WAT | 6WAT | 8WAT | 2WAT | 4WAT | 6WAT | 2WAT | 4WAT | 6WAPT | 8WAT | 2WAT | 4WAT | 6WAT |
| Rainy | 13.50 | 18.06 | 22.10 | 26.61 | 4.775 | 13.48 | 13.48 | 11.65 | 13.92 | 17.67 | 23.32 | 5.29 | 7.62 | 9.79 |
| Dry | 19.12 | 26.75 | 30.36 | 31.66 | 4.33 | 15.92 | 15.92 | 7.15 | 18.12 | 25.25 | 29.14 | 9.12 | 13.25 | 15.92 |
| **F-LSD (0.05)** | **2.552** | **4.511** | **3.400** | **1.558** | **0.1400** | **1.465** | **1.553** | **4.333** | **1.260** | **4.260** | **1.255** | 1.819 | **2.542** | **3.891** |
| Manure Type | | | | | | | | | | | | | | |
| Poultry | 9.70 | 23.25 | 26.99 | 29.82 | 4.683 | 13.55 | 15.56 | 9.36 | 17.11 | 24.21 | 28.41 | 8.19 | 12.44 | 14.22 |
| Piggery | 8.74 | 21.56 | 25.47 | 28.45 | 4.425 | 11.25 | 13.83 | 7.93 | 16.34 | 21.24 | 25.99 | 7.50 | 10.31 | 13.53 |
| **F-LSD (0.05)** | **0.713** | **NS** | **0.903** | **0.512** | **NS** | **1.452** | **1.490** | **0.615** | **NS** | **0.753** | **0.574** | **NS** | **1.566** | **1.312** |
| Manure Rates (tonnes) | | | | | | | | | | | | | | |
| 0 | 6.68 | 11.49 | 15.85 | 18.80 | 3.150 | 9.63 | 11.25 | 5.82 | 10.97 | 13.02 | 15.81 | 6.50 | 9.11 | 10.39 |
| 10 | 8.24 | 15.03 | 21.56 | 25.99 | 4.033 | 12.22 | 14.38 | 7.64 | 16.02 | 23.42 | 26.68 | 7.61 | 11.17 | 12.29 |
| 20 | 11.03 | 19.55 | 26.59 | 30.60 | 5.675 | 12.20 | 17.04 | 10.33 | 20.62 | 28.42 | 34.72 | 8.67 | 12.78 | 16.50 |
| 30 | 10.94 | 19.17 | 25.62 | 29.52 | 5.358 | 13.54 | 16.12 | 10.79 | 19.28 | 26.03 | 31.58 | 8.61 | 12.44 | 15.67 |
| **F-LSD (0.05)** | **0.979** | **1.711** | **2.544** | **2.706** | **0.3804** | **1.260** | **1.255** | **3.049** | **3.875** | **4.235** | **5.647** | **1.475** | **1.801** | **1.876** |

WAT = Weeks after transplanting.

**Table 4.** Combined effect of season, manure type and manure rates on the growth attributes of cauliflower for 2019 and 2020.

| | | 2019 | | | | | | | 2020 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Season | Manure Type | Plant Height (cm) | | | | Number of Leaves | | | Plant Height (cm) | | | | Number of Leaves | | |
| | | 2WAT | 4WAT | 6WAT | 8WAT | 2WAT | 4WAT | 6WAT | 2WAT | 4WAT | 6WAPT | 8WAT | 2WAT | 4WAT | 6WAT |
| Rainy | Poultry | 9.95 | 14.13 | 18.54 | 22.40 | 5.117 | 7.47 | 12.68 | 13.17 | 15.49 | 19.70 | 24.49 | 4.25 | 4.67 | 6.75 |
| | Piggery | 8.65 | 12.87 | 17.58 | 21.80 | 4.433 | 6.38 | 10.42 | 10.12 | 12.34 | 15.64 | 22.14 | 4.83 | 5.92 | 8.50 |
| Dry | Poultry | 9.46 | 18.92 | 27.96 | 31.58 | 4.250 | 9.33 | 14.42 | 7.46 | 17.92 | 26.46 | 30.36 | 4.42 | 8.92 | 12.08 |
| | Piggry | 8.83 | 19.33 | 25.54 | 29.13 | 4.417 | 8.92 | 12.08 | 6.83 | 18.33 | 24.04 | 27.91 | 4.25 | 9.33 | 14.42 |
| | **F-LSD (0.05)** | **NS** | **NS** | **NS** | **2.9017** | **NS** | **NS** | **NS** | **3.7977** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| Season | Manure Rates (tonnes) | | | | | | | | | | | | | | |
| Rainy | 0 | 10.40 | 15.63 | 19.35 | 23.87 | 3.300 | 5.25 | 8.77 | 9.13 | 9.75 | 9.90 | 13.37 | 4.17 | 4.50 | 6.33 |
| | 10 | 11.49 | 16.05 | 20.61 | 24.78 | 4.233 | 6.48 | 11.27 | 9.33 | 12.88 | 19.08 | 19.75 | 3.50 | 4.17 | 7.17 |
| | 20 | 15.69 | 20.26 | 24.17 | 28.59 | 6.183 | 8.17 | 13.40 | 13.42 | 17.03 | 22.42 | 32.53 | 5.17 | 5.67 | 8.33 |
| | 30 | 16.43 | 20.31 | 24.26 | 29.20 | 5.383 | 7.78 | 12.75 | 14.70 | 16.00 | 19.27 | 27.62 | 5.33 | 6.83 | 8.67 |
| Dry | 0 | 12.58 | 16.08 | 18.25 | 19.38 | 3.000 | 7.50 | 10.50 | 4.17 | 11.58 | 14.58 | 17.03 | 3.00 | 7.50 | 10.50 |
| | 10 | 18.58 | 27.08 | 31.37 | 32.73 | 3.833 | 9.33 | 13.17 | 6.80 | 17.58 | 25.58 | 30.15 | 3.83 | 9.33 | 13.17 |
| | 20 | 23.42 | 32.92 | 37.03 | 39.47 | 5.167 | 10.17 | 15.00 | 8.78 | 22.42 | 31.42 | 35.81 | 5.17 | 10.17 | 15.00 |
| | 30 | 21.92 | 20.92 | 34.78 | 35.07 | 5.333 | 9.50 | 14.33 | 8.83 | 20.92 | 29.42 | 33.56 | 5.33 | 9.50 | 14.33 |
| | **F-LSD (0.05)** | **2.470** | **3.944** | **3.714** | **4.003** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| Manure Type | Manure Rate (tonnes) | | | | | | | | | | | | | | |
| Poultry | 0 | 7.45 | 10.92 | 14.57 | 17.77 | 3.117 | 6.60 | 9.52 | 5.97 | 10.03 | 11.06 | 14.26 | 3.56 | 6.44 | 9.67 |
| | 10 | 7.63 | 13.72 | 21.94 | 27.36 | 3.617 | 7.97 | 13.27 | 7.49 | 15.12 | 25.36 | 28.91 | 3.11 | 8.00 | 11.89 |
| | 20 | 11.40 | 20.81 | 29.01 | 31.34 | 5.950 | 9.85 | 15.98 | 11.52 | 22.82 | 32.52 | 36.81 | 5.44 | 9.44 | 14.56 |
| | 30 | 12.33 | 20.65 | 27.48 | 31.50 | 6.050 | 9.18 | 15.42 | 12.47 | 20.46 | 27.89 | 22.64 | 5.67 | 8.89 | 13.67 |
| Piggry | 0 | 5.91 | 12.06 | 17.14 | 19.84 | 3.183 | 6.15 | 9.75 | 5.68 | 11.91 | 14.99 | 17.35 | 3.22 | 6.56 | 8.56 |
| | 10 | 8.85 | 16.35 | 21.19 | 24.62 | 4.450 | 7.85 | 11.17 | 7.80 | 16.91 | 21.48 | 24.45 | 4.33 | 7.22 | 10.44 |
| | 20 | 10.65 | 18.30 | 24.17 | 29.87 | 5.400 | 8.49 | 12.42 | 9.13 | 18.42 | 24.21 | 32.63 | 4.89 | 7.89 | 11.0 |
| | 30 | 9.55 | 17.70 | 23.75 | 27.54 | 4.667 | 8.10 | 11.67 | 9.11 | 18.10 | 24.18 | 29.52 | 5.00 | 8.33 | 11.22 |
| | **F-LSD (0.05)** | **1.302** | **2.493** | **3.417** | **NS** | **0.5941** | **NS** | **1.893** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

### Effect of season, manure type, and rates on the yield of cauliflower

Season significantly ($p \leq 0.05$) influenced the curd diameter and weight at 8 and 10 WAT (Table 5). The rainy season produced bigger curds (12.94 cm) and an average curd weight of 134.84 t/ha at 10 WAT while the dry season had smaller curds (6.58 cm) and curd weight of 58.95 t/ha in 2019. It followed the same trend in 2020 where the rainy season had bigger curds (7.61 cm) and curd weight of 7.93 t/ha, while the dry season had smaller curds (5.25 cm) and curd weight of 4.27 t/ha significantly ($p \leq 0.05$) influenced the curd diameter and curd weight at 10 WAT (Table 5). Poultry manure produced bigger curds (10.08 cm) and curd weight of 9.97 t/ha while pig manure had smaller curd diameter and lesser curd weight of 9.44 cm and 9.40 t/ha at 10 WAT in 2019. It did not follow the same trend in 2020, pig manure outperformed poultry manure by producing bigger curds with bigger curd weights (6.29 cm and 5.69 t/ha) respectively while poultry manure had smaller curd diameter and lesser curd weights of 5.78 cm and 5.29 t/ha at 10 WAT.
MR significantly ($p \leq 0.05$) influenced the curd diameter but did not influence the curd weight at 10 WAT (Table 4). 30 t/ha produced cauliflower with a bigger curd diameter (10.54 cm). The head weight was not significant in 2019. In 2020, the curd diameter and weight were statistically ($p \leq 0.05$) significant. 30 t/ha produced cauliflower with bigger curd diameter and weight (6.58 cm and 5.88 t/ha) respectively.
The interaction between season and MT (Table 6) was significant ($p \leq 0.05$) at 8 WAT but not significant at 10 WAT for the curd diameter. At 10 WAT, in 2019, planting in the rainy season and using pig manure produced a bigger cauliflower curd weight (138.49 t/ha) while the interaction between the dry season and pig manure had a smaller curd (44.10 cm) with a curd weight of 15.10 t/ha. In 2020, planting in dry season and utilizing poultry manure had a smaller curd weight of 56.96 t/ha while dry season with pig manure curd weight of 60.93 t/ha.
The interaction between season and MR (Table 6) was not statistically significant ($p > 0.05$) at 10 WAT for curd diameter but highly significant for the curd weight. The rainy season with 30 t/ha recorded 145.87 t/ha curd weight while interaction between the dry season and 0 t/ha had a smaller weight of 53.33 t/ha in 2019. In 2020, both curd diameter and curd weight were not significant.
The interaction between MT and MR (Table 6) was significant ($p \leq 0.05$) at 10 WAT in 2019 and 2020. In 2019 combination of pig manure at 30 t/ha produced cauliflowers with bigger curd diameter and weight (11.33 cm and 111.14 t/ha) while the control (0 t/ha) had a smaller curd diameter and weight (8.68 cm and 53.53 t/ha). In 2020 combination of pig manure at 30 t/ha produced cauliflower with a bigger curd diameter and weight (7.17 cm and 63.84 t/ha) while the control (0 t/ha) had a smaller head diameter and weight (5.24 cm and 48.47 t/ha).
The results from the study showed significant variations in the two growing seasons considered. Cauliflower produced taller plants at 8 WAT during the dry season. The yield of cauliflower was significantly higher during the rainy season (134.84 ton/ha). This may be probably due to a reduction in evapotranspiration during the rainy season that led to adequate water use efficiency. This affected all aspects of the production of the cauliflower. This observation aligns with the findings of Li and Troy (2018), where he linked the high yield of maize to rainfall other than irrigated maize. Previous findings of Tesfaye and Walker (2004) established the relationships between crops and the environment.

**Table 5.** Main effect of season, manure type and manure rates on the yield of cauliflower for 2019 and 2020.

| | 2019 | | | | | | 2020 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Curd Diameter | | Curd Weight at Harvest | | | | Curd Diameter | | Curd Weight at Harvest | | | |
| | 8WAT | 10WAT | Per plant (kg) | Per plot (kg) | Per hac (kg) | Per hac (tonnes) | 8WAT | 10WAT | Per plant (kg) | Per plot (kg) | Per hectare (kg) | Per hac (tonnes) |
| Season | | | | | | | | | | | | |
| Rainy | 8.04 | 12.94 | 1.50 | 13.48 | 134.84 | 13.48 | 4.73 | 7.61 | 0.88 | 7.93 | 79.32 | 7.93 |
| Dry | 5.54 | 6.58 | 0.66 | 5.89 | 58.95 | 5.89 | 5.02 | 5.25 | 0.47 | 4.27 | 42.75 | 4.27 |
| **F-LSD (0.05)** | **1.062** | **0.509** | **0.093** | **0.841** | **84.110** | **8.411** | **NS** | **0.287** | **0.066** | **0.598** | **59.76** | **5.97** |
| Manure Type | | | | | | | | | | | | |
| Poultry | 7.36 | 10.08 | 1.11 | 9.97 | 99.71 | 9.97 | 4.24 | 5.78 | 0.59 | 5.29 | 52.90 | 5.29 |
| Piggery | 6.22 | 9.44 | 1.05 | 9.41 | 94.08 | 9.40 | 5.60 | 6.29 | 0.63 | 5.70 | 56.98 | 5.69 |
| **F-LSD (0.05)** | **0.776** | **0.181** | **0.013** | **0.122** | **12.230** | **1.223** | **0.775** | **0.196** | **0.013** | **0.119** | **11.90** | **1.190** |
| Manure Rates (tonnes) | | | | | | | | | | | | |
| 0 | 5.42 | 8.75 | 0.97 | 8.75 | 87.54 | 8.74 | 3.86 | 5.29 | 0.54 | 4.87 | 48.72 | 4.87 |
| 10 | 6.31 | 9.33 | 1.04 | 9.32 | 93.24 | 9.32 | 4.49 | 5.72 | 0.59 | 5.28 | 52.80 | 5.28 |
| 20 | 7.53 | 10.42 | 1.15 | 10.31 | 103.09 | 10.30 | 5.52 | 6.55 | 0.66 | 5.94 | 59.40 | 5.94 |
| 30 | 7.89 | 10.54 | 1.15 | 10.37 | 103.70 | 10.70 | 5.84 | 6.58 | 0.65 | 5.88 | 58.83 | 5.88 |
| **F-LSD (0.05)** | **0.570** | **0.492** | **0.056** | **0.507** | **50.691** | **NS** | **0.550** | **0.347** | **0.039** | **0.350** | **35.012** | **3.501** |

**Table 6.** Combined effect of season, manure type and manure rates on the yield of cauliflower for 2019 and 2020.

| | | 2019 | | | | | | 2020 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Season | Manure Type | Head Diameter | | Head Weight at Harvest | | | | Head Diameter | | Head Weight at Harvest | | | |
| | | 8WAT | 10WAT | Per plant (kg) | Per plot (kg) | Per hectare (kg) | Per hac (tonnes) | 8WAT | 10WAT | Per plant (kg) | Per plot (kg) | Per hectare (kg) | Per hac (tonnes) |
| Rainy | Poultry | 7.86 | 12.59 | 1.46 | 13.12 | 131190 | 131.19 | 4.83 | 7.82 | 0.91 | 8.15 | 81461.99 | 81.46 |
| | Piggery | 8.22 | 13.29 | 1.54 | 13.85 | 138490 | 138.49 | 4.62 | 7.41 | 0.86 | 7.72 | 77171.83 | 77.17 |
| Dry | Poultry | 4.57 | 6.29 | 0.63 | 5.69 | 56960 | 56.96 | 5.99 | 5.53 | 0.50 | 4.47 | 44731.56 | 44.73 |
| | Piggry | 6.51 | 6.86 | 0.68 | 6.09 | 60930 | 60.93 | 4.05 | 4.97 | 0.45 | 4.08 | 40764.55 | 40.76 |
| | **F-LSD (0.05)** | **0.924** | **NS** | **0.088** | **0.789** | **7896** | **7.896** | **0.865** | **NS** | **NS** | **NS** | **NS** | **NS** |
| Season | Manure Rates (tonnes) | | | | | | | | | | | | |
| Rainy | 0 | 6.42 | 11.67 | 1.35 | 12.16 | 121550 | 121.55 | 3.77 | 6.86 | 0.79 | 7.15 | 71502.69 | 71.50 |
| | 10 | 7.62 | 12.38 | 1.43 | 12.90 | 129020 | 129.02 | 4.48 | 7.28 | 0.84 | 7.59 | 75895.00 | 75.89 |
| | 20 | 8.88 | 13.72 | 1.59 | 14.29 | 142910 | 142.91 | 5.23 | 8.07 | 0.93 | 8.41 | 84066.74 | 84.07 |
| | 30 | 9.23 | 14.00 | 1.62 | 14.59 | 145870 | 145.87 | 5.43 | 8.24 | 0.95 | 8.58 | 85803.23 | 85.80 |
| Dry | 0 | 4.42 | 5.83 | 0.59 | 5.35 | 53330 | 53.33 | 3.90 | 4.50 | 0.41 | 3.73 | 37329.31 | 37.33 |
| | 10 | 5.01 | 6.28 | 0.64 | 5.75 | 57460 | 57.46 | 4.49 | 4.95 | 0.46 | 4.13 | 41255.30 | 41.26 |
| | 20 | 6.18 | 7.127 0.70 | 6.33 | 63270 | 63.27 | 5.66 | 5.79 | 0.52 | 4.71 | 47068.78 | 47.07 | |
| | 30 | 6.56 | 7.08 | 0.68 | 6.15 | 61540 | 61.54 | 6.04 | 5.75 | 0.50 | 4.53 | 45338.82 | 45.34 |
| | **F-LSD (0.05)** | **NS** | **NS** | **0.085** | **0.763** | **7627** | **7.627** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| Manure Type | Manure Rates (tonnes) | | | | | | | | | | | | |
| Poultry | 0 | 5.09 | 8.83 | 0.98 | 8.81 | 88100 | 88.10 | 3.39 | 5.34 | 0.54 | 4.90 | 48975.07 | 48.98 |
| | 10 | 5.61 | 9.20 | 1.03 | 9.23 | 92290 | 92.29 | 3.53 | 5.61 | 0.58 | 5.21 | 52110.53 | 52.11 |
| | 20 | 6.94 | 10.00 | 1.11 | 9.97 | 99660 | 99.66 | 4.80 | 6.17 | 0.63 | 5.67 | 56705.65 | 56.71 |
| | 30 | 7.21 | 9.75 | 1.07 | 9.63 | 92260 | 92.26 | 5.25 | 6.00 | 0.60 | 5.38 | 53810.01 | 53.81 |
| Piggry | 0 | 5.74 | 8.68 | 0.97 | 8.69 | 53530 | 53.53 | 4.32 | 5.24 | 0.54 | 4.85 | 48465.81 | 48.47 |
| | 10 | 7.01 | 9.46 | 1.05 | 9.42 | 94190 | 94.19 | 5.44 | 5.84 | 0.59 | 5.35 | 53493.21 | 53.49 |
| | 20 | 8.12 | 10.84 | 1.18 | 10.65 | 106520 | 106.52 | 6.23 | 6.93 | 0.69 | 6.21 | 62097.22 | 62.10 |
| | 30 | 8.58 | 11.33 | 1.23 | 11.11 | 111140 | 111.14 | 6.42 | 7.17 | 0.71 | 6.38 | 63843.91 | 63.84 |
| | **F-LSD (0.05)** | **NS** | **0.615** | **0.069** | **0.626** | **6262** | **6.262** | **NS** | **0.446** | **0.048** | **0.436** | **4363.035** | **4.363** |

The study revealed that variability existed among the two organic manures utilized in this study on the growth and yield, of the cauliflower. Growth attributes were highest with poultry manure where the pig manure supported the yield components. These results may be attributed to the release of nutrients from the early decomposition of poultry-based manure whereas pig-based organic manure tends to release nutrients slower than poultry. The variability observed may also be attributed to increased organic matter component in poultry manure as opined by Øvsthus et al. (2015) and Hameed et al. (2019). From the physicochemical properties of the field, poultry, and pig manure utilized during this study, showed that their organic matter content is 47.98% and 32.69% respectively. Total N, available K and P, exchangeable Ca, and Mg also varied. Poultry manure contains high N, P, and K. Organic matter content is high in poultry-based manure compared with the pig slurry. Organic matter as opined by Ayinla et al. (2018) is the major determinant of soil fertility in most tropical soils which accounts for its use to raise seedlings in tropical areas. Singh et al. (2020) also observed that the addition of organic manure can sustain soil fertility. Poultry manure as suggested by Ani and Baiyeri (2008) is a valuable source of nutrients, organic matter, and available N and K. Manure is an excellent source of Nitrogen, Phosphorus, and Potassium as opined by Al-Jebarii (2017). Growth and yield of cabbage as stated by Reza et al. (2016) are greatly influenced by organic and inorganic nutrients where he established that the use of inorganic manure on crops is not good for health due to residual effects but does not occur with the use of organic manure. He further stated that organic manure increases the productivity of soil as well as crop quality and yield. Organic soil amendment sustains crop production systems since it forms an integral source of N and Carbon (Liang et al., 2012; Rinaldi et al., 2014). It is also an important part of soil pH moderation (Abubakari et al., 2015). Manure provides secondary nutrients and amino acids that are required by plants for photosynthetic activities, cell division cell enlargement, and accumulation of dry matter content (Hameed et al., 2019). Thapa et al. (2021) and El-Monem and Hamed (2017) stated that nutrient from chicken sources slowly releases nutrients that anchor root development leading to higher yield and better-quality soil and broccoli. The findings are also in consonance with the findings of Laczi et al. (2016) who observed that organic manure (Horse effluents) in comparison with cow dung and inorganic fertilizer in Chinese cabbage production gave more yield than that of cow dung.

Higher fertilization rates are common in crucifer production. From the results of these studies, different rates of manure (0, 10, 20, and 30 t/ha) had variations in plant height, number of leaves, and yield. 20 and 30 t/ha gave the highest plant height, number of leaves, and yield of cauliflower. The higher value of morphological and yield attributes of this crucifer with the application of different rates of manure suggests that they are highly responsive to manure application. Islam et al. (2017) studied the effects of the rate of organic fertilizers on broccoli and found that the use of different rates of poultry manure increases vegetative development and yield. The observations were also in tandem with the findings of Agbede (2010); Adekiya et al. (2020); Hover et al. (2019); Adeleye et al. (2010) and Yaldız et al. (2019).

## 4. Conclusion

Rainy season supported the best growth and yield parameters in cauliflower production. Application of poultry manure improved growth, while pig manure supports higher yield in the production of Cauliflower. Since yield is the major concern for the farmers, pig manure is recommended in the production of cauliflower in Southeastern Nigeria. Among the four rates of poultry and pig manure (0, 10, 20, and 30 t/ha) utilized, 30 t/ha of poultry and pig manure enhanced growth and yield parameters, and this could be recommended in the study area.

**Authors contributions**

The authors confirm the study conception and design: Ugwuoke K.I. Baiyeri K.P and Ishieze P.U.; data collection: Ishieze P.U.; analysis and interpretation of results: Ishieze P.U. and Olajide K.; draft manuscript preparation: Ishieze P.U. The results were evaluated by all authors, and the final version of the manuscript was approved.

**Availability of data and materials**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Conflict of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.



## References

Abubakari AH, Atuah L, Banful B, Bayor H (2015) Use of soil amendments for urban horticulture in the savannah and forest areas of Ghana. *J Soil Sci Environ Manag* 6 (3): 51–57.

Adekiya AO, Ejue WS, Olayanju A, Dunsin O, Aboyeji CM, Aremu C, Akinpelu O (2020) Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. *Sci Rep* 10 (1) https://doi.org/10.1038/s41598-020-73291-x

Adeleye EO, Ayeni LS, Ojeniyi SO (2010) Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on alfisol in southwestern Nigeria. *J American Sci* 6 (10): 871–878. https://doi.org/10.7537/marsjas061010.99

Agbede TM (2010) Tillage and fertilizer effects on some soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria. *Soil Till Res* 110 (1): 25–32. https://doi.org/10.1016/j.still.2010.06.003

Al-Jebarii QHM (2017) The effect of animal manure in the growth and yield of three hybrids of broccoli plant. MS Thesis, University of Diyala.

Ani JU, Baiyeri PK (2008) Impact of poultry manure and harvest season on juice quality of yellow passion fruit (*Passiflora edulis* var. *flavicarpa* Deg.) in the subhumid zone of Nigeria. *Fruits* 63 (4): 239–247. https://doi.org/10.1051/fruits:2008017

Avato P, Argentieri MP (2015) Brassicaceae: A rich source of health improving phytochemicals. *Phytochem Rev* 14:1019–1033. https://doi.org/10.1007/s11101-015-9414-4

Ayinla A, Alagbe IA, Olayinka BU, Lawal AR, Aboyeji OO, Etejere EO (2018) Effects of organic, inorganic and organo-mineral fertilizer on the growth, yield and nutrient composition of *Corchorus Olitorious* (L). *Ceylon J Sci* 47 (1): 13–19. https://doi.org/10.4038/cjs.v47i1.7482

Din M, Qasim M, Jan NE (2007) Response of different sowing dates on the growth and yield of cauliflower. *Sarhad J Agric* 23 (2): 289–291.

El-Monem A, Hamed M (2017) Response of some Barley cultivars productivity and available soil nutrients to chicken manure rates under sandy soil conditions. *J Soil Sci Agric Engin* 8 (12): 715–721. https://doi.org/10.21608/jssae.2017.38235

Favela-González KM, Hernández-Almanza AY, Fuente-Salcido NM (2020) The value of bioactive compounds of cruciferous vegetables (Brassica) as antimicrobials and antioxidants: A review. *J Food Biochem* 44 (10): e13414. https://doi.org/10.1111/jfbc.13414

Hameed F, Xu J, Rahim SF, Wei Q, Khalil R, Liao Q (2019) Optimizing nitrogen options for improving nitrogen use efficiency of rice under different water regimes. *Agronomy* 9 (1): 39. https://doi.org/10.3390/agronomy9010039

Hover NL, Law JY, Long LAM, Kanwar RS, Soupir ML (2019) Long-term impact of poultry manure on crop yield, soil and water quality, and crop revenue. *J Environ Manag* 252:109582. https://doi.org/10.1016/j.jenvman.2019.109582

Islam MA, Ferdous G, Akter A, Hossain MM, Nandwani D (2017) Effect of organic, inorganic fertilizers and plant spacing on the growth and yield of cabbage. *Agriculture* 7 (4): 31. https://doi.org/10.3390/agriculture7040031

Laczi E, Apahidean A, Luca E, Dumitrascedilla A, Boanca P (2016) Headed Chinese cabbage growth and yield influenced by different manure types in organic farming system. *Hort Sci (Prague)* 43 (1): 42–49. https://doi.org/10.17221/6/2015-HORTSCI

Li X, Troy TJ (2018) Changes in rainfed and irrigated crop yield response to climate in the western US. *Environ Res Lett* 13 (6): 064031. https://doi.org/10.1088/1748-9326/aac4b1

Liang Q, Chen H, Gong Y, Fan M, Yang H, Lal R, Kuzyakov Y (2012) Effects of 15 years of manure and inorganic fertilizers on soil organic carbon fractions in a wheat-maize system in the North China Plain. *Nutr Cyc Agroecosys* 92 (1): 21–33. https://doi.org/10.1007/s10705-011-9469-6

Manchali S, Murthy KNC, Patil BS (2012) Crucial facts about health benefits of popular cruciferous vegetables. *J Func Foods* 4 (1): 94–106. https://doi.org/10.1016/j.jff.2011.08.004

Raiola A, Errico A, Petruk G, Monti DM, Barone A, Rigano MM (2018) Bioactive compounds in Brassicaceae vegetables with a role in the prevention of chronic diseases. *Molecules* 23 (1): 15. https://doi.org/10.3390/molecules23010015

Reza MS, Islam AS, Rahman MA, Miah MY, Akhter S, Rahman MM (2016) Impact of organic fertilizers on yield and nutrient uptake of cabbage (*Brassica oleracea* var. capitata). *Journal of Science, Technology and Environment Informatics* 03 (02): 231–244. https://doi.org/10.18801/jstei.030216.26

Rinaldi S, Lucia B De, Salvati L, Rea E (2014) Understanding complexity in the response of ornamental rosemary to different substrates: A multivariate analysis. *Sci Hortic* 176:218–224. https://doi.org/10.1016/j.scienta.2014.07.011

Satheesh N, Fanta S Workneh (2020) Kale: Review on nutritional composition, bio-active compounds, anti-nutritional factors, health beneficial properties and value-added products. *Cogent Food Agric* 6 (1): 1811048. https://doi.org/10.1080/23311932.2020.1811048

Singh TB, Ali A, Prasad M, Yadav A, Shrivastav P, Goyal D, Dantu PK (2020) In Naeem M (ed) Role of organic fertilizers in improving soil fertility. *Contaminants in Agriculture: Sources, Impacts and Management,* 61–77.

Tesfaye K, Walker S (2004) Matching of crop and environment for optimal water use: the case of Ethiopia. *Physics and Chemistry of the Earth, Parts A/B/C* 29 (15-18): 1061–1067. https://doi.org/10.1016/j.pce.2004.09.024

Thapa S, Bhandari A, Ghimire R, Xue Q, Kidwaro F, Ghatrehsamani S, Goodwin M (2021) Managing micronutrients for improving soil fertility, health, and soybean yield. *Sustainability* 13 (21): 11766. https://doi.org/10.3390/su132111766

Yaldız G, Çamlıca M, Özen F, Eratalar SA (2019) Effect of poultry manure on yield and nutrient composition of sweet basil (*Ocimum basilicum* L.). *Comm Soil Sci Plant Anal* 50 (7): 838–852. https://doi.org/10.1080/00103624.2019.1589488

Øvsthus I, Breland TA, Hagen SF, Brandt K, Wold AB, Bengtsson GB, Seljasen R (2015) Effects of organic and waste-derived fertilizers on yield, nitrogen and glucosinolate contents, and sensory quality of broccoli (*Brassica oleracea* L. var. *italica*). *J Agric Food Chem* 63 (50): 10757–10767. https://doi.org/10.1021/acs.jafc.5b04631