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Growth and Yield Response of Two Onion (*Allium cepa* L.) Varieties to Organic and Inorganic Fertilizers in the Forest- Savannah Transitional Zone of Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author EKA and MEE managed the analyses of the study. Author MEE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The objective of the experiment was to evaluate the influence of organic and inorganic fertilizers on growth and yield of two onion varieties in the transitional zone of Ghana. The experiment was laid out in a split plot design with 3 replications. Two varieties [Bawku Red and Red Creole] were laid as main plots and fertilizer rates [10 t/ha Cow dung, 10 t/ha Poultry manure, 300 kg/ha NPK, 5 t/ha PM + 150 kg/ha NPK, 5 t/ha CD + 150 kg/ha NPK) and control (without amendment)] were assigned to sub-plots. The two field experiments were conducted in 2016 and 2017 cropping seasons at the research field of the College of Agriculture Education, University of Education Winneba, Mampong campus. The result showed that Bawku Red planted on 5 t/ha PM + 150 kg/ha NPK produced (P=.05) higher number of leaves per plant and shoot fresh and dry weight than the control during the 2016 cropping season. Red Creole planted on 10 t/ha PM had higher number of

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leaves per plant, taller plants and higher marketable bulb yield than the control during the 2016 cropping season. In both 2016 and 2017 cropping seasons, Bawku Red and Red Creole planted on 5 t/ha PM + 150 kg/ha NPK produced (P=.05) higher total bulb yield than the control. For maximum vegetative growth and yield in onion production, preferably Bawku red, sole poultry manure (10 t/ha) and/or in combination with NPK (5 t/ha PM+150 kg/ha NPK) is recommended.

Keywords: Onion varieties; organic and inorganic fertilizers; yield.

1. INTRODUCTION

Onion (*Allium cepa* L.) belongs to the genus *Allium* of the family *Alliaceae* [1]. It is one of the most important crops cultivated commercially in most parts of the world [2]. It probably originated from Central Asia between Turkmenistan and Afghanistan where some of its relatives still grow in the wild [2].

Onion is mainly grown for its bulbs, although the green shoots of salad onions are also consumed. Onions add significant nutritional value to the human diet and also possess medicinal properties with unique flavour and the ability to enhance the flavour of other foods [3].The matured onion bulb contains important nutrients such as starch, appreciable quantities of sugars, some protein, and vitamins such as vitamins A, B, and C [4]. It is also used as preservative and medicine in most parts of the world.

Onions are sensitive to day length, as a result several onion types exist depending upon the latitude at which they grow. Generally, onions are grown extensively throughout Ghana with commercial production occurring in the Northern, Upper East and Upper West regions [5]. However, yields in Ghana are rather low. The comparatively lower onion bulb yields in Ghana could be attributed to inappropriate agronomic practices which include poor soil amendment [6]. The use of appropriate agronomic management practices play a huge role in increasing crop yields.

Maintaining adequate level of soil fertility has been seen as one of the best management practices that influence growth, development and yield of plants [7]. One of the options to maintain soil fertility as well as higher yield is through application of organic manure along with inorganic fertilizer [8]. The objective for the study was to determine the effect of organic and inorganic fertilizers on growth and yield of two varieties of onion in the forest- savannah transitional zone of Ghana.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was carried out at the Multipurpose Crop Nursery of the College of Agriculture Education, University of Education, Winneba, Mampong- Ashanti campus located in the forest-savannah transitional zone of Ghana. Two experiments were conducted: the first experiment was carried out in the minor rainy season from August to December, 2016 and the second from April to August, 2017 in the major rainy season.

Mampong-Ashanti has bimodal rainfall pattern with the major rainy season occurring from March to July and minor rainy season from September to November. Between the two seasons is a short dry spell in August. The soil at the experimental site is of the Bediese series of the savannah Ochrosol. The FAO classification of the soil at the experimental site is of Chromic Luvisol. The soil is sandy loam, well drained with thin layer of organic matter with characteristic deep yellowish red colour, friable and free from stones. The pH ranges from 6.5-7.0 [9]. It is permeable, and has moderate water holding capacity [10]. The site has an altitude of 457.5 m above sea level and occurs within latitude 7° and 8° North of Equator and longitude 1º and 24° West of the Greenwich [11].

The climatic conditions during the field research periods showed that differences in environmental factors (rainfall, temperature and relative humidity) were shown during both 2016 and 2017 cropping seasons. In 2016 cropping season, the average total rainfall from August to December, 2016 was 385.4 mm. The average monthly temperature during the experiment was between 22.1ºC and 33.1ºC with the highest daily of 33.1ºC occurring in November. The average relative humidity ranged from 54.0% and 78.0% with the highest occurring between September and November. In 2017 cropping season, the average total rainfall from April to

August was 781.7 mm. The average monthly temperature was between 22.0ºC to 33.6ºC with the highest daily of 33.6ºC occurring in April. The average relative humidity ranged from 59.0% to 98.0% with the highest occurring between June and August.

2.2 Experimental Design and Treatments

A Split Plot Design with three (3) replications was used. Each block contained 2 main plots, to which the two onion varieties were assigned (Bawku Red and Red Creole). Each main plot was split into 6 sub-plots, to which five different fertilizer rates and a control (without any amendment) were assigned. The factors studied included: (A) Variety [Bawku red and Red Creole] (B) Fertilizer rates [10 t/ha cow dung, 10 t/ha poultry manure, 300 kg/ha NPK 15:15:15, 5 t/ha cow dung + 150 kg/ha NPK 15:15:15, 5 t/ha poultry manure + 150 kg/ha NPK 15:15:15 and no fertilizer (control)]. The fertilizer rates were converted from t/ha and kg/ha to g/m^2; the equivalent rates in grams were measured with a balance per the plot size of 1.2 m^2.

2.3 Organic Manure Preparation and Analysis

Two weeks old poultry manure from a deep litter system of housing and Cow Dung from the cattle kraal were collected from the animal farm at the College of Agriculture Education, Mampong Campus. The poultry manure and cow dung were heaped under shade for two weeks and covered with plantain leaves, supported by sticks to minimize the volatilization of N through Ammonia gas. Samples of the poultry manure and cow dung were sent to CSIR- Soil Research Institute, Kwadaso-Kumasi for analysis.

2.4 Land Preparation, Manure Application and Planting

The experimental field was marked out, ploughed, disked and harrowed to a fine tilth. A total land size of 191.75 square meters was marked out. There were two main plots. Each main plot was made up of 6 sub-plots. Each plot measured 1.2 m^2 with 0.5 m between plots. The treatments were replicated 3 times with 1.0 m left between blocks. Well composted poultry manure and cow dung were incorporated into respective treatment plots two weeks before the transplanting of onion seedlings. Healthy and vigorous growing seedlings were selected 30 days after nursing and transplanted in the field. This was done late in the afternoon to reduce the risk of desiccation and poor establishment after being hardened by increasing watering interval. Each plot was made up of four rows with ten plants per row giving a plant density of 40 plants per plot. The distance within plant in a row was 15 cm and the distance between rows was 20 cm.

2.5 Agronomic Practices

NPK 15:15:15 was applied at full rate of 300 kg/ha as sole treatment and at half rate of 150 kg/ha as a supplement to organic manured plot. The NPK fertilizer was applied 5 cm away from the plant by side placement two weeks after transplanting the seedlings.

The plants were regularly irrigated twice in a day, depending on the weather condition, till the first signs of neck break when irrigation interval was extended to 10 days till 70% maturity. All plants received the same amount of water. Hoeing of weeds was done two weeks after transplanting and at every two weeks before bulbing to keep plots free from weeds during the growth period. The paths between the blocks and plots were weeded with cutlass and hoe four times during the experimental period in both seasons.

Earthening-up was done every two weeks after the seedlings had been established to cover exposed roots by watering. The inter-rows were stirred up with hand fork at two weekly intervals throughout the growing period to improve aeration for enhancement of growth of the crop [12]. Deltameterine and Malathion were used to control pests. This was done twice; 2 and 6 weeks after transplanting.

2.6 Data Collection and Statistical Analysis

2.6.1 Plant sampling and data collection

Data were collected on vegetative growth, yield and yield components. In the case of vegetative data, 5 randomly tagged plants from the two middle rows were selected for determination of plant height, number of leaves per plant, shoot fresh weight and shoot dry weight. Determination of marketable bulb yield, unmarketable bulb yield and total bulb yield was done from the net harvestable area.

Plant Height was taken with a meter rule, from the base of the plant to the apex of the longest leaf at 2 weeks after transplanting and hereafter at 2 weeks interval and the mean estimated. The total number of leaves per plant was counted on sampled plants from the two middle rows at 2 weeks after transplanting and at two weeks interval and the means estimated. The above ground fresh biomass of the plant, was harvested by cutting five randomly selected plants taken from each plot, from the crown and measured with an electronic weighing scale and the average recorded. The aboveground dry biomass was harvested by cutting five randomly selected plants taken from each plot from the crown and chopped into small 1-2 cm cubes, mixed thoroughly, and a sub-sample each weighing 100 grams were weighed out. The exact weight of each sub-sample was determined and recorded as fresh weight. Each subsample was placed in a paper bag and put in an oven until a constant dry matter was attained. Each sub-sample was then immediately weighed and recorded as dry shoot weight [13].

Marketable bulb yield is the weight of healthy and marketable bulbs from 60 g and above [13]. This parameter was determined from the two middle rows per plot at final harvest and expressed as t/ ha. The total weight of unmarketable bulbs that were under sized (< 60 g), diseased, decayed and bulbs from plants with physiological disorder, such as thick neck and split; were measured from the two middle rows per plot at final harvest and expressed in t/ ha [13]. The total bulb yield was determined from the two middle rows per plot as a sum of the weight of marketable and unmarketable yields that were measured in kg per plot and finally converted into t /ha.

2.7 Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using GENSTAT -VERSION 11. Significant means obtained were separated by Least Significant Difference (LSD) method at 5% significance level.

3. RESULTS

3.1 Nutrient Levels of Organic Manure Used in the Experiment

Poultry manure had the higher nitrogen (N), total phosphorus (P) and total magnesium (Mg). Cow dung had the higher calcium (Ca) content. The pH of both poultry manure and cow dung was basic (Table 1.)

3.2 Soil Chemical Properties at the Experimental Site

From Tables 2a and 2b, for both 2016 and 2017 cropping seasons, the soil at 0-20 cm was acidic. Organic matter content and nitrogen level were consistently lowest under general conditions (control, no fertilizer). The cation levels in the background soil (control, no fertilizer) recorded lower values. Available P and K were low from the results obtained from the background soil (control, no fertilizer). The low levels of the cations (Mg, Ca, K and Na) had an effect on the total exchangeable bases (TEB) and the effective cation exchange capacity (ECEC) which shows lowest base saturation of 69.4% and 68.3% respectively.

3.3 Soil Nutrient Levels after Fertilizer Application

In both 2016 and 2017 cropping seasons, the soil pH for treated plots recorded an increase over the control (Table 2a and 2b). The manure treated plots and their combination gave higher levels of organic carbon, percentage total N and organic matter content than the sole NPK and the control (Tables 2a and 2b). The 10 t/ha PM and the 5 t/ha PM + 150 kg/ha NPK recorded higher Ca and Mg levels while the sole 300 kg/ha NPK recorded the highest K levels among the exchangeable bases in both seasons. The sole poultry manure and cow dung as well as their combination with NPK gave an increase in TEB than the sole NPK and the control in both cropping season.

Additionally, results both sites (Table 2a and 2b) indicated that the treated plots gave higher ECEC levels than the control. The sole poultry manure and its combination with NPK gave the highest ECEC levels. Again, results from both seasons (Table 2a and 2b) indicated that all the treated plots had higher base saturation levels than the control.

The 10 t/ha PM and the 300 kg/ha NPK gave higher available P and K than the control in both cropping seasons (Tables 2a and 2b). All the treatments recorded higher organic carbon and organic matter levels in 2017 cropping season than in 2016 cropping season. However, total nitrogen was slightly higher in 2016 cropping season than in 2017 cropping season.

3.4 Vegetative Growth

3.4.1 Number of leaves per plant

There were marked differences in the number of leaves per plant in 2016 and 2017 cropping seasons. For Bawku Red in 2016 cropping season, the 10 t/ha poultry manure and 10 t/ha

Cow dung showed a steady growth from 2 to 8 weeks after transplanting (WAT) (Table 3). The 5 t/ha PM + 150 kg/ha NPK had the hightest number of leaves per plant at 4 and 6 WAT and (P=.05) higher than the control. All the amended treated plots recorded highter number of leaves per plant than the control at 10 WAT (Table 3). For Red Creole in 2016 cropping season, all the treated plots showed a steady increase in leaf numbers throughout the growing period. The poultry manure produced the highest number of leaves at 4 WAT and was (P=.05) higher than the control. At 6 WAT, the sole poultry manure again produced the highest number of leaves per plant, though similar to its combination with NPK. At 4 to 10 WAT all the treated plots recorded highter number of leaves per plant than the control (Table 3).

For Bawku Red in 2017 season, the sole poultry manure recorded the highest number of leaves per plant at and 6 WAT and was (P=.05) different from the control. From 2 to 10 WAT, all the treated plots recorded higher number of leaves per plant than the control (Table 3). For Red Creole in 2017 season, the sole poultry manure and its combination with NPK recorded a steady increase in leaf number throughout the growth period. The 10 t/ha PM and the 10 t/ha CD treatments recorded the highest number of Leaves per plant from 4 WAT to 6 WAT and these were (P=.05) higher than the control. From 2 to 10 WAT, all the fertilized treatments recorded higher number of leaves per plant than the control treatment (Table 3).

3.4.2 Plant height

There were observed differences in plant height in 2016 and 2017 cropping season. For Bawku Red in 2016 cropping season, the sole poultry manure and its combination with NPK recorded a steady increase from 2 to 10 WAT (Table 4). The 10 t/ha PM and 5 t/ha PM +150 kg/ha NPK produced the tallest plants at 4 WAT and was (P=.05) different from the control. At 6 WAT, the 5 t/ha PM +150 Kg/ha NPK produced the highest plant height (44.1 cm) which was (P=.05) different from the control. All the treated plots recorded taller plant height at 10 WAT than the control (Table 4). For Red Creole in 2016 cropping season, the sole poultry manure treated plots recorded the tallest plants at 4 and 6 WAT, which was (P=.05) different from the rest of the treated plots and the control (Table 4).

In 2017 cropping season, the sole poultry manure and its combination with NPK produced the tallest plant at 4 WAT for both varieties, which were (P=.05) different from the control (Table 4). At 6 WAT, the 10 t/ha CD gave the tallest plant for Bawku Red and was different (P=.05) from the control but not (P>.05) different from the 5 t/ha PM +150 kg/ha NPK. However, the sole poultry manure gave the tallest plants for Red Creole at 6 WAT and was (P=.05) higher than the control but was at par with its combination with NPK (Table 4). At 8 WAT and 10 WAT, the sole NPK and its combination with cow dung recorded the tallest plants. Also, all the treated plots recorded taller plants than the control from 4 WAT to 10 WAT for both varieties (Table 4).

3.4.3 Fresh and dry shoot weight

For Bawku Red in 2016 cropping season, the 5 t/ha PM +150 kg/ha NPK recorded the highest fresh shoot weight, and this was (P =.05) different from the control but not (P>.05) different from the 5 t/ha CD +150 kg/ha NPK (Table 5). All the sole treatments recorded higher fresh shoot weight than the control (Table 5). For Red Creole, 10 t/ha PM recorded the highest fresh shoot weight (20.6 g) followed by the 300 kg/ha NPK 918.6 g) and these were (P =.05) different from the control. The rest of the treated plots all gave higher fresh bulb weight for both varieties in both cropping seasons than the control (Table 5).

In 2017 cropping season, the 5 t/ha PM +150 kg/ha NPK recorded the highest (17.8 g) fresh shoot weight for Bawku Red variety (Table 5). However, the 5 t/ha PM + 150 kg/ha NPK gave the highest (99.8g) fresh shoot yield for Red Creole, and this was (P =.05) different from the control. All the sole treatments and treatment combinations gave higher fresh shoot weight for both varieties in both cropping seasons than the control (Table 5).

Table 1. Chemical properties of poultry and cattle manure used in the field studies

Property	pH	Ca (%)	Mg (%)	P (%)	K (%)	N (%)
Chicken Manure	8.3	0.94	1.32	1.39	0.63	2
Cow dung	7.5	2.7	0.91	0.7	0.53	1.6

Table 2a. Soil chemical properties after fertilizer application, 2016

Treatment	pH, H_2O 1:25	Organic carbon (%)	Total nitrogen (%)	Organic matter (%)	Exchangeable cations (me/100g)				T.E.B	Exchangeable aluminium (Al + H)	E.C.E.C (me/100g)	Base saturation (%)	Available	
					Ca	Mg	K	Na					P(mgdm^{-3})	K(mg dm^{-3})
10 t/ha CD	6.59	0.83	0.08	1.44	4.01	2	0.04	0.03	6.08	0.5	6.58	97.3	49.8	13.3
10 t/ha PM	6.25	0.91	0.09	1.56	4.67	2.94	0.04	0.02	7.67	0.1	7.77	98.71	181	14.5
300 kg/ha NPK	6.91	0.73	0.07	1.37	3.2	1.34	0.06	0.03	4.62	0.3	5.55	83.24	152	15.8
5 t/h CD+ 150 kg/ha NPK	6.19	0.8	0.08	1.44	3.74	1.6	0.04	0.02	5.4	0.15	5.55	97.3	62.9	13.4
5 t/ha PM+ 150 kg/ha NPK	6.34	0.91	0.08	1.56	4.67	4.07	0.05	0.03	7.8	0.1	7.93	98.74	146	13.9
Control (no fertilizer)	5.17	0.63	0.06	1.25	3.2	2.14	0.03	0.02	5.39	0.15	4.92	69.4	44.9	9.48

**CD= Cow Dung, PM= Poultry Manure, T.E.B= Total Exchangeable Bases, E.C.E.C= Effective Cation Exchange Capacity*

Table 2b. Soil Chemical Properties after fertilizer application, 2017

Treatment	pH, H_2O 1:25	Oranic carbon (%)	Total nitrogen (%)	Organic matter (%)	Exchangeable cations (me/100g)				T.E.B	Exchangeable aluminium (Al + H)	E.C.E.C (me/100g)	Base saturation (%)	Aailable	
													P(mg dm^{-3})	K(mg dm^{-3})
					Ca	Mg	K	Na						
10 t/ha CD	6.95	0.89	0.07	1.54	4.51	2.93	0.04	0.02	6.18	0.52	6.78	97.1	48.8	14.3
10 t/ha PM	6.25	0.96	0.07	1.65	4.67	2	0.05	0.02	6.67	0.16	7.17	97.81	183	14.4
300 kg/ha NPK	6.91	0.79	0.06	1.76	3.2	1.34	0.07	0.03	4.12	0.2	5.85	82.34	154	15.9
5 t/h CD+ 150 Kg/ha NPK	6.12	0.82	0.07	1.64	4.74	1.69	0.04	0.02	5.45	0.15	5.15	97.6	61.9	13.4
5 t/ha PM+ 150 kg/ha NPK	6.54	0.94	0.07	1.76	4.67	4	0.06	0.03	7.7	0.17	7.39	98.72	147	13.1
Control (no fertilizer)	5.16	0.65	0.05	1.35	3.4	2.34	0.04	0.02	5.49	0.13	4.27	68.3	44.9	9.36

**CD= Cow Dung, PM= Poultry Manure, T.E.B= Total Exchangeable Bases, E.C.E.C= Effective Cation Exchange Capacity*

Table 3. Effect of manure and inorganic fertilizer on number of leaves per plant

		Number of leaves at WAT, 2016					Number of leaves at WAT, 2017				
Treatment(T)/Variety(V)	**Sampling time (WAT)**	**2**	**4**	**6**	**8**	**10**	**2**	**4**	**6**	**8**	**10**
Bawku red	10 t/ha CD	3.9	4.8	6.1	7.1	6.4	3.8	4	4.7	4.8	5.8
	10 t/ha PM	4.1	5.1	6.4	7.5	6.6	3.4	4.9	5.3	5.9	7.5
	300 Kg/ha NPK	3.5	4.9	5.7	6.5	6.3	2.7	3.7	4.7	4.8	5.3
	5 t/ha CD + 150 Kg/ha NPK	3.9	4.9	5.3	5.4	5.9	3.1	4.4	4.9	5	5.7
	5 t/ha PM + 150 Kg/ha NPK	3.8	5.5	7.5	8.1	8.1	3.3	4.7	5.1	5.6	5.9
	CONTROL	3.7	4.1	5.1	5.3	5.4	2.7	3.8	3.9	4.1	4.8
Red Creole	10 t/ha CD	3.3	4.6	5.8	6.8	7.5	3.2	4.5	5	5.1	5.3
	10 t/ha PM	4.1	5.7	6.9	7.8	7.4	3.9	4.6	4.8	5.1	6.8
	300 Kg/ha NPK	3.4	4.8	5.8	6.5	6.9	2.5	3.3	4.3	4.9	5
	5 t/ha CD + 150Kg/ha NPK	3.3	4.7	6.1	7.1	7.3	3.6	4.1	5	5	5.1
	5 t/ha PM + 150 Kg/ha NPK	3.5	5.5	6.8	7	7.4	3.3	4.3	4.9	5.2	5.7
	CONTROL	3.4	4.1	5.6	6.4	6.7	3.7	3.7	4	4.1	4.2
	LSD (P=0.05)	0.2	0.6	0.8	1.2	1.9	0.9	0.8	1	1.6	1.6
	CV (%)	19	28	40	32	22	26	38	28	43	41
	T×V Interaction	0.1	0.7	0.4	0.07	0.6	0.3	0.9	0.9	0.8	0.8

CD= Cow Dung, PM= Poultry Manure, WAT= Weeks after Transplanting

Table 4. Effect of manure and Inorganic fertilizer on plant height

		Plant height (cm) at WAT, 2016					Plant height (cm) at WAT, 2017				
Treatment(T)/Variety(V)	**Sampling time(WAT)**	**2**	**4**	**6**	**8**	**10**	**2**	**4**	**6**	**8**	**10**
Bawku red	10 t/ha CD	17.7	29.2	35.8	42.5	42.6	14.3	20.5	31.2	30.6	31
	10 t/ha PM	18.6	35.8	40.9	43.9	44	15	24.6	31.4	31.6	31.9
	300 kg/ha NPK	16.6	26.9	33.1	41.8	42.1	12.6	17.4	28.4	29.8	30.8
	5 t/ha CD + 150 kg/ha NPK	17	28.5	33.9	36.5	43.8	14.2	23.3	28	35.3	35.8
	5 t/ha PM + 150 kg/ha NPK	18.6	34.3	44.1	46.2	47.3	16.4	28.6	30	32.8	32.9
	Control	15.8	30.5	31.7	32.9	41.3	11.3	16.1	19	24.3	24.3
Red creole	10 t/ha CD	14.1	24.2	30.8	41.9	48.5	13.2	20.1	30.8	33.5	33.7
	10 t/ha PM	18.9	37.9	49.2	50.9	51	17.7	29.7	32.7	33.3	40.9
	300 kg/ha NPK	15.9	24.7	33.7	39.4	47	12.9	18.7	22	31.4	31.7
	5 t/ha CD + 150 kg/ha NPK	15.1	27.8	36.2	40	49.5	14.1	25.6	32.5	33	34.7
	5 t/ha PM + 150 kg/ha NPK	16.4	34.6	43.2	49.9	50.9	15.8	29.2	31.7	34.2	38.2
	Control	13.7	22.4	31.7	41.9	44.4	12.2	16	20	21.1	21.2
	LSD (P=.05)	2.37	5.58	6.72	6.45	10.4	3.18	6.71	6.8	9.63	9.97
	CV (%)	23	25	32	40	22	22	32	18	26	27
	T×V Interaction	0.35	0.67	0.47	0.18	0.82	0.86	0.9	0.6	0.82	0.84

**CD= Cow Dung, PM= Poultry Manure, WAT= Weeks after Transplanting*

Table 5. Effect of manure and inorganic fertilizer on shoot fresh weight and dry weight

Treatments((T)/Variety (V)		Shoot fresh weight(g)		Shoot dry weight(g)	
		2016	**2017**	**2016**	**2017**
Bawku Red	10 t/ha CD	53	58.2	3.5	3.9
	10 t/ha PM	66	66.8	4.3	4.4
	300 kg/ha NPK	74.7	56.8	4.9	3.8
	5 t/ha CD+ 150 kg/ha NPK	86	67.5	5.6	3.7
	5 t/ha PM+150 kg/ha NPK	92	78.8	6.3	5.7
	Control	61	43.4	4	2.9
Red Creole	10 t/ha CD	135	83.2	9	5.8
	10 t/ha PM	206	113	8	4.5
	300 kg/ha NPK	186	62.4	7	2.4
	5 t/ha CD+ 150 kg/ha NPK	146	96.2	7	4.8
	5 t/ha PM+150 kg/ha NPK	141	99.8	10	7.9
	Control	127	43.8	6	2.4
	LSD(P=0.05)	44.3	43.5	1.71	2.27
	C V (%)	30.8	0.98	30.7	26.4
	V×T Interaction	0.62	0.62	0.68	0.52

**CD= Cow Dung, PM= Poultry Manure*

Table 6. Effect of manure and inorganic fertilizer on marketable bulb yield, unmarketable bulb yield and total bulb yield

Treatments(T)/Variety (V)		Marketable bulb Yield (t/ha)		Unmarketable bulb Yield (t/ha)		Total Bulb Yield (t/ha)	
		2016	**2017**	**2016**	**2017**	**2016**	**2017**
Bawku red	10 t/ha CD	4.96	4.63	1.43	1.15	6.39	5.78
	10 t/ha PM	6.86	6.83	1.42	1.23	8.28	8.06
	300 kg/ha NPK	6.38	6.00	0.86	0.50	7.24	6.50
	5 t/ha CD+ 150 kg/ha NPK	6.64	5.23	1.27	1.41	7.91	6.65
	5 t/haPM+150 kg/ha NPK	8.44	7.63	1.22	1.79	9.67	9.42
	Control	1.16	1.07	1.25	1.15	2.41	2.31
Red Creole	10 t/ha CD	4.69	1.53	1.96	1.77	6.64	3.30
	10 t/ha PM	9.2	8.50	2.87	1.93	12.1	9.43
	300 kg/ha NPK	3.86	2.20	1.70	1.55	5.56	3.75
	5 t/ha CD+ 150 kg/h NPK	4.99	2.67	1.55	1.12	6.54	3.78
	5 t/haPM+150 kg/ha NPK	6.64	5.23	1.27	1.41	7.91	7.27
	Control	1.18	1.07	0.89	0.97	2.07	1.04
	LSD(P=0.05)	3.34	2.76	0.91	1.02	3.28	2.51
	C V (%)	51.3	51.4	48.1	60.2	19.1	35.6
	V×T Interaction	0.55	0.10	0.38	0.58	0.34	0.07

**CD= Cow Dung, PM= Poultry Manure*

For Bawku Red in 2016 cropping season, the 5 t/ha PM +150 kg/ha NPK recorded (P =.05) higher dry shoot weight than the 10 t/ha PM, the 300 kg/ha NPK, the 10 t/ha CD and the control, but was not (P>.05) different from the 5 t/ ha CD + 150 kg/ha NPK (Table 5). The 5 t/ha PM +150 kg/ha NPK recorded (P =.05) higher dry shoot weight than the control and the rest of the treatments for Red Creole in 2016 cropping season (Table 5). In 2017 cropping season, the sole poultry manure and its combination with NPK recorded (P =.05) higher dry shoot weight than the control for both varieties (Table 5).

3.5 Yield and Yield Components

3.5.1 Marketable, unmarketable and total bulb yield

For Bawku Red in 2016 cropping season, the 5 t/ha PM+150 kg/ha NPK amended plot produced (P=.05) higher (8.44 t/ha) marketable bulb yield than the 10 t/ha CD, the 5 t/ha CD +150 kg/ha NPK (6.64 t/ha) and the control (1.16 t/ha) (Table 6). However, there was no (P>.05) difference between the 10 t/ha PM and 300 kg/ha NPK. All the treated plots recorded (P=.05) higher marketable bulb yield than the control for Bawku Red in 2016 cropping season (Table 6). For Red Creole in 2016 cropping season, the sole poultry manure recorded the highest (9.20 t/ha) marketable bulb yield and was (P=.05) different from the sole cow dung, sole NPK and the control (Table 6).

In 2017 cropping season, the 5 t/ha PM +150 kg/ha NPK gave the highest (7.63 t/ha) marketable bulb yield for Bawku Red whereas the sole poultry manure gave the highest (8.50 t/ha) for Red Creole, and these were (P =.05) different from the control for both onion varieties (Table 6).

In 2016 cropping season, the 10 t/ha PM recorded the highest unmarketable bulb yield for Bawku Red (Table 6). The 10 t/ha PM recorded the highest unmarketable bulb yield for Red Creole and this was (P=.05) different from the 5 t/ha CD +150 kg/ha NPK and the control (Table 6).

In 2017 cropping season, the 5 t/ha PM +150 kg/ha NPK recorded the highest unmarketable bulb yield for Bawku Red whereas the 10 t/ha PM recorded the highest (11.93 t/ha) unmarketable bulb yield for Red Creole (Table 6). In both 2016 and 2017 cropping seasons, the combined poultry manure and NPK treatment recorded the highest total bulb yield (9.67 t/ha and 9.42 t/ha respectively) for Bawku Red, whereas the sole poultry manure gave the highest bulb yield (12.10 t/ha and 9.43 t/ha respectively) for Red Creole, and these were (P=.05) different from the control in both cropping seasons (Table 6). Again the sole NPK recorded (P=.05) higher total bulb yield than the control for Bawku Red in both cropping seasons (Table 6).

3.6 Effect of Cropping Season on Total Bulb Yield

Total bulb yields recorded by the treatments in 2016 cropping season were higher than the bulbs yields recorded by the treatments in 2017 cropping season for both varieties (Table 6). In 2016 cropping season, the mean bulb yield was 7.12 t/ha and 6.80 t/ha for Bawku Red and Red Creole, respectively. In 2017, mean bulb yield were 6.6 t/ha and 5.31 t/ha for Bawku Red and Red Creole, respectively (Table 6).

4. DISCUSSION

The increase in the number of leaves and plant height as well as the steady growth in response to sole poultry manure as recorded in Red Creole in 2016 may be attributed to the release of macro and micro nutrients by poultry manure during the course of microbial decomposition [14]. The improvement in plant height and number of leaves with application of poultry manures might also be due to better moisture holding capacity and favorable soil conditions [15]. This is in line with [16,17,18] who reported that there was higher release of nutrients from added organic sources such as poultry manure.

The increase in plant height and the number of leaves per plant by Bawku Red in response to the combination of poultry manure and NPK in both cropping seasons may be attributed to enhanced release of macronutrients from the added source of N, P and K. as well as release of nutrients on mineralization and changes in the physic-chemical properties of soil due to application of organic carbon in the form of poultry manure thereby improving the soil nutrients status. These findings are in line with the findings of Cyril [19] who reported that application of organic and inorganic fertilizers supply plant nutrients for crop growth, plant height and leaves and affect plant physiological process which is very instrumental in crop yield.

The highest fresh shoot weight in 2016 cropping season and dry shoot weight in 2017 cropping season in response to 5 t/ha Poultry Manure + 150 kg/ha NPK combination may be attributed to the contribution of organic manure to the increase in new leaf formation and extended activity of older leaves .This is in line with the findings of Abd et al. [20] who reported that the increment in vegetative growth parameters of onion plants in response to N was probably due to the positive role N plays in increasing photosynthesis through improving leaf area index and chlorophyll contents and uptake of other mineral nutrient, thereby resulting in higher vegetative growth.

The increased marketable bulb yield and total bulb yield over the control with poultry manure might be because of rapid availability and utilization of N for various internal plant processes for carbohydrates production. Later on these carbohydrates may undergo hydrolysis and get converted into reproductive sugars which ultimately helped in increasing yield. Organic manures activating many species of living organisms which release phytohormones which may stimulate the plant growth and absorption of nutrients and thereby increases onion yield [21]. Similar result was also reported by Choudhary et al. [22].

The high total bulb yield and marketable bulb yield due to the integrated poultry and NPK fertilization (5 t/ha PM + 150 kg/ha NPK) could be attributed to the role of the combined effect of the two treatments in improving the physicochemical structure of the soil and nutrients supplied by their combinations. The NPK promoted faster release of the macro-nutrients which gave the plants good start in growth while the slow release of nutrients by the poultry manure ensures continuous supply of nutrients for the plants [15]. This is in line with the findings of Mohanty et al. [23] reported that 50% organic and 50% inorganic fertilizer application resulted in maximum yield of onion, improved soil physical and chemical properties. This has the tendency to uplift the livelihood of farmers.

Since the crop was raised under the identical level of management, resources and cultivation practices, the variation in growth and yield between the two cropping seasons could be the result of weather conditions that prevailed during growth, which, in turn, might have influenced the yield. Weather condition is a principal input parameter which could bring about year to year variation in productivity of agricultural crops despite consistency of other input parameters and practices of crop husbandry [24].

5. CONCLUSION

The vegetative growth of onion recorded marked differences in the two seasons from 4 to 10 weeks after planting. The 10 t/ha poultry manure and the 5 t/ha PM + 150 kg/ha NPK were higher at 4 and 6 WAT than the control and other amendments in plant height and number of leaves per plant for Red Creole and Bawku Red, respectively. With the yield and yield components, the sole poultry manure and its combinations with NPK performed better in terms of marketable bulb yield and total bulb yield for both seasons. Maximum bulb yield was obtained in the minor rainy season (September to December) in both onion varieties planted on 5 t/ha PM + 150 kg/ha NPK.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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