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EVALUATION OF POST-MANURE APPLICATION PLANTING TIME AND POULTRY MANURE RATE ON GROWTH, SEED YIELD AND YIELD COMPONENTS OF EGUSI MELON

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Abstract
Egusi melon (*Citrullus colocynthis* L) is a vegetable crop commonly cultivated for the seeds that majorly supply oil in human diet. Animal manure is used to amend and reclaim infertile soils. The rate and timing of manure application are determinants of its nutrient supply efficiency. Two field trials were conducted from September to December in 2017 and repeated from June to October in 2018 at the Federal University of Agriculture Abeokuta to determine effects of time and quantity of poultry manure application on growth and seed yield of Egusi melon. The factors were poultry manure rate of 0, 5, 10 or 15 t·ha^{-1} and post-manure application planting time at 2 or 4 weeks after manure application (WAMA). Treatments were arranged in a 2 × 3 factorial fitted into a randomized complete block design, replicated 4 times. In 2017, average number of leaves/plant was generally lower with Egusi melon planted at 2 weeks after manure application (WAMA), relative to 4 WAMA when the highest number of leaves was from 5 t·ha^{-1}. Average leaf area and vine length were higher with planting at 4 WAMA. In 2018, number of leaves/plant and leaf area were similar with planting time and manure rate. First flowering in 2017 was attained in about 32 days with planting at 2 WAMA but in about 38 days with planting at 4 WAMA. In 2018, flowering was attained in 34 days with planting at 2 WAMA and in 32 days with planting at 4 WAMA. Seed yield at 2 WAMA in 2017 was highest (162 kg·ha^{-1}) from 5 t·ha^{-1} and 237 kg·ha^{-1} at 4 WAMA. In 2018, highest seed yields were 1262 kg·ha^{-1} from 10 t·ha^{-1} at 2 WAMA, and 702 kg·ha^{-1} at 4 WAMA from 15 t·ha^{-1}. Average fruit weight was higher in 2018. Number of seeds per fruit was highest in 2017 with planting at 4 WAMA. Application of 10 t·ha^{-1} poultry manure with Egusi melon planted at 2 WAMA is optimum for seed yield.

Keywords: *Citrullus colocynthis*, manure, application, seed yield

Introduction

Egusi melon (*Citrullus colocynthis* L.) is an underutilized vegetable in tropical agriculture. The seed serves a good source of potassium and calcium. The seed oil is a good source of natural antioxidants such as vitamin E and β carotene. It is usually used as a live mulch to control weeds as it provides early vegetative cover which suppresses weed growth (Anuebuwa, 2000). As with other creepers, the ability of Egusi melon to cover the ground also makes it useful in reducing soil run off when intercropped (Moser, 2009). Organic manures can be used as an alternative to synthetic fertilizers. They release nutrients slowly over a longer period and improve soil fertility by activating soil microbial biomass (Ayuso *et al*., 1996; El-Shakweer *et al*., 1998; Belay *et al*., 2001). Time of manure application is a consideration for optimum growth, yield and nutrient composition of crops. To obtain maximum economic value of plant nutrients, poultry manure should be applied to match crop nutrient demand (Ozores-Hampton, 2012). Appropriate timing of nutrient application ensures nutrient availability, when required to avoid nutrient loss. For effective plant use of nutrients from either organic or inorganic fertilizer, placing the nutrient in a way that it provides timely uptake to reduce potential loss is important in optimizing crop response to nutrient supply (Steward, 2006). The study was undertaken to determine effects of post manure application planting time and poultry manure rate on growth and seed yield performance of Egusi melon.

Materials and Methods

The study was carried out at the Teaching and Research Farm of the Directorate of University Farms in the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, from September to December 2017 and June to October 2018. The location is at Latitude 7°25´N and Longitude 3°25′E at 100 m above sea level. The Oxic Paleudulf soil was ploughed and harrowed. The soil was leveled manually with a West African hoe. Removal of stumps and debris was done manually. Plot size was 4 × 3 m with a 2 m margin around each plot. The recommended 10 t·ha^{-1} of poultry manure was applied 2 weeks before planting (Ogbonna and Obi, 2007). A reduced rate, applied 4 weeks prior to planting was investigated with application of 5 t·ha^{-1} of poultry manure. Application of 15 t·ha^{-1} of poultry manure was investigated to determine the potential of a single application for 2 consecutive plantings. The factors were poultry manure rate of 0, 5, 10 or 15 t·ha^{-1} and post-manure application planting time at 2 or 4 weeks after manure application (WAMA). Treatments were arranged in a 2 × 3 factorial fitted into a randomized complete block design, replicated 4 times. The unfertilized control (0) treatment is the standard production practice among farmers in the region. Analysis was done of soil taken from the field before and after planting in both experiments. The pre-cropping soil sample for 2017 was collected by obtaining random core samples from different locations within the field, which were bulked to obtain a composite sample from which a portion was collected and analyzed for physical and chemical properties. Post cropping sampling was done by taking 3 core samples with a soil auger per treatment plot after harvest in 2018 which were bulked to obtain a composite sample per treatment plot, from which a portion was collected and analyzed for nitrogen, phosphorus and potassium. Cured poultry manure was obtained from a battery cage poultry farm in a semi-dry condition. The poultry manure was analyzed for its chemical properties. It was broadcast over each plot and manually worked into the soil. The poultry manure was left to decompose and mineralize for 2 or 4 weeks. Seeds were sourced from a local market in Abeokuta, Ogun State; using the landrace black and white edged Bara, commonly cultivated in south western Nigeria. Planting was at 2 or 4 weeks after application of poultry manure. In 2018, planting was repeated on the same individual plots, at the same interval. Plants were established at 2 seed per hole at a spacing of 1× 1 m, at a planting depth of 2-3cm. Plants were thinned to 1 per stand at 2 weeks after planting (WAP) to give a plant population of 10,000 plants·ha^{-1}. Weeding was done manually at 3 and 5 WAP. Foliar pests were controlled with application of 400 mL·ha^{-1} Cymbush® 10EC (containing 100 g·L^{-1} Cypermethrin in 500 L of water) at 6 WAP. Mature fruits were harvested, separated from dried vines and bludgeoned to accelerate rotting. Fruits were piled together, covered with grass and left for 14 days to allow fruit to rot for extraction of seeds. The fermented pulp was extracted, which contained the seed that is highly valued for its oil content. These were washed and kept in a basket to drain. Afterwards, they were air dried at room temperature range of 21-32°C for about 5 days. Data were collected on growth and yield from plants at 6 WAP in 2017 and 2018. Five plants were tagged per plot from middle rows for collection of growth data; 5 fruits were randomly selected per plot for yield data. Growth and yield data were obtained for: number of leaves per plant, length of primary vines, and leaf area per plant estimated from relationship with the mid-rib length of the central lobe as described by Wahua (1985). Mid-rib length was measured from the leaf apex of the central lobe to the leaf base (point of attachment to the leaf stalk), number of branches per plant, days to first flowering from planting, number of fruits per plant, average fruit weight of 5 randomly selected fruits, fruit yield•ha^{-1}, seed to fruit percent where fruit weight•ha^{-1} was divided by seed weight and multiplied by 100, number of seeds per fruit, seed yield·ha^{-1} as weight of air dried seeds per plant multiplied by plants·ha^{-1}, 100 seed weight, and shelling percent determined by dividing the difference between seed weight and shelled seed weight by the seed weight and multiplying by 100. Data were subjected to analysis of variance using GENSTAT Discovery (12th ed., VSN International, Hemel Hempstead, UK). If interactions were significant, they were used to explain the results. If interactions were not significant, means were separated using Least Significant Difference at 5% probability.

Results and Discussion

Total rainfall during the experimental period was less in 2017 than 2018 (Table 1). Temperatures were similar in both years. The range of relative humidity was less in 2017 than 2018 (Table 1). At pre-planting, the Oxic Paleudulf soil was a sandy clay loam, slightly acidic (Table 2). Organic matter content, Nitrogen content and available phosphorus were low. The soil had exchangeable potassium; calcium sodium and magnesium contents typical of cultivated tropical soils. The poultry manure was slightly alkaline, with moderate contents of organic matter Nitrogen; available phosphorus and exchangeable K (Table 2). With 2 years cropping, soil total nitrogen was slightly reduced (Table 3). Planting at 2 WAMA with application of 5 or 15 t·ha^{-1} of manure, as well as unfertilized plots had nitrogen contents slightly reduced by 6% while plots with application of 5 t·ha^{-1} of manure had nitrogen content reduced by 11%. Planting at 4 WAMA had nitrogen content reduced by 6% with application of 5 or 15 t·ha^{-1} manure but with retained content with application of 10 t·ha^{-1} of manure (Table 3). Soil phosphorous contents were generally reduced. Cropping without fertilizer reduced the initial phosphorous content by 13% with planting at 2 WAMA but to about 14% with applications of 5, 10 and 15 t·ha^{-1} manure. Planting at 4 WAMA had phosphorous contents reduced to about 15% with applications of 5, 10 and 15 t·ha^{-1} manure (Table 3). Soil potassium contents were generally increased. Initial potassium content was increased by about 4% with cropping without fertilizer. Plots treated with either 5 or 15 t·ha^{-1} poultry manure, planted at 2 WAMA, had potassium contents increased by 7% while plots treated with 10 t·ha^{-1} had 12% increase. Planting at 4 WAMA had potassium contents increased by about 11% with application of 5 t·ha^{-1} manure but with retained potassium contents with applications of 10 and 15 t·ha^{-1} manure (Table 3). Number of leaves was not affected by main effects or interactions (Table 4). Leaf area was affected by planting year, interaction of planting year and manure rate and interaction of planting year and planting time (Table 4). Vine length was affected by planting year and also by planting year and planting time interaction (Table 4). Number of branches was affected by planting year (Table 4). Days to first flowering was affected by planting year and planting time as well as planting year and planting time interaction (Table 4). Number of fruits·ha^{-1} was affected by planting year, interaction of planting year and manure rate, interaction of manure and planting time and the interaction of planting year, manure rate and planting time (Table 5). Average fruit weight was affected only by year (Table 5). Fruit weight was affected by year and all possible interactions; seed yield was affected by all main factors and interactions (Table 5). The 100 seed weight was affected by year, planting time, interaction of year and manure rate, manure rate and planting time and the interaction of year, manure rate and planting time (Table 5). The 100 shelled seed weight was affected by year, planting time, interaction of manure rate and planting time and interaction of year, manure rate and planting time (Table 5).

There was a significant interaction of year of cultivation and poultry manure rate on leaf area at 6 weeks after planting (Figure 1). Egusi melon supplied with 5 t.ha^{-1} poultry manure in the second year produced wider leaves compared to those with no poultry manure, or 5, 10 and 15 t·ha^{-1} in the first year and 15 t·ha^{-1} in the second year, but was similar to those with no poultry manure and 10 t·ha^{-1} poultry manure in the second year (Figure 1). There was a significant interaction of year of cultivation and time of planting on leaf area, vine length, days to 1st flowering and number of seeds/fruit (Table 6). In 2018, Egusi melon planted at 4 WAMA produced wider leaves compared to those planted at 2 and 4 WAMA in 2017 and 2 WAMA in 2018 (Table 6). In 2018, Egusi melon planted at 4 WAMA produced longer vines compared to those planted at 2 and 4 WAMA in 2017 and 2 WAMA in 2018 (Table 6). In 2017, Egusi melon planted at 2 WAMA flowered earlier compared to those planted at 4 WAMA in 2017 and 2 WAMA in 2018, but was similar to those planted at 4 WAMA in 2018 (Table 6). Egusi melon planted at 4 WAMA in 2017 produced more seeds per fruit compared to those planted at 2 and 4 WAMA in 2018 and 2 WAMA in 2017 (Table 6). Year of cultivation affected number of branches and average fruit weight of Egusi melon with more branches produced in 2018 than 2017 (Table 7). Egusi melon planted in 2018 had heavier fruits compared with those planted in 2017 (Table 7). There was an interaction of year of cultivation, poultry manure rate and time of planting on some yield attributes of Egusi melon (Figure 2). In 2017, Egusi melon planted at 2 WAMA with application of 10 t·ha^{-1} of poultry manure produced more fruits compared with other rates. In 2018, planting at 2 WAMA with application of 10 t·ha^{-1} of manure produced more fruits compared with other rates but with application of 15 t·ha^{-1} of manure at 4 WAMA (Figure 2). Egusi melon planted at 2 WAMA with 10 t·ha^{-1} manure produced higher fruit weight·ha^{-1} compared with those planted at 2 and 4 WAMA with applications of 5, 10, 15 t·ha^{-1} and no manure in 2017 and those planted at 2 WAMA with applications of 5, 15 t.ha^{-1} and no manure and 4 WAMA with applications of 5, 10, 15 t·ha^{-1} and no manure in 2018 (Figure 3). Egusi melon planted at 2 WAMA with application of 10 t·ha^{-1} manure in 2018 produced higher seed yield·ha^{-1} compared with those planted at 2 and 4 WAMA with applications of 5, 10, 15 t·ha^{-1} and no manure in 2017 and those planted at 2 WAMA with applications of 5, 15 t·ha^{-1} and no manure and 4 WAMA with applications of 5, 10, 15 t·ha^{-1} and no manure in 2018 (Figure 4). In 2017 planting at 2 WAMA, 100 seeds of harvested Egusi melon were heaviest from planting with application of 15 t·ha^{-1} of manure but with 5 or 10 t·ha^{-1} in 2018. With planting at 4 WAMA in 2018, 100 seed weight were heaviest with application of 10 t·ha^{-1} of manure (Figure 5). The 100 shelled seeds of Egusi melon in 2017 were heavier with planting at 2 WAMA with application of 15 t·ha^{-1} manure and with 10 t·ha^{-1} in 2018. With planting at 4 WAMA, it was heaviest with 10 t·ha^{-1} of manure (Figure 6).

The soil was slightly acidic but within the favorable range for Egusi melon (Van der Vossen *et al.*, 2004). The low organic C, but adequate total N with the critical level of 1.5 g·kg^{-1} (Aduayi *et al*, 2002) qualified the soil for a study on fertilizer response. Also making the soil fit for the study was the available P that was high, based on the 8-12 mg·kg^{-1} critical level (Udo *et al*., 2009) as well as the exchangeable K content that was lower than the critical 0.6-0.8 cmol·kg^{-1} content recommended in the region for cultivation of tropical arable crops, including Egusi melon (Adeoye and Agboola, 1985). The high content of sand; medium content of silt and low clay content, contributed to making it an adequate soil for cultivating Egusi melon. Weather conditions were favorable in the first year. With the higher rainfall in the second year, yields were higher; an indication that rainfall benefits growth and yield of Egusi melon. The poultry manure had a moderate concentration of organic matter and nitrogen, with a high level of phosphorus and potassium. These attributes qualify poultry manure as a good nutrient source for Egusi melon on this soil.

Variations in responses of Egusi melon in 2017 and 2018 imply environmental factors impacted growth and yield. Growth was relatively better with planting at 4 WAMA than planting at 2 weeks. Plant nutrients were made available with 4 weeks delay. Plant residues of the first year cropping recycled into the soil without fertilizers had beneficial effects. The adequate nitrogen content and the high potassium content of the soil aided crop growth, without fertilizers. This was reflected in number of leaves/plant; average leaf area and plant vine lengths that were higher in the second year. Plant growth that was generally aided with planting at 4 WAMA resulted in earlier flowering in the first year. By the second year, sub-adequate availability of nutrients and plant growth with planting at 2 WAMA led to plants initiating flowers earlier, supporting observation of Olaniyi (2008) that egusi melon flower initiation is affected by nutrient supply. Higher growth rate in 2018 characterized by higher rainfall negates findings of Ogbona and Obi,

(2007) that planting during heavy rainfall with high cloud cover and lower solar radiation reduces crop growth and yield. Higher rainfall in the second year was accompanied by more sunshine hours, relative to the previous year which may have contributed to higher yields. Growth attributes assessed at 6 weeks after planting of fertilized and unfertilized plants were comparable due to the slow release nature of poultry manure that might not make available optimum quantity of nutrients at this period, indicating that a longer period of time is required for nutrient release to impact growth. The situation was however reversed with yields affected by manure application. Nutrient release from organic manures has been reported to be at 71% during 120 days incubation (Dey *et al.*, 2019). The release is less than 25% up to 30 days and thereafter increased from 50 days. Yield attributes that increased with manure and planting time was due to more time available for poultry manure to decompose and mineralize, making nutrients available for uptake by the plant as reported on Egusi melon (Ogbona and Obi, 2007). Unfertilized plots, with only plant residue recycled that had higher yield than from application of 5 $t{\cdot}ha^{-1}$ PM, with planting at 2 WAMA was likely due to native nutrient contents of the soil and nutrient chelation for manure mineralization with application at 5 $t{\cdot}ha^{-1}$ PM. Planting Egusi melon at 4 WAMA with application of 5 or 10 $t{\cdot}ha^{-1}$ PM seems adequate for growth. Planting at 4 WAMA with 5 $t{\cdot}ha^{-1}$ PM gave the highest yield for one cropping. Application of 10 $t{\cdot}ha^{-1}$ PM with planting at 2 WAMA gave optimum yields for 2 croppings. The rates of manure applied along with the period of time allowed for mineralization are important considerations for cultivation of Egusi melon. For optimum yields, planting Egusi melon at 2 weeks after application of 10 $t{\cdot}ha^{-1}$ manure appears appropriate.

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Table 1: Weather during experimental period for year 2017 and 2018

Month in year	Rainfall (mm)	Temperature (°C) maximum	Temperature (°C) minimum	Relative humidity (%)	Sunshine (hour)
2017					
September	50.0	30.0	22.1	69.1	2.1
October	92.2	31.9	27.8	72.8	4.2
November	85.4	30.2	24.8	65.5	0.2
December	0.00	34.9	21.6	Na	4.2
Total	227.6				
Average	56.9	31.8	24.1	69.1	2.7
2018					
June	172.9	30.4	22.7	76.3	3.6
July	221.1	27.5	23.0	80.3	3.2
August	161.8	29.1	22.6	77.2	1.9
September	270.0	30.0	23.0	74.8	2.8
October	173.4	31.9	22.7	73.3	4.0
Total	999.2				
Average	199.8	29.8	22.8	76.4	3.1

Na: Not Available

Table 2: Manure and pre-cropping soil chemical and physical analysis

Property	Soil	Poultry manure
pH (H_2O)	6.40	7.80
Organic carbon ($g{\cdot}kg^{-1}$)	5.40	63.20
Organic matter ($g{\cdot}kg^{-1}$)	9.50	110.60
Nitrogen ($g{\cdot}kg^{-1}$)	1.90	21.50
Avg. P ($mg{\cdot}kg^{-1}$)	41.86	126.32
Exchangeable. K	0.52 $cmol{\cdot}kg^{-1}$	11.14 $mg{\cdot}kg^{-1}$
Na	0.41 $cmol{\cdot}kg^{-1}$	6.03 $mg{\cdot}kg^{-1}$
Ca	0.28 $cmol{\cdot}kg^{-1}$	1.81 $mg{\cdot}kg^{-1}$
Mg	0.34 $cmol{\cdot}kg^{-1}$	1.81 $mg{\cdot}kg^{-1}$
Ex. Acid (meq/100 g)	0.20	0.50
Sand ($g{\cdot}kg^{-1}$)	721	-
Clay ($g{\cdot}kg^{-1}$)	26	-
Silt ($g{\cdot}kg^{-1}$)	253	-
Textural class	Sandy clay loam	

Table 3: Interactive Effects of Post Manural Planting Time and Rate on Post Cropping Soil Total Nitrogen, Available Phosphorus and Exchangeable Potassium

Manure Rate ($t.ha^{-1}$)	*WAMA	Total Nitrogen ($g.kg^{-1}$)	Available P ($mg.kg^{-1}$)	Exch. K ($cmol.kg^{-1}$)
0		1.80	367.60	0.54
5	2	1.70	361.90	0.56
10		1.80	367.40	0.58
15		1.80	342.20	0.56
5	4	1.80	359.30	0.58
10		1.90	360.60	0.56
15		1.80	343.20	0.55
LSD (5%)		0.02	ns	ns

WAMA= weeks after manure application

Table 4: Analysis of variance response for Egusi growth attributes at 6 weeks after planting

Source	df	No. of leaves	Leaf area	Vine length	No. of branches	Days to first flowering
Year (Y)	1	1271.02	1291.07**	13021.8***	53.088***	42.188**
Manure rate (L)	3	95.74	69.54	533.4	0.320	7.243
Planting time (P)	1	513.52	30.40	541.4	2.717	35.021**
Y × L	3	517.74	441.54*	1166.5	0.718	3.243
Y × P	1	892.69	2954.74***	6007.7**	0.859	165.021***
L × P	3	532.02	143.90	183.4	1.059	5.076
Y × L × P	3	108.08	115.61	8.7	0.081	3.299
Residual	30	375.41ns	127.58	461.9	0.928	3.271

ns, *,**, *** not significant or significant at P<0.05, P<0.01, or P<0.001

Table 5: Analysis of variance response for Egusi yield attributes

Source	df	No. of Fruits ·ha^{-1}	Av. fruit weight	Fruit weight·ha^{-1}	No. of seeds /fruit	Seed yield·ha^{-1}	100 seed weight	100 shelled seed weight
Year (Y)	1	5121539635***	2412717***	1453.21***	14242.3***	1687024***	24.5102***	32.177***
Manure rate (L)	3	284125027	1858	95.17*	988.4	127673***	0.4085	0.117
Planting time (P)	1	163787037	17242	98.76	2035.5	194457**	2.0419*	1.235*
Y × L	3	366154060*	1858	127.67**	878.0	163067***	1.2819**	0.442
Y × P	1	509168981	17262	232.80**	3626.5*	277465***	0.0919	0.152
L × P	3	952055443***	4446	182.35***	489.6	227056***	1.0169*	0.759*
Y × L × P	3	726116759**	4447	148.35**	1157.9	185697***	0.8769*	0.621*
Residual	30	123037296	7181	25.28	708.4	17060	0.2825	0.194

ns, *,**, not significant or significant at P<0.05, P<0.01, or P<0.001***

Table 6: Interaction of year of cultivation and time of planting on leaf area, vine length, days to 1st flowering and number of seed/fruit of Egusi melon

Year	Time of planting (WAMA)	Leaf area (cm^2)	Vine length (cm)	Days to 1st flowering	Number seeds/fruit
2017	2	54.12	68.88	32.00	73.14
	4	48.80	79.44	37.58	124.97
2018	2	40.02	53.22	34.00	77.50
	4	66.08	108.53	32.17	94.56
LSD 0.05)		9.42	17.92	1.51	22.19

[a] Data in the interaction analyzed with Least Squares Means and means separated with Least Significant Difference, P = 0.05; WAMA = Weeks after manure application

Table 7: Year of cultivation on number of branches and average fruit weight of Egusi melon

Year	Number of branches	Average fruit weight (g)
2017	3.68	200.35
2018	5.79	448.75
LSD (0.05)	0.57	49.96

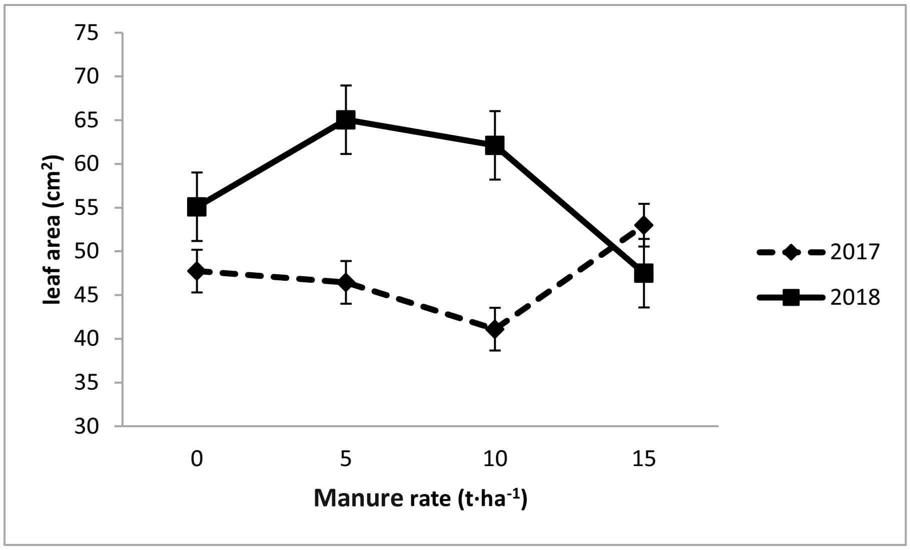

Figure 1: Interaction of year and poultry manure rate on leaf area of Egusi melon at 6 weeks after planting
[a] Data in the interaction analyzed with Least Squares Means and means separated with Least Significant Difference, P = 0.05

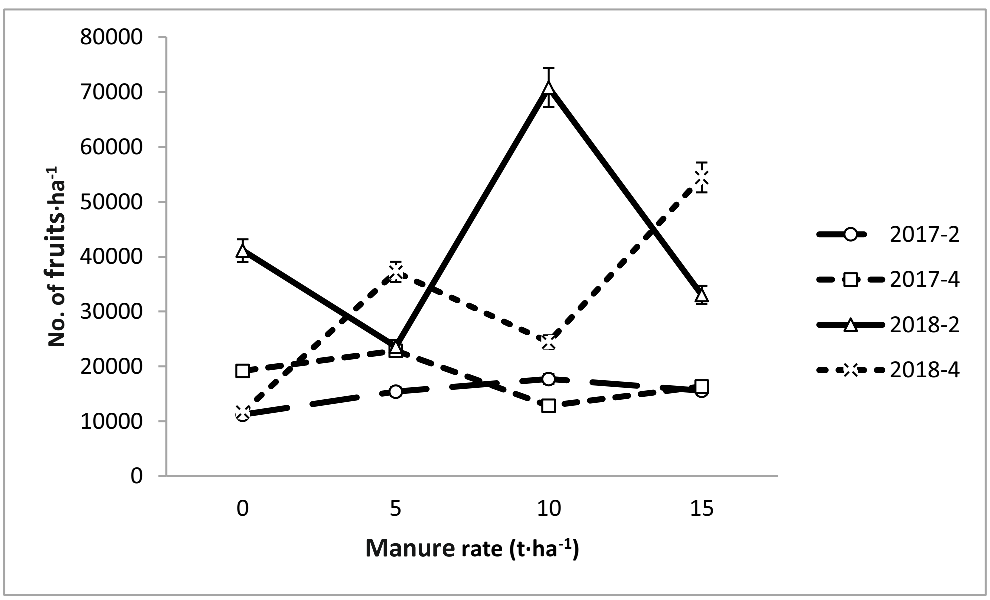

Figure 2: Interaction of year of cultivation, manure rate and time of planting on number of fruits ·ha^{-1} of Egusi melon
Data in the interaction analyzed with Least Squares
Means and means separated with Least Significant Difference, P = 0.05.
2017-2; 2017-4= Planting at 2 and 4 Weeks after manure application in 2017
2018-2; 2018-4= Planting at 2 and 4 Weeks after manure application in 2018

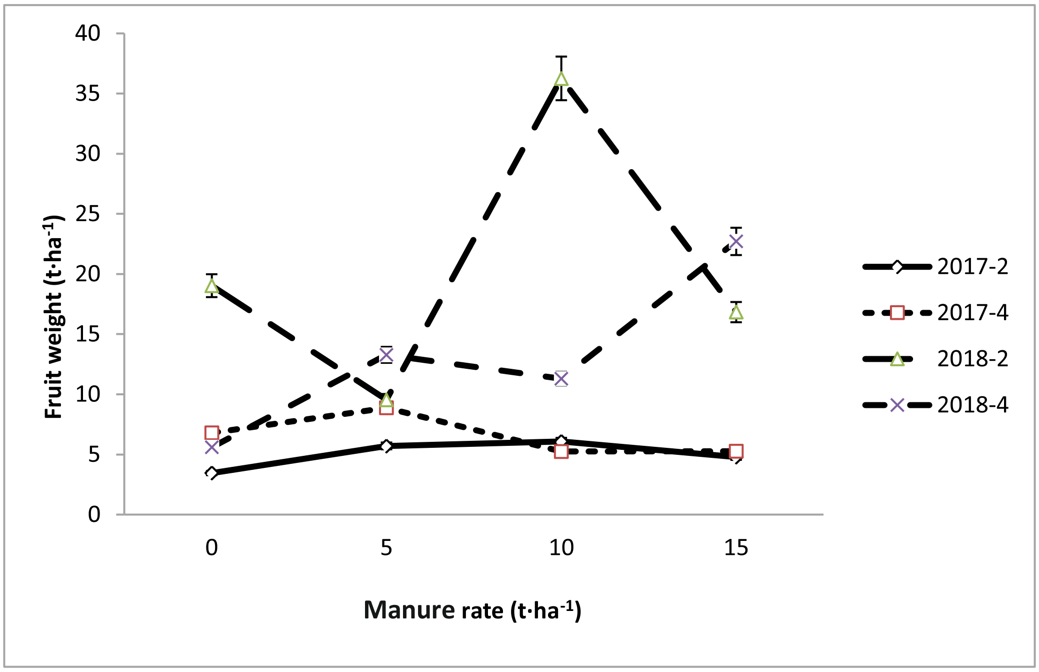

Figure 3: Interaction of year of cultivation, manure rate and time of planting on fruit weight of Egusi melon

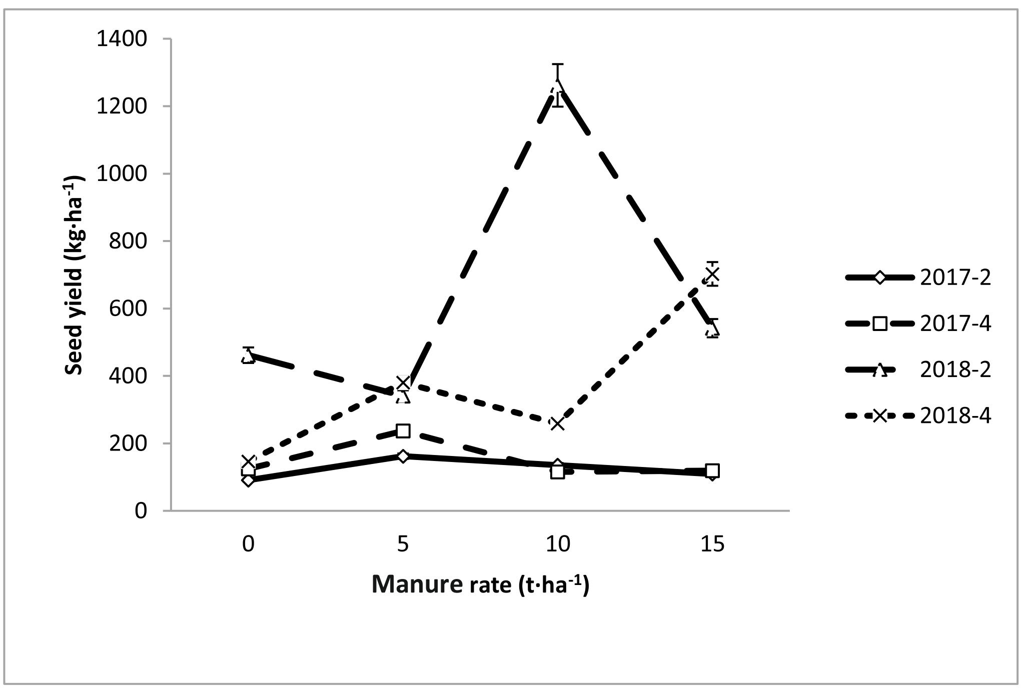

Figure 4: Interaction of year of cultivation, manure rate and time of planting on seed yield of Egusi melon

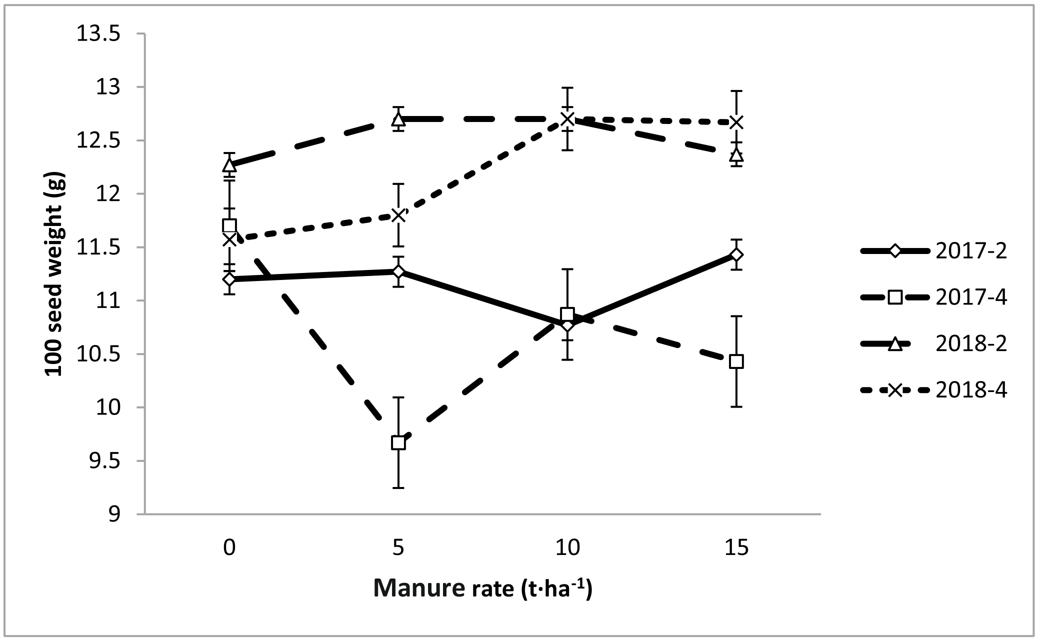

Figure 5: Interaction of year of cultivation, manure rate and time of planting on 100 seed weight of Egusi melon

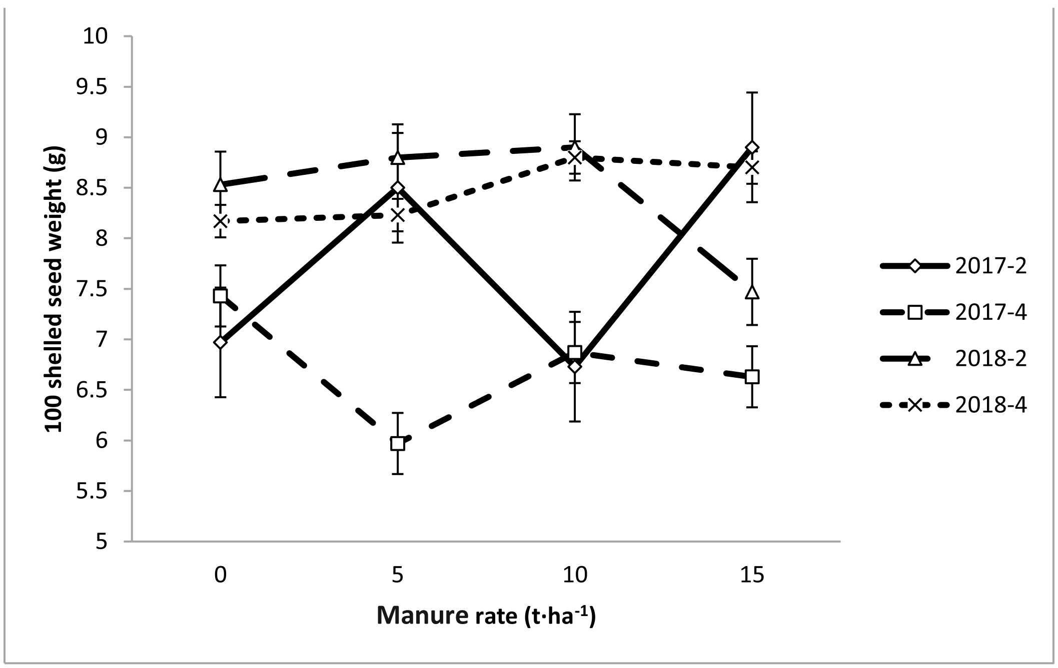

Figure 6: Interaction of year of cultivation, manure rate and time of planting on 100 shelled seed weight of Egusi melon