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Cropping system and NPK fertilizer rate influenced productivity of garden egg (*Solanum gilo*) and egusi melon (*Colocynthis citrullus*) in garden egg/egusi melon intercropping system

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Abstract

A field experiment was conducted in the research field of National Horticultural Research Institute's substation at Mbato, Okigwe, Nigeria to evaluate the effect of NPK 15-15-15 fertilizer rates (0, 200, 400 and 600 kg per hectare) on the growth and yield of garden egg and egusi melon, in their sole and intercrop systems. The experiment was laid as a randomized complete block design (RCBD) comprising twelve treatments and replicated three times. There were reductions in the growth and yield parameters of the component crops in the intercrop system compared to when they were grown in their sole plots. The application of fertilizer significantly ($p<0.05$) increased growth and yield parameters of garden egg (number of leaves, leaf area, weight of fruits and fresh fruit yield/ha) and egusi melon (vine length, number, weight and diameter of fruits, the number of seeds/fruit, 100-seed weight and seed yield). Increase in fertilizer rate increased these parameters, however, there was a decline when 600 kg/ha of the fertilizer was applied. The lowest weed dry weight at six weeks after planting (3.36 and 4.13 g/m^2) and at harvest (1.21 and 1.47 g/m^2) was recorded in intercropped plots in 2009 and 2010, respectively. There were yield advantages in all the intercrop treatments, with a maximum yield advantage of 140 and 159 % in 2009 and 2010, respectively with the application of 400 kg/ha fertilizer. Therefore, the application of 400 kg/ha NPK fertilizer was recommended if *Solanum gilo* and *Colocynthis citrullus* are intercropped especially in the study area.

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Introduction

Garden egg (*Solanum gilo*), a fruit vegetable that belongs to the Solanaceae family of flowering plants is rising in its social and economic importance in Nigeria. The fruit is widely eaten fresh as snack and dessert across the country. Among the Ibos of Eastern Nigeria, it is fast replacing nicotine-containing kola nut (*Cola nitida* and *Cola acuminata*) in the traditional customs and ceremonies. It also serves as a prominent component of a favourite dish - African salad which is a combination with '*ugba*' (slices of oil bean seed *Pentaclethra macrophyllum*), 'tapioca' from cassava and garden egg fruit.

According to Sabo and Dia (2009) garden egg plant contains phyto-nutrients such as nasunin and chlorogenic acid. Nasunin is a potent antioxidant and free radical scavenger that has been shown to protect cell membranes from damage. Garden egg is also a very good source of dietary fiber, potassium, manganese, copper and vitamin B6, folate, magnesium and niacin. It is a valuable vegetable for canning industries for garden-egg paste, sautéed garden-egg and other products. The fruits are fried, stewed, marinated and prepared in other ways. The garden egg plant with its bitter taste and spongy texture could really make an amazing pot of stew and eaten with boiled yam or rice. Medicinally, a meal of garden egg is proven to be of benefits to patients suffering from raised intraocular pressure (glaucoma) and convergence insufficiency, as well as in heart diseases and *Arteriosccerosis* (Harish *et al*., 2008).

Egusi melon (*Colocynthis citrullus*) is an oil seed vegetable (Ayodele and Salami, 2006) that belongs to the *Cucurbitaceae* family. It is an important vegetable in Nigeria (Ogbonna, 2001). The dehusked and ground seed of egusi melon is used in thickening soup and sometimes stew. Similarly, dehusked egusi seeds are coarsely ground and left to ferment in order to produce '*Ogiri*', a seasoner for preparing soup and other foods. Egusi seeds are also used as the main ingredient of the popular egusi cake called '*osu*'. Egusi seed contains up to 50.2% edible oil on dry matter basis (Akobundu *et al*., 1982). This oil is refined and used for industrial products such as candle, soap and other products. According to Ayodele and Salami (2006), the use of egusi melon for thickening soup, and its high oil content qualifies it for classification as vegetable crop on the one hand and oil crop on the other hand.

The whole seeds of egusi melon are shelled (dehusked) by breaking and removing the soft testa, ground and used as condiment in egusi soup (Burkill, 1985)The seed contains up to 41.6% crude protein and 57.3% total lipid, on dry weight basis (Fakou *et al*., 2004), which can be extracted. The oil is clear, semi- drying and easily refinable, suitable for cooking and use in soap making, illuminants and pharmaceuticals (Adewusi *et al*., 2000.).

This form of utilization classifies egusi as an oil seed. Also, the role of egusi as live-mulch for weed control and soil moisture conservation has been recognised for pineapple, plantain/banana, citrus, okra, yam, maize and cassava based intercropping systems, in which complete soil cover is attained at high populations (Ikeorgu, *et al*., 1989).

One of the major constraints to crop production in southeastern Nigeria is poor fertility status as a result of the leaching of nutrients associated with rainfall. Exogenous nutrient supply in the field and the practice of different cropping system are few practices in order to ameliorate this challenge.

Garden egg and egusi melon are not usually intercropped together in spite of obvious benefits that could be derived from such intercropping system for increased productivity. It is therefore, pertinent to determine the productivity of both garden egg and egusi melon in their intercropping system. On the other hand, inadequate fertilizer application in an intercropping system is among the factors that could affect the yield and productivity of the intercrop system (Bowen and Kratky, 1986). Hence, the objective of this study is to investigate the productivity of garden egg and egusi melon vis-à-vis fertilizer application in garden egg/egusi melon intercropping system.

Materials and methods

Study location

The field experiment was carried out at National Horticultural Research Institute (NIHORT) Mbato, Okigwe sub-station in 2009 and 2010 cropping seasons. Mbato-Okigwe is situated in the humid forest zone of Southern Nigeria. Mbato substation lies on latitude 05°33´N and longitude 07°23´E with altitude of 130 m above sea level.

Ten different soil representative samples from the experimental site were bulked into a composite sample for each cropping season (2009 and 2010). These composite soil samples were subjected to physicochemical analysis and the results are presented in Table 1.

The soils of the experimental site were mostly sandy loam. Nitrogen content was moderate, available phosphorus was low and potassium was also low according to the soil Fertility Assessment Guide of Chude *et al.* (2004).

Treatment and treatment allocation

The treatments consisted of sole egusi melon, sole garden egg and intercropped plots of garden egg/egusi melon. Either of these three cropping systems received NPK 15-15-15 fertilizer at 0, 200, 400 and 600 kg/ha rates. In other words, there were twelve treatment combinations laid out as completely randomized block design with three replications. The planting materials were seeds of '*Serewe*' variety of egusi melon (*Colocynthis citrullus*) and six weeks old seedlings of garden egg (*Solanum gilo*).

Cultural practices

The six weeks old seedlings of garden egg and seeds of egusi melon were planted and sown same day. A seedling of garden egg and two seeds of egusi melon were each planted per hole. Egusi melon was later thinned to one per hole at seedling establishment. In the sole plots, the plant spacing for both crops was 0.5 m × 1.0 m. In the intercrop plots, the plant spacing was 1.5 m × 1.5 m and 1.0 m × 1.0 m for garden egg and egusi melon, respectively.

The plot dimension was 3 m x 3 m. Two hoe-weedings were done each year. The first was done at 3 weeks after planting (WAP) and the other at 6 WAP. The plots were subsequently sprayed twice with Cymbush insecticide to ward off grass-hoppers (*Zonocerus* spp) and other insects that pierce and suck the fruits of both garden egg and egusi melon.

Data collection

Data were taken at 10 WAP from four randomly tagged garden egg plants for plant height, number of branches per plant, number of leaves per plant. Numbers of fruits per plant and weight of fresh fruits per plant were recorded as candidate plants fruited.

Longest vine length, at 10 WAP, number, weight and diameter of fresh fruits of egusi melon were also recorded from four randomly tagged egusi melon stands. The fresh weed biomass was collected from each plot. The dry weights were also determined after drying them to a constant weight.

From the yield data, land equivalent ratio (LER) and gross monetary return (GMR) were determined. The LER was calculated according to Mead and Willey (1980) formula, LER= (YA + YB)/(LA + LB), where YA and YB are the individual crop yields in intercrop and LA and LB are their yields as sole crop.

The gross monetary return (GMR) was assessed in naira per hectare by multiplying the yield of the crop with the prevailing market price of the commodity in the locality. Garden egg price was ₦133.30/kg while that of egusi melon was ₦320.00/kg.

Statistical analysis of data

All the data collected from each crop were analyzed according to two-factor analysis of variance (ANOVA) in randomized complete block design (RCBD), using GENSTAT Release 7.2 Discovery Edition 3 (GENSTAT, 2007). Treatment means were compared with Fishers least significant different (F-LSD) at 5 % level of significance.

Results

Garden egg growth

In both 2009 and 2010 cropping seasons, the intercropped garden egg plants were significantly ($p<0.05$) taller than their sole crops (Table 2). However, the number of branches and leaves per plant were higher when garden egg was grown singly than when intercropped with egusi melon. The leaf area however, was statistically similar both in the sole and intercropped system.

Table 1. Physicochemical properties of the experimental site in 2009 and 2010.

Soil parameters	2009	2010
Physical characteristic		
Sand (%)	92.90	92.82
Silt (%)	3.18	2.36
Clay (%)	4.92	4.82
Texture	Sandy loam	Sandy loam
Chemical characteristics		
pH (H_2O)	5.87	5.67
Organic Carbon (g kg^{-1})	1.31	1.56
Total N (g kg^{-1})	0.31	0.30
Available P (mg kg^{-1})	3.53	3.62
Calcium (cmol/kg)	2.00	2.00
Magnesium (cmol/kg)	1.20	1.20
Potassium (cmol/kg)	0.10	0.09
Sodium (cmol/kg)	0.05	0.05
Exchange acidity (cmol/kg)	2.40	2.20
ECEC (cmol/kg)	5.75	5.54
Base saturation (%)	58.26	60.29

Table 2. Main effects of cropping system and NPK fertilizer rate on growth parameters of garden egg at 10 weeks after planting (WAP) in garden egg/egusi melon intercropping system.

	Plant height (cm)		Number of branches/plant		Number of leaves/plant		Leaf area (cm^2)/plant	
	2009	2010	2009	2010	2009	2010	2009	2010
Cropping system								
Sole garden egg	58.3	57.3	12.40	14.11	53.00	54.20	6836	68.78
Intercropped garden egg	74.5	75.3	10.29	9.50	41.30	42.80	5326	5497
$LSD_{0.05}$	7.82	7.95	ns	1.382	4.35	6.64	ns	ns
NPK fertilizer rate (kg/ha)								
0	39.70	40.50	11.13	7.88	31.00	30.70	3940	3498
200	67.00	69.80	11.46	12.83	45.20	46.80	6165	6421
400	78.10	76.90	11.21	13.96	64.20	67.70	9339	9833
600	80.70	78.00	11.58	12.54	48.20	48.88	4880	4999
$LSD_{0.05}$	6.37	7.10	ns	2.35	10.27	8.60	1820	1857

The effect of NPK 15:15:15 fertilization showed that all the growth attributes (plant height, number of leaves and branches and leaf area) increased with increase in NPK 15:15:15 rates (Table 2).

The increase in the plant height, number of leaves and branches and leaf area peaked when 400 kg/ha NPK was applied but declined at 600 kg/ha application except the plant height. Although the growth parameters declined with the application of 600 kg/ha NPK, the mean values for plant height, number of leaves and branches as well as leaf area obtained with the application of 600 kg/ha NPK were significantly ($p<0.05$) higher than the mean values obtained with no fertilizer application (control).

Garden egg yield and yield components

The number and weight of fruits per plant and the fresh fruit yield of garden egg were not significantly (p>0.05) influenced by cropping system (Table 3). On the other hand, these attributes increased significantly with increase in NPK 15:15:15 rates up till 400 kg/ha and declined with the application of 600 kg/ha in both 2009 and 2010. The highest number of fruits, heaviest fruits and fresh fruit yield were produced with 400 kg/ha NPK application. There was 85.02%, 28.55% and 57.15% increase in fresh fruit yield of garden egg in 2010 with the application of 400 kg/ha NPK as compared to 0, 200, 600 kg/ha NPK application, respectively. However, the mean values obtained for the number and weight of fruits as well as fresh fruit yield when 600 kg/ha NPK was applied significantly (p<0.05) differed with those obtained with no fertilizer application (control).

Table 3. Main effects of cropping system and NPK fertilizer rates on garden egg yield in garden egg/egusi melon intercropping system.

	Number of fruits/plant		Weight of fruits/plant (g)		Fresh fruit yield (kg/ha)	
	2009	2010	2009	2010	2009	2010
Cropping system						
Sole garden egg	33.70	35.20	1215	1147	12154	11472
Intercropped garden egg	29.50	28.80	1048	980	10484	9802
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns
NPK fertilizer rate (kg/ha)						
0	23.40	23.40	835	778	8351	7783
200	30.20	30.30	1085	1120	10815	11202
400	37.50	39.20	1324	1440	13245	14400
600	35.10	35.10	1284	916	12837	9163
$LSD_{0.05}$	7.09	7.13	181.90	140.1	1819.3	1401

Table 4. Main effects and interaction effect of cropping system and NPK fertilizer rates on egusi melon growth at 10 weeks after planting (WAP) in garden egg/egusi melon intercropping system.

	Vine length (cm)		Aboveground dry weight (g)	
	2009	2010	2009	2010
Cropping system				
Sole egusi melon	278.6	276.4	146.6	156.4
Intercropped egusi melon	269.6	268.6	95.3	103.2
LSD 0.05	ns	ns	39.90	13.42
NPK fertilizer rates (kg/ha)				
0	261.2	253.5	57.7	60.4
200	281.7	282.5	79.7	87.5
400	291.3	290.5	156.6	165.7
600	262.2	260.4	189.7	205.5
$LSD_{0.05}$	ns	30.08	13.56	14.41
Cropping system x NPK fertilizer rates (kg/ha)				
Sole egusi melon + 0	258.8	245.0	78.9	75.8
Sole egusi melon + 200	316.4	323.0	86.6	97.9
Sole egusi melon + 400	290.6	289.4	178.6	189.8
Sole egusi melon + 600	248.8	248.1	242.1	262.0
Intercropped egusi melon + 0	263.7	262.1	36.6	43.0
Intercropped egusi melon + 200	247.1	247.9	72.8	77.1
Intercropped egusi melon + 400	292.0	291.5	134.6	141.5
Intercropped egusi melon + 600	275.5	272.7	137.2	149.1
$LSD_{0.05}$	49.79	45.82	30.47	18.6

Egusi melon growth

Cropping system did not significantly influence the vine length of egusi melon in both years but the vine (aboveground biomass at dry basis) dry weight was significantly higher in sole crop than in the intercrop (Table 4).

The application of different rates of NPK 15:15:15 did not significantly affect the vine length in 2009 but in 2010 the vine length progressively increased as the NPK rate increased from zero to 400 kg/ha and thereafter declined with 600 kg/ha application. Similarly, the dry weight of aboveground biomass increased with increasing rate of NPK 15:15:15 application in 2009 and 2010.

Table 5. Main effects and interaction effect of cropping system and NPK fertilizer rates on egusi melon fruit yield in garden egg/egusi melon intercropping system in 2009 and 2010 cropping seasons.

	No. of fruits/plant		Fruit weight/plant (kg)		Fruit circumference (cm)	
	2009	2010	2009	2010	2009	2010
Cropping system						
Sole egusi melon	2.47	3.28	2.13	2.75	11.80	12.40
Intercropped egusi melon	1.84	2.10	1.42	1.76	10.47	10.89
$LSD_{0.05}$	0.24	ns	0.48	ns	0.41	0.82
NPK fertilizer rates (kg/ha)						
0	1.41	2.00	0.87	1.13	9.75	10.25
200	1.83	2.45	1.23	1.62	11.22	11.45
400	2.76	3.18	2.83	3.32	12.55	12.95
600	2.62	3.15	2.18	2.95	11.02	11.93
$LSD_{0.05}$	0.54	0.57	0.38	0.85	0.64	1.24
Cropping system x NPK fertilizer rates (kg/ha)						
Sole egusi melon + 0	1.77	1.33	1.23	1.58	10.50	11.17
Sole egusi melon + 200	2.12	1.88	1.59	2.03	11.83	12.10
Sole egusi melon + 400	3.16	2.56	3.21	3.88	13.40	13.80
Sole egusi melon + 600	2.83	2.65	2.49	3.53	11.47	12.33
Intercropped egusi melon + 0	1.04	2.66	0.50	0.67	9.00	9.33
Intercropped egusi melon + 200	1.55	3.00	0.83	1.22	10.60	10.80
Intercropped egusi melon + 400	2.36	3.60	2.45	2.77	11.70	12.10
Intercropped egusi melon + 600	2.41	3.66	1.86	2.37	10.57	11.33
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns

Egusi melon yield and yield components

The number of fruits per plant, weight of fruits per plant, fruit diameter, number of seed per fruit, weight of seed per fruit, weight of seed per plant, weight of 100-seeds and seed yield were all significantly higher in sole egusi plots than in intercropped plots in both 2009 and 2010 with the exception of the number and weight of fruits produced in 2010, which were not affected by cropping system (Table 5). However, in both 2009 and 2010 all the yield and yield components progressively increased with increased rate of NPK 15:15:15 fertilizer up till 400 kg/ha and thereafter declined with the application of 600 kg/ha NPK. For instance, the addition of 400 kg/ha NPK in 2009 increased the number of fruits and seed yield by 95.74% and 256.29%, respectively as compared to no fertilizer application.

Cropping system and NPK fertilizer interaction effect on growth and yield of egusi melon

The longest vine in 2009 (316.4 cm) and 2010 (323.0 cm) was produced with the application of 200 kg/ha NPK 15:15:15 in the sole crops (Table 5). Shortest vine was attributed to sole egusi melon that received 600 kg/ha and no fertilizer in 2009 and 2010 respectively, although the value, 245.0 cm obtained in 2010 was statistically at par with 248.1 cm which represented the value for sole egusi melon vine with the application of 600 kg/ha NPK 15:15:15 fertilizer. Intercropped egusi melon with no fertilizer application recorded lowest plant dry weight in 2009 and 2010.

Table 6. Main effects and interaction effect of cropping system and NPK fertilizer rates on egusi melon seed yield and yield components in garden egg/egusi melon intercropping system.

	No. of seeds/fruit		Seed weight/fruit (g)		Seed weight/plant (g)		100-seeds weight (g)		Seed yield (kg/ha)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Cropping system										
Sole egusi melon	191.80	199.9	37.08	39.19	139.90	138.60	12.00	12.50	1399	1386
Intercropped egusi melon	144.00	146.7	28.25	29.83	97.0	97.20	9.48	9.89	970	973
$LSD_{0.05}$	30.49	19.08	1.79	7.51	36.69	21.34	1.42	1.97	369.5	213.4
NPK fertilizer rates (kg/ha)										
0	102.50	107.20	22.00	23.33	51.70	49.20	7.45	7.83	517	492
200	146.90	149.20	30.33	32.00	87.80	85.80	10.18	10.68	878	858
400	232.40	241.90	41.00	43.17	184.20	184.50	13.23	13.83	1842	1842
600	189.70	194.80	37.33	39.50	150.20	152.20	12.08	12.46	1502	1522
$LSD_{0.05}$	17.07	15.43	2.85	2.83	17.90	16.22	0.94	1.108	179	162.2
Cropping system x NPK fertilizer rates (kg/ha)										
Sole egusi melon + 0	113.90	120.50	27.67	28.67	60.70	55.30	8.33	8.67	607	553
Sole egusi melon + 200	157.80	159.40	34.33	36.33	104.70	98.30	11.03	11.70	1047	983
Sole egusi melon + 400	277.10	293.50	46.67	49.67	216.70	218.70	15.47	16.13	2167	2187
Sole egusi melon + 600	218.30	226.00	39.67	42.00	177.70	182.00	13.17	13.50	1777	1820
Intercropped egusi melon + 0	91.10	93.80	16.33	18.00	42.70	43.00	6.57	7.00	428	430
Intercropped egusi melon + 200	136.00	139.00	26.33	27.67	71.00	73.30	9.33	9.67	710	733
Intercropped egusi melon + 400	187.70	190.20	35.33	36.67	151.70	150.30	11.00	11.50	1517	1503
Intercropped egusi melon + 600	161.00	163.70	35.00	37.00	122.70	122.30	11.00	11.40	1227	1223
$LSD_{0.05}$	ns	20.97	ns	ns	ns	22.38	1.36	1.71	ns	223.8

WAP = Weeks after planting.

The interaction of cropping system and NPK fertilizer significantly influenced only 100-seed weight in 2009 and number of seeds per fruit, seed weight per plant, 100-seed weight and seed yield of egusi melon in 2010 (Table 6).

Highest number of seeds per fruit (293.5), heaviest seeds per plant (218.7 g) and heaviest 100-seeds (15.47 g and 16.13 g, respectively for 2009 and 2010) were attributed to sole egusi melon that received 400 kg/ha NPK. Expectedly, the number of seeds per fruit (93.80), seed weight per plant (43.0 g), seed yield (430 kg/ha), 100-seed weight (6.57 and 7.00 g, respectively in 2009 and 2010) were least when egusi melon was intercropped with garden egg without NPK fertilizer.

Weed density as influenced by cropping system and NPK fertilizer rate

At 3 WAP, the weed density in the plots was not affected by cropping system, NPK fertilizer rates and their interactions (Table 7).

But at 6 WAP and at harvest, the intercropping system greatly reduced the density of weed in the plots. In 2009 at 6 WAP, there was 35% and 194.74% reduction in weed density by the intercrop (with no NPK fertilizer) when compared to the sole egusi melon and sole garden egg (either of which received no fertilizer), respectively.

Similarly at harvest and in comparison with the sole egusi melon and sole garden egg (with no NPK fertilizer), the intercrop system (with no NPK fertilizer) reduced the weed density by 33.52% and 190.14%, respectively. In 2010, highest weed density was recorded under sole garden egg plots, especially the plots that received 600 kg/ha, both at 6 WAP and harvest.

Table 8. Linear correlation coefficient between fruit yield of garden egg and some garden egg plant characters.

Garden egg plant characters	2009	2010
Number of fruit / plant	0.971**	0.774**
Weight of fruit / plant	0.985**	0.961**
Leaf area	0.640**	0.392**

**Correlation is significant at 0.01 level of significance.

The main effect of fertilizer rates on weed density indicated that the application of fertilizer rather increased the weed density at 6 WAP and harvest in 2010.

There was increase in weed density as the fertilizer rates increased. Plots that received no fertilizer had the least fresh weed density. Similarly, greatest weed suppression at 6 WAP and harvest was recorded in the intercrop plots that received no fertilizer.

Correlation of garden egg fruit yield and some other characteristics

The correlation coefficient showed that the number of fruits per plant (r = 0.970**), weight of fruits per plant (r = 0.985**) and leaf area (0.640**) in 2009 were strongly and positively associated with the fruit yield of garden egg (Table 8). In 2010, these parameters showed strong and positive relationship with the garden egg fruit yield except the leaf area which had very weak but positive relationship (r = 0.392**) with the fruit yield.

Table 9. Linear correlation coefficient between seed yield of egusi melon and some egusi melon plant characters.

Egusi melon fruit character	2009	2010
Number of fruits per plant	0.970**	0.843**
Weight fruit per plant	0.984**	0.982**
Diameter of fruit	0.868**	0.911**
Number of seeds per fruit	0.987**	0.777**
Weight of seeds per fruit	0.955**	0.950**
Weight of seeds per plant	1.000**	1.000**
Weight of 100 seeds	0.968**	0.961**

**Correlation significant at 0.01 level of significance.

In 2009 and 2010, respectively, the seed yield of egusi melon was strongly associated with the number of fruits per plant (r = 0.970** and 0.843**), weight of fruit per plant (r = 0.984** and 0.982**), fruit diameter (r = 0.868** and 0.911**) and weight of seed per fruit (r = 0.955** and 0.950**) (Table 9).

Productivity of the intercrop system

The productivity of the intercrop system, as determined by the land equivalent ratio, showed that in all the cropping systems, the LERs were above 1.00 in both cropping seasons (Table 10). The LERs in 2009 and 2010 indicated increase in LER as NPK 15:15:15 fertilizer rate increased, with the highest (2.41 and 2.59, respectively for 2009 and 2010 cropping season) when 400 kg/ha NPK was applied in the intercrop. In comparison with no fertilizer application in the intercropping system, the application of 400 kg/ha NPK in the intercrop plots produced a yield advantage of 127% and 149%, respectively in 2009 and 2010. However, there was a decline in the LER (2.13 and 1.90, respectively for 2009 and 2010) with 600 kg/ha NPK application.

Gross monetary return (GMR) of sole cropped garden egg was greater than the GMR of intercropped garden egg; and was more than 200% greater than those of sole egusi melon and intercropped egusi melon in 2009 and 2010 (Table 11). Amongst the treatments, GMR increased with increased NPK 15:15:15 fertilizer rates, attaining highest value (>₦2 million) at 400 kg/ha NPK in both 2009 and 2010. In all instances, garden egg contribution to total GMR was higher than that of egusi melon in spite of the price value of the later (₦320.00/kg) which was greater than the price of the former (₦133.30/kg).

Discussion

The taller garden egg plants in the mixture may be associated with the growth resource competition between the component crops. There is usually higher inter-specific competition for resources in the intercropping situation than in the sole plots. The effect of this higher inter-specific competition must have resulted in etiolation, hence elongation of the internodes with its corresponding taller shoots and lesser number of branches and leaves. Muoneke *et al.* (2012) opined that etiolated plants mostly possess narrow leaves which may convert less light energy to dry matter than plants with broad leaves.

This explains why the intercropped garden egg plants were significantly ($P<0.05$) taller than their sole crops and the number of branches and leaves per plant higher when garden egg was grown singly than when intercropped with egusi melon, in both 2009 and 2010 cropping seasons.

Table 10. Land equivalent ratio (LER) of garden egg and egusi melon intercrop as affected by cropping system and NPK fertilizer rates.

	2009			2010		
	Partial LER			Partial LER		
Cropping system + NPK fertilizer rate (kg/ha)	Garden egg	Egusi melon	Total	Garden egg	Egusi melon	Total
Intercrop + 0	0.69	0.37	1.06	0.68	0.36	1.04
Intercrop + 200	0.89	0.63	1.52	0.98	0.62	1.60
Intercrop + 400	1.09	1.31	2.41	1.26	1.33	2.59
Intercrop + 600	1.06	1.07	2.13	0.80	1.10	1.90

Garden egg growth and yield parameters were increased by the application of NPK 15:15:15 fertilizer. The increase peaked when 400 kg/ha NPK 15:15:15 was applied, but declined at 600 kg/ha application. The advantageous effects of applying NPK fertilizer on the vegetative growth of crops have been elucidated in many works (Insaidoo and Quarshie-sam, 2007; Abayomi *et al.*, 2008; Ekwu *et al.*, 2012; Ndukwe *et al.*, 2014). Inorganic fertilizers exert strong influence on plant growth, development and yield (Stefano *et al.*, 2004).

The influence indicates the efficiency of fertilizer in producing more vigorous plants than when no fertilizer was applied especially in low fertile soils. The nutrient released by the NPK 15:15:15 application as well as their utilization by the crops may have been optimal at 400 kg/ha application hence the decline after the rate. Increased plant height, number of leaves and branches as well as leaf area with the increased application of NPK (60 and 120 kg/ha) to 'White Yalo' and 'Green Yalo' varieties of garden egg had been reported by Akinsanya (2010).

The declined at 600 kg/ha NPK application implied that 400 kg/ha of NPK fertilizer application could represent an optimum NPK level for optimum growth and yield of garden egg in the study area. The 600 kg/ha may be said to be the toxic level since it retarded the number and weight of fruits as well as fresh fruit yield. This is in agreement with (Law-Ogbomo and Law-Ogbomo, 2009) who suggests that the 400 kg/ha NPK may be regarded as the optimum level of the nutrient elements while the 600 kg/ha NPK may be said to be toxic level, since it retarded growth (dry matter accumulation) and grain yield of maize in Benin City, Nigeria. The 400 kg/ha NPK application in this report, may have supplied optimum nutrients, particularly potassium which enhanced fruit and seed development of garden egg. The absence of inter-specific competition in the egusi melon sole cropping system compared to the intercropping system (where there is much inter-specific competition), may have resulted in the accumulation of higher dry matter in the egusi melon vine. This could explain why the vine (aboveground biomass at dry basis) dry weight was significantly higher in sole crop than in the intercrop.

Table 11. Gross monetary return (GMR) of garden egg and egusi melon intercrop as affected by cropping system and NPK fertilizer rates.

	2009			2010		
	Partial GMR (₦)			Partial GMR (₦)		
	Garden egg	Egusi melon	Total	Garden egg	Egusi melon	Total
Sole garden egg	1,620128.2		1,620128.2	1,529217.6		1,529217.6
Intercrop garden egg	1,397517.2		1,397517.2	1,306606.6		1,306606.6
Sole egusi melon		447680	447680		443520	443520
Intercrop egusi melon		310400	310400		311360	311360
Intercrop + 0 kg NPK	1,113188.3	165440	1,278628.3	1,037473.9	157440	1,194913.9
Intercrop + 200 kg NPK	1,445638.5	280960	1,726598.5	1,493226.6	274560	1,767786.6
Intercrop + 400 kg NPK	1,765558.5	589440	2,354998.5	1919520	589440	2,508960.0
Intercrop + 600kg NPK	1,711172.1	480640	2,191812.1	1,221427.9	487040	1,708467.9

Egusi melon responded to fertilizer application since the vine length and dry weight of aboveground biomass progressively increased as the NPK 15:15:15 rate increased from zero to 400 kg/ha and thereafter declined to 600 kg/ha application in 2009 and 2010. The decline of the vine length with application of 600 kg/ha NPK indicated that this rate could represent the toxic level of the nutrients to the plant.

Higher number of fruits per plant, weight of fruits per plant, fruit diameter, number of seeds per fruit, weight of seed per fruit, weight of seed per plant, weight of 100-seeds and seed yield obtained in sole crop egusi plots was probably as a result of reduced or no interspecific competitions in the plot. The application of 400 kg/ha NPK may be regarded as the optimum level of the nutrient elements while the 600 kg/ha NPK may be said to be the toxic level, in the system since all the yield and yield components of egusi melon were highest at 400 kg/ha application and declined at 600 kg/ha.

Intercropped egusi melon with no fertilizer application recorded lowest plant dry weight in 2009 and 2010 and this could be as a result of less accumulation and partitioning of dry matter, probably due to lesser amounts of nutrients available in the no fertilized plots.

The highest number of seeds per fruit, heaviest seeds per plant and heaviest 100-seeds attributed to sole egusi melon that received 400 kg/ha NPK 15:15:15 indicated that there should have been a reduced intra-specific competition in the sole egusi melon plots and that 400 kg/ha NPK 15:15:15 may be regarded as the optimal dose of nutrients in the study area for egusi melon production. This fertilizer rate may have enhanced and sustained release of adequate nutrients for optimum dry matter partitioning in the egusi melon seeds. Expectedly, the number of seeds per fruit, seed weight per plant, seed yield and 100-seed weight were least when egusi melon was intercropped with garden egg without applying NPK 15:15:15 fertilizer.

Resources for crop growth and development must have been unfavorably competed between the component crops. This may have also been worsened by lack of exogenous nutrient input as the treatment was garden egg intercropped with egusi melon without NPK 15:15:15 fertilization.

The reduction in weed density by the intercropping systems agreed with previous reports who revealed that the intercropping system helps to suppress weed through more efficient use of environmental resources by the component crops (Poggio, 2005; Eskandari and Kazemi, 2011) especially with no fertilizer application as plants in these plots will have less nutrients. The growth and development of the weeds must have been impeded in the intercrop plots due to less availability of environmental resources (nutrients, light, and moisture) necessary for their development within the intercropping systems as the component crops must have had better utilization of these resources. In addition, egusi melon is a creeper and serve as cover crop thereby (enhancing the weed-suppressive ability) suppressing weeds better than garden egg. This could probably explain why the suppression of weeds was more in egusi melon plots than in garden egg plots.

However, higher weed density in the sole plots of the component crops, especially with the application of NPK 15:15:15 could be due to higher availability of nutrients and less inter- and intra-specific competition of the nutrients to the plants. High total nutrient uptake in intercropping has been reported (Bulson *et al.*, 1997). This greater nutrient uptake is usually presumed to be possible, because of some complementary exploration of the soil profile by intercrop components (Ahlawat *et al.*, 1985) of fuller use of resources over time (Willey, 1990). Weed biomass have also been reported to be significantly greater in sole crop systems than in the intercrop systems in maize and cowpea intercropping systems (Eskandari and Kazemi, 2011).

There was increase in weed density as the fertilizer rates increased. The nutrient supply with fertilizer application may have not only enhanced the growth and development of the component crops but also the weeds. However, the greatest weed suppression at 6 WAP and harvest was recorded in the intercrop plots that received no fertilizer can be attributed to less availability of nutrients in the no-fertilized plots, hence leaving the component crops and weeds less nutrients to compete for, unlike the fertilized plots where there should be more nutrients available for both inter- and intra-competition.

The strong and positive correlation associated with the fruit yield and number of fruits per plant, weight of fruits per plant and leaf area corroborated with the finding of College of Agricultural Sciences (2013) that fruit yield is a function of number of fruits per acre and average fruits size. The number of fruits and weight of fruits were also reported to have a strong and combined effect on bunch yield of plantain (Baiyeri and Mbah, 1997). They concluded that number and fruit weight will enhance breeding efforts to improve on plantain yield. Therefore, the number and weight of garden egg fruits could be useful parameters in predicting fruit yield of garden egg in the mixture.

The seed yield of egusi melon was also strongly related to number of fruits per plant, weight of fruit per plant, fruit diameter and weight of seed per fruit. The seed yield of any fruit is a function of seed number and seed size (Nerson and Paris, 2000). The implication, according to our results, is that the number of fruits, weight fruit, fruit diameter and weight of seed per fruit of egusi melon could be used to predict the seed yield of egusi melon.

The productivity of the intercrop system (as determined by the land equivalent ratio and gross monetary returns), showed that the LER were above 1.00 in all the cropping systems and in both cropping seasons. The implication is that intercropping of garden egg and egusi melon is advantageous.

The highest LER and GMR obtained with the application of 400 kg/ha NPK 15:15:15 further confirmed that the optimum level of NPK 15:15:15 fertilizer in garden egg and egusi melon intercrop is 400 kg/ha and the application beyond this may result in nutrient toxicity.

In all instances, garden egg contribution to total GMR was higher than that of egusi melon in spite of the price value of the later (₦320.00/kg) which was greater than the price of the former (₦133.30/kg). This could be attributed to the successive fruit harvest and selling of the garden egg unlike that of egusi melon which was harvested once.

This successive harvest from garden egg may explain why the component crop contributed to total GMR than the other component crop, egusi melon.

Conclusion

Intercropping of *Solanum gilo* and *Colocynthis citrullus* proved advantageous. Similarly, the addition of exogenous nutrients improved the growth and yield of these component crops. Hence, the application of 400 kg/ha NPK fertilizer was recommended if *S. gilo* and *C. citrullus* are intercropped, especially in the study area. This rate enhanced the optimum growth and yield of both component crops. Similar work can be carried out in other locations. Further investigation may be carried out to ascertain the complementary effect of both organic and inorganic fertilizers on the productivity of *S. gilo* and *C. citrullus* intercrop.

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