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Research Paper

Growth and yield parameters of maize and *egusi* melon in intercrop as influenced by the cropping system and different rates of NPK fertilizer

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Abstract. The effect of different rates of NPK 20:10:10 fertilizer on the growth and yield of *egusi* melon (*Colocynthis citrullus* L. Schrad)/maize (*Zea mays* L.) intercropping system were examined in 2011 and 2012 cropping seasons. Maize and *egusi* melon were planted sole, and also in intercrop: the maize and *egusi* melon constituted the main plot treatment while the sub plot was different fertilizer rates (0, 200, 400 and 600 kg/ha). Intercropping reduced the grain yield of maize and the seed yields of *egusi* melon. Application of 200 kg/ha NPK 20:10:10 fertilizer significantly (P = 0.05) promoted the yield of maize and *egusi*-melon. The competitive abilities of the component crops were enhanced at increased fertilizer application rate. The total LER in all intercropping situations were greater than one, indicating that the two crops in mixture were able to utilize the growth factors maximally for their optimum yield and productivity.

Keywords: Cropping system, NPK fertilizer, *egusi* melon, maize.

INTRODUCTION

Intercropping is a farming system which involves growing two or more crops simultaneously on the same field. It is a stable and sustainable agro-ecosystem in the humid tropics. It is used extensively in areas of survival in tropical agriculture (Federer, 1999; Ayoola et al., 2011). The peasant farmers generally prefer the intercropping system because it produces higher total crop yield per unit area, provides insurance against total crop failure, and also reduces incidences of pests and diseases (Lyocks et al., 2013; Muoneke et al., 2002). Intercropping, as a system of farming, is becoming more popular among the small scale farmers as it offers the yield advantages relative to sole cropping through yield stability and improved yield (Bhatti et al., 2006). A very serious set-back of the intercropping system though, is the difficulty experienced in the practical management of the intercrop; the component crops in intercrop have different requirements for pesticide, herbicide and fertilizer (Teriah, 1990; Santalla et al., 1994). It is therefore difficult to determine the best input required for optimum yield of the component crops. Fertilizer requirements of the mixed intercropping systems has been a matter of conjecture; some workers suggest that fertilizer requirements of the dominant component (maize) be applied (Ahmed and Gunasena, 1979), others recommend that the sum of the sole crop requirements, be applied (Haizel, 1994). But Teriah (1990) stated that both practices have proved either inadequate or wasteful.

The aims of this research therefore were to: (i) establish the optimum fertilizer NPK 20:10:10 application rate for maize and *egusi* melon in intercrop;

Table 1. Physico-chemical properties of soil at the upper 15 cm of the experimental site.

Soil characteristics	2011	2012
Physical properties		
Sand (%)	78.4	79.2
Clay (%)	17.3	16.6
Silt (%)	4.3	4.2
Texture	Sandy loam	Sandy loam
Chemical properties		
pH (1:2.5, soil: water)	5.10	6.7
Organic matter (%)	2.15	2.18
Total N(%)	0.07	0.05
Available P (mg kg^{-1})	10.05	9.9
Exchangeable	Bases (C.mol kg^{-1})	
Ca	1.62	1.98
K	0.08	0.14
Na	0.26	0.38
Mg	0.16	0.24

and also to (ii) evaluate the productivity of the mixture.

MATERIALS AND METHODS

The experiment was conducted during the 2011 and 2012 cropping seasons at the National Cereals Research Institute, Owot Uta Substation, near Uyo. Owot Uta lies on Latitude 04°32' and 05°3' N, and Longitude 08°02' and 07°32'E. It received annual rainfall of about 2697.8 mm in 2011, and 2204.6 mm in 2012. The physical and chemical properties of the upper 15 cm of the soil profile are presented in Table 1.

The experimental plot was ploughed and harrowed. Lime at the rate of 0.5 tons/ha was incorporated into the soil two weeks before sowing, as the soil analysis result indicated high acidity (pH 5.10). Hybrid maize (Oba Super 2) and local *egusi* melon (*sewere*) seeds were used for the experiment. The experiment comprised 3 × 4 split plots in randomized complete block design (RCBD) replicated three times. The main plot was cropping system comprising sole maize, sole *egusi* melon and maize/*egusi* melon intercrop. The sub plots were the fertilizer rates (0, 200, 400 and 600 kg/ha).

Maize was sown at a population density of 53,330 plants/ha (75 × 25) cm, *egusi* melon was planted between the maize rows at (75 × l00) cm, giving a plant population of 13,330 plants/ha. The experiment was conducted between 28th March 2011, and on 18th March 2012. Each sub plot measured (6 × 3.75) m, and were separated by paths measuring 1.2 m wide.

The fertilizer was applied at 2 weeks after sowing (WAS) using side-dressed method at 15 cm from the stand of maize and melon. The plots were kept weed-free by hoe weeding when necessary. Five plants each of maize and *egusi* melon from the inner rows were randomly selected and tagged for the purpose of data collection. Data were taken on plants height (cm) and leaf area index (for maize), and length of vines, and flowering to podding interval (for *egusi* melon).

Data on yield and yield components were taken from five crops each of maize and *egusi* melon from the inner rows. The grain yield of maize was taken at 15% moisture contents. Land equivalent ratio (LER) was computed to ascertain the productivity of the intercropping system.

This was calculated using the equation:

$$\text{LER} = \frac{\text{Yield of intercropped maize}}{\text{Yield of sole maize}} + \frac{\text{Yield of intercropped } \textit{egusi} \text{ melon}}{\text{Yield of sole } \textit{egusi} \text{ melon}}$$

The Gross Monetary Returns (N/ton) of the component crops were determined by the prevailing prices of maize grains and melon seeds in Uyo main market.

Data analysis

Data were analyzed separately on each crop using the procedures for RCBD as outlined by Steel and Torrie (1980). Significant treatment mean differences were separated using Fishers Least Significant Difference (F-SLD) at probability of 0.05.

RESULTS

Height of maize plants were not affected by the cropping

Table 2. Effects of cropping system and different NPK fertilizer/rates on height, tarselling and silking of maize.

Parameter	Plant height (cm)					Days to 50% tarselling	Days to 50% silking
	4 WAP	6 WAP	8 WAP	10 WAP	12 WAP		
2011 cropping season							
Cropping system							
Sole	27.27	56.50	112.62	150.62	171.60	57.33	65.17
Intercrop	19.90	43.18	85.18	131.88	151.83	57.67	65.83
LSD (P = 0.05)	N.S	N.S	N.S	N.S	N.S	N.S	N.S
NPK fertilizer rate (kg/ha)							
0	20.77	45.33	95.97	137.30	160.10	58.3	67.00
200	22.67	47.43	96.23	145.03	165.13	57.67	65.83
400	27.10	52.47	100.93	141.43	158.30	52.50	65.50
600	23.80	54.13	102.47	141.23	163.33	56.50	63.67
LSD (P = 0.05)	N.S	N.S	N.S	N . S	N.S	1.90	1.84
2012 cropping season							
Cropping system							
Sole	17.50	61.67	108.92	144.33	158.42	57.50	66.42
Intercrop	17.58	69.08	148.67	177.33	189.92	58.25	66.42
LSD (P = 0.05)	N.S	N.S	25.89	24.72	25.37	N.S	N.S
NPK fertilizer rate (kg/ha)							
0	14.50	36.50	79.00	135.50	156.83	58.17	67.50
200	15.83	70.17	147.50	179.33	187.00	57.17	66.00
400	17.50	77.17	142.33	158.00	173.83	58.17	66.67
600	22.33	77.67	146.33	170.50	179.00	58.00	64.87
LSD (P = 0.05)	3.26	14.19	36.62	34.96	N.S	1.09	1.36

system in 2011, but in 2012 intercropped maize were taller than sole maize (Table 2). Fertilizer application also significantly increased the height of maize during the two cropping seasons. In 2012, the effect of NPK fertilizer, even at lowest rate (200 kg/ha) was significant. Maize plants in all the plots that received fertilizer were similar in height, but they were all taller than those that received no fertilizer. Applying 600 kg/ha NPK delayed silking by 3 days in 2012 whereas tarselling was not affected by application of similar fertilizer rate in 2011. Length of vines of *egusi* melon plants, up to 8 WAS were not affected by the cropping system (Table 3). But fertilizer application significantly ($P < 0.05$) increased vine length of melon which increased with increase in NPK fertilizer application rate. Longest *egusi* melon vines were produced in plots fertilized with highest rate (600 kg/ha) of NPK fertilizer in both years. Nonetheless, days to flowering and flowering to fruiting interval were significantly influenced by fertilizer application.

Yield

Grain yield (kg/ha) of maize was reduced due to interspecific and intraspecific competition in the growth environment (13% in 2011 and 8.3% in 2012) (Table 4). Number of cobs/m^2 and the weight of 100 grains were also reduced in 2011 but not in 2012. Length of cobs and kernel weight per cob of maize were not affected by intercropping. However, the grain yield of maize increased as the NPK fertilizer application rates increased.

In 2011 cropping season, the mean yield produced at fertilizer application rate of 400 kg/ha was 11.43% higher than those produced in the control plot. The highest grain yields (1758.47 kg/ha) was produced at the highest NPK application rate of 600 kg/ha. This however was not significantly different from grain yield (kg/ha) obtained in plots fertilized with 200 or 400 kg/ha NPK. Kernel weight per maize cob was not affected by NPK fertilizer application. The number of kernels per cob was significant in 2011, but not in 2012. Cob length however increased with increase in NPK fertilizer application rate.

Melon seed yield was reduced due to the cropping system (Table 5). Reduction in seed yield was 15.74% in 2011 and 0.14% in 2012. Fruit sizes, number of seeds per fruit and number of fruits per m^2 were also reduced in intercropped plots. Melon seed yield was however increased when fertilizer was applied; the highest seed yield was constantly produced at fertilizer application rate of 400 kg/ha.

Table 3. Effects of cropping system and NPK different fertilizer/rates on vine length, flowering and fruiting of melon.

Parameter	Vine length (cm)			Days to 50% flowering	flowering to fruiting interval (days)
	4 WAP	6 WAP	8 WAP		
2011 cropping season					
Cropping system					
Sole	51.04	152.02	266.38	26.58	11.92
Intercrop	51.78	166.57	289.32	27.17	12.42
LSD (p = 0.05)	N.S	N.S	N.S	N.S	N.S
NPK fertilizer rate (kg/ha)					
0	49.40	128.00	259.07	26.50	10.67
200	51.63	150.90	276.77	26.33	11.17
400	52.45	176.63	283.47	26.33	12.67
600	52.17	181.63	292.10	28.33	14.17
LSD (P = 0.05)	2.9	31.03	24.71	0.99	0.98
2012 cropping season					
Cropping system					
Sole	49.83	68.17	131.33	29.92	13.42.
Intercrop	52.75	75.83	129.75	30.00	13.17
LSD (P =0.05)	N.S	N.S	25.89	N.S	N.S
NPK fertilizer rate (kg/ha)					
0	37.33	54.17	105.00	30.0	13.00
200	50.17	67.67	121.00	29.67	13.83
400	50.17	72.33	146.17	29.50	13.33
600	60.50	93.83	150.00	30.67	13.00
LSD (P = 0.05)	10.01	10.84	24.05	N.S	N.S

Fertilizer application rate of 600 kg/ha produced the highest number of fruits per plant. NPK 20:10:10 application rate of 200 kg/ha was however significant, but the highest mean yield for the two cropping seasons was obtained at application rate of 400 kg/ha. It was also observed that fruit sizes and number of seeds per fruit, seeds weight and number of fruits per plant produced at NPK fertilizer application rate of 600 kg/ha were not significantly ($P < 0.05$) different from those produced at fertilizer application rate of 400 kg/ha in 2011.

The total LER in all the intercropped plots were greater than one (Table 6), indicating higher productivity of the intercropping system. NPK application rate of 400 kg/ha produced the highest LER in 2011, while in 2012, 600 kg/ha gave the highest LER.

DISCUSSION

Maize grows erect and is noted for its rapid growth rate and aggressiveness in competition with associated crops (Uzo, 1983).

Maize plants in intercrop with egusi melon increased their height in 2012. Increase in the height of maize may be attributed to the early competition in the growth environment, and the desire of maize to expose its leaves to sunlight for photosynthesis (Muoneke et al., 1997). Lyocks et al. (2013) reported that maize and ginger plants grew taller in intercrop in attempt to absorb direct sun rays and thus accumulate dry matter in the process. Delayed maturity of maize could be attributed to the effect of Nitrogen; it seem high doses of Nitrogen promoted vegetative growth of the component crops at the expense of reproductive factors; high doses of Nitrogen have been implicated in the delayed maturity of maize (Harper, 1983). Hardter et al. (1991) reported a depression of maize yield when sown in mixture with cowpea; they attributed the reduction in maize yields to competition for growth factors between the associated crops. Similar results have also been reported by Terriah (1990) and Wahua (1983). Considering that maize yields produced at fertilizer application rate of 400 kg/ha was not significantly different from the yields obtained at application rate of 600 kg/ha. It is apt to suggest that fertilizer application at the rate of 400 kg/ha be adopted for optimum performance and yield of maize and *egusi* melon intercropping system.

The total LER in all the intercropped plots were greater

Table 4. Effects of cropping system and different NPK fertilizer/rates on yield and yield components of maize.

Parameter	Weight of kernels per cob (g)	Weight of 100 grains (g)	Number of cob/m^2	Number of grains/cob	Length of cobs/(cm)	Grain yields (kg/ha)
2011 cropping season						
Cropping system						
Sole	110.83	25.56	6.93	699.2	18.85	1717.76
Intercrop	110.26	25.21	6.93	692.3	18.67	1491.49
LSD (P = 0.05)	N.S	N.S	N.S	N.S	N.S	87.73
NPK fertilizer rate (kg/ha)						
0	110.38	24.58	6.84	999.2	18.37	1497.02
200	108.94	25.15	6.93	389.9	18.67	1577.76
400	112.59	25.54	6.97	401.9	18.93	1690.35
600	110.29	26.28	6.98	394.1	19.06	1653.32
LSD (P = 0.05)	N.S	N.S .	0.06	918.04	0.67	124.07
2012 cropping season						
Cropping system:						
Sole	111.61	25.71	6.87	402.66	18.77	1770.10
Intercrop	108.22	24.85	6.90	386.94	18.48	1623.51
LSD (P = 0.05)	N.S	0.78	N.S	14.32	N.S	67.83
NPK fertilizer rate (kg/ha)						
0	106.78	24.30	6.80	384.33	17.99	1590.86
200	111.81	25.22	6.87	398.83	18.70	1718.63
400	112.38	25.32	6.91	397.35	18.90	1719.25
600	108.68	26.29	6.97	398.68	18.91	1758.47
LSD (P = 0.05)	N.S	0.10	1.13	N.S	0.61	95.92

Table 5. Effects of cropping system and different NPK fertilizer / rates on yield and yield component of melon.

Parameter	Fruit diameter (cm)	Number of seeds per fruit	Number of fruits per m^2	Weight of 100 seeds (g)	Seed yield (kg/ha)
2011 cropping season					
Cropping system					
Sole	14.58	345.73	0.12	11.38	517.19
Intercrop	13.14	299.02	0.11	11.17	435.78
LSD (P = 0.05)	0.49	17.96	0.02	0.20	62.27
NPK fertilizer rate (kg/ha)					
0	13.99	300.50	0.12	10.49	413.63
200	13.58	314.40	0.10	11.30	450.89
400	14.38	346.20	0.12	11.54	564.37
600	13.49	328.40	0.12	11.67	477.04
LSD (P = 0.05)	0.69	25.39	0.03	0.28	88.06
2012 cropping season					
Cropping system					
Sole	15.48	368.24	0.14	11.2	571.1
Intercrop	13.98	328.68	0.13	10.94	524.44
LSD (P = 0.05)	0.65	26.72	0.01	0.15	77.8

Table 5. Contd.

NPK Fertilizer rate (kg/ha)					
0	14.17	313.62	0.12	10.42	435.56
200	14.98	370.00	0.15	10.80	519.26
400	14.43	326.05	0.12	11.43	954.07
600	15.32	384.18	0.15	11.66	642.22
LSD (P = 0.05)	0.92	37.79	0.02	0.21	110.10

Table 6. Effects of cropping system and NPK fertilizer/rates on Land Equivalent Ratio (LER) and Gross Monetary Returns (GMR) in sole and intercropped maize and melon.

Parameter	Land Equivalent Ratio			Gross Monetary Return (₦/ton)		
	Partial		Total	Partial		Total
	Maize	Melon		Maize	Melon	
2011 cropping season						
Cropping system						
Sole maize	1.00	-	1.00	171,776.00	-	171,776.00
Sole melon	-	1.00	1.00	-	62,062.00	62,062.00
NPK fertilizer rates (kg/ha)						
0	0.87	0.80	1.67	149,702.00	49,635.60	199,337.60
200	0.92	0.87	1.79	157,776.00	54,106.80	211,882.80
400	0.98	1.09	2.07	169,035.00	67,724.40	236,759.40
600	0.96	0.92	1.88	165,332.00	57,224.00	222,556.00
2012 cropping season						
Cropping system						
Sole maize	1.0	-	1.0	177,010.00	-	177,010.00
Sole melon	-	1.0	1.0	-	62,932.80	62,932.80
NPK fertilizer rates (kg/ha)						
0	0.89	0.83	1.72	159,086.00	52,267.20	211,353.20
200	0.97	0.99	1.96	171,863.00	62,311.20	234,174.40
400	0.97	1.13	2.10	171,926.00	71,288.40	243,214.40
600	099	1.22	2.21	1 75, 847. 00	77 ,066.40	252,913.40

than one (Table 6), indicating higher productivity due to intercropping. It seems the NPK fertilizer application rate of 600 kg/ha actually promoted biological yield at the expense of economic yield, this can be seen in the lower LER value (1.88) obtained at that level of fertilizer application compared to 2.07 obtained when 400 kg/ha was applied. Harper (1983) stated that if the cost of fertilizer is deducted from the value of the crop, profitability begin to decline after 100 kg/ha N. The LER value of 2.21 obtained in 2012 cropping season was only marginally higher than 2.10 (LER) obtained at 400 kg/ha in the same year, indicating that application rate of 400 kg/ha NPK was cost effective. Ayoola et al. (2011) reported highest significant cassava root yield from NPK fertilizer application rate of 400 kg /ha. The average GMR for the two cropping seasons therefore suggest that it is more profitable to apply NPK 20:10:10 fertilizer at the rate of 400 kg/ha to maize/melon intercropping system.

The control plot had the lowest returns in the two cropping seasons suggesting that NPK 20:10:10 fertilizer even at the rate of 200 kg/ha could produce significant returns. Ano and Okwor (2006) stated that fertilizer application at 200 kg/ha (NPK 20:10:10) significantly increased yam yield and productivity of the sole yam minisette cropping system.

Conclusion

The result of this experiment indicate that maize and egusi melon could be intercropped for optimum productivity if the correct regimes of NPK 20:10:10 fertilizer applied.

Results also indicate that NPK fertilizer application rate of 400 kg/ha (or 80 kg N/ha, 40 Kg [P_2O^5]/ha, 40kgK_2O/ha) was cost effective.

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