academicJournals

Vol. 14(50), pp. 3282-3287, 16 December, 2015
DOI: 10.5897/AJB2015.14858
Article Number: 1215D3B56605
ISSN 1684-5315

http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Fertilizer use efficiency by maize (*Zea mays*) and egusi-melon (*Colocynthis citrullus*) in various cropping ratios in an ultisol in Edo rainforest area of Nigeria

J. O. Ehigiator[1], G. O. Iremiren[2] and E. J. Falodun[2]*

[1]Department of Soil Science, Faculty of Agriculture, University of Benin, Nigeria.
[2]Department of Crop Science, Faculty of Agriculture, University of Benin, Nigeria.

Received 16 July, 2015; Accepted 19 November, 2015

Three separate field studies were conducted in a rainforest area to determine efficient use of applied fertilizers by maize and egusi-melon in various ratios of mixtures in an ultisol in Nigeria. The experiment was a factorial combination of seven cropping ratios of maize and egusi-melon (MA:EM 1:0, 1:1, 2:1, 3:1, 1:2, and 1:3, respectively) tested under four levels of NPK 20:10:10 (0, 200, 400, and 600 kg/ha) fertilizers replicated three timesfor two years as experiments 2009 and 2010, respectively. The fertilizer rates were increased by two levels (800 and 1000 kg/ha) in the third year as experiment 3 to validate earlier results of experiments 2009 and 2010. Efficient use of the applied fertilizers by maize and egusi-melon was determined in the 3 year study. Fertilizer use efficiency (FUE) was generally higher in experiments 2010 and 2011 than in 2009 and was also higher in sole cropping of maize and egusi-melon than their intercrop. The two crops efficiently used the applied fertilizers better with the lower rates (200 and 400 kg/ha) than the higher rate (600 kg/ha) in experiments 2009 and 2010, respectively. Even when the rates of the fertilizer were increased to 800 and 1000 kg/ha, respectively in experiment 3, FUE became progressively lower. Effectiveness of both crops with respect to FUE gradually declined with increasing levels of the fertilizer in all the trials. In intercrop, FUE was better for maize when intercropped with egusi-melon at 3:1 ratio than the other ratios in the three experiments. And for egusi-melon, FUE was best at the crop mixture of 1:2 in 2011. At each rate of the fertilizer, FUE of sole maize was similar to the value obtained for it in intercrop with egusi-melon at 3:1 ratio in all the experiments; FUE for sole egusi-melon at each fertilizer rate was significantly better ($p<0.01$) than the corresponding values from it in intercrop with maize in all the cropping ratios in each experiment. The implication of this finding is that egusi-melon is a poor competitor with maize for applied fertilizers and inherent soil nutrients while maize is a better competitor as its intercrop with egusi-melon had no adverse effect on its FUE when compared with sole maize.

Key words: Fertilizer use efficiency,cropping ratios, Intercropping.

INTRODUCTION

Intercropping system involving various crops and their rotations are common practices in the tropical and temperate regions for many reasons (Yamoah et al., 2003). High and stable yields with enhance income are some of the reasons for the practice in Niger, Burkina Faso, while in the USA, it is used to reduce the levels of

diseases and pests infestation. And in Nigeria, it is used to avoid complete crop failure and reduce incidence of weeds, which are added reasons for the practice (Ehigiator, 1998). Growing crops in mixtures have been ascribed the benefit of improving yield of companion crops in intercrop (Yamoahet al., 2003) and have not received adequate research attention. However, cropping ratios of crops in mixtures with respect to fertilizer useefficiency (FUE) lack research information. Over the years, blanket fertilizer recommendations have been applied to crop mixtures (Fondufe et al., 2001; Agoume and Birang, 2009). Fertilizers recommendation is usually based on fertilizer need of the choice of one crop for the other(s) in intercrop; and not supported by any research data. Scarcity of mineral fertilizer and the attendant high cost (Ojeniyi, 2010) are constraints to its use among small scale farmers in Africa (Rahman, 2004) and the use of organic manure is not reliable owing to its limitations including low content and slow release of the nutrients (Onwu et al., 2014; Ehigiator, 1998). Efficient use of the inorganic fertilizer by crops will be of advantage and profit to farmers.

Maize (*Zea mays*) and egusi-melon (*Colocynthis citrullus*) are important crops in Nigeria owing to their food values; hence, they are commonly grown in mixture without reference to cropping ratios and use of fertilizers. This may have accounted for their low yields over the years relative to yield output from similar countries in the tropics or temperate (Nwosu, 2005). Maize is consumed boiled, roasted or processed into other forms of food and flour for confectionaries. Egusi-melon seeds are important condiments in soups and also processed into vegetable oil for cooking. This informed the objective of this study which was to determine the FUE by maize and egusi-melon in mixtures and various ratios.

MATERIALS AND METHODS

The experiment was conducted under rain fed conditions for three years (2009, 2010, and 2011) at University of Benin (5°04' and 6° 43E, 6° 14'S and 7° 34'N), Nigeria, 500ft above the sea level.The experiment was conducted between March and August each year. The vegetation of the study area is tropical low land rainforest with mean annual rainfall of 2300mm. The predominant weeds at the experimental site prior to cultivation were guinea grass *(Panicum maximum*) and *Chromolaena odorata* with sparse population of *Centrosema* species at the background. The soil of the study area is of the order ultisols (Ojenuga et al., 1981). The experiment consisted of the combination of seven cropping ratios and four rates of NPK 20:10:10 fertilizer arranged in randomized complete block design. In 2011, the fertilizer rates were increased to six to further determine the optimum level of the fertilizer. The seven cropping ratios of maize and egusi-melon and their corresponding plant populations in each plot were as follows: 1:0, sole maize (64); 0:1, sole egusi-melon (64); 1:1(MA 32:32 EM); 2:1(MA 48:24 EM); 3:1(MA 48:16 EM); 1:2(MA 24:48 EM); 1:3(MA 16:48 EM); MA, Maize; EM, Egusi-melon.

Each plot was separated from the other by border row of 1.5m to avoid interaction effect. There were total of 28 plots replicated three times (84 plots) in 2009 and 2010 experiments; and 42 in 2011 experiment replicated three timesto give a total of 126 plots. Maize variety used were DMR-ESR-W (Downy) mildew resistant, early maturing streak resistant white colour obtained from International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria. Egusi-melon seeds were obtained from local farmer (in Orhionmwon) in Edo State Nigeria. The variety was "Bini" cultivar commonly grown in Edo South, medium in size smooth brown with no clear edges similar to "serewe" classified by Adeniran and Wilson (1981).The experimental area was ploughed, harrowed and marked into 84 plots of 162.2 m^2 each for experiments 1 and 2; and 126 plots (162.2 m^2 each)for experiment 3. In each year, maize and egusi-melon either in sole or intercrop were planted at spacing of 75 × 90 cm geometry as recommended by Norman (1992) at 3 seeds/hill in 16.2m^2 plots thinned to 2 seeds/hill at 5 days after seedling emergence.The plots in each experiment were weeded manually three times using hand hoe. Fertilizers were applied to the crops in two equal splits at 3 and 8 weeks after planting (WAP) coinciding with peak of vegetative growth and reproductive stages.

Maize was harvested dry at 85 days after planting; sun dried to 10% moisture content for final grain yield in kg/ha. Egusi-melonpods were collected after the vines and leaves had dried completely; the pods were partially split open at tops using cutlass for fermentation to take place before seeds were extracted, washed and sun dried to 12% moisture content to obtain seed yield (kg/ha).

FUE by the crops denotes the kilogrammes of either maize grain or egusi-melon seed produced per kilogram of the applied fertilizer. It was determined by the method described by Yamoah et al. (2003) as:

$$\frac{Yield\ due\ to\ native\ soil\ fertility\ +\ yield\ due\ to\ fertilizer\ (kg/ha)}{Total\ amount\ of\ fertilizer\ applied\ (kg/ha)}$$

FUE is a measure of nutrient use efficiency.

The datawas analyzed using the Genstat statistical analysis systems, (SAS, 1990). Differences between treatments and their interactions were compared using standard errors of the means (SE) least significant difference (LSD).

RESULTS

FUE of maize and egusi-melon intercrop

FUE was generally higher in 2009 and 2010 than in 2011 (Table 1). Also, FUE was higher in sole cropping of maize andegusi-melon than their intercrop. Both crops effectively utilized the applied fertilizers better at the lower rate of 200 and 400 (kg/ha) of 20:10:10 NPK than the higher rate of 600 kg/ha in 2009 and 2010, respectively. Even when the rates were increased to 800 and 1000 kg/ha, respectively in 2011, FUE became

*Corresponding author. E-mail: ehifalodun@yahoo.com.

Table 1. Fertilizer use efficiency of maize-egusi melon cropping ratios.

Cropping/Ratios/Fertilizer (kg/ha)	rates	Experiment 1		Experiment 2		Experiment 3	
		Yield (kg/kg 20:10:10: NPK fertilizer applied)					
	0	MA : EM		MA : EM		MA : EM	
	200	24.60	-	29.50	-	34.00	-
	400	14.00	-	15.00	-	17.50	-
1:0 Sole maize (MA1 : 0 EM)	600	9.83	-	11.17	-	8.11	-
	800	-	-	-	-	9.25	-
	1000	-	-	-	-	6.90	-
	200	-	11.11	-	7.45	-	8.43
	400	-	6.23	-	4.38	-	4.74
0:1 (Sole egusi-melon)	600	-	4.42	-	2.63	-	2.86
	800	-	-	-	-	-	2.10
	1000	-	-	-	-	-	1.61
	200	20.5	5.30	19.00	3.60	23.50	4.35
	400	10.87	3.00	10.00	1.95	12.50	2.34
MA1:1EM	600	7.46	2.37	7.00	1.50	8.66	1.68
	800	-	-	-	-	6.50	1.22
	1000	-	-	-	-	4.83	0.93
	200	25.60	5.90	29.00	3.95	33.00	4.23
	400	15.40	3.50	15.75	2.30	17.75	2.25
MA2:1EM	600	10.18	3.50	11.33	2.22	13.05	1.63
	800	-	-	-	-	9.46	1.19
	1000	-	-	-	-	7.40	0.91
	200	26.75	6.60	28.50	4.40	35.50	2.90
	400	14.43	4.05	15.50	2.56	18.75	1.48
MA3:1ME	600	10.18	2.98	10.85	1.93	13.05	1.00
	800	-	-	-	-	9.50	0.71
	1000	-	-	-	-	7.30	0.53
	200	14.40	5.25	14.00	3.40	20.15	4.80
	400	7.63	2.86	7.50	1.85	11.08	2.76
MA1:2EM	600	5.68	2.28	5.33	1.45	7.44	2.42
	800	-		-	-	5.83	1.75
	1000	-		-	-	4.50	1.33
	200	6.05	3.10	6.00	2.10	8.65	2.90
	400	3.68	1.60	3.50	1.05	5.00	1.35
MA1:3EM	600	3.03	1.28	3.00	0.83	4.00	1.00
	800	-	-	-	-	2.88	0.71
	1000	-	-	-	-	2.10	0.53
SE	-	1.28*	0.44*	1.35**	0.29**	1.58**	0.39**

*p<0.05, **p<0.01; MA: Maize; EM: egusi melon.

progressively, lower. Thus the effectiveness of both crops in terms of FUE gradually declined with increasing level of fertilizer rates (Table 1). In intercrops, FUE was better for maize where both crops were intercropped at 3:1

Table 2. Effects of cropping ratios of maize and Egusi-melon on yield and yield components of maize.

Parameter	Cropping ratios						
	1:0	1:1	2:1	3:1	1:2	1:3	SE
Experiment 1							
Number of ears/m^2	3.7	1.7	2.8	2.8	1.3	0.9	0.04*
Ear wt (g)	298.0	225.0	311.0	301.0	173.0	85.0	4.01*
Shelling (%)	75.0	74.8	74.6	74.2	74.9	74.3	0.56
Mean grain wt (g)	0.272	0.276	0.273	0.277	0.273	0.274	0.000
Grain (seed) yield (t/ha)	2.98	2.25	3.11	3.01	1.73	0.85	0.07***
Experiment 2							
Number of ears/m^2	3.9	2.0	2.9	2.8	1.5	1.0	0.14*
Ear wt (g)	342.0	214.0	327.0	325.0	172.0	84.0	5.0*
Shelling (%)	75.0	74.1	74.7	75.2	75.2	75.5	0.51
Mean grain wt (g)	0.277	0.274	0.274	0.277	0.275	0.277	0.0006
Grain (seed) yield (t/ha)	3.42	2.14	3.27	3.25	1.72	0.84	0.10***
Experiment 3							
Number of ears/m^2	3.9	1.9	2.8	2.0	1.5	1.0	0.5***
Ear wt (g)	312.0	196.0	275.0	275.0	154.0	115.0	6.97***
Shelling (%)	72.5	72.5	73.0	73.0	73.o	72.6	0.63
Mean grain wt (g)	07.276	0.276	0.275	0.278	0.277	0.277	0.0007
Grain (seed) yield (t/ha)	4.1	2.8	4.0	3.9	2.5	1.3	0.2***

*$p<0.05$.

ratio. For egusi-melon, this was only true in 2009 and 2010as FUE was best at the crop mixture of 1:2 ratio in2011 (Table 1). At each fertilizer rate, the FUE of sole maize was similar to the value obtained for maize when it was intercropped with egusi-melon at the 3:1 ratio, whereas the FUE for sole egusi-melon at each fertilizer rate was significantly higher ($p<0.01$) than the corresponding values obtained for intercropped egusi-melon at all cropping ratios in each experiment.

Effect of cropping ratios of maize and egusi-melon on yield and yield components of maize

Intercropping maize with egusi-melon significantly reduced the number of ears/$m^2$when compared with sole maize (Table 2) in 2009 and 2010 trials. The decrease progressed with increase in the ratio of egusi-melon with maize. Cropping ratio had no significant effect on shelling percentage and seed weight of maize (Table 2). However, grain yield of maize in 2:1 and 3:1 ratio with egusi-melon were significantly better than those of the other ratios, including the solecrop.

Effect of cropping ratios of maize and egusi-melon on pod yield and yield components ofegusi-melon

Egusi-melon consistently produced more number of pods/m^2in sole than its intercrop with maize in all the experiments (Table 3). Values obtain in the mixtures with higher ratios of maize (2:1 and 3:1) were similar to those of the sole crop, while mixture with higher ratios of egusi-melon (1:3) severely decreased the number of pods/m^2as oppose to sole crop. The various cropping ratios had no effect on the shelling percentage and mean seed weight of egusi-melon in each of the experiment (Table 3).Significant seed yield/ha differences were obtained with the value for sole crop out yielding those of egusi-melon in mixture with maize (Table 3). Progressive decrease in seed yield/ha of egusi-melon was greater in its higher component with maize particularly 1:3 ratio.

DISCUSSION

FUE which was a measure of nutrient use efficiency was generally higher under intercrop and low rate of 20:10:10 NPK fertilizer than anywhere else in the three experiments.

The FUE was highest under 200kg/ha rate of 20:10:10 NPK fertilizer than the higher rates. The reason being that the low rate of the applied fertilizer (200 kg/ha) was more efficiently utilized with crops, because of reduced competition than the high N rates which tend to enhance relative competitiveness of the maize (Azeez and Adetunji, 2007); and also, the high N rates may have

Table 3. Effects of cropping ratios of maize and egusi-melon on pod yield and yield components of egusi- melon.

Parameter	Cropping ratios						
	0:1	1:1	1:2	1:3	2:1	3:1	SE
Experiment 1							
Number of pods/m^2	4.8	2.9	3.0	1.8	4.4	4.2	o.12*
Fresh pod wt (kg/m^2)	2.9	1.4	1.6	0.9	2.1	2.0	0.01*
Pod dry matter yield (g/m^2)	184.8	117.0	116.5	76.7	178.8	164.7	0.05**
Shelling (%)	72.0	71.8	70.6	71.5	71.2	70.7	0.52***
Mean seed wt (g)	86.5	86.4	88.0	88.2	87.1	88.2	0.21
Seed yield (t/ha)	1.35	0.61	0.64	0.35	0.88	0.86	0.05*
Experiment 2							
Number of pods/m^2	5.0	2.9	3.0	1.8	4.7	4.1	0.12**
Fresh pod wt (kg/m^2)	2.5	1.5	1.5	1.0	2.2	2.0	0.05***
Pod dry matter yield (g/m^2) 75.3	189.5	166.7	120.1	75.1	175.4	165.2	0.03*
Shelling (%)	71.9	72.7	72.2	72.8	72.4	72.6	2.5**
Mean seed wt (g)	87.0	86.0	87.0	87.3	87.4	87.8	0.34*
Seed yield (t/ha)	0.89	0.45	0.41	0.23	0.57	0.56	0.03*
Experiment 3							
Number of pods/m^2	5.2	3.4	3.3	1.9	4.9	4.5	0.36**
Fresh pod wt (kg/m^2)	2.9	2.0	1.8	1.4	2.5	2.4	0.2**
Pod dry matter yield (g/m^2)	185.8	130.1	126.2	75.3	181.1	168.1	2.5**
Shelling (%)	71.9	72.7	72.2	72.8	72.4	72.6	0.53
Mean seed wt (g)	87.1	86.9	86.8	86.5	86.9	87.0	0.17
Seed yield (t/ha)	0.95	0.54	0.50	0.30	0.67	0.73	0.08**

*p<0.05; **p<0.01; ***p<0.001.

resulted in wastage either through luxury consumption of the fertilizer by the crops (Brady and Weil, 2004), therefore, not economical or leaching of the nutrients may have occurred (Ali et al.,2014) common in areas of high rainfall (Eche et al., 2014) in which the trials were done.It was observed that FUE decreased with an increase in 20:10:10 NPK fertilizer rates even when the rates of the fertilizer were increased beyond 600kg/ha in 2009 and 2010 to 800 and 1000 kg/ha in 2011. Yamoah et al. (2003) had earlier reported similarly that FUE will decrease with corresponding increase in fertilizer rates. Azeez and Adetunji (2007) also reported that N utilization efficiency by maize was the highest under low rate of 30kg/ha than the 90 kg/ha. The report added that N uptake and utilization efficiency at lower N rates was better than at higher N rates. The FUE was higher in 2011 than 2009 and 2010 for maize, while for egusi-melon the FUE was higher in experiment 2009 than 2010 and 2011.

The implication of this finding is that egusi-melon is a poor competitor with maize for applied fertilizers and inherent soil nutrients, while maize is a better competitor as intercropping it with egusi-melon has no adverse effect on its FUE when compared with sole maize. Increase inthe number of pods/m^2,fresh pod weight (kg/m^2) and pod dry matter yield were consistent with the previous findings of Ayoola and Adeniyan (2006) who stated that intercropping increases the number of pods and total dry matter yield. The decline in the number of pods and dry matter yield of egusi-melon in its low population with maize (2:1 and 3:1) indicated greater competition for space due to the high population of maize in the mixture (Fondufe et al., 2001).The result on seed yield of egusi-melon indicated that a significantly higher yield would occur from the sole crop, but if the crop is to be intercropped with maize, a 1:1 ratio will do as no yield benefit results from higher components of it with maize. Although maize yield in 1:1 ratio was significantly higher than those from the crop mixtures with high components of egusi-melon, the results indicate that maize yield was adversely affected and declined with progressive increases in its ratio with egusi-melon. This contradicted the results of Ikeogu (2004), but agreed with findings of Fondufe et al. (2001) and Ayoola and Adeniyan (2006).

Conclusion

FUE was generally higher under intercrop and low rate of the fertilizer than anywhere else in the three experiments.

The FUE was the highest under 200 kg/ha rate of the fertilizer with yield of sole maize at 34.00kg/kg of the applied fertilizer and 11.11 kg/kg of the fertilizer for sole egusi-melon.

In intercrop, FUE by maize in 3:1 ratio with egusi-melon produced yield of 35.50 kg/kg of the applied. The FUE by maize was the highest in its 3:1 ratio with egusi melon and at 200 kg/ha of the fertilizer; while for egusi-melon, it was 6.60kg/kg of the fertilizer. The FUE by both crops in sole or intercrop decreased with a corresponding increase in applied fertilizer. Grain yield of maize in 2:1 and 3:1 ratio with egusi-melon were significantly better than those of the other ratios including the sole crop.

Egusi-melon was found to be a poor competitor with maize for applied fertilizers. Egusi-melon consistently produced more number of pods/m^2 in sole than its intercrop with maize in all the experiments.Maize was a better competitor with egusi-melon. Intercropping maize with egusi-melon had no adverse effect on its (egusi-melon) FUE when compared with the sole maize.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Adeniran MO, Wilson GF (1981). Seed type: classification of egusi-melon in Nigeria 5th African Horticulture symposium, University of Ibadan, Nigeria 9 – 25 July 1981.

Agoume V, Birang AM (2009). Impact of Land Use systems on some physical and chemical soil properties of an oxisol in the Humid Forest zone of southern Cameroon.Tropicultura 27(1):15-20.

Ali A, Achor IO, Adaikwu AO (2014). Effect of *leucaenaLeucocephala* Biomass on soil physical and chemical properties in the sub-humid southern guinea savannah zone of Nigeria. Niger. J. Soil Tillage Res. 1:103-110.

Ayoola OT, Adeniyan ON (2006). Influence of Poultry manure and NPK Fertilizer on yield and yield components of corps under different cropping systems in South West Nigeria. Afr.J. Biotechnol. 5(15):1386-1392.

Azeez JO, Adetunji MT (2007). N-Use Efficiency of maize genotypes under weed pressure in a tropical alfisol in Northern Nigeria. Tropicalul 25(3):174-179.

Brady NC, Weil RR (2004). Role of N in plant nutrition in Elements of the Nature and property of soil.2nd Edition Pearson and Prentica Hall, New Jersey.

Eche NM, Amapu JY, Bruns MA, Odunze AC, Uyovbisere E (2014). Fertility management effect on soil physical and chemical properties under long term maize cropping in an Alfisol in Northern Guinea savannah zone. Niger. J. Soil Sci. 24(1):134-146.

Ehigiator JO (1998). Farm yard manure: Need for its Adoption as an Alternative to Chemical Fertilizer. Niger. J. Hortic. Sci. 3:1-9.

Fondufe EY, Eneji AE, Agboola AA, Yamamoto S, Honna T (2001). An Assessment of some fertilizer Recommendations under Different cropping systems in a Humid Tropical Environment. Tropicultura 19(1):21-27.

Ikeogu JEG (2004). Use of egusi melon to improve the productivity of yam mini setts/maize intercrop.Niger. Agric. J. 35:30-39.

Norman DW (1992).Cucurbitaceae crops in Tropical Vegetable crops. A.H. Stockwell Limited Publishers, Great Britain 242 p.

Nwosu KI (2005). Agricultural Rebirth for improved production in Nigeria. Proceedings, 39th Conference, Agricultural Society of Nigeria, University of Benin, Benin City, Nigeria.9 – 13 October, 2005 403 p.

Ojeniyi SO (2010). Advances in Integrated Nutrient Management for crop production in Nigeria.A Monograph.Dominion publishers plots 3 Government Reserved Area Ibadan Nigeria.

Ojenuga AU, Lekwa G, Akamigbo FOR (1981). Survey classification and Gensis of Acid bands in Acid Sands of Southern Nigeria: E.J. Udoh and R.A. Sobulo (eds.) Soil Science Society of Nigeria (SSSN) Special Publication Monograph 1:164.

Onwu AC, Ali A, Ayuba SA (2014). Effect of Fertiplus on Soil Properties, Growth and yield of Jatropha (*Jathrophacarcusi*) in Benue State Nigeria. Niger. J. Soil Tillage Res. 1:111-118.

Rahman SA (2004). Place of organic Manure in Sustaining Agricultural Development in Nigeria. Paper presented at Science Technology and Society, National Workshop in Lafia, Nasarawa, Nigeria 11th July 2004.

Yamoah CF, Batiano A, Shapiro B, Koala S (2003). Soil Management Practices to Improve Nutrient-use Efficiencies and Redcued Risk in Millet-based cropping systems in Sahel. Tropicultura 21(2):66-72.