GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 7 NO. 1 2008: 65 - 69

EFFECTS OF DIFFERENT COMPANION CROPS AND INCREASING NPK FERTILIZER LEVELS ON THE PERFORMANCE OF MAIZE (*ZEA MAYS L.*) IN SOUTHWESTERN NIGERIA

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(Received 23 March, 2007; Revision Accepted 3 August, 2007)

ABSTRACT

Field experiments were conducted at the Teaching and Research Farm of the University of Ibadan, Nigeria, during 2002 – 2003 cropping seasons to appraise the effects of different companion crops, increasing NPK fertilizer levels, and the interaction between these two treatments on the growth and yield indices of maize. The design was a split-plot arrangement, laid out in a randomized complete block with three replications. Companion crops constituted the main-plot treatment, namely: sole cropped maize (control), maize/melon, maize / cassava and maize / cassava / cocoyam. NPK fertilizer was the sub-plot factor, applied at five levels, namely: no fertilizer (control), 100, 200, 300 and 400 kgNPK ha^{-1}. The results obtained indicated that there were significant differences ($P<0.05$) between the treatments in the growth and yield parameters of maize. The mean effects of companion crops on maize leaf area were 0.61, 0.60, 0.60 and 0.52 m^2/plant for sole maize, maize / melon, maize / cassava and maize / cassava / cocoyam, respectively. The two – year average values indicated that NPK fertilizer significantly increased maize leaf area from 0.33 m^2/plant for control to 0.60, 0.86, 1.05 and 1.19 m^2/plant for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. The mean effects of companion crops on maize grain yield were 1.87, 1.92, 1.89 and 1.75 t ha^{-1} for sole maize, maize/melon, maize/cassava and maize/cassava / cocoyam, respectively. NPK fertilizer significantly increased maize grain yield from 0.72 t ha^{-1} for control to 1.92, 2.11, 2.62 and 2.89 t ha^{-1} for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. Companion crops significantly interacted with NPK fertilizer in the growth and yield components of maize. Treatment combination (400 kgNPK ha^{-1} + sole maize) gave the highest values of growth and yield indices of maize in both years.

KEYWORDS: companion, fertilizer, performance, maize

INTRODUCTION

In the humid tropics, maize is scarcely grown as a sole crop, rather, it is traditionally grown in association of certain arable crops such as cassava, yam, melon, sweet potato etc (Atilola, 2005; Agbede, 2007). Maize is the principal cereal, usually combined with cassava in the humid tropics, and the reason behind the popularity of cassava / maize mixture is that of the high productivity and compatibility of the mixture. The faster growing maize exploits the micro-environmental resources earlier in the growing season than the slow growing cassava (Agbede, 2007). Atilola (2005) noted that maize grain yield in a cassava / maize mixture was not significantly affected by the associated cassava, but the growth and yield indices of cassava were significantly reduced by maize in a cassava / maize mixture.

Maize (*Zea mays L.*) requires relatively high soil fertility, particularly nitrogen, phosphorus and potassium for optimum performance (Aitu, 2004; Veen, 2007). In the past, high soil fertility used to be maintained through bush fallow, however, the fallow period has been shortened, following increasing population pressure and a higher demand for land for agricultural and non-agricultural human activities, which have consequently resulted in a sharp decline in soil fertility. This has necessitated the use of fertilizers to improve soil fertility, and hence, crop yield.

Significant responses of maize to NPK fertilizer had been demonstrated by many studies (Brauzel, 2003; Aitu, 2004; Caitt, 2005 and Veen, 2007). These authors noted significant increases in the growth and yield parameters of maize with increasing NPK fertilizer levels. However, too liberal application of NPK to maize, results in excessive vegetative growth and increased lodging (Veen, 2007). Been *et al*; (2006), however, noted that the degree of responsiveness of maize to NPK fertilizer, depends on the nature of the preceding crop(s). They concluded that where maize is preceded by soybeans, the latter is likely to have contributed about 30 – 50 kgN ha^{-1} to maize crops.

Although, in the southwestern Nigeria, many aspects of the Agronomy of maize had been researched, with a view to raising the present level of maize yield on farmers' farms. However, the growth and yield of maize as influenced by companion crops, increasing NPK fertilizer levels, and the interaction between these two treatments have not been accorded enough research attention. Thus, this paper reports a two-year trial, aimed at appraising the influence of different companion crops, increasing NPK fertilizer levels, and the interaction between these two factors on the growth and yield components of maize.

MATERIALS AND METHODS

Study site

The experiments were conducted at the Teaching and Research Farm of the University of Ibadan, Nigeria, in 2002 – 2003 cropping seasons. The soil of the study site belongs to the broad group alfisols (USDA, 1975) of the basement complex, though, locally classified as Ibadan series (Smyth and Montgomery, 1962). The soil is highly leached, with low to medium organic matter content, deep – red clay profile with top sandy loam texture, slightly acidic to neutral. The study site had earlier been cultivated to a variety of arable crops such as cassava, yam, melon, maize, sweet potato etc, but was under fallow for four years prior to the commencement of this study. The fallow vegetation was manually slashed, and the residues were burnt. The land was ploughed and harrowed.

Collection and analysis of soil samples

Prior to planting, ten core soil samples, randomly collected from 0 – 15 cm top-soil were mixed to form a composite sample, which was analyzed. The soil samples were air – dried, ground and passed through a 2 mm diameter sieve. The sieved samples were then analyzed. The pH was determined by glass electrode pH meter. Bray P-1 extractant was used to extract available P, organic C and total N were determined by Walkey – Black oxidation and Kjeldahl digestion techniques, respectively. Exchangeable K, Ca, Mg and Na were extracted by neutral normal ammonium acetate. K, Ca, Mg and Na were determined by flame photometry, while Mg was by the Atomic

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Absorption Spectrophotometry. Effective Cation Exchange Capacity was obtained by summation method (i.e. sum of K, Ca, Mg, Na and exchangeable acidity). The determination of exchangeable acidity was by extraction – titration method described by Mclean (1965). Particle size distribution was done by the hydrometer method of soil mechanical analysis as outlined by Bouyoucous (1951).

Experimental design and treatments

The design was a split-plot arrangement, laid out in a randomized complete block with three replications. Companion crops constituted the main-plot treatment, namely: sole cropped maize (control), maize / melon, maize / cassava and maize / cassava / cocoyam. NPK fertilizer was the sub-plot factor, applied at five levels, namely: no fertilizer (control), 100, 200, 300 and 400 kgNPK ha^{-1}. The NPK fertilizer was applied in two split doses, at three weeks after planting (WAP) and 6 WAP. The gross plot size was 6 m x 4 m, with 2 m margin round each plot.

Planting

In 2002 and 2003, planting was done on March 8 and March 6, respectively. The maize variety, Oba Super 1, dressed with Apron Plus was planted on the flat at a spacing of 100 cm x 50 cm (20,000 plants ha^{-1}). Melon seeds, cassava stem-cuttings and cocoyam corm setts were planted at a spacing of 1 m x 1 m apart. Weeds were controlled manually using the hoe.

Collection and analysis of data

Data were collected from five randomly selected maize crops from the two central rows of each plot in accordance with information for maize trial management in IITA'^{s} maize research programme pamphlet on growth and yield parameters. Leaf area was determined by finding the product of the length and breadth of the leaf, and multiplying by a factor of 0.75 (Saxena and Singh, 1965). Stem girth was measured by using Venier calipers. Dry seed weight was measured on a metler weighing balance. Analysis of variance was carried out and means were compared using the Duncan'^{s} Multiple Range Test (DMRT).

RESULTS

The physical and chemical analyses of soil of the study site indicated that the soil was sandy loam in texture, with a pH of 5.5 . Organic C and total N were 2.88 and 1.30 gkg^{-1}, respectively. The available P was 1.81 mgkg^{-1}. Exchangeable bases – K, Ca, Mg and Na were 0.30, 2.00, 1.64 and 0.24 cmolkg^{-1}, respectively. Exchangeable acidity and Effective Cation Exchange Capacity were 0.30 and 4.48 cmolkg^{-1}, respectively.

Maize leaf area

Table 2 shows the effects of different companion crops and increasing NPK fertilizer levels on maize leaf area. The mean effects of companion crops on maize leaf area were 0.61, 0.60, 0.60 and 0.52 m^2/plant for sole maize, maize / melon, maize / cassava and maize / cassava / cocoyam, respectively. The two-year mean values indicated that NPK fertilizer significantly increased maize leaf area from 0.33 m^2/plant for control to 0.60, 0.86, 1.05 and 1.19 m^2/plant for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. Companion crops significantly interacted with NPK fertilizer in maize leaf area.

Maize stem girth:

The effects of companion crops and NPK fertilizer on maize stem girth are presented in Table 3. The two-year average values indicated that companion crops decreased maize stem girth from 2.45 cm for sole maize to 2.44, 2.43 and 2.32 cm for maize / melon, maize / cassava and maize / cassava / cocoyam, respectively. In contrast, NPK fertilizer significantly increased maize stem girth from 2.24 cm for control to 2.44, 2.66, 2.77 and 2.88 cm for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. Companion crops significantly interacted with NPK fertilizer in maize stem girth.

Grain yield and fresh stover yield of maize

The effects of companion crops and NPK fertilizer on grain and fresh stover yield of maize are presented in Table 4. The mean effects of companion crops on maize grain yield were 1.87, 1.92, 1.89 and 1.75 t ha^{-1} for sole maize, maize / melon, maize / cassava and maize / cassava / cocoyam, respectively. NPK fertilizer significantly increased maize grain yield from 0.72 t ha^{-1} for control to 1.92, 2.11, 2.62 and 2.89 t ha^{-1} for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. The mean values of maize stover yield adduced to companion crops were 2.43, 2.46, 2.42 and 2.32 t ha^{-1} for sole maize, maize / melon, maize / cassava and maize / cassava / cocoyam, respectively. NPK fertilizer significantly increased maize stover yield from 1.86 t ha^{-1} for control to 2.35, 2.60, 2.93 and 3.15 t ha^{-1} for 100, 200, 300 and 400 kgNPK ha^{-1}, respectively. Companion crops significantly interacted with NPK fertilizer in the grain and stover yield of maize.

Table1: The physical and chemical composition of soil of the study site before cropping .

Parameters	Values
pH ($_{H20}$)	5.5
Total N (gkg^{-1})	1.30
Organic C (gkg^{-1})	2.88
Available P (mgkg^{-1})	1.90
Exchangeable K (cmolkg $^{-1}$)	0.30
Exchangeable Ca(cmolkg^{-1})	2.00
Exchangeable Mg (cmolkg^{-1})	1.64
Exchangeable Na (cmolkg^{-1})	0.24
Exchangeable acidity (cmolkg^{-1})	0.30
ECEC (cmolkg-1)	4.48
Texture (gkg^{-1})	
Sand	600
Silt	216
Clay	184

Table 2: Effects of different companion crops and NPK fertilizer levels on maize leaf area

	Maize leaf area (m2/plant)						
	3 WAP		6 WAP		9 WAP		
Treatments	2002	2003	2002	2003	2002	2003	Mean
Companion Crops							
Sole maize (control)	0.34a	0.31a	0.67a	0.64a	0.87a	0.84a	0.61
Maize/ Melon	0.31a	0.33a	0.65a	0.63a	0.85a	0.83a	0.60
Maize / Cassava	0.33a	0.30a	0.67a	0.65a	0.84a	0.82a	0.60
Maize/ Cassava/ Cocoyam	0.32a	0.33a	0.51b	0.53b	0.71b	0.73b	0.52
NPK fertilizer levels (kg NPK h^{-1})							
0 (control)	0.20e	0.18e	0.28e	0.30e	0.53e	0.51e	0.33
100	0.35d	0.32d	0.58d	0.61d	0.88d	0.85d	0.60
200	0.53c	0.51c	0.95c	0.91c	1.14c	1.14c	0.86
300	0.71b	0.68b	1.20b	1.16b	1.30b	1.27b	1.05
400	0.8.3a	0.80a	1.40a	1.38a	1.42a	1.40a	1.19
C x F	S	S	S	S	S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at p = 0.05 (DMRT). WAP = Weeks after planting, C = companion crops, F = fertilizer, S = significant

Table 3: Effects of different companion crops and NPK fertilizer levels on maize stem-girth.

	Maize Stem –girth (cm)						
	3 WAP		6 WAP		9 WAP		
Treatments	2002	2003	2002	2003	2002	2003	Mean
Companion Crops							
Sole maize (control)	1.50a	1.51a	2.41a	2.38a	3.46a	3.44a	2.45
Maize/ Melon	1.48a	1.49a	2.38a	2.41a	3.44a	3.41a	2.44
Maize / Cassava	1.48a	1.50a	2.41a	2.37a	3.42a	3.40a	2.43
Maize/ Cassava/ Cocoyam	1.49a	1.48a	2.27b	2.25b	3.23b	3.20b	2.32
NPK fertilizer levels (kg NPK h^{-1})							
0 (control)	1.20e	1.21e	2.26e	2.25e	3.28e	3.25e	2.24
100	1.34d	1.30d	2.50d	2.48d	3.51d	3.50d	2.44
200	1.49c	1.45c	2.75c	2.73c	3.76c	3.77c	2.66
300	1.63b	1.61b	2.88b	2.87b	3.83b	3.82b	2.77
400	1.75a	1.73a	2.97a	2.95a	3.94a	3.92a	2.88
C x F	S	S	S	S	S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at p = 0.05 (DMRT). WAP = Weeks after planting, C = companion crops, F = fertilizer, S = significant

Table 4: Effects of different companion crops and NPK fertilizer levels on grain yield and fresh stover yield of maize at harvest

	Maize grain yield (t/ha)			Fresh maize stover yield (t / ha)		
Treatments	2002	2003	Mean	2002	2003	Mean
Companion Crops						
Sole maize (control)	1.88a	1.86a	1.87	2.45a	2.41a	2.43
Maize/ Melon	1.93a	1.90a	1.92	2.47a	2.45a	2.46
Maize / Cassava	1.89a	1.88a	1.89	2.43a	2.41a	2.42
Maize/ Cassava/ Cocoyam	1.79b	1.74b	1.75	2.33b	2.31b	2.32
NPK fertilizer levels (kg NPK h^{-1})						
0 (control)	0.71e	0.73e	0.72	1.88e	1.83e	1.86
100	1.90d	1.93d	1.92	2.36d	2.34d	2.35
200	2.10c	2.12c	2.11	2.61c	2.59c	2.60
300	2.60b	2.63b	2.62	2.94b	2.91b	2.93
400	2.88a	2.89a	2.89	3.16a	3.14a	2.15
C x F	S	S		S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at P = 0.05 (DMRT). C = companion crops, F = fertilizer, S = significant.

DISCUSSION

The non-significant difference in the growth and yield indices of maize interplanted with cassava and those of the sole cropped maize agrees with the findings of Atilola (2005) and Agbede (2007). This suggests compatibility of cassava/maize mixture, especially that the faster growing maize exploits the micro-environmental resources earlier in the growing season than does cassava. Consequent upon this, there was no prolonged period of competition between maize and cassava for the growth resources because maize and cassava make maximum demand on growth resources at different times, and maize would have completed its life cycle before cassava canopies closed (Atilola, 2005 and Otelo, 2006). Hence, the compatibility and high productivity of maize and cassava mixture explain its dominance in many mixed cropping systems in southwestern Nigeria (Otelo, 2006). The numerical, although, non-significant difference in the grain and stover yield of maize between sole cropped maize and maize interplanted with melon agrees with the findings of Aribe

(2004); Otelo (2006) and Agbede (2007). The higher grain and stover yield of maize interplanted with melon than sole cropped maize can be ascribed to the provision of additional nutrients and improvement of soil conditions for maize by melon (Viny, 2004 and Saito, 2006). Similarly, the higher cormel yield of cocoyam in cocoyam / melon mixture than the sole cropped cocoyam was adduced to the addition of residual nitrogen to the soil by melon (Ale, 2003 and Udeata, 2006). Much as the difference in grain and stover yield of maize between sole cropped maize and maize /melon mixture can be ascribed to the addition of more nutrients and improvement of soil conditions for maize by melon, another factor that can be implicated for the difference in the grain and stover yield of maize is the less incidence of weed interference in maize/melon plots, compared to sole cropped maize plots. This is because melon, being a cover crop, smothered weeds considerably (Zinta, 2004). In addition, the inclusion of melon in the mixture drastically reduced leaching losses, run-off and erosion, with resultant preservation of organic matter in the topsoil for maize use. The lowest values of growth and grain yield of maize recorded in maize / cassava / cocoyam mixture, suggests the existence if inter – and intra – specific competitions among the three crops for below – and above – soil growth resources (air, water, light, nutrients etc). These prevented maize crops from putting forth much vegetative growth, which perhaps, led to decreased supply of photosynthates to the sink, with resultant reduced grain yield (Tai, 2006).

The significant increases in the growth and yield parameters of maize with increasing NPK levels are in agreement with the reports of Brauzel (2003); Aitu (2004); Caitt (2005) and Veen (2007). These authors noted significant increases the growth and yield parameters of maize on increasing NPK fertilizer levels. The increases in the growth and yield indices of maize associated with increasing NPK levels point to the indispensability of nitrogen, phosphorus and potassium in the nutrition of maize. Nitrogen has been known to play crucial roles in the formation of vegetative structures in plants because N is an active constituent of protoplasm, enzyme and chlorophyll, plays a role of catalytic agent in various physiological processes, accelerates cell division and speeds up photo-assimilation process, which in turn, boost up plant growth, thus, hastening the attainment of reproductive phase (Pande, 1992). Similarly, phosphorus strengthens the skeletal structure of plants, increases plant resistance to diseases, and accelerates flowering, fruiting and seed formation processes in plants (Pande, 1992; Been *et al*; 2006 and Veen, 2007). Potassium activates various plant enzyme systems, particularly those that are connected with growth. Potassium also plays important roles in plant metabolism, in carbohydrate formation and translocation of starch to all plant parts. Potassium strengthens straw and stalk of plants, thereby helping the plants to resist fungal and bacterial attack, as well as to resist lodging (Tankou, 2004 and Hea, 2006). The significant interactions between companion crops and NPK fertilizer, imply that the magnitude of the differences in the growth and yield indices of maize under different companion crops was affected by NPK fertilizer.

CONCLUSION

The results of this study have indicated that the growth and yield parameters of maize increased linearly with increasing NPK fertilizer. Melon and cassava did not significantly reduce the yield of maize, contrasting a significant reduction in the growth and yield of maize by cocoyam.

REFERENCES

Agbede, G. M., 2007. Evaluation of the productivity of maize – based cropping systems in Nigeria. Crop Science, 4 (1): 181 - 186

Aitu, C. M., 2004. The influence of tillage practices and NPK fertilization on the growth and yield of maize. Journal of Sustainable Agriculture, 4: 79 – 83.

Ale, F. O., 2003. Effects of different companion crops and tillage methods on the growth and yield indices of cocoyam. Journal of Applied Science, 3 (1): 258 – 263.

Aribe, K. P., 2004. Studies on maize – based intercropping systems in the humid tropics. *Crop Science* 3: 303 – 308.

Atilola, M. S., 2005. Preliminary investigations on different intercropping systems in the humid tropics. Premier Journal of Agricultural Research, 4 (2): 76 – 82.

Been, T. P., Mai, K. S. and Lot, C. O., 2006. Effects of planting date and nitrogen application on the performance of maize. Journal of Sustainable Agriculture, 6 (2): 88 – 93.

Bouyoucous, G. J., 1951. A recalibration of the hydrometer method for mechanical analysis of soils. Agronomy J ournal 43: 434 – 438.

Brauzel, F. G., 2003. Improving maize yield through NPK fertilization. Crop Science Journal, 3: 112 – 117.

Caitt, B. E., 2005. The growth and yield parameters of maize as influenced by varying planting densities and NPK fertilization. Journal of Applied Science, 3: 18 – 25.

Hea, B. K., 2006. The influence of different planting densities and NPK fertilization on the growth and yield components of maize. Tropical Agronomy, 8 (3): 333 – 338.

Mclean, E. O., 1965. Aluminium. In: C. A. Black (ed.) Methods of soil analysis. Agronomy No 9, Part 2. American Society of Agronomy, Madison, Wisconsin, P. 978 – 998.

Otelo, B. F., 2006. Studies on maize / melon intercropping system in the humid tropics. Crop Science Research, 8: 171 – 176.

Pande, A. K., 1992. Response of tumeric to various levels of nitrogen under terrace conditions of mid – altitude Mizoram. Indian Cocoa, Arecanut and Spices Journal, 16: 14 – 16.

Saito, P. D., 2006. Studies on the influence of melon interplanted with maize on soil quality factors. Soil Science, 3: 205 – 209.

Saxena, M. C. and Singh, Y., 1965. A note on leaf area estimation of intact maize leaves. Indian Journal of Agronomy, 10: 437 – 439.

Smyth, J. A. and Montgomery, R. F., 1962. Soils and land use in central western Nigeria. Government Press of western Nigeria, Ibadan, 265 pp.

Tai, B. T., 2006. Dry matter production, yield components and grain yield of maize crop. Advanced Agronomy Journal, 3 (2): 58 – 62.

Tankou, J. F., 2004. The role of organic and inorganic fertilizers in soil fertility maintenance and crop production. Soil Science, 6 (2): 331 – 337.

Udeata, M. R., 2006. Effects of different companion crops and organic fertilizer rates on the performance of cocoyam. Journal of root and tuber crops, 4: 215 – 220.

United States Department of Agriculture (USDA)., 1975. Agricultural handout, No 436 SCA/USA, Washington D. C; USA, 200 pp.

Veen, R. J., 2007. Influence of organic and chemical fertilizers on the growth and yield components of maize. Crop Science, 6 (4): 301 – 306.

Viny, R. O., 2004. Maintaining soil fertility through cover cropping. Soil Science 4 (3): 318 – 322.

Zinta, F. N., 2004. The role of cover crops in weed control in the traditional mixed cropping systems in Nigeria. Journal of Sustainable Agriculture, 6 (3): 321 – 326.