Original Research Article

EFFECTS OF SPATIAL ARRANGEMENTS AND FERTILIZERS ON PRODUCTIVITY IN MAIZE (*Zea mays*) and SPINACH (*Celosia argentea*) INTERCROP

Abstract

Maize production falls short of demands in the world because of continuous cropping of a land area, which result into loss of natural soil fertility and decline in yield. This study was undertaken to investigate the performance of maize to organic and inorganic fertilizer and to ascertain spacing for maize-spinach intercrop. The experiment was conducted at the National Horticultural Research Institute, Ibadan. The nutrient sources were farmyard organic manure (derived from household waste materials), and inorganic fertilizer (NPK 15:15:15). These soil nutrient sources were applied at the rate of 100Kg N/ha. The plant spacing used for the maize/spinach intercrop include; 75 x 50 cm, 75 x 75 cm, 75 x 25 cm-sole maize and 25 x 10 cm-sole spinach. Data collected were; plant height, number of leaves, stem girth, leaf area, and yield per cob and fresh weight of spinach. All data were analyzed using the Analysis of variance (ANOVA) and means separated by the least significant difference at 5% probability (LSD, 0.05). F_1T_1 and F_2T_4 produced better values for growth and yield parameters than other treatments. The highest value for fresh weight of spinach was obtained at F_2T_2 (9.30Kg).The results suggested that the application of NPK fertilizer was the best nutrient source for maize production and maize-spinach intercrop should be planted at either 75 x 50 cm spacing, although organic fertilizer is environmental friendly, cheaper and release nutrients contents are slowly, store longer in the soil, thus subsequent planting can still benefit already from previous application.

Keywords: NPK 15:15:15, farmyard manure, maize-spinach intercrop, yield, LER

1. INTRODUCTION

Maize (*Zea mays*) is one of the oldest crops in the world, is the highest yielding grain having multiple uses. Maize is a major crop grown for both human and livestock consumption. It is generally believed to have originated from Mexico. It is one of the most important food grains in the world most especially in the developing countries. It's an amazing energy storing crop which grows up to 4 meters or more depending on varieties Maize meals provide more calories and vitamin A than rice and wheat in equivalent.

In Nigeria, maize is an important crop as it provides inexpensive nutrition that helps to sustain the rapidly increasing population. Apart from providing the staple diet for the population, it is also an important crop in industrial and livestock production in the country and has become the most important raw material for animal feed (1). World production of maize is around 790 million tones, providing more than one-third of the calories and proteins in some countries (2) and maize is predicted to become the crop with the greatest production globally, in the developing world by 2025 (3). It is generally believed to have originated from Mexico but reported for the first time in West Africa in 1498 (4). Among cereal crops, maize has the highest average yield per ha and remains third after rice in total area and production in the world.

Spinach (*Celosia* species) is a fast-growing annual leafy vegetable, cultivated in southwestern Nigeria (5). The most commonly cultivated species is *Celosia argentea*, which has its origin in West Africa. Its leaves and young shoots are used in soups and the seed contains significant amount of edible oil (5). *C. argentea* is used in the treatment of diarrhoea, piles, bleeding nose, disinfectant, inflammation, haematological and gynaecologic disorders in folk medicine (6).

Despite the importance of maize and spinach, their production still fall short of demands because of cultivation of poor-yield varieties, unpredictable weather conditions, pests and diseases, and continuous cropping of a land area and poor soil fertility, which result into decline in yield. Thus, different fertilizers, organic and inorganic are used to improve soil fertility to boost plant production.

Nitrogen (N) is the most important nutrient required for the production of both maize and spinach. Continuous use of inorganic fertilizer often result into number of problems such as leaching, surface water and ground water contamination, soil acidification, reduction in useful microbial communities and increased sensitivity to harmful insects (7).Thus, there is the need for alternative, organic sources of Nitrogen (8). Use of organic manures have been known to farmers in early agriculture for their favourable effects on soil, and could be a potential substitute to inorganic fertilizers. The use of organic manure serves as a means of increasing and maintaining soil fertility (9). Organic manures are sourced from cheap and abundant household wastes (10). Animal manures, when properly and efficiently applied, ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching, because the nutrients contained in manures are slowly released and can be stored for a longer period in the soil. The need to reduce the cost of crop fertilization and improved environmental conditions necessitate the utilization of organic manure. Studies have also shown that crops fertilized with organic manure are more naturally nourished, stored longer and do not show susceptibility to rapid mould and rotting (11). Also, Organic matter improves soil aeration and water infiltration, and it also improves both water and nutrient holding capacity of soils. They increase water retention by the soil and are important in maintaining soil tilth (12).

Intercropping is a crop management system involving two or more economic species grown together in a production cycle and planted sufficiently close to each other. Intercropping enhance efficient use of available land nutrients, yield stability, soil and water conservation, reduced leaching of nutrients, balanced distribution of labour and higher economic returns and reduces the weed pressure (13).

Much work has been done on the sole cropping of maize (14), spinach (15) and intercropping of either maize or spinach with other crops such as cowpea and cassava (16). There are limited reports on maize-spinach intercrop, especially in relation to the spatial arrangement and relative plant population densities. Therefore, the present study was carried out to evaluate the effects of farmyard organic manure and NPK 15: 15: 15 fertilizer on the growth and yield of maize-spinach intercrops.

2. MATERIAL AND METHODS

2.1 Site description and Experimental design

The experiment was carried out at the National Horticultural Research Institute (NIHORT) between May and July, 2010 at the Farming Systems Experimental Field, Ibadan (latitude 7°22'N longitude 3°58'E). The experimental design was conducted as a split-plot in a randomized complete block design (RCBD) with three replications. The main plot treatments were two nutrient sources, organic and inorganic manure. The sub-plots treatments were different spatial arrangements, 75 x 50 cm, 75 x 75 cm 75 x 25 cm, sole maize and 25 x 10 cm, sole spinach. Treatment combinations are presented in Table 1. The organic manure was applied one week before planting while the chemical fertilizer (NPK 15: 15: 15) was applied two weeks after planting. The amount of fertilizer applied was calculated based on 100KgN/ha. The maize seeds were planted at the rate of 2 seeds per hole and 4plants per plot. Spinach seeds (SokoTLV8) were sown at the rate of 2 seeds per hole. Weeding was done manually and insecticide containing lambda-cyhalothrinas as active ingredient (Trade name: Karate®) was applied to control insect pests.

2.2. Soil Sampling Physical and Chemical Analysis

Top soil (0-15 cm) samples were randomly collected from experimental site, bulked to form a composite sample; air dried and sieved using a 2mm mesh size. Routine analysis as described in (17) for physical and chemical properties were carried out on the soil sample.

Table 1: Experimental layout of nutrient sources and spatial arrangement using split-plot

Designation of treatments	Crop combinations	Spacing (cm)
Organic manure		
*F_1T_1	Sole maize	75 x 25
*F_1T_2	Sole spinach	25 x 10
F_1T_3	Maize/spinach	75 x 50
F_1T_4	Maize/spinach	75 x 75
(NPK 15: 15: 15)		
*F_2T_1	Sole maize	75 x 25
*F_2T_2	Sole spinach	25 x 10
F_2T_3	Maize /spinach	75 x 50
F_2F_4	Maize /spinach	75 x 75

Asterisk*: sole planting

2.3 Agronomic Analysis of maize and spinach

Data collection started at 4 weeks after planting. The number of leaves was taking by counting the leaves present on the two plants tag for sampling and later divided by two to get the average, plant height was measured using tape rule from tip of the plant to base, stem girth was done using Verner caliper to measured the plant width and leaf area was determined by measuring the length and breadth of the leaf. Data were taken weekly. Destructive sampling was carried out at two weeks interval on maize, in which one plant was uprooted, weighed, and separated into leaves, stem and roots. The plant parts were later oven-dried to a constant weight and the value of dry weight was recorded, the fresh weight of spinach were determined at 6 weeks after planting.

Land equivalent ratio (LER): the indicator of the efficiency of intercropping for using the resources of the environment compared with monocropping.

The LER was calculated as: LER=$\frac{YAB}{YAA} + \frac{YBA}{YBB}$

Where:

YAB= yield of crop A (maize) when intercropped with crop B (spinach)

YBA=yield of crop B (spinach) when intercropped with crop A (maize)

YAA= yield from sole planted crop A

YBB=yield from sole planted crop

2.4 STATISTICAL ANALYSIS

The recorded data on growth performance of the crops were subjected to analysis of variance (ANOVA) and the means were separated using Duncan Multiple Range Test (DMRT).

3. **RESULTS**

3.1 Soil Analysis

Table2 shows the values of the physical and chemical properties of the soil sample collected from the experimental site. The soil belongs to the textural class of sandy loam with 812g/kg sand, 94g/kg silt and 94g/kg clay contents. The Nitrogen status of the soil (0.49g/kg) was lower than the critical value (10-15g/kg), hence nitrogen fertilization was needed.

3.2 Growth performance and yield of maize

Table3 shows that the height of maize was affected by the treatments at different weeks of sampling. It was observed that the plant height increased progressively as the sampling week increases. There were no significant differences on plant height in relation to the nutrient sources and spacing. The plant height obtained from F_2T_4 at 8 weeks after planting (192.60 cm) was significantly higher compared to other treatments. The number of leaves increased till 8 weeks after planting. At 4-5 weeks after planting, there was no significant difference in the number of leaves observed among the plots sampled (Table4). Table5 shows the yield components of maize plant. There were significant differences in the weight of cobs and total yield produced per plant based on the spacing and nutrient sources applied, treatment F_2T_4

produced the highest value of 260.54g and 400.43 for cob weight and total yield per plant respectively.

3.3 Growth performance and fresh weight of spinach

Treatment F_2T_2 gave the highest fresh weight of 9.30Kg in (Table 6), which was significantly higher than other treatments used in the experiment, followed by F_1T_2 (7.0Kg), which was significantly different from F_2T_3 (4.54Kg), while F_2T_4 gave the lowest fresh weight (2.10Kg). In addition, though F_2T_2 gave the highest value of 92.50 cm and 193.80 cm for leaf area at week 4 and 8 respectively but not significantly different from other treatments in the above weeks of sampling.

Table 2: Physical and chemical properties of experimental soil

Physical Parameters	Value(g/kg)
Sand	812
Silt	94
Clay	94
Textural class	Sandy loam
Chemical properties	**Value(g/kg)**
pH	1.20
Organic carbon	4.80
Total Nitrogen	0.49
Available P (mg/kg)	18.80
Total acidity	1.50
Exchangeable bases	**(cmol/kg)**
K	0.42
Ca	13.50
Mg	2.50
Na	1.24

Table 3.Effect of fertilizers and spacing on plant height (cm) of maize (*Zea mays*)

Treatments	Weeks after planting				
	4	5	6	7	8
*F_1T_1	47.60	51.40	87.40	121.30	170.00
*F_1T_2	-	-	-	-	-
F_1T_3	37.60	42.30	76.00	102.90	150.50
F_1T_4	45.90	45.50	86.90	121.90	167.60
*F_2T_1	49.00	56.30	90.00	121.00	156.60
*F_2T_2	-	-	-	-	-
F_2T_3	43.70	53.20	74.70	115.20	169.50
F_2T_4	41.90	59.40	107.90	156.00	192.60
	ns	ns	ns	Ns	Ns

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

Table 4. Effect of nutrient sources and spacing on the number of leaves of maize

Treatments	Weeks after planting					
	4	**5**	**6**	**7**	**8**	**9**
*F_1T_1	9	10	12	13	15	15
*F_1T_2	-	-	-	-	-	-
F_1T_3	8	12	13	12	14	14
F_1T_4	9	11	13	13	14	15
*F_2T_1	10	11	13	13	14	14
*F_2T_2	-	-	-	-	-	-
F_2T_3	10	10	13	13	15	15
F_2T_4	8	9	11	13	14	15
	ns	ns	ns	ns	ns	ns

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

Table5: Effect of different fertilizers and spacing on cob weight and total yield of maize (*Zea mays)*

Treatment	Cob weight per plant (g)	Total Yield per plant(g)
*F_1T_1	159.15cd	222.55c
*F_1T_2	-	-
F_1T_3	171.23bcd	225.96c
F_1T_4	99.02d	280.00bc
*F_2T_1	106.99d	208.07c
*F_2T_2	-	-
F_2T_3	280.70a	296.25bc
F_2T_4	260.54a	400.43a

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

Table 6: Effect of different fertilizers and spacing on leaf area (cm) of spinach

Treatments	weeks after planting				
	4	**5**	**6**	**7**	**8**
F_1T_1	-	-	-	-	-
F_1T_2	63.60ab	101.90ab	151.90abc	139.90abc	145.50ab
F_1T_3	65.90ab	112.70ab	105.00bc	116.20abc	179.20ab
F_1T_4	84.70ab	105.00ab	168.40ab	167.30abc	169.40ab
F_2T_1	-	-	-	-	-
F_2T_2	92.50ab	94.03ab	170.80ab	180.50ab	193.80ab
F_2T_3	67.20ab	82.20abc	132.60abc	145.10abc	162.60ab
F_2T_4	86.10ab	109.50ab	174.50ab	156.20abc	178.40ab

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

Table 7: Fresh weight of Spinach in maize/spinach intercrop

Treatment	Fresh weight of Spinach (Kg)
*F_1T_1	-
*F_1T_2	7.0ab
F_1T_3	2.13cd
F_1T_4	4.90bc
*F_2T_1	-
*F_2T_2	9.30a
F_2T_3	4.54bcd
F_2T_4	2.10cd

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

3.4 Land Equivalent Ratio

Table 8 indicates the land equivalent ratio of maize/spinach intercrop. The LER was more than one (>1) for treatments; F_1T_3, F_2T_3 andF_2T_4, thus indicating yield advantage in the different spacing used in the above treatments , and intercropping pattern was more advantageous than sole cropping. The highest value (1.51) was recorded at F_2T_3 while the lowest value (0.86) was recorded by $F_1T_{4.}$

Table 8: Land Equivalent Ratio of maize/spinach intercrop

Treatment	Total yield per plot (Kg)		Land equivalent ratio
	Maize	Spinach	
*F_1T_1	3.10	-	-
*F_1T_2	-	7.00	-
F_1T_3	2.18	2.13	1.09
F_1T_4	0.76	4.30	0.86
*F_2T_1	2.98	-	-
*F_2T_2	-	8.50	-
F_2T_3	2.90	4.54	1.51
F_2T_4	3.13	1.33	1.21

Asterisk *: sole planting, ns: no significant difference, F: Fertilizer, (F_1= Farmyard organic manure, F_2=NPK 15:15:15 Fertilizer); T: plant spacing, (T_1=75 x 25 cm, T_2= 25 x 10 cm, T_3=75 x 50 cm, T_4=75 x 75 cm). Mean with different letter in the same column are significantly different at 5% probability.

4. DISCUSSION

Maize production throughout Africa depends solely on fertilizer application, especially for the production of the vegetative part and nitrogen is an important nutrient for the production of maize, thus this nitrogen can be derive from either organic or inorganic fertilizer sources but more importantly from the organic sources because they are environmentally friendly, also improve and enriches the soil fertility status.

As regards morphological parameters, the highest value for plant height of maize was obtained at treatment F_2T_4 (192.60cm) over the weeks of sampling. This could be attributed to the fact that NPK, being a chemical fertilizer readily released its constituent nutrients especially nitrogen, for plant growth and development. Considering the number of leaves produced a continuous increase was observed until 8 weeks after planting when the plant attained the reproductive stage and senescence set in to cause slight reduction in number of leaves. As the planting spacing increases, and the number of leaf increases, the assimilatory capacity of such plant also increases. Since the stem determines the stoutness of the plant, and tends to carry a significant proportion of total dry matter of the plant; this deposited dry matter is withdrawn at a later stage of growth to support reproductive development.

In the case of maize yield per plant, it was observed that in most of samples collected, NPK-treated plots with larger spacing gave the highest yield. According to (18), the application of N-fertilizer to maize often influences dry matter production by increasing leaf area development and photo- efficiency of the leaf area. Thus, the lowest yield of maize per plot resulting from low leaf area was obtained in organic-treated plot (F_1T_4) with 0.76Kg, while the highest was obtained from NPK- treated plot (F_1T_1) which was 3.10Kg and there were significant differences among the treatments at 5% level of probability. There were significant differences in the weight of cobs and total yield produced per plant based on the spacing and nutrient sources applied, in which treatment F_2T_4 produced the highest value of 260.54g and 400.43 for cob weight and total yield per plant respectively. (19) Reported that all the organic fertilizers used performed significantly better that control at $P<0.05$ in growth parameters. This pattern was likewise recorded for most of the morphological parameter mentioned above. Also, F_2T_2 gave the highest fresh weight of 9.30Kg, which was significantly higher than other treatments used in the experiment, followed by F_1T_2 (7.0Kg), which was significantly different from F_2T_3 (4.54Kg), while F_2T_4 gave the lowest fresh weight (2.10Kg). These result shows that the organic manure used in this experiment performed very well for the growth of spinach. Accordingly, (20) explained that organic fertilizers are also responsible for the formation of soil aggregates which are very essential in maintaining soil fertility.

The land equivalent ratio (LER) can be used to standardize intercrop yields against the sole crop. In this study, the LER values were greater than one for treatments; F_1T_3, F_2T_3 andF_2T_4, these implies that those treatments were highly efficient and therefore exhibited higher degree of mutual compensation (21). This still agreed with the report of (22) that reported LER in intercropping corn and soybean of to be higher than monoculture.

5. SUMMARY AND CONCLUSION

Tropical soils are inherently low in fertility hence the need to supply external nutrient input which may either be from either organic or inorganic sources that are essential to improve and sustain crop production on our soil. Inorganic fertilizers are costly and beyond the reach of poor farmers, on the other hand organic fertilizer is easily available and cheap and the results obtained from organic fertilizer treated plots in some plots are not significantly different from the results obtained from inorganic treated plot. Also the organic fertilizer will be more economical at the long run for increasing crop production by the poor farmers, and takes longer time to release nutrient, hence other crop planted after maize/spinach can still benefit from the organic fertilizer already applied. It could be explained that while the application of inorganic fertilizer has an obvious advantage of immediate release of its nutrient to the soil for plant growth and development, the application of organic fertilizer has its own advantage of enriching the soil organic matter and thereby constituting longer-term benefit to the soil and the plant. Manure application in a given year will influence not only crops grown that year but its residual effects will continue to influence crops in the succeeding years, because decomposition of the organic matter is not completed within one year (23). Application of organic materials as fertilizers provides growth regulating substances and improves the physical, chemical and microbial properties of the soil (24).

The results obtained in this experiment also showed that maize under intercropping with spinach did best at wider spacing of 75 x 75 cm and spinach can best be intercropped with maize which is a C_4 plant. The result in treatment F_2T_2 for fresh weight of spinach can be attributed to the quick response of inorganic fertilizer used in the experiment, compare to the organic fertilizer which usually takes longer time to decompose but in the longer run gives better support to soil and plant and since the LER is greater than one, the intercropping favours the growth and yield of both maize and spinach. The LER greater than one (LER>1.0) has been reported with various maize intercropping experiments (25).

6. References

1. Pimentel, D. and Patzek,T.W. (2005). Natural Resources Research volume 14 issues 1, pp65-76
2. Chulze, S.N. (2010). Strategies to reduce mycotoxin levels in maize during storage: a review. Food Additives and Contaminants, 27, 5, 651-657. European commission (2006): Commision regulation (EC) No. 401 / 2006. Official Journal of the European Union, L70, 12
3. Rosegrant, M. W., S. Msangi, C. Ringler, T. B. Sulser, T. Zhu, and S. A. Cline. (2008). International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model description. Washington, D.C.: International Food Policy Research Institute.
4. Van Eijatten 1965.STowards the improvement of maize in Nigeria Ph.D thesis Wageningen the Netherlands.
5. Schippers.R.R.2000. African Indigenous Vegetable, An overview of the cultivated species.
6. Wiart, C. (2000). *Medicinal plants of Southeast Asia*, Pelanduk Publications.
7. Chen, J.H. (2006). The combined use of chemical organic fertilizers and/or bio fertilizer for crop growth and soil fertility. Proceeding of international workshop on sustained management of the soil-Rhizosphere system for efficient crop production and fertilizer use.

8. Akanbi, W.B., Baiyewu, R.A. and Tairu, F.M. (2006). Effect of organic based fertilizer and spacing on growth and yield of *Celosia* (*C. argentea*). *Journal of Agriculture, Forestry and Fisheries,* 1: 5-10.
9. Alasiri, K.O. and Ogunkeyede, S.A. (1999). Effect of different levels of poultry manure on seed yield of okra. *Soil Science,* 25: 102-102.
10. Ondo State Government, (2012). Organic manures sourced from cheap and abundant household wastes.
11. Makinde, E.A., Ayeni L.S., and Ojeniyi, S.O. (2011).Effects of organic, organomineral and npk fertilizer treatments on the nutrient uptake of *Amaranthus cruentus(*L.) on Two soil types in Lagos. J. Central Eur. Agric. 12:114-23.
12. Sarka, A.K, Siegh, R.O (2002). Importance of Long Term Fertilizers Use for Sustainable Agriculture in Jharkhand. The Second International Congress on Balancing Food *and* Environmental Security-A Continue Challenge, New Delhi. India, 26-30 November 2002.Fertilizer News 2002; 47:107-117.
13. Hailu, G.D. (2015). A review on the comparative advantage of intercropping on mono-cropping system, Journal of Biology, Agriculture and Healthcare, Vol5, No9, 2015.
14. Babatunde, S.A., Ovigwe, H.E. and Howard, C.k. (2016). Effectiveness of sunshine organic fertilizer, organomineral fertilizer and mineral fertilizer on soil nutrients, growth and yield of maize.
15. Abdulmalia, S.Y., Isah., M.K., Loko, A.M., Bello, O.B and Mahamood , J. (2016). Growth and yield of Lagos spinach (*Celosia argentea*) as influenced by intra-row spacing and cow dung rates in Lapai, southern guinea savannah of Nigeria.

16 Akinyemi, S. and Tijani-Eniola, H. (1997). Effects of cassava density on productivity of productivity of plantain and cassava intercropping system. *Fruits,* 50: 17-23.

17 Udo, E J., T.O. Ibia, J.O. Ogunwale, A.O. Ano & I. Esu (2009). Manual of Soil, Plant and Water Analysis. Sibon Books Ltd. Lagos.

18 Akintoye H.A., Lucas E. O. and Kling J. G. (1999). Nitrogen use efficiency of single, double and synthetic maize lines grown at four N levels in three ecological Zones of West Africa. *Field crops Research* 60: 189-199.Winconsin. *American Society of Agronomy*. 1141-1174.

19 Ball, B.C, Bingham I, Rees R.M, Watson C, Litterick (2005). The role of crop rotation in determining soil structure and crop growth conditions: Canadian J. Soil. Sci. 85 (50): 557 578

20 Ipinmoroti, R. R. and Adeoye G. O. 2002. Organic and N.P.K. fertilizer effects on tea performance in a humid lowland ecological area of southwestern Nigeria. Proceedings of Horticultural Society of Nigeria.

21 Rahimy, MM, Mazaheri D, Khodabandeh N, Heidari H. 2003. Assessment of product in corn and soybean intercropping in Arsanjan region.Agricultural Science 9: 109-126. (In Persian with English Summary)

22. Bayu, W, Rethman Nfg, Hammes Ps, Alamu G (2006). Effects of farmyard manure and Inorganic Fertilizers on sorghum Growth, Yield and Nitrogen use in a semi- arid area of Ethiopia. J. Plant Nutri. 29(2):391-407.

23. Belay, A, Classens A.S, Wehner F.C, De Beer J.M (2001). Influence of residual manure on selected nutrient elements and microbial composition of soil under long-term crop rotation. South African J. of Plant and Soil, 18:16.

24 Odo, P.E. and Futuless, K.N. (2002). Millet-soyabean intercoropping as affected by different sowing date of soyabean in a semi-arid environment. Cereal Research Communications, Hungary, 28 (1-2):153-160.

25 Saban, Y., Mehmt, A and Mustafa, E. (2007). Identification of Advantages of Maize-Legume intercropping over solitary Cropping through Competition indices in the East Mediterranean Region.Turk. J. agric. 32:111-119.