ISSN 2277-0836; Volume 1, Issue 4, pp. 53-59; July 2012.
Journal of Agriculture and Biodiversity Research

Full Length Research

Available Online at http://www.onlineresearchjournals.org/JABR

Advantages of Maize-Cowpea Intercropping over Sole Cropping through Competition Indices

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Downloaded 30 May, 2012 Accepted 17 June, 2012

Different mix-proportions and planting patterns of maize (*Zea mays L.*) and cowpea (*Vigna unguiculata L.*) were compared with the sole cropping of each crop during 2010 and 2011 growing seasons under the southern Guinea savanna conditions in Nigeria. The experiment comprised of 6 treatments: sole maize (51,282 plants ha-1), sole cowpea (61,538 plants ha-1) and 4 maize-cowpea intercropping mix-proportion: 100 maize:100 cowpea, 50 maize:50 cowpea, 60 maize:40 cowpea and 40 maize:60 cowpea, using randomized complete block design with three replications. Evaluation of the intercropping patterns was performed on basis of several intercropping indices such as land equivalent ratio (LER), relative crowding coefficient (K), aggressivity (A), competitive ratio (CR), actual yield loss (AYL), and intercropping index (IA). The study revealed that the mix-proportion of 50 maize: 50 cowpea, gave a similar grain yield compared to other intercropped plots, better land use efficiency, significantly ($p\leq 0.05$) lowest actual yield loss of 23 % and a significantly ($p\leq 0.05$) higher intercropping advantage of +574.66. The study also revealed that intercropping systems could be an eco-friendly approach for reducing weed problems through non-chemical methods, mix-proportion of 50 maize: 50 cowpea, planted on alternate rows could be a better intercropping pattern.

Keywords: Mix-proportion, planting pattern, weeds, maize, cowpea.

INTRODUCTION

Intercropping is the simultaneous growing of two or more crops in the same field. Farmers practice different cropping systems to increase productivity and sustainability [1]. Cropping system characteristics can fundamentally alter the abiotic and biotic features of an agroecosystem and could modify the life cycle of pests such as weeds [2]. A Cropping system that reduces weed population may provide a weed suppressive foundation upon which cultural weed control could be laid [3].

The use of intercropping by smallholder and peasant farmers is a common practice [4] that dates back to ancient civilization [5] in the tropics [6] and rain-fed areas of the world [7]. The advantages of intercropping include soil conservation, lodging resistance, yield increment [8] and weed control [2] over the monocropping. The individual crops that constitute an intercrop can differ in their use of resources spatially, temporally, or in form, resulting in overall more complementary and efficient use of resources than when they are grown in sole cropping; thus decreasing the amount available for weeds [1]. For example, when growing pea and barley in intercrops, Hauggard-Nielsen et al. [1] found that there was an increased efficiency in utilizing environmental resources for plant growth and a better competitive ability towards weeds as compared to sole crops. Baumann et al. [9] reported that intercropping increase light interception by the weakly competitive component and can, therefore, shorten the critical period for weed control and reduce growth and fecundity of late-emerging weeds. The apparent increased competitiveness of intercropping systems makes them potentially useful for adoption into low in-put farming systems in which options for chemical weed control are reduced or non-existent [10].

When two crops are planted together, intra and/or inter specific competition or facilitation between plants may occur [11]. Studies showed that mixtures of cereals and legumes produce higher grain yields than either crop grown alone [12,13]. The yield increase is not only due to improved nitrogen nutrition of the cereal component, but also to other unknown causes [14]. Competition among mixture is thought to be a major aspect affecting yield as compared with sole cropping of cereals [15] and a number of indices such as land equivalent ratio, relative crowding coefficient, competitive ratio, actual yield loss, monetary advantages and intercropping advantages have been used to describe competition between component crops of intercropping systems [16-18]. The objectives of the present study were to examine the effect of cropping systems and planting patterns on weed suppression and crop yield, and to evaluate the systems for better management of resources using different competitive indices.

MATERIALS AND METHODS

The experiments were conducted during 2010 and 2011 growing seasons in the University of Ilorin Teaching and Research Farm. The farm is located at Bolorunduro, Ilorin, in the southern Guinea savanna ecological zone (90 29' N, 40 35' E) of Nigeria, and is 307 m above sea level. Total annual rainfall of the area in 2010 was 1330.7 mm while 1499.4 mm was recorded in 2011 An average daily temperature range of 20oc – 35oc was recorded in both years. The soil was a sandy clay loam, classified as a plinthustaffs with approximately 74.12 % sand, 5.54 % silt and 20.69 % clay, organic matter 2 % and pH 5.5.

The experiment was randomized complete block design with three replications. The experimental plots were 5m x 11m = 55 m2 involving 11 rows. The experiment was done over a period of two consecutive years. The treatments included sole maize (suwan I) planted at the rate of 51,282 plants ha-1, sole cowpea (Ife BPC) planted at the rate of 61,538 plants ha-1 and four intercropping mixtures of maize (M) with cowpea (C) which were:

(i) Planting both crops on same row (MZCP)
(ii) Planting the crops in alternate rows (1M: 1C)
(iii) Planting 2 rows of maize to a row of cowpea (2M: 1C and
(iv) Planting 2 rows of cowpea to a row of maize (1M: 2C).

The land was ploughed and harrowed twice within the first two weeks of July in each cropping year and sowing was done manually by planting two seeds by planting station. The rows were thinned to the required experimental populations at two weeks after planting (WAP).

No fertilizer was applied to cowpea plant while NPK (20:10:10) fertilizer was applied to maize plants in splits at the rate of 200 kg ha-1 at 3 WAP and 100 kg ha-1 at 7 – 8 WAP. The cowpea plants were sprayed with 1.2 kg ha-1 Karate(R) (cypermethrin 10 % EC) at weekly intervals for three weeks after commencement of flowering, to control foliage and pod insect infestations.

Maize was harvested at complete maturity and cowpea was harvested when the first pod of the plants fully matured and dried. Seeds were weighed and adjusted to constant moisture levels of 15 % and 13 % maize and cowpea, respectively.

Data on weed seedling emergence (weed density) and weed biomass were monitored in two fixed quadrats (0.5 m2) at 3, 6, 9 and 12 WAP in each sub-plot. The weed species from each quadrat in each sub-plot were counted, and pulled out. Samples from the same plot were bulked and oven-dried for 24 hours at 80oC to a constant mass.

Evaluation of the cropping systems was carried out as in [18] using the following indices:

(i) Land equivalent ratio (LER) which verifies the effectiveness of intercropping for using the resources of the environment compared to sole cropping. The LER values were calculated as: LER = (LERM + LERC), where LERM = YIM/YM and LERC = YIC/YC, where YM and YC are the yields of maize and cowpea as sole while YIM and YIC are the yields of maize and cowpea as intercrops, respectively;
(ii) Relative crowding coefficient (K) which measures the dominance of one species over the other in a mixture. K was calculated as: K = KM x KC, where KM = YIM x ZIC / (YM – Yml) x ZIM and KC = Ylm x ZIM / (YC – Ylm) x ZIC where ZIM and ZIC were proportions of maize and cowpea in the intercrops, respectively. When the value of K is greater than 1, there is a yield advantage; when K is equal to 1, there is no yield advantage; and, when it is less than 1.00, there is a disadvantage;
(iii) Aggressivity (A) was used to determine the competitive relationship between 2 crops in a mixture. The aggressivity was calculated as: AM = (YIM/YM x ZIM) – (YIC/YC x ZIC), and AC = (YIC/YC x ZIC) – (YIM/YM x ZIM).
(iv) Competitive ratio (CR) gives more desirable competitive ability for the crops. The CR represents simply the ratio of individual LERs of the two component crops and takes into account the proportion of the crops on which they are initially sown. The CR index was calculated using the following formula: CRM = (LERM / LERC) (ZIC / ZIM) while CRC = (LERC / LERM) (ZIM / ZIC).
(v) Actual yield loss (AYL) index, which gave more accurate information about the competition than the other indices between components of intercropping system. The AYL is the proportionate yield loss or gain of intercrops compared to sole crop. The AYL was calculated as: AYL = AYLM + AYLC, where AYLM = {(YIM/XIM) / (YM /XM)} – 1, and AYLC = {(YIC/XIC) / (YC/XC)} -1, where X is the sown proportion of intercrop components and
(vi) Intercropping advantage (IA) was estimated as IA = AYL x Price of cowpea or maize (the current price of cowpea and maize is 400 Naira and 200 Naira per kg,

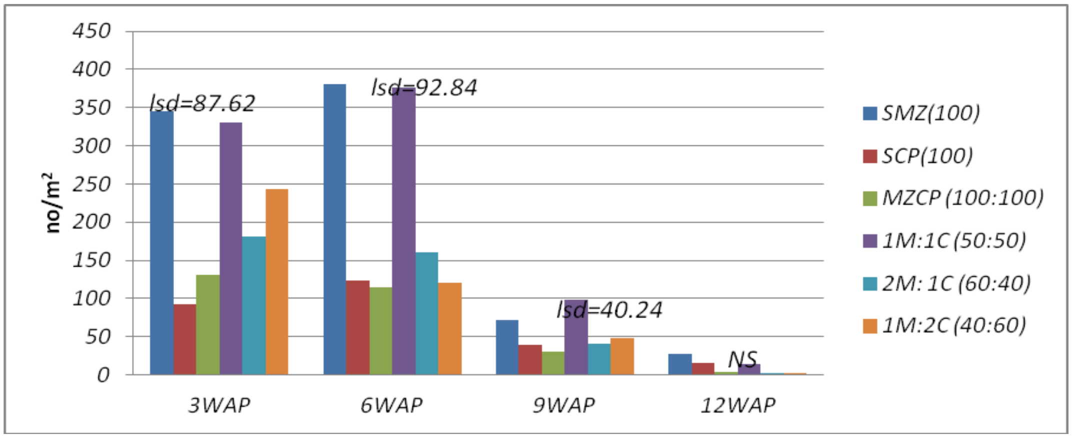

Figure 1A. Weed seedling emergence for sole stands and intercrop of maize with cowpea in four planting pattern.

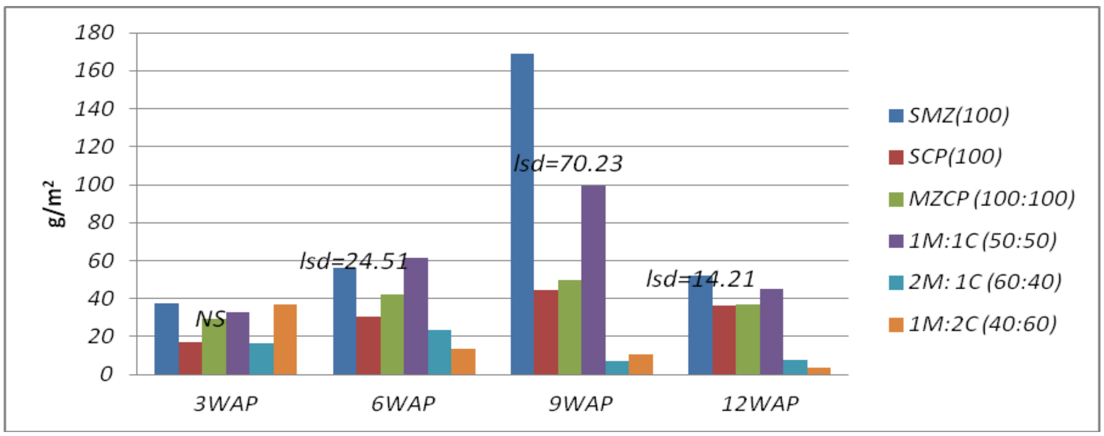

Figure 1B. Weed biomass for sole stands and intercrop of maize with cowpea in four planting pattern.

WAP = weeks after planting, SMZ= sole maize, SCP= sole cowpea, MZCP = maize–cowpea intercrop planted at 1:1 on the same row, 1M:1C, 2M:1C, 1M:2C, represent planting pattern of maize: cowpea, numbers represent number of rows.

respectively).

Data were analysed using the Genstat Discovery Edition 4. A combined analysis of variance over two years was performed for weed density, weed biomass and crop yields, as well as for all indices.

RESULT

Weed seedling emergence

Weed density in the sole cowpea plots reduced weed seedling emergence significantly lower than sole maize and similar to the intercrops irrespective of planting pattern except 1M:1C (mix-proportion of 50M:50C) plots. The latter plots had similar weed density with the sole maize plots. While weed density in sole cropping and 1M:1C plots increased from 3 WAP to peak at 6 WAP and gradually decreased, other intercrop plots gradually decreased from 3-12 WAP. In other words, the population of weeds in most of the intercropped treatments reduced as the cropping season advanced (Figure 1A). The weed biomass in the intercrops, irrespective of planting pattern and sole cowpea, reduced weed biomass significantly lower than the sole maize treatment. The weed biomass in 1M:2C plots were significantly lower in all the intercropped treatment although similar to MZCP and sole cowpea plots at 6 and 8 WAP (Figure 1B). Weed biomass in sole crop plots and intercropped plots with mix-proportion of 100M:100C or 50M:50C increased from 3-9 WAP then decreased, intercropped plots with mix-

Table 1. Grain yield, land equivalent ratio (LER) and relative crowding coefficient (K) for sole stands and intercrop of maize with cowpea in four planting pattern.

		Grain yield (ton/ha)			LER values			K values		
Planting pattern	**mix- proportion (%)**	**Maize**	**Cowpea**	**Total**	**Maize**	**Cowpea**	**Total**	**Maize**	**Cowpea**	**Total**
Sole maize	100	3.53	-	3.53				1.00		1.00
Sole cowpea	100	-	1.90	1.90					1.00	1.00
MZCP	100:100	1.73	1.08	2.81	0.96	0.59	1.55	0.29	1.89	0.34
1M:1C	50:50	2.02	0.65	2.67	1.42	0.35	1.77	-0.11	0.69	-0.06
2M:1C	60:40	1.77	0.43	2.20	1.54	0.19	1.74	-0.56	0.66	0.18
1M:2C	40:60	1.22	0.38	1.60	0.63	0.49	1.11	-2.43	0.61	-1.39
Sed		0. 427	0.213	0.209	0.657	0.189	0.719	1.805	0.606	2.19

MZCP = maize–cowpea intercrop planted at 1:1 on the same row, 1M:1C, 2M:1C, 1M:2C, represent planting pattern of maize: cowpea, numbers represent number of rows.

proportion of either 60M:40C or 40M:60C gradually reduced as the cropping season advanced.

Grain yield, Land equivalent ratio and Relative crowding coefficient

The highest grain yield was obtained from sole cropping plots while intercropped plots at mix-proportion of 100M:100C gave the highest intercrop total grain yield, 2.81 ton/ha (table 1). The highest intercropped maize was from 1M:2C plots with mix-proportion of 50M:50C while the highest intercropped cowpea grain yield was obtained from MZCP plots. The significance of the above results could be explained using the competition indices below.

In general, partial LER for cowpea was lower than 0.50 in all mixtures except mix-proportion of 100M:100C where 0.59 was recorded. The partial LER for cowpea increases with an increase in the proportion of cowpea in the mixture, however, LER for maize was above 1.00 in maize: cowpea mixtures proportion of 50M:50C and 60M:40C while it decreased when the maize was more than 60% (table 1).

The intercropped cowpea had higher K values than the intercropped maize. The K value for cowpea increased when the proportion of cowpea in the intercrop mixture increases and the K value was higher than 1 in mix-proportion of 100M:100C. Negative K values for maize were obtained in all intercropped mixtures (table 1).

Aggressivity, Competitive ratio and Actual yield loss

In all mixtures, positive A values for maize showed that maize was the dominant species (table 2). Intercropped maize had higher CRs in all mixtures except mix-proportion of 40M:60C. The highest CR value for maize was obtained in mix-proportion of 50M:50C and decreased gradually as the maize proportion in the mixture increases. On the other hand, the CR values for cowpea increased with an increase in proportion of cowpea in the mixtures (table 3). Actual yield loss for maize had positive values when the maize proportion was 100% and less than 40% and the highest AYL value of maize was obtained from 60M:40C intercropped mixture. Both the AYL and the total AYL values for cowpea were negative (table 2).

The IA, which is an indicator of the economic feasibility of intercropping systems, affirmed that the most advantageous mixture was the maize-cowpea mixture of single-row 50M:50C with IA value of +574.66 (table 2). The lowest IA value of -385.34 showed that 40M:60C lead to highest loss and there were fewer negative values for maize while IA values for cowpea were all negative.

DISCUSSION

The general reduction in weed density and dry matter in intercropped plots compared with the sole crop plots was in line with the results obtained by other workers [19-22]. The reduction was not only due to the high plant population in the intercropped plots than the sole cropped plots but also the different planting pattern that in turn

Table 2. Aggressivity (A), competitive ratio (CR), actual yield loss (AYL) and Intercropping advantage (IA) for intercrop of maize with cowpea in four mixture and planting pattern.

		A		CR		AYL			IA		
Planting pattern	**mix- proportion (%)**	**Maize**	**Cowpea**	**Maize**	**Cowpea**	**Maize**	**Cowpea**	**Total**	**Maize**	**Cowpea**	**Total**
MZCP	100:100	0.37	-0.37	1.41	0.96	-0.040	-0.257	-0.30	-86.67	-102.67	-189.34
1M:1C	50:50	1.02	-1.02	3.66	0.65	0.420	-0.647	-0.23	833.33	-258.67	574.66
2M:1C	60:40	0.42	-0.42	2.47	0.58	0.52	-0.813	-0.29	104.67	-325.33	-220.66
1M:2C	40:60	0.22	-0.22	0.78	0.84	-0.37	-0.77	-1.15	-74.67	-310.67	-385.34
Sed		0.563	0.563	1.703	0.327	0.656	0.178	0.604	131.27	71.05	111.87

MZCP = maize–cowpea intercrop planted at 1:1 on the same row, 1M:1C, 2M:1C, 1M:2C, represent planting pattern of maize: cowpea, numbers represent number of rows.

Table 3. Aggressivity (A), competitive ratio (CR), actual yield loss (AYL) and Intercropping advantage (IA) for intercrop of maize with cowpea in four mixture and planting pattern.

		A		**CR**		**AYL**			**IA**		
Planting pattern	**mix- proportion (%)**	**Maize**	**Cowpea**	**Maize**	**Cowpea**	**Maize**	**Cowpea**	**Total**	**Maize**	**Cowpea**	**Total**
MZCP	100:100	0.37	-0.37	1.41	0.96	-0.040	-0.257	-0.30	-86.67	-102.67	-189.34
1M:1C	50:50	1.02	-1.02	3.66	0.65	0.420	-0.647	-0.23	833.33	-258.67	574.66
2M:1C	60:40	0.42	-0.42	2.47	0.58	0.52	-0.813	-0.29	104.67	-325.33	-220.66
1M:2C	40:60	0.22	-0.22	0.78	0.84	-0.37	-0.77	-1.15	-74.67	-310.67	-385.34
Sed		0.563	0.563	1.703	0.327	0.656	0.178	0.604	131.27	71.05	111.87

MZCP = maize–cowpea intercrop planted at 1:1 on the same row, 1M:1C, 2M:1C, 1M:2C, represent planting pattern of maize: cowpea, numbers represent number of rows.

led to better ground cover which inhibited weed seed germination and subsequent growth thus the slight differences in weed emergence between the intercropping systems. Baumann et al [9] suggested that intercropping helps to improve weed suppression relative to monoculture, whose open canopy structure permits weeds to proliferate. Banik et al. [23]; Szumigalski and Van Acker [10]; Saucke and Ackermann [24] similarly concluded that annual intercrops can enhance both weed suppression and crop production compared with sole crops.

The results from this study showed that sole cropping yielded higher than all the maize-cowpea intercrops. The land equivalent ratio indices were the greatest in maize component of the intercropping systems. The total LER values were higher than one showing the advantage of intercropping over sole cropping in regard to the use of environmental resources for plant growth [25]. The crowding coefficient (K) values for both crops were less than one except at 100M:100C plots where cowpea had K value of 1.89, indicating an absolute yield advantage over maize in that plot while other plots showed that there was no advantage of one crop over another. This result is in contrast to Davis and Liebman [23] in chickpea- wheat intercropping, Dhima et al., [7] in cereal-vetch intercropping and Saucke and Ackermann [24] in maize-cowpea/common bean intercropping similarly reported a yield advantage of cereal over the legume.

Considering all mix-proportions and planting patterns, Aggressivity (A) values for maize were always positive while such values for cowpea were all negative, showing that maize was the dominant species as reported by previous studies [7,18]. The results of competitive ratio CR) index were higher in maize and the CR value increased with an increased A value of maize. The 50M:50C had the highest CR value followed by 60M:40C plots. This indicated that maize was more competitive than cowpea in all mix-proportions and planting patterns. The AYL values for cowpea were all negative and ranges from -0.257 to -0.813 indicating a yield loss of 25.7% - 81.3%, compared to sole cowpea yield. Yilmaz et al [18] reported a yield loss of 2 % - 42 % in the East Mediterranean region. The AYL values for maize were positive in 50M:50C and 60M:40C plots indicating a yield gain of 42 % and 52%, respectively, compared to sole maize yield. The total AYL values showed an intercropped yield loss with a minimum yield loss value of 23 %. The intercropping advantage (IA) showed that the most advantageous mixture was 50M:50C with the highest IA value of +574.66.

CONCLUSION

This study concludes that intercropping system can be an eco-friendly approach for reducing weed problems through non-chemical methods. Intercropping maize and cowpea in different patterns and mix-proportions may affect grain yield due to competition between the 2 crops compared to sole cropping. The land equivalent ratios were higher than one in all intercropping plots indicating an optimum exploitation of the environmental resources. In all mix-proportions and planting patterns, maize was the dominant species. The mix-proportion of 50M:50C, gave a similar grain yield compared to other intercropped plots, better land use efficiency, an actual yield loss of 23 % and a significant intercropping advantage of +574.66. Therefore, mix-proportion of 50M:50C, planted on alternate rows could be a better intercropping pattern.

REFERENCES

[1] Hauggard-Nielson H, Ambus P, Jensen ES. Evaluating pea and barley cultivars for complementary in intercropping at different levels of soil N availability. Field Crops Res., 2001; 72: 185-196.

[2] Banik P, Midya A, Sarkar BK, Ghose SS. Wheat and chickpea intercropping systems in an additive series experiment: advantages and weed smothering. Eur. J. Agro., 2006; 24: 325-332.

[3] Tsubo M, Walker S, Ogindo HO. A simulation model of cereal–legume intercropping systems for semi-arid regions. II. Model application. Field Crops Res., 2005; 93: 23-33.

[4] Ofuso-Amin J, Limbani NV. Effect of intercropping on the growth and yield of cucumber and okra. Int. J. Agric. Biol., 2007; 9(4): 594-597.

[5] Dahmardeh M, Ghanbari A, Syasar B, Ramroudi M. Effect of intercropping maize with cowpea on green forage yields and quality evaluation. Asian J. Plant Sci., 2009; 8(3): 235-239.

[6] Banik P, Sasmal P, Ghosal K, Bagchi DK. Evaluation of mustard (Brassica compestris var. Toris) and legume intercropping under 1:1 and 2:1 row-replacement series system. J. Agro. Crop Sci. 2000; 185: 9-14.

[7] Dhima KU, Lithourgidis AA, Vasilakoqlou IB, Dordas CA. Competition indices of common vetch and cereals intercropping in two seeding ratio. Field Crops Res. 2007; 100: 249-258.

[8] Anil L, Park J, Philips RH, Miller FA. Temperate intercropping of cereals for forage: a review of the potential for growth and utilization with particular reference UK. Grass Forage Sci. 1998; 53: 301-317.

[9] Baumann DT, Kropf MJ, Bastiaans L. Intercropping leeks to suppress weeds. Weed Res. 2000; 40: 361–376.

[10] Szumigalski A, Van Acker R. Weed suppression and crop production in annual intercrops. Weed Sci., 2005; 53: 813–825.

[11] Zhang FS, Li L. Using competitive and facilitative interactions in intercropping systems enhances crop productivity and nutrient-use efficiency. Plant Soil 2003; 248: 305-312.

[12] Olufemi O, Pitan R, Odebiyi JA. The effect of intercropping with maize on the level of infestation and damage by pod-sucking bugs in cowpea. Crop Protect., 2001; 20: 367-372.

[13] Dapaah HK, Asafu-Agyei JN, Ennin SA, Yamoah C. Yield stability of cassava, maize, soya bean and cowpea intercrops. J. Agric. Sci. 2003; 140: 73-82.

[14] Connolly J, Goma HC, Rahim K. The information content of indicators in intercropping research. Agric. Ecosyst. Environ. 2001; 87: 191-207.

[15] Ndakidemi PA. Manipulating legume/cereal mixtures to optimize the above and below ground interactions in the traditional African cropping systems. Afri. J. Biotechnol. 2006; 5(25): 2526-2533.

[16] Ghosh PK. Growth, yield, competition and economic of groundnut / cereal fodder intercropping systems in the semi-arid tropics of India. Field Crops Res. 2004; 88: 217-237.

[17] Mazaheri D, Ahad M, Meysan O. Assessing the land equivalent ratio of two corn varieties intercropping at various nitrogen levels in Karaj, Iran. J. Central Eur. Agric. 2006; 7(2): 359-364.

[18] Yilmaz S, Atak M, Erayman M. Identification of advantages of maize-legume intercropping over solitary cropping through competition indices in the East Mediterranean Region. Turkey J. Agric., 2007; 16: 217-228.

[19] Shrestha A, Kenzevic C, Roy SZ, Ball-Coelho BR, Swanton C J. Effects of tillage, cover crop and crop rotation on the composition of weed flora in a sandy soil. Weed Res., 2002; 42: 76–87.

[20] Ngouajio M, Mennan H. Weed populations and pickling cucumber (Cucumis sativus) yield under summer and winter cover crop systems. Crop Protect., 2005; 24: 521-526.

[21] Kolo MGM. Intercropping of selected cultivars of cowpea and soybean for weed control in maize production system. J. Sustain. Trop. Agric. Res. 2007; 22:22-28

[22] Takim FO, Fadayomi O. Influence of Tillage and Cropping Systems on Field Emergence and Growth of Weeds and Yield of Maize (Zea mays L.) and Cowpea (Vigna unguiculata L.) . Aus. J. Agric. Eng. 2010; 1(4): 141-148

[23] Davis AS, Liebman M. Cropping systems effects in giant foxtail demography: I. Green manure and tillage timing. Weed Sci., 2003; 51: 919-929.

[24] Saucke H, Ackermann K. Weed suppression in mixed cropped grain peas and false flax (Camelina sativa). Weed Res., 2006; 46: 453-461.

[25] Mead R, Willey RW. The concept of a land equivalent ratio and advantages in