International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.6, pp 556-564, 2015

Effect of Maize - Cowpea Intercropping on Light Interception, Yield and Land Use Efficiency

Abd El-Lateef, E.M.; M.S. Abd El-Salam; S.F. El-Habbasha and M.A. Ahmed

Field Crops Research Dept., National Research Centre, 33 Bohouth St., Dokki, Giza, Egypt.

Abstract: Two field experiments were conducted during summer seasons of 2013 and 2014 in a private farm at El-Gmalia district, Dakahlia Governorate, Egypt. The objective of the experiments was to study the effect of maize (*Zea mays* L.) cv. TH-310 intercropping with cowpea (*Vigna unguiculata* (L.) Walp) cv. Karim-1 by alternation of 1, 2 and 2 ridges of maize with 3, 4 and 2 ridges of cowpea to form 1:3, 2:4 and 2:2 intercropping patterns. Additional plots of cowpea and maize were grown at the solid recommended culture (solid I) and the comparative treatment where the same plant density adopted under intercropping (solid II), on growth, light interception, yield and yield components, as well as land use efficiency. The data of light interception expressed as light energy flux density (J m^{-2} s^{-1}) showed reductions along the intercropped cowpea canopies at the different heights of measuring, compared with the solid recommended cultures (SI and SII). The greatest reduction inside cowpea canopies occurred at 2:2 intercropping pattern. On contrast, reversible magnitude in light energy flux density was reported for the intercropped maize plants, which were less competitive for light under intercropping than that in the solid cultures. Cowpea showed reductions in DM, number and weight of pods per plant, 100-seeds weight and seed yield per plant compared with the solid cultures. However, beneficial effects due to intercropping were reported for maize; i.e., number of ears/plant, number of grains/row and 100-grains weight. The relative yield increases per plant were (161.7, 160.9 and 159.8 %) for the intercropping patterns 1:3, 2:4 and 2:2 over the comparative treatment (Solid II). The data of the land equivalent ratio (LER) showed yield advantages due to intercropping by 15-23%. The highest LER value for maize-cowpea was reported with 2:4 intercropping pattern. It could be concluded from this study that maize - cowpea intercropping increase land use efficiency by 15-23% compared with each crop grown alone and 1:3 intercropping pattern is better than the other combinations.

1. Introduction

Intercropping of field crops is regarded as an essential practice when several economic field crops are competing for the same limited land area. Also, it is a common practice on small-scale farming system in the developing countries. Intercropping offers to farmers the opportunity to engage nature's principle of diversity at their farms. Spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops. Intercrops can be more productive than growing pure stands. Pest management benefits can also be realized from intercropping due to increased diversity[1]. Many researchers work in the intercropping procedures one of them[2] have been emphasized that intercropping is the most effective tool which permits higher grain yields and greater land use efficiency per unit land area. Moreover, an additional proven benefit from intercropping is the improvement in soil fertility through the addition of nitrogen by fixation from the component legume[3]. A great deal of work has been focused on maize-soybean intercrops[4-10].

Cowpea (*Vigna unguiculata* (L.) Walp) has been introduced to the Egyptian agriculture as a promising double purpose forage and seed crop for its green canopy or using it in animal diets as dry seeds as well as it is a primary source of plant protein for humans and animals[11]. It is a high nutritive value and known in Africa for human consumption. Cowpea as a summer crop will compete with other summer dominant crops, likely, it has a wide range of compatibility with other crop species in intercropping systems. At the same time, cowpea is an important legume crop. It is a primary source of plant protein for humans and animals[11]. Therefore, cowpea intercropping may offer a potential method of incorporating such crop in the Egyptian agricultural structure. Therefore, the objective of this study is to investigate the effect of intercropping maize with cowpea growth, light interception, yield and yield components of the component intercrops and land use efficiency.

2. Materials and Methods

Two field experiments were conducted during the two successive summer seasons 2013 and 2014 in a private farm El-Gmalia district, Dakahlia Governorate, Egypt. The experiments aimed to study the growth, yield and land use efficiency of cowpea under relay intercropping with maize grown at different intercropping patterns. Cowpea (*Vigna unguiculata* (L.) Walp) variety Karim-1 was used. Cowpea was planted in solid cultures at the densities of 444.4 and 666.7x10^3 plants ha^{-1} while maize was planted as solid cultures at 66.7 and 83.3x10^3 plants ha^{-1} for solid I (The recommended practice) and solid II (The planting density under intercropping patterns), respectively. The planting densities of cowpea were equal to 100 and 150 % while for maize it represented 100 and 125 % of the solid cultures for solid I and solid II, respectively. Cowpea plants were intercropped with maize in three intercropping patterns by alternating 1, 2 and 2 ridges of maize with 3, 2 and 4 ridges of cowpea to form the intercropping patterns of 1:3, 2:2 and 2:4, respectively. These intercropping patterns provide 25, 50 and 33.3% of the cultivated area to maize and 75, 50 and 66.7% to cowpea for 1:3, 2:2 and 2:4 intercropping patterns, respectively. Thus, the experiment included seven treatments arranged in Complete Randomized Block Design with four replicates.

The experimental soil was ploughed twice, ridged and divided to experimental plots. A boarder of 1 meter was left between each two experimental plots to avoid shading effects. Cowpea seeds were sown on both sides of ridge in hills 10 cm apart and 60 cm width in intercropping and solid II cultures whereas, in solid I cultures sowing was carried out at 15 cm hill space and 60 cm between ridges. Maize was also sown in hills at 25 cm space in solid I culture while for solid II and intercropping patterns sowing was applied in hills 40cm apart. Cowpea was sown in the assigned ridges in 12 and 15 May in 2013 and 2014 seasons, respectively. Two weeks later and before the first irrigation of cowpea. Maize was sown in the predetermined ridges.

After the germination was completed, cowpea seedlings were thinned to two plants per hill to obtain the required density for each pattern. Maize seedlings were thinned at two plants per hill for solid II and intercropping patterns while thinning was applied at one plant per hill for solid I culture. The theoretical numbers of maize, cowpea under the different cropping patterns are listed in Table-1. Cowpea seeds were inoculated with the specific Rhizobium strain. Phosphatic fertilization was applied in the form of calcium super phosphate 15.5 % P_2O_5 at the rate of 260 kg ha^{-1} during seed-bed preparation. Nitrogen was added as a starter dose at 36 kg N ha^{-1} as ammonium nitrate 33.5% N while maize plants were fertilized with 252 kg N ha^{-1} in two doses 168 and 84 kg N before the first and second irrigations, respectively. The recommended agronomic practices for cowpea and maize were applied during the growing seasons.

Table 1. The theoretical number of maize and cowpea plants under the different cropping patterns applied.

Cropping pattern		Number of plants ha^{-1} x 10^3 plants	
Maize	**Cowpea**	**Maize**	**Cowpea**
1	3	21.00	500.25
2	2	42.00	332.70
2	4	27.96	444.50
Maize solid I (recommended)		67.70	…
Maize solid II (comparative)		83.30	…
Cowpea Solid I (recommended)		…	444.40
Cowpea Solid II (comparative)		…	666.70

Cowpea plants flowered (50% flowering) at 42 and 47 days and matured after 94 and 101 days from sowing in 2013 and 2014 seasons, respectively. Maize tasseling occurred after 56 and 58 days, silking after 67 and 69 days from sowing and maturity after 120 and 117 days from sowing in 2013and 2014seasons, respectively. During the growing seasons, two vegetative samples were taken from cowpea after 45 and 60 days from sowing to determine the total dry weight per plant. Leaf area was determined and leaf area index (LAI) was calculated. At maturity, ten plants were taken randomly from each experimental unit, and then pod number and weight, 100-seeds weight, and seed yield per plant were determined. Two ridges of each crop were devoted to determine seed yield per hectare. Maize yield characters i.e., number of ears per plant number of rows/ear; number of grains/row, grain yield per plant, 100-grains weight and grain yield per hectare were determined. The land equivalent ratio for maize (L_m), cowpea (L_c) and the total land equivalent ratios (L_m+ L_c) were estimated according to[12] as follows.

$$L_m = \frac{\text{Intercropped yield of maize}}{\text{Pure stand yield of maize}}$$

$$L_c = \frac{\text{Intercropped yield of cowpea}}{\text{Pure stand yield of cowpea}}$$

Total LER = (L_{m} + L_c)

Light interception measurements.

The light interception was measured for the solid and intercropping systems by using luxmeter in luxes according to[13] then the units were converted to energy flux density units in J m^{-2} s^{-1} according to the relationship described by[14].

1 w m^{-2} = 111.8 lux
1 w m^{-2} = 1 J m^{-2} s^{-1}

Statistical analysis.

The data were subjected to the proper statistical analysis using COHORT 6 package since the data in both seasons took similar trends, Bartlett's test was applied and the combined analysis of the data was done. For means comparison Duncan's multiple range test was applied at 5% level according to[15].

3. Results and Discussion

3.1. Effect of intercropping pattern on cowpea characters.

3.1.1. Light energy flux density (J m^{-2} s^{-1}).

Data presented in Table-2 show the light energy flux density (J m^{-2} s^{-1}) in the upper, mid and the lower third of cowpea canopies under the different cropping patterns. In general ,intercropping cowpea with maize significantly depressed light energy flux density compared with the recommended solid cultures (solid I) or under the comparative treatment where the same plant arrangement was allocated under intercropping (solid II). Comparing the intercropping patterns, the data show that 1:3 intercropping pattern significantly surpassed the other two intercropping patterns 2:4 and 2:2 in the ability of light capturing. Moreover, the difference between 1:3 intercropping pattern and the comparative treatment (solid II) was insignificant. The overall percentage of light energy flux density from the full light energy flux density were 62.8, 35.8 and 48.0% in the upper third 27.5, 19.2 and 19.1% in the mid third and14.6, 6.3 and 6.8% in the lower third for 1:3, 2:4 and 2:2 intercropping patterns, respectively.

The reduction in light penetration inside cowpea canopies was expected, but the data show that the biological stress resulted from the companion maize crop was minimized to reach similar values of light energy flux density under the same planting density in solid cultures of cowpea (SII). Such results indicate that the relay intercropping (cultivation a crop during a part of the life cycle of another crop) enabled cowpea seedlings to escape from the severe competition on light between maize and the legume crop since the later was grown two weeks earlier. Thus, the biological stress which resulted from the companion tall crop (maize) was relatively reduced especially at the lower heights of measuring in the intercropping patterns of 1:3 and 2:4

where cowpea occupied greater proportion of land than maize. Moreover, such reduction in the biological stress may decrease the lower leaves of cowpea from being parasitic on the upper leaves[16]. In this respect, several investigators attributed the variability of legume tolerance to shading effects to the difference in the foliage architecture of the intercropped legumes[17-21].

Table 2. Effect of cropping pattern on light energy flux density (J m^{-2} s^{-1}) at different heights inside cowpea canopy. (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping			Solid	
	1M:3C	**2M:4C**	**2M:2C**	**I**	**II**
Light energy flux density (J $m^{-2}s^{-1}$) (upper-third)	674 a	424 b	568 b	706 a	626 a
Light energy flux density (J $m^{-2}s^{-1}$) (mid-third)	303 b	221 c	221 c	404 a	371 a
Light energy flux density (J $m^{-2}s^{-1}$) (lower-third)	169 ab	73 c	52 c	193 a	139 b
Upper-Third (%)	62.8	35.8	48	61	56
Mid-third (%)	27.5	19.2	19.1	34.9	33.7
Lower-third (%)	14.6	6.3	6.8	16.3	12

M: Maize, C: Cowpea, (%) Relative to light energy flux density in the full sun-light intensity, Row which have the same letter (s) are not significant according Duncan Multiple Range at 5% level.

3.2. Leaf area index (LAI) and dry matter accumulation plant^{-1}.

Table-3 summarizes the data of leaf area index and dry matter accumulation of cowpea with the different cropping patterns after 45 and 60 days from sowing. Cowpea plants which intercropped with maize at 2:2 and 1:3 patterns significantly, exceeded those which intercropped at 2:4 pattern in LAI at 45 days from sowing. Cowpea plants tended to accumulate greater dry matter per plant when intercropped with maize at 1:3 pattern than that accumulated under 2:2 intercropping pattern.

It is worthy to note that relay intercropping of cowpea with maize helped in minimizing the competition between legume crop and maize in the critical period of legume life cycle, especially at the early stage of growth, thus severe reductions in LAI and dry matter accumulation was not reported. The reduction in dry matter accumulation in the intercropped cowpea compared with the solid cultures could be attributed to the competition between cowpea plants on light as a result of the biological stress caused by the tall companion crop (maize) which decreased the photosynthesized metabolites and consequently the reduction in dry matter occurred.

In this conceded the productivity of a crop depends on photosynthesis, partitioning, and transfer of assimilates to the economically important parts. The differences in canopy height of (cowpea and maize), the two species not only competed for nutrient and water but also for sunlight. The shading effect of tall intercropped maize may have adversely affected the biomass and photosynthesis of intercropped cowpea. Similarresults were obtained by[1,21,2].

3.3. Cowpea yield and its components.

Data presented in Table-4 show significant effects on pod number and weight due to cropping patterns. The solid recommend culture significantly exceeded the other cropping patterns in weight of pods per plant. When comparing the intercropping patterns with the same solid planting density (solid II), the data show no significant differences between 1:3 and 2:2 patterns and solid II treatment in weight of pods per plant. The highest pod weight of cowpea under intercropping was recorded under 1:3 intercropping pattern.

Table 3. Effect of cropping pattern on Cowpea leaf area index and total dry weight /plant at 45 and 60 days from sowing (DAS). (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping			Solid	
	1M:3C	**2M:4C**	**2M:2C**	**I**	**II**
Leaf area index/plant at 45 DAS	3.15 ab	2.75 c	3.35 a	2.90 bc	2.75 c
Leaf area index/plant at 60 DAS	3.25 c	3.94 b	5.16 a	3. 38 c	3.31 c
Total dry weigh (g/plant) at 45 DAS	11.13ab	9.05 c	10.07 b	12.5 a	10.3 b
Total dry weigh (g/plant) at 60 DAS	18.45 c	21.2 ab	23.25 a	19.9 b	21.5 a

M: Maize, C: Cowpea, Row which have the same letter (s) are not significant according Duncan Multiple Range at 5% level.

Cowpea seed yield per plant was significantly affected by cropping pattern. Cowpea yield per plant was similar under the solid recommended culture and solid II treatment. Meanwhile, when comparing the intercropping patterns at the same solid plant arrangement (solid II), cowpea seed yield per plant was significantly reduced. The highest seed yield per plant under intercropping patterns was reported with 2:4 and 2:2 patterns. On the other hand, the lowest cowpea seed yield per plant was reported with 1:3 intercropping pattern.

From the same table, it is shown that intercropping led to significant reduction in 100-seed weight compared with the solid recommended culture. The highest 100-seeds weight was reported under 1:3 intercropping pattern in both seasons.

Cowpea seed yield per hectare was significantly affected by cropping patterns. Seed yield of the solid II treatment was higher than that of solid I. As expected, significant differences among intercropping patterns were reported and are mainly attributed to differences in the proportion of the legume crop in the mixture where 50, 67 and 75% of the cultivated area were occupied with legumes in 2:2, 2:4 and 1:3 intercropping patterns. Furthermore, the reduction in seed yield per plant under intercropping patterns compared to the solid II culture also shared in such reduction per hectare. Intercropping pattern 2:4 and 1:3 gave higher seed yield per hectare without significant differences, compared with 2:2 intercropping pattern. The reduction in seed yield by intercropping could be due to interspecific competition and depressive effect of maize, as C4 species on cowpea as C3 crop. Crops with C4 photosynthetic pathways such as maize have been known to be dominant when intercropped with C3 crops like cowpea.

The reduction in the intercropped legume growth and yield characters was reported by several investigators. Abd El Lateef [22] showed a reduction percent in mungbean seed yield per plant by 44.6, 43.2 and 29.3 % for the intercropping pattern 2:2, 2:3 and 2:4 respectively compared with the pure stand culture. Morgado and Willey[23] reported that intercropping significantly decreased bean biomass yield and harvest index at all bean populations as compared to sole cropping system. Also, Muoneke *et al*.[9] reported a reduction in the intercropped soybean seed yield per hectare by 42 and 46% in early and late seasons, respectively they attributed such reduction to the decrease in number of pods per plant. Also, Mohamed *et al*.[24] in Nigeria found that cowpea grain yield and its components were highest at 2:4 row arrangement while lowest values were recorded at 1:1 arrangement where intercrop competition was most intense.

Table 4. Effect of cropping pattern on cowpea yield and its components. (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping			Solid	
	1M:3L	2M:4L	2M:2L	I	II
No of pods plant^{-1}	17.35 a	14.85 b	10.28 c	15.63ab	17.50 a
Pod weight (g plant^{-1})	8.60 b	7.19 c	8.02 b	10.82 a	9.38 ab
Seed yield (g plant^{-1})	2.23 c	3.84 b	2.96 c	6.46 a	6.90 a
Relative yield/plant%	32.3	55.6	42.8	93.6	100
100-Seed weight (g)	4.61 b	4.40 b	4.20 b	5.25 a	5.30 a
Seed yield (ton ha^{-1})	0.859 b	0.730 b	0.421 c	1.318 a	1.514 a

M: Maize, C: Cowpea, Row which have the same letter (s) are not significant according Duncan multiple range at 5% level.

3.4. Effect of cropping pattern on maize characters.

3.4.1. Light energy flux density (J m^{-2} s^{-1}).

Table-5 shows the light energy flux density (J m^{-2} s^{-1}) in the upper, mid and lower third of maize in the different intercropping patterns. In general, more light was captured when maize was intercropped with cowpea than that of solid cultures. Moreover, significant increases in light interception were reported from the intercropping patterns over the solid plantings I and II. The data show that maize at 1:3 intercropping pattern received more light in the upper third than that in the other intercropping patterns. However, in the mid and lower thirds maize plants were able at 2:4 patterns to capture more light than that of 2:2 and 1:3 intercropping patterns.

The overall percentage of light energy flux density relatively to the full light energy flux density were 87.1, 83.1, 73.2, 75.1 and 75.3% in the upper third 52.5, 58.4, 36.3, 32.1 and 24.6% in the mid third and 17.5, 31.7, 13.4, 10.2 and 8.7% in the lower third for the cropping patterns 1:3, 2:4, 2:2 solid I and solid II treatments. Such reductions indicate that maize under intercropping patterns was less competitive for light than that under solid patterns. In other words, light energy flux density criteria at the different heights under intercropping patterns indicate more efficient use of light. Such efficiency could be attributed to the deeper free spaces resulted from the adjacent short crop (cowpea) which minimized the competition for light between maize and the cowpea. Furthermore maize as C4 plant with larger canopy (dominant crop) was more able to hunt more light than the dominated crop (Cowpea). Maize had greater radiation use efficiency in intercropping than cowpea. Such efficiency could be attributed to the differences in canopy height of (maize and cowpea), growth and requirement of solar energy.

Several intercropping studies have shown that mixed canopies tend to intercept more light than single species[18,19,25] demonstrated that intercrops have greater radiation use efficiency than solecrops.

3.4.2. Maize yield and its components.

Data given in Table-6 show that number of ears per plant was not significantly affected by intercropping with cowpea. It can be noticed that greater number of ears per plant was recorded under intercropping patterns compared with the solid cultures in both seasons. The intercropping patterns of 1:3 and 2:4 gave the highest significant number of ears per plant. Number of rows per ear was not significantly affected by cropping pattern and it was greater when maize was intercropped with cowpea. Intercropping patterns significantly exceeded the solid cultures (solid I and solid II) in number of grains per row and the difference between intercropping patterns and solid II culture was significant.

Table 5. Effect of cropping pattern on light energy flux density (J $m^{-2} s^{-1}$) at different heights inside maize canopy. (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping			Solid	
	1M:3C	**2M:4C**	**2M:2C**	**I**	**II**
Light energy flux density (J $m^{-2}s^{-1}$) Upper third	1005.6 a	907.1 a	846.1 b	880.7 b	871 b
Light energy flux density (J $m^{-2}s^{-1}$) Mid-third	605.9 b	673.7 a	476.2 c	370.6 d	284 e
Light energy flux density (J $m^{-2}s^{-1}$) Lower third	202.2 b	365.8 a	125.2 c	120.9 c	101.1d
Upper-third (%)	87.1	83.1	73.2	75.1	75.3
Mid-third (%)	52.5	58.4	36.3	32.1	24.6
Lower-third (%)	17.5	31.7	13.4	10.2	8.7

M: Maize, C: Cowpea, (%) Relative to light energy flux density in the full sun-light intensity, Row which have the same letter (s) are not significant according Duncan Multiple Range at 5% level.

From the same table, it is clear that no significant difference in maize yield per plant was reported due to intercropping with cowpea and resulted in significant increase in grain yield per plant compared with solid cultures. The beneficial effect due to intercropping could be realized through the direct comparison of maize grain yield per plant at the different intercropping patterns with that yielded at the same plant arrangement (solid II culture). The relative yield increases in grain yield per plant were 61.7, 60.9 and 59.8 for the intercropping patterns 1:3, 2:4 and 2:2, respectively. Similar magnitude was reported for 100-grains weight where insignificant effects were reported on maize 100-grains weight. The intercropping patterns 1:3 and 2:4 gave greater 100-grains weight compared with 2:2 pattern and the solid cultures. The superiorly of maize plants under intercropping, could be attributed to the lower competition between maize and cowpea plants, as well as the better illumination conditions resulted from the deeper spaces created from alternating tall canopy (maize) with shorter canopy (cowpea). Such conditions, led to more light energy used by maize plants, consequently better yield was attained. Similar results were reported by using maize - soybean intercrops[6,7,20]. Also, Azraf-ul-Haq *et al.*[26] when intercropping semi dwarf grain sorghum with cowpea and Saban *et al*.[27] using maize -legume intercrops came to similar conclusion. With regard to the total grain yield per hectare, the data clearly show that the solid recommended culture significantly exceeded the other cropping patterns. Intercropping maize cowpea did not show significantdifference in grain yield per hectare. The intercropping pattern of 2:2 significantly surpassed 1:3 and 2:4 patterns. Such superiority could be explained due to the variation of the cultivated area with maize where 50, 25 and 33.3% were only occupied by maize under intercropping patterns 2:2, 1:3 and 2:4 respectively. In other words, the superiority of maize yield per plant could not compensate the reduction in the occupied area. Similar results were reported by by[22,20,27]. Takim[28] 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 yieldloss of 23 % and a significantly ($p \leq 0.05$) higher intercropping advantage of +574.66. He added 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.

Table 6. Effect of cropping pattern on maize yield and its components. (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping			Solid	
	1M:3C	2M:4C	2M:2C	I	II
No of ears plant^{-1}	1.11 a	1.12 a	1.08 a	1.03 b	0.96 c
No of rows ear^{-1}	15.1 a	15.5 a	14.5 a	14.1 a	14.3 a
No of grains row^{-1}	47.5 a	50.0 a	43.0 ab	41.0 b	34.0 c
Grain yield (g plant^{-1})	182.0 a	176.6 a	174.7 a	146.0 b	107.5 c
Relative yield plant^{-1}	161.7	160.9	159.8	135.8	100.0
100-grain weight (g)	42.60 a	39.00 b	38.50 b	37.05 b	34.70 c
Grain yield (ton ha^{-1})	3.49 e	4.15 d	6.20 c	7.40 a	6.67 b

M: Maize, C: Cowpea, Row which have the same letter (s) are not significant according Duncan Multiple Range at 5% level.

3.5. Effect of intercropping pattern on land use efficiency.

The partial land equivalent ratios of the intercropping component crops; maize (L_m) and cowpea (L_c) as well as the total land equivalent ratio LER are given in Table-7. The data show that the greatest LER for cowpea (L_c) was obtained by intercropping pattern of 1:3 while the greatest for maize (L_m) was obtained at 2:2 intercropping pattern.

From the same table, it can be realized that the intercropping patterns gave total LER values more than the unity (LER >1), thus yield advantage was reported by intercropping. The highest yield advantage for cowpea and maize (LER=1.23) was obtained from intercropping pattern 2:4. The overall yield advantage of intercropping was 1.16. In this respect several investigators reported yield advantages from intercropping cowpea and cowpea with other crops [29,2,30,,31,28].

Table 7. Effect intercropping pattern on partial LER of maize (L_m), cowpea (L_c) and the total land equivalent ratio (LER). (Combined data over two seasons 2013 and 2014).

Treatment / Character	Intercropping		
	1M:3C	2M:4C	2M:2C
LER, Maize (L_m)	0.47 c	0.61 b	0.83 a
LER, Cowpea (L_c)	0.76 a	0.55 b	0.32 c
Total LER (L_m +L_c)	1.23 A	1.16 B	1.15 B

Row which have the same letter (s) are not significant according Duncan Multiple Range at 5% level.

Conclusion

It can be concluded from this study that maize-cowpea intercropping increased land use efficiency by 15 to 23% than that when each crop was grown separately. Also, the intercropping combination of maize-cowpea and 1:3 intercropping pattern is better than the other combinations.

4. References

1. Ghosh P.K. (2004). Growth, yield, competition and economics of groundnut/cereal fodder intercropping in the semi-arid tropics of India. Field Crops Res., 88,227–237.
2. Abd El-Salam M.S. and El Habbasha S.F. (2008). Evaluation of maize-mungbean intercropping system at different sowing dates for forage production. Egyptian J. Agron., 30(2), 279-294.

3. Schöll L.V. and Nieuwenhuis R. (2004): Soil fertility management. Agrodok 2. Agromisa Foundation, Wageningen, 4Ed 24.
4. Abd EL Gawad A.A., Edris A.S. and Abo Shetaia M.A. (1985). Effect of intercropping soybean with maize on growth, yield and yield components of soybean. Annals Agric. Sci., Faculty of Agriculture, Ain shams Univ., 30 (1), 207-221.
5. Abd EL Lateef E.M. (1988). Effect of some cultural practices on the intensification of maize and soybean production. Ph.D. Thesis, Faculty of Agriculture Cairo Univ.
6. Sakthivel N.S., Radhamani A.B. and Subbian P. (2003). Comparative performance of different maize based intercropping systems and planting patterns under rained situation. Madras Agric. J., 90 (7-9), 416-420.
7. Muneer, A.P., Memon, F.H. Kalhoro, M.A. and Soomro, M.I. (2004): Performance of maize in intercropping system with soybean under different planting patters and nitrogen levels. J. Applied Sci., 4(2), 201-204.
8. Adeniyan O.N. and Ayoola O.T. (2007). Evaluation of four improved soybean varieties under different planting date in relayed cropping system with maize under soybean/maize/cassava intercrop. African J. Biotechnol., 6 (19), 2220-2224.
9. Muoneke C.O., Ogwuche M.A.O. and Kalu B.A. (2007). Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agro ecosystem. African J. Agric. Res., 2 (12), 667-677.
10. Raji J. A. (2007). Intercropping soybean and maize in a derived savanna ecology. African J. Biotechnol., 6 (16), 1885-1887.
11. Hamd Alla W.A., Shalaby E.M., Dawood R.A. and Zohry A.A. (2014). Effect of cowpea (*Vigna sinensis* L.) with maize (*Zea mays* L.) intercropping on yield and its components. International Journal of Biological, Food, Veterinary and Agricultural Engineering, 8(11), 1200-1206.
12. Willey R.W. (1985). Evaluation and presentation of intercropping advantages. Experimental Agriculture, Cambridge, England, 21(2), 119-133.
13. Pearce R.B., Brown R.H. and Blaser R.E. (1996). Relationship between leaf area index, light interception and net photosynthesis in orchard grass. Crop Sci., 5, 553-556.
14. Milthorpe, F.L., and Moorby, J. (1979): An Introduction to Crop Physiology. Cambridge International Student, Edition, 2*nd* Ed, London.
15. Duncan D.B. (1955). Multiple ranges and multiple F test. Biometrics, 11, 1-41.
16. Ottman M.J. and Welch L.F. (1989). Planting patterns and radiation interception, plant nutrient concentration, and yield in corn. Agron. J., 81, 167-174.
17. Naveed A., Mirza M.H. Akhtar A. and Muhammad R. (2000). Intercropping Maize with Cowpea under rained conditions. Pakistan J. Biol. Sci., 3(4), 647-648.
18. Tsub M. and Walker S. (2002). A model of radiation interception and use by maize –bean intercrop canopy. Agricultural and Forest Meteorology 3(110), 203-215.
19. Awal M.A., Koshi H. and Ikeda T. (2006). Radiation interception and use by a maize /peanut intercrop canopy. Agricultural and Forest Meteorology, 1-2(139), 74-83.
20. Asmat U., Ashraf M.B. Gurmani, Z.A. and Imran M. (2007). Studies on planting patterns of maize (*Zea mays* L.) facilitating legumes intercropping. J. Agric. Res., 45(2), 112-118.
21. Ghosh P. K., Mannab M. C., Bandyopadhyayb K. K., Ajayb A. K., Tripathib R. H., Wanjarib K. M., Hatib A.K., Misrab, C.L. and Subba R.A. (2006). Interspecific interaction and nutrient use in soybean/sorghum intercropping system. Agron. J., 98, 1097-1108.
22. Abd El Lateef E.M. (1993). Effect of mungbean (*Phaseolus aurus* Roxb) intercropping with maize (*Zea mays* L.) on productivity and land use efficiency. Egyptian J. Applied Sci., 8(5), 32-45.
23. Morgado L.B. and Willey R.W. (2003). Effects of plant population and nitrogen fertilizer on yield and efficiency of maize-bean intercropping. Pesq. Agropec. Bras. Brasília, 38(11), 1257-1264.
24. Mohammed I.B., Olufajo O.O., Singh B.B., Oluwasemire K.O. and Chiezey U.F. (2008). Productivity of millet /cowpea intercrop as affected by cowpea genotype and row arrangement. World J. Agric. Sci., 4 (5), 818-824.
25. Szumigalski A.R. and Van Acker R.C. (2008). Land Equivalent Ratios Interception, Light A. R and Water Use in Annual Intercrops in the Presence or Absence of In-Crop Herbicides. Agron. J., 100, 1145-1154.

26. Azraf-ul-Haq A., Riaz, A. and Naeem M.P. (2007). Production potential and quality of mixed sorghum forage under different intercropping systems and planting patterns. J. Agric. Sci., 44(2), 203-207.
27. Saban Y., Mehmet A. and Mustafa E. (2008). Identification of advantages of maize-legume intercropping over solitary cropping through competition indices in the east Mediterranean region. Turk. J. Agric. For., 32, 111-119.
28. Takim F.O. (2012). Advantages of maize-cowpea intercropping over sole cropping through competition indices. J. of Agric. and Biodiversity Res., 1 (4), 53-59.
29. Oroka F.O. and Omoregie A.U. (2007). Competition in rice –cowpea intercrop as affected by nitrogen fertilizer and plant population. Sci. Agric., 64(6), 621-629.
30. Mohammed I.B., Olufajo O.O., Singh B.B., Oluwasemire K.O., Chiezey U.F. (2009). Cowpea genotype and row arrangement effects on the productivity and economic returns of sorghum/cowpea intercrop in the Nigerian savanna. Agric. Tropical ET Subtropical, 42 (3), 145-151.
31. Abd El Lateef E.M., M. Hozayn and Magda H. Mohamed (2010). Effect of maize – mungbean intercropping on light interception, yield and land use efficiency. Bull. NRC, 35(2), 169-184.

*****