Egypt. J. Agron. **Vol. 33**, No. 1, pp.35 - 49 (2011)

Effect of Cowpea Intercropping Date in Maize and Sorghum Fields on Productivity and Infestation Weed

M.A. Abou-Keriasha, Sahar T. Ibrahim and E.E.A.Mohamadain
Crop Intensification Research, Department Field Crops Research Institute, Agriculture Research Centre, Giza, Egypt.

TWO FIELD experiments were carried out at Malawi Agricultural Research Station, Minia Governorate, Egypt during 2008 and 2009 summer seasons, to study the effect of cowpea intercropping date on maize (the first one) and sorghum (the second one) on productivity and associated weeds. Three intercropping dates of cowpea with maize or sorghum, were three weeks preceding (D_1), synchronized plantation (D_2) and post maize or sorghum plantation with three weeks (D_3) as well as solid plantation of the three crops. The results indicated that cowpea intercropping date significantly affected plant heights of either maize or sorghum. The preceding cowpea intercropping (D_1) significantly decreased maize and sorghum plant height while neither (D_2) nor (D_3) had shown significant effects on plant height. The grain yields of both maize and sorghum were remarkedly reduced by 50.4 and 36.6% with preceding cowpea intercropping, respectively, while the post plantation cowpea intercropping (D_3) tended to insignificant increase the grain yield of maize or sorghum. Effective reduction reached 90% and 93.7% of weed biomass, when maize and sorghum were intercropped with cowpea at the same time (D2), respectively. The post plantation cowpea intercropping with maize and sorghum caused less weed biomass reductions reached 65.5% and 80.6%, respectively. Green forage yield of cowpea over all cuts was decreased as the results of post plantation cowpea intercropping (D_3) than the other two dates (D_1 and D_2). The reduction was 63.4 and 70.2% when cowpea as compared with solid cropping of cowpea was intercropped with maize and sorghum, respectively, while, the reduction diminished to 27.5% and 32.4% when the preceding cropping of maize and sorghum was applied. Maize and sorghum were the dominant crops, whereas cowpea was the dominated one. The highest land equivalent ratios recorded 1.4 when cowpea intercropped three week after maize (D_3) and 1.5 for synchronized cowpea intercropping (D_2) with maize and sorghum, respectively. The most benefit realized was associated with post plantation cowpea intercropped with maize expressed as monetary index of 1840.63. The total actual yield loss was negative in the three intercropping dates with maize or sorghum which decrease in yield of these crops compared with solid state. It could be concluded that synchronized cowpea intercropping (D_2) with maize and sorghum is the most profitable and preferred for reduce weed infestation.

Keyworsds: Intercropping, Cowpea, Sorghum, Maize.

Researchers and producers carry out different cropping systems to increase productivity and sustainability through practicing crop rotation, relay cropping and intercropping legumes with annual cereals. Intercropping legumes with cereals has become a popular practice due to its advantages for soil conservation, weed control, lodging resistance, yield increment and forage preservation compared with pure culture.

Many investigations were carried out on intercropping legumes with cereals, such as bean, cowpea, vetch, etc. Investigators well-known that crop species or cultivars, sowing date, cropping system, seed ratio affected growth and yields of the crops used in intercropping systems, but the combined yield from the intercropping system was higher than the total yield of any the crops in pure stand. The reduction in intercropped maize yield ranged from 10 to 15% of the pure stand compared with a higher reduction ranging from 45 to 67 % in legume crops (cowpea and bean) pure stand yields (Fininsa, 1997 and Abou Keriasha *et al.*, 2009). Whereas, Reddy *et al.* (1992), Okpara (2000), Dasaraddi *et al* (2002), Lima, (2002) and Yilmaz *et al* (2007), showed that maize, sorghum or millet grain yields were increased or slightly affected by intercropping system compared with the sole crop, but that of legume crop yields (cowpea, bean) showed decrement of 50%. Okpara (2000), stated that intercropping cowpea with maize significantly increased plant height in both crops and grain yield of maize in first season and reduced it in the second season, but cowpea yield was reduced in the two seasons.

Changing sowing date had a major effect on yield and yield components of both associated crops in any intercropping systems. Tariah & Wahua (1985), found that sowing cowpea two weeks after maize reduced cowpea yield but favored the intercropped maize. Francis & Stern (1987) indicated that delaying maize planting in cowpea + maize intercropping system increases cowpea yield by 46%. He added that delaying cowpea sowing increased maize yield, but decreased cowpea yield. Reddy & Visser. (1997), noted that delaying sowing from simultaneous sowing cowpea with millet to 7 weeks after millet led to significantly lower crop growth rates from 19 to 10 kg.h.d. and lowered grain from 1110 to 100 kg.h. and dry matter yield of cowpea from 2110 to 560 h. Okpara (2000) showed that plant height, leaf area index, dry matter and pod yield in vegetable cowpea as well as yield in maize were decreased significantly following delaying the introduction of either crop in mixture, usually the component crop that was planted earlier in the mixture gave a stiffer by growth and yield values. Adipala *et al.* (2002) noted that the reduction in growth and yield of cowpea due to delaying plantation four weeks, therefore they recommended simultaneous planting of maize and cowpea to achieve yield benefit.

The intercropping systems are recognized as methods for reducing weeds in fields. However, farmers suffer weed spreading specially when they depend on a main crop for a long period. Zougmore *et al.* (2000) showed that sorghum/cowpea intercropping reduced weeds manifestation by 20-30% compared to a sorghum monoculture.

The intercropping arrangements were more productive and profitable than sole cropping. Reddy *et al*. (1992), showed that land equivalent ratio (LER) were 1.48, 1.43 and 1.08 in intercropping millet with cowpea sown 1, 2 and 8 weeks after millet, respectively. Padhi (2001), found that intercropping maize with runner been (*Phasoelus vulgaris*) gave the highest-equivalent yield productive efficiency, land equivalent ratio, net returns, monetary advantage index. Adipala *et al.* (2002) showed that date of introducing cowpea into maize significantly affected both growth and yield of cowpea. Simultaneous planting generally showed a yield advantage LER of cowpea intercropped maize when delayed sowing of cowpea was as low as 0.75 when cowpea was planted four weeks after planting maize. Ghosh (2004), Yilmaz *et al.* (2007) and Abou Keriasha *et al.* (2009) found that when LER, Agg and CR were higher there was also a significant economic benefit expressed with higher monetary advantage index (MAI) values.

The objectives of this study were to investigate the effects of cowpea intercropping date on maize and sorghum productivity and on weed infestation.

Materials and Methods

Two adjacent field trials were carried out during 2008 and 2009 summer seasons at Mallawi Agricultural Research Station, Minia Governorate (Middle Egypt) on clay soil with ph 8.1. The experiment design was randomized complete block design with three replicates. Every experiment included five treatments were as follows:

First experiment:

- Intercropping cowpea three weeks before maize planting D_1.
- Intercropping cowpea at the same date of planting maize D_2.
- Intercropping cowpea three weeks after maize planting D_3.
- Solid maize (cv T.W.C. 310).
- Solid cowpea (cv. Cream).

Second experiment:

- Intercropping cowpea three weeks before sorghum planting D_1.
- Intercropping cowpea at the same date of planting sorghum D2.
- Intercropping cowpea three weeks after sorghum planting D_3.
- Solid sorghum (cv. Giza 15).
- Solid cowpea (cv. Cream).

Maize or sorghum (solid and intercropped) in each experiment was grown (1^{st} June) in both season on one side of ridge (70cm width) and thinned to one plant/hill, 30cm apart between hill. Solid cowpea (1^{st}June) was sown on one side of ridge (70cm width) and thinned to two plants/hill, 30cm apart. Cowpea was intercrop on the other side of maize or sorghum ridges with the same planting density of solid planting (100% maize or sorghum + 100% cowpea).

The experimental unit was 10 rows, six m in length and 70cm in width giving a total area $42m^2$ ($1/100$ fed^{-1}). Cultural management and pest control programs of maize, sorghum and cowpea crops were practiced as recommended by the Egyptian Ministry of Agriculture.

During seed bed preparation, 50 kg P_2O_5 fed^{-1} in the form of ordinary calcium superphosphate, (15.5% P_2O_5) was added. Potassium fertilizer was added at the rate of 24 kg K_2O fed^{-1} before planting in form sulfate potassium. Nitrogen fertilizer for maize and sorghum was added at the rate of 120 and 75 kg N fed^{-1}, respectively, of ammonium nitrate (33.5%N) in three equal splits doses. The first was added after thinning, whereas the second and third were added after two and four weeks later. Cowpea was fertilized with 20 kg N fed^{1} ammonium nitrate after thinning.

Data recorded

Maize

At harvest ten guarded maize plants from each plot were taken randomly to determine plant height, ear length, number of rows ear^{-1}, number of kernels row^{-1}, weight of kernels/ear, 100-kernels weight and the shelling percentage.

Sorghum

At harvest ten guarded sorghum plants from each plot were taken randomly to determine plant height, weight of kernels $head^{-1}$, 100-kernels weight, and the shelling percentage.

Grain yield of maize or sorghum were determined in plot basis and consequently were converted in ardab /fed (ardab= 140 kg, fed = 4200 m^2).

Cowpea

Two cuts of cowpea were taken after two and four months from planting (either solid or intercropping). At each cutting the green forage yield /fed was estimated for the green forage yield $plot^{-1}$ (kg), and the fresh cuts were totaled in tons.

Weeds

The fresh weight of annual weeds (broad leaves and grasses) were weighted at each cowpea cut as well as the weights of collected weed plants during agricultural practices, all fresh weights were summed for each plot (kg).

Competitive relationships

Land equivalent ratio (LER)

LER is determined as the sum of the fractions of the yield of intercrops relative to their sole crop yield (Willey & Osiru, 1972). LER was determined according to the following formula:

$$\text{LER} = \frac{yab}{yaa} + \frac{yba}{ybb}$$

where: Y_{aa} is pure stand yield of crop a, Y_{bb} is pure stand yield of crop b, Yab is intercrop yield of a (when combined with b) and Y_{ba} yield of b (when combined with a).

Area time equivalent ratio (ATER)

A concept that considers the date factor along with land area is ATER proposed by Hiebsch & McCollum (1987). It is calculated as follows ;

$$\text{ATER} = \left(\frac{tM}{tI} \times \frac{Yab}{Yaa}\right) + \left(\frac{tM}{tI} \times \frac{Yba}{Ybb}\right)$$

where: t_M =duration of crop in monocropping

t_I = total duration of the intercrop system

The ATER accurately estimates the biological efficiency, which is defined as the rate at which radiant energy is converted to harvestable biological energy via myriad processes that take place in green plants .

Aggressivity (Agg) (Aggressive behavior)

Aggressivity was proposed by Mc–Gilichrist (1960), and was determined according to the following formula:

$$\text{Agab} = \frac{yab}{yaa \times zab} - \frac{yba}{ybb \times zba}$$

An aggressivity value of zero indicates that the component crops are equally competitive. For any other situation, both crops will have the same numerical value but, the sign of the dominant crop is positive and the dominated is negative. The greater was the numerical value of (Agg), the greater the difference in between actual and expected yields.

Competitive ratio (CR)

It was calculated by the following formula as given by Willey & Rao (1980).

$$\text{CR} = \text{CR}_a + \text{CR}_b \qquad \text{CR}_a = \left\{\left(\frac{LERa}{LERb}\right) \times \left(\frac{Zba}{Zab}\right)\right\}$$

where: $\text{LER}_{\mathbf{a}}$ and $\text{LER}_{\mathbf{b}}$ represent relative yield of a and b intercrops, respectively. Since the CR values of the two crops will be the reciprocals of each other. $\text{CR}_{\mathbf{a}}$, $\text{CR}_{\mathbf{b}}$ are the competitive ratio for intercrop where $Z_{\mathbf{ab}}$ representing the sown proportion of intercrop a (legume crops) in combination with b (maize) and $Z_{\mathbf{ba}}$ the sown proportion of intercrop maize in combination with a legume crop.

Actual yield loss (AYL)

It was calculated ording to Banik (1996) as follows:

$$\text{AYL} = \text{AYL}_a + \text{AYL}_b = \left[\left\{\frac{(Yab / Zab)}{(Yaa / Zaa)}\right\} - 1\right] + \left[\left\{\frac{(Yba / Zba)}{(Ybb / Zbb}\right\} - 1\right]$$

Where: AYL_a and AYL_b are the partial yield loss of intercrop legume crop (cowpea) and maize, respectively. Yab representing the yield of intercrop a (cowpea) in combination with b (maize) in combination with a (cowpea).

Monetary advantage index (MAI)

Suggests that the economic assessment should be in terms of the value of land saved; this could probably be most assessed on the basis of the rentable value of this land. MAI was calculated according to the formula of Willey (1979).

$$MAI = \frac{\text{Value of combined intercrops} \times (LER - 1)}{LER}$$

The average market price in the two seasons for green forage yield and grain yield of maize were 90 LE/ton for green forage yield of cowpea and 220 LE/ardab of maize and sorghum.

The statistical analysis was carried out for each crop separately according to Snedecor & Cochran (1982), using MSTAT computer V4 (1986). LSD at 0.05 levels was used to compare the differences between treatment means.

Results and Discussion

Since the two experiments were adjacent and completely similar except the main crop in intercropping system which was maize for the first one and sorghum for the second one the results were presented and discussed together.

Effect of cowpea intercropping date on yield, yield component and associated weeds

Data in Tables 1 and 2 showed significant difference in all studied characters of maize and sorghum in both seasons except in case of number of rows ear^{-1} of maize in first season due to varying cowpea-intercropping date. Sowing cowpea before maize or sorghum on the intercrop by three weeks (D_1) caused a shortness of maize and sorghum plants. On the contrary, the second sowing date (D_2) of cowpea intercropped with maize or sorghum increased the height of main crops. Whereas, when cowpea was intercropped later three weeks after sowing maize and sorghum (D_3), the plant height of maize and sorghum didn't significantly varied than their solid planting. These effects on plant heights of either maize or sorghum may be due to the shading effect of cowpea plants sown early three weeks in the first date (D_1) on small seedling of the main crops. Okpara (2000) observes similar results.

The grain yield of the two main crops followed similar trends. Sowing intercropped cowpea three weeks before the main crops maize or sorghum by three weeks (D_1) remarkably reduced the grain yield by 50.3% and 50.6% in maize and 34.6 and 38.4% in sorghum in the 1^{st} and 2^{nd} seasons, respectively. These deleterious effects of cowpea intercropped with maize and sorghum may be due to the sever competition between emerging maize or sorghum seedling with taller cowpea plants due to increased shading effect of cowpea, hence high competition for intercepted light. These results were supported by Francis & Stern (1987). The reduction of maize yield was 24.8% and 18.0% in the first and second seasons, respectively, in the second dated (D_2). Whereas, incase of sorghum difference in grain yield between solid cropping and these intercropped

in the second date (D_2) failed to reach the 5% level of significant, it is clear that the effects on maize were more than those on sorghum. However, the productivity of maize and sorghum didn't differ significantly between the solid crop and those intercropped in the third date. Similar results were reported by Reddy *et al.* (1992) and Fininsa (1997).

TABLE 1. Effect of cowpea intercropping date on yield and yield components of maize and the biomass of associated weeds in 2008 and 2009 seasons .

Trait / Treat-ment	Plant height cm	Ear length cm	No. of rows/ear	No. of kernels/ row	Kernels weight / ear g	100 kernels weight g	Shelling %	Grain yield ardab/fed	Weed fresh weight/plot kg
First season									
Solid	289.0	22.4	12.7	46.2	239.7	41.3	84.7	25.8	3.1
D_1	258.0	20.7	12.3	43.3	222.0	36.3	83.3	12.8	0.4
D_2	305.0	21.7	12.0	48.2	242.7	40.7	83.3	19.3	0.2
D_3	287.7	22.7	12.7	51.8	259.3	41.7	86.3	26.2	0.9
LSD 0.05	19.2	1.1	NS	5.2	11.2	3.7	2.5	3.9	0.2
Second season									
Solid	283.3	22.4	13.3	49.5	224.5	43.0	87.6	25.0	2.4
D1	265.0	20.0	12.0	40.2	222.8	37.8	82.4	12.4	0. 6
D2	295.0	22.2	13.7	50.2	249.7	43.6	87.5	20.5	0.3
D3	289.3	22.6	14.0	51.9	259.3	43.7	87.9	25.6	0.9
LSD 0.05	8.8	1.0	1.4	2.8	4.2	1.5	0.9	4.3	0.3

TABLE 2. Effect of cowpea intercropping date on yield and yield component of sorghum and biomass of associated weeds in 2008 and 2009 seasons.

Trait / Treatment	Plant height cm	Kernels weight /head g	100-kernels g	Shelling (%)	Grain yield ardab/fed	Weed fresh weight/plot kg
First season						
Solid	351.3	54.8	5.1	50.3	11.2	4.0
D_1	292.7	33.0	4.7	37.3	7.3	0.4
D_2	351.0	59.1	5.6	53.4	12.1	0.2
D_3	348.0	65.3	5.9	53.6	12.4	0.7
LSD 0.05	7.01	3.4	0.5	5.7	2.0	0.2
Second season						
Solid	349.0	49.5	5.2	47.3	12.5	3.3
D_1	305.0	37.8	4.7	38.0	7.7	0.4
D_2	346.7	53.9	5.4	51.4	12.7	0.3
D_3	345.0	54.8	5.7	54.2	12.8	0.7
LSD 0.05	8.5	2.5	0.1	1.9	2.1	0.3

The comparable yield components of maize and sorghum were kernels weight per ear or head, 100 kernels weight and shelling percentage. The kernel weight per ear or head of the two main crops were reduced when cowpea was sown early by 7.4% and 0.75% than the solid maize and 39.8% and 23.6% than the solid sorghum in the first and second seasons, respectively. Also, sowing cowpea early (D_1) reduced 100 kernels weight by 12.1% and 12.2% for maize and 8.4% and 8.7% for sorghum compared with solid crop, in the two seasons, respectively. While the reduction in shelling ratio was 1.6% and 6.0% in maize and 25.8% and 19.7% in sorghum for the two seasons, respectively. The previous trends were similar with that occurred with the D_2 intercropping system. More ear traits were studied to interpret the influence of intercropping on maize productivity, these traits were ear length, number of rows ear^{-1} and number of kernels row^{-1} (Table 1). The means over different sowing dates of cowpea and seasons displayed trends concerted with the other yield components of maize. Plant height is one of the most agronomic characters that demonstrate the effects of associated crops in any intercropping system. However, the plant height of either maize or sorghum were statistically equal for all intercropping systems except incase of (D_1) reached 10.7% and 6.5% for maize and 16.7% and 12.6% for sorghum compared with solid crop over the two seasons, respectively. These results are in same line with those obtained by Reddy *et al.* (1992), Francis & Stem (1987) and Okpara (2000).

The results in Tables 1 and 2 showed that the biomass of weeds plot kg^{-1} was significantly affected by intercropping date. The weight of associated weeds (broad leaves and grasses) under intercropping was significantly decreased compared with that in solid planting. The reductions under cowpea intercropping pre-maize (D_1) were 86.8% and 76.2%, in synchronized with maize (D_2) were 92.6% and 89% and post- maize (D_3) were 70.7% and 60.3% in first and second seasons, respectively. The trend of weed reduction under cowpea intercropped with sorghum was identical with maize one. The reductions under cowpea intercropping pre- sorghum (D_1) were 89.5% and 88.8%, in synchronized with sorghum (D_2) were 95.0% and 92.4% and post sorghum (D_3) were 81.8% and 79.5% in first and second seasons, respectively. These results indicated that weed biomass can be arranged on descended manner D_2, D_1 and D_3 as they had adverse effect on weeds growth (Camel *et al.* 1983 and Zougmore *et al.* 2000).

Effect of cowpea intercropping date on green forage yield of cowpea

The results in Tables 3 and 4 showed a significant adverse effect on green forage yield of cowpea intercropped with either maize or sorghum in all dates and seasons. The green forage yield in D_3 intercropping system significantly decreased than other dates (D_1 and D_2). The average reduction in green forage yield of cowpea intercropped with maize in D_3 intercropping system were 62.0 and 63.4% compared with solid cowpea in both season, respectively. It is clear that the competition between the two-associated crops amplified by maize elongation and consequently its large shading on cowpea. In addition, the reduction in green forage yield was higher in the second cut than in the first cut at

the all dates compared with solid plant in both seasons. The large reduction in the second cut due to the highest competition of maize and sorghum with shading effect of the taller component crops (maize or sorghum which obstructed solar radiation from penetrating into the lower cowpea canopy. These results are in same line with those obtained by Adipala *et al.* (2002) and Wahua *et al.* (1981). Whereas, the average reductions were 29.6 and 25.3% for D_1 intercropping system in the two seasons, respectively. The lowest shading of young maize plants on cowpea accompanies with the lowest competitions and in consequence lowest forge yield reduction. The reductions in green forage yield resulted from intercropping cowpea with sorghum displayed the same trend shown with maize. The average reductions in D_3 intercropping system were 71.6 and 68.5% in the first and second season, respectively. The average reductions in D_1 intercropping system were 36.4 and 28.2% compared with planting solid in the two seasons, respectively. The highest reductions of green forge yield were shown in the D_3 intercropping system in which the juvenile cowpea plants suffer the highest competition of sorghum tall plants shading on cowpea and decreasing effective sunrays. Similar results were obtained by Tariah & Wahua (1985) and Adipala *et al.* (2002).

TABLE 3. Effect of time of intercropping cowpea with maize on green forage yield (ton/fed) in two seasons.

Trait / Treatment	First season			Second season		
	First cut	Second cut	Total cuts	First cut	Second cut	Total cuts
Solid	16.8	10.5	27.3	16.0	9.1	25.1
D_1	12.1	7.2	19.2	12.5	6.2	18.8
D_2	11.3	3.2	14.3	11.7	3.7	15.4
D_3	8.0	2.1	10.1	7.2	1.9	9.1
LSD 0.05	0.6	1.4	1.0	1.0	0.5	1.4

TABLE 4. Effect of time of intercropping cowpea with sorghum on green forage yield (ton/fed) in two seasons.

Trait / Treatment	First season			Second season		
	First cut	Second cut	Total cuts	First cut	Second cut	Total cuts
Solid	15.5	11.0	26.5	15.0	9.8	24.8
D_1	11.8	5.8	18.6	12.1	5.7	17.8
D_2	10.4	0.8	11.2	10.3	1.3	11.6
D_3	6.9	0.7	7.5	6.8	1.0	7.8
LSD 0.05	0.6	0.4	1.4	0.6	0.6	1.5

Competitive relationships and yield advantages

Results in Table 5 indicated that land equivalent ratio (LER), area time equivalent ratio (ATER), aggressivety (AGG), competitive ratio (CR), actual yield loss (AYL) and monetary advantage index (MAI) were varied considerably due to cowpea intercropping date with maize and sorghum particularly in the combined data of the two seasons.

Land equivalent ratio (LER)

The results revealed that intercropping cowpea with maize or sorghum caused significant decrements of cowpea yields, while both maize and sorghum displayed modest changes in yields compared with solid plantations, exceptin case of (D_1). The relative yield of maize RY_M (1.02) and the relative yield of sorghum RY_{So} (1.06) when cowpea was intercropped three weeks after both (D_3) crops surpassed those in solid planting. Whereas, the relative yield of cowpea RY_{Co} was 0.37 and 0.3 when intercropped with maize and sorghum, respectively. Contrary, the RY_M (0.50) and RY_{So} (0.63) for cowpea when sown early three weeks before the main scrop (D_1). Whereas, the relative yield of cowpea RY_{Co} was 0.72 and 0.67 when intercropped with maize and sorghum, respectively. It is apparent that there is negative association between relative yields of the main crop with relative yield of the secondary crop, high relative yield of main crop accompany with low secondary and vice versa.

These results clearly indicated that neither maize nor sorghum was adversely affected by late intercropping of cowpea. However, cowpea was adversely affected by late intercropping probably due to adverse shading effect of maize or sorghum plants as well as unfavorable environment effects of the late sowing. Nevertheless, the land equivalent ratio (LER) values were greater than the unit meaning that the actual productivity of any one of the intercropped crops was more productive than the productivity of solid plantation. When cowpea was intercropped in maize or sorghum with different sowing dates, the highest LER value (1.5) was observed with synchronize intercropped with sorghum (D_2) followed by intercropping cowpea with maize (1.4) when late sowing of cowpea was applied. These results are confirmed with those of Reddy *et al.* (1992) and Adipala *et al.* (2002).

Area time equivalent ratio (ATER)

Results in Table 5 show that the estimates of area time equivalent ratio (ATER) were different. This refers to advantage of the intercropping date of cowpea with maize or sorghum. The higher values ATER were observed when maize or sorghum were sown at the same of sowing cowpea (D_2), while the lowest values were observed when cowpea was sown before sowing maize and sorghum.

TABLE 5. Effect of cowpea intercropping date with maize and sorghum on competitive relationships and yield advantages (average of the two seasons).

Traits	Yield/fed		Relative yields (RY)		LER	ATER	Ag		CR			AYL			MAI
	Maize ardab	Cowpea ton	L_M	L_{Co}			Ag_m	Ag_{co}	C_M	C_{Co}	Total	Maize	Cow-pea	Total	
Solid	25.4	26.2													
D_1	12.6	19.0	0.5	0.7	1.2	1.0	-0.2	+0.2	0.7	1.5	2.2	-0.5	-0.3	-0.8	789.1
D_2	19.9	14.8	0.8	0.6	1.4	1.3	+0.2	-0.2	1.4	0.8	2.2	-0.2	-0.4	-0.6	1545.4
D_3	25.9	9.6	1.0	0.4	1.4	1.2	+0.7	-0.7	2.8	0.4	3.2	+0.1	-0.7	-0.6	1840.6
Traits	**Yield/fed**		**Relative yields(RY)**		**LER**	**ATER**	**Ag**		**CR**			**AYL**			**MAI**
	Sorghum ardab	Cowpea ton	L_{So}	L_{Co}			Ag_{So}	Ag_{Co}	C_{So}	C_{Co}	Total	Sorg-hum	Cow-pea	Total	
Solid	11.9	25.6													
D_1	7.5	17.3	0.6	0.7	1.3	1.1	-0.1	+0.1	0.9	1.1	2.0	-0.4	-0.3	-0.7	350.4
D_2	12.4	11.4	1.1	0.4	1.5	1.5	+0.6	0.6	2.4	0.4	2.8	+0.1	-0.6	-0.5	702.9
D_3	12.6	7.7	1.1	0.3	1.4	1.2	+0.8	-0.8	3.5	0.3	3.8	+0.1	-0.7	-0.6	481.7

Aggressivety (Agg)

Results of aggressivety revealed that the estimates Agg for the main crops *i.e.,* maize or sorghum were positive in cases of (D_2 and D_3), while in (D_1) the estimates of either maize or sorghum were negative, the reverse was observed for the second crop cowpea. It means that main crop maize or sorghum was the dominant crop and cowpea was dominated in the course of this study. Aggressivety estimates of the main crop (maize or sorghum) were increased with delaying of cowpea sowing date. The aggressive behavior may be due to taller plants of either main or second crops that shading on the short plants.

Competitive ratio (CR)

Results of competitive ratio, which express the exact degree of competition, indicated that the main crop (maize or sorghum) was more competitive than cowpea under different intercropping conditions, indicating the dominance of maize or sorghum over cowpea (Table 5). The degree of competition was affected by intercropping date of cowpea. Competition ratio of maize or sorghum (main crop) was higher when cowpea was sown later (D_3), while competitive ratio of cowpea was higher in the early sowing (D_1). These results are in harmony with those of Tariah & Wahua (1985) and Fininsa (1997).

Actual yield loss (AYL)

Similar trend to that of LER, ATER, Agg and CR was also observed for AYL (Table 5). Particularly, AYL for the cowpea was negative when intercropping with maize or sorghum under different sowing dates indicating the disadvantage of these dates for sowing cowpea, probably because of the adverse effect of maize or sorghum on it. Also, AYL for maize was negative in the three cowpea intercropping system. AYL of sorghum was negative when cowpea was intercropped three weeks before sorghum (D_1) and was positive when (D_2) and (D_3) were applied which indicates yield advantage for sorghum. The negative estimates of AYL for cowpea can be interpreted by dominating maize or sorghum on cowpea. Thus there was total AYL for maize + cowpea when grown together under the three different dates of sowing cowpea which ranged from -0.77 to -0.61, indicating a yield loss of 77 to 61% compared with solid planting of maize + cowpea. The total AYL sorghum + cowpea under the three different dates of sowing cowpea ranged from -0.70 to -0.51, revealing yield losses ranged from 70 to 51% compared with solid planting of sorghum +cowpea. However, these results indicate that cowpea intercropped three weeks after sowing maize (D_3) was successful. Similar results were obtained by Francis & Stern (1987) and Reddy & Visser (1997).

Monetary advantage index (MAI)

The MAI, is an indicator of the economic feasibility of intercropping systems. These values were positive due to intercropping cowpea with maize or sorghum under the three sowing dates. The highest MAI value (1840.63) was observed when cowpea was sown three weeks after sowing maize, sowing cowpea and maize at the same time ranked the second (1545.36) whereas sowing cowpea in the same date of sowing sorghum ranked the fourth (702.94). These results

indicated that intercropping cowpea with maize favored the growth and yield of both crops particularly when cowpea was intercropped three weeks after maize sowing. These findings (CR, AYL and MAI) are in agreement with the results of LER and Agg. Similar results were observed by Padhi (2001), Adipala *et al.* (2002) and Abou Keriasha *et al*. (2009).

It could be concluded that intercropping cowpea with maize or sorghum in the same date (D_2) is profitable and preferred to reduce weed infestation.

References

Abou Keriasha, M.A., Abd El-Hady, M.A. and Nawar, F.R. (2009) Response of some cowpea varieties to intercropping with maize under upper Egypt condition. *Egypt. J. Appl. Sci.* **24**, 495-514.

Adipala, E., Ocaya, C.P. and Osiru, D.S.O. (2002) Effect of time of planting cowpea (*Vign unguiculata* L.*)* relative to maize *(Zea mays* L.) on growth and yield of cowpea. *Tropicultura*, **20** (2), 49-57.

Banik, P. (1996) Evaluation of wheat (*Tritcum aestivum*) and legume intercropping under 1:1 and 2:1 row replacement series system. *J. Agron. & Crop Sci.* **176**, 289-294.

Camel, M.S, Abdel-Raouf, M.S. Mahmoud, E.A. and Boyoumi, R.B. (1983) The influence of weed control and some intercropping systems of soybean with corn on the common associated weeds**.** *Proceding of the 1st Conf.* of *Agron.,* **1**: pp.195-207.

Dasaraddi, S.V., Hiremeth, S.M. and Patil, R.H. (2002) Performance of legumes as intercrops in maize. *J. Res., Birsa.Agric. Univ.* **14**, 241-244.

Fininsa, C. (1997) Effects of planting, relative planting date and inter-row spacing on a haricot bean/maize intercrop. *African Crop Sci. J*. **5**(1), 15-22.

Francis, O. and Stern, W.R. (1987) Relative sowing time and density of component crops in a maize/cowpea intercrop system. *Experimental Agriculture,* **23**, 41-52.

Ghosh, P.K. (2004) Growth, yield competition and economics of groundnut/ cereal fodder intercropping systems in the semi-arid tropics of India. *Field Crops Res.* **88**, 227-237.

Hiebsch, C.K. and McCollum, R.E. (1987) Area- x- Date Equivalency Ratio: A method for evaluating the productivity of intercrops. *Agron. J.* **79**, 15-22.

Lima, F.J. (2002) Physiological responses of maize and cowpea to intercropping. *Pesquisa Agropecuaria Brasileir*. **35**(5), 915-921.

Mc-Gillichrist, C.A. (1960) Analysis and competition experiments. *Biometrics*, **21**, 975-985.

MSTATC (1986) *A Microcomputer Program of the Design Management and Analysis of Agronomic Research Experiments.* Michigan State Univ. USA.

Okpara, D.A. (2000) Growth and yield of maize and vegetable cowpea as influenced by intercropping and nitrogen fertilizer in the low land humid tropics. *J. Sustainable Agric. and the Environ.* **2**, 188-194.

Padhi, A.K. (2001) Effect of vegetable intercropping on productivity, economics and energetics of maize (*Zea mays*). *Indian J. Agron.* **46**, (2), 204-210.

Reddy, K.C. and Visser, P.L. (1997) Cowpea intercrop growth and yield as affected by time of planting relative to millet. *African Crop Sci. J.* **5**, 351-357.

Reddy, K.C., Visser, P. L. and Buckner, P. (1992) Pear millet and cowpea yield in sole and crop productivity. *Field Crops Res.* **28** (4), 315-326.

Snedecor,G.W. and Cochran, W.G. (1982) "*Statistical Methods"***.** 7th ed. Iowa State Univ. Press, Ames, Iowa, USA.

Tariah, N.M. and Wahua, T.A.T (1985) Effects of component populations on yields land equivalent ratios of intercropped maize and cowpea. *Field Crops Res.* **12**, 81-89.

Wahua, T.A.T., Babalola, O. and Aken Oven, M.E. (1981) Intercropping morphologically different types of maize with cowpea: LER and growth attributes of associated cowpea. *Exp. Agric.* **17**(4), 407-413.

Willey, R.W. (1979) Intercropping its importance and research needs. Part 1: Competition and yield advantages. *Field Crop Abst.* **32**, 1 -10.

Willey, R.W. and Rao, M.R. (1980) Competitive ratio for quantifying competition between intercrops. *Exp. Agric.* **16**, 117-125.

Willey, R.W. and Osiru, S.O. (1972) Studies on mixture of maize and beans (*Phasolus vulgaris*) with particular reference to plant populations. *J. Agric. Sci. Camb.* **79**, 519-529.

Yilmaz, F., Atak, M. and Erayman, M. (2007) Identification of advantages of maize-legume intercropping over story cropping through competition indices in the East Mediterranean Region. *Turk. J. Agric*. **32**, 111-119.

Zougmore, R., Kambou, F.N. Ouattara, K. and Guillobez, Z.S. (2000) Sorghum-cowpea intercropping effective technique a against run off and soil erosion in the Sahel (Saria, Burkina Faso). *Arid Soil Res. and Rehabitation*, **14**, 329-340.

(*Received* 21/3/2011;
accepted 16/6/2011)

تأثير ميعاد تحميل لوبيا العلف في حقول الذرة الشامية و الذرة الرفيعة على الإنتاجية والحشائش المصاحبة

محمد أبو العيون أبو كريشة ، سحر طلعت إبراهيم و إسماعيل عويس السيد محمدين
قسم بحوث التكثيف المحصولي- مركز البحوث الزراعية – الجيزة – مصر .

أقيمت تجربتان حقليتان بمحطة بحوث ملوي - محافظة المنيا- مصر خلال موسمي صيف ٢٠٠٨ ، ٢٠٠٩ لدراسة تأثير ميعاد تحميل لوبيا العلف مع الذرة الشامية والذرة الرفيعة على الإنتاجية والحشائش المصاحبة٠ اشتملت كل تجربة على خمسة معاملات وهى تحميل لوبيا العلف قبل زراعة الذرة الشامية أو الذرة الرفيعة بثلاث أسابيع، تحميل لوبيا العلف في نفس ميعاد زراعة الذرة الشامية أو الذرة الرفيعة ، تحميل لوبيا العلف بعد زراعة الذرة الشامية و الذرة الرفيعة بثلاثة أسابيع، الزراعة المنفردة للمحاصيل الثلاثة٠

تشير النتائج إلى أن طول نبات الذرة الشامية و الذرة الرفيعة تأثر بميعاد زراعة لوبيا العلف حيث كانت النباتات قصيرة في الميعاد الأول وطويلة في الميعاد الثانى٠ أنخفض محصول الحبوب لكلا المحصولين بحوالي ٥٠,٤ و ٣٦,٦٪ في الميعاد الأول بينما زاد غلة كلا المحصوليين بحوالي ١، ٢ و ٩، ٥ ٪ عن الزراعة المنفردة في الميعاد الثالث على التوالي. أنخفض وزن الحشائش المصاحبة بحوالي ٩٠- ٩٣٪عندما زرعت لوبيا العلف في نفس ميعاد زراعة الذرة الشامية والرفيعة، بينما عند زراعة لوبيا العلف في الميعاد الثالث كان وزن الحشائش المصاحب ٦٥,٥و ٨٠,٦٪ على التوالى٠ انخفض محصول العلف الأخضر من لوبيا العلف كثيرا في الميعاد الثالث مقارنة بالميعاد الأول والثاني، والنقص في الميعاد الأول كان ٢٧,٣ و ٣٢,٤٪ وفى الميعاد الثالث كان ٦٣,٤ و ٧٠,٢٪ عندما حملت مع الذرة الشامية و الذرة الرفيعة على التوالي مقارنة بالزراعة المنفردة عندما حملت مع الذرة الشامية والذرة الرفيعة على التوالي ٠ كان محصول الذرة الشامية و الذرة الرفيعة هما المحاصيل السائدة بينما لوبيا العلف كان المحصول المسود٠ أعلى قيمة لمعدل كفاءة استخدام الأرض كان ١,٤ و١,٥عندما حملت لوبيا العلف مع الذرة الشامية و الذرة الرفيعة في الميعاد الثاني على التوالي وقيمة الدليل النقدي كان ١٨٤٠,٦٣ في الميعاد الثالث مع الذرة الشامية الفقد الحقيقي في المحصول كان سالبا في المواعيد الثلاثة مع كلا المحصوليين وهذا يؤكد انخفاض الإنتاجية في جميع المحاصيل المحملة٠ مقارنة بالزراعات المنفردة.

يمكن الاستنتاج أن زراعة لوبيا العلف مع الذرة الشامية أو الذرة الرفيعة في نفس الميعاد يكون مربح ومفيد بجانب انخفاض الحشائش٠