1 Egypt. J. Agron . **Vol. 33,** No.1, pp.1-18 (2011)

# The Influence of Preceding Crops and Intercropping Maize with Cowpea on Productivity and Associated Weeds

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TWO FIELD experiments were carried out at Mallawi Agric. Res. St. (Middle Egypt) during the two summer seasons of 2008 and 2009. The objectives of this study were to investigate the effect of preceding crops and intercropping maize with cowpea on productivity and associated weeds. A randomized complete block design (RCBD) in a split plot arrangement with three replications was used in both seasons. The main plots were devoted to the three preceding winter crops (wheat, faba bean and berseem), while sub plots were allocated for three solid planting namely solid maize, solid cowpea cut two months (forage) and solid cowpea left without cutting (seeds), as well as two intercropping treatments namely: maize + cowpea cut after two months (forage) and maize + cowpea left without cutting (seeds).

The results showed that maize preceded by faba bean was superior in most studied characters, while the lowest values were observed when it grown after wheat. The weed density in maize sequenced by legume crops was less than this grown in maize sequenced by wheat. The yield and yield components of maize was decreased under intercropping conditions. The lowest values were observed when cowpea (forage) was preceded by wheat. The reduction in maize grain yield when intercropping with cowpea was 4.7% (combination of the two seasons). The reduction in weed weight was 72.8% when intercropped cowpea was forage and 72.0% when cowpea was seeds compared with solid planting.

The forage and seeds yield of cowpea were more decreased under intercropping condition. The reduction in forage and seeds yield were 52.2 and 74.3% compared with solid planting, respectively.

The highest values of land equivalent ratio (LER) (1.46), area time equivalent ratio (ATAR) (1.19) and monetary advantage index (MAI) (1874.66) were observed when sequenced by berseem and intercropped cowpea with cut after two months.

**Keyword:** Sequence crops, Intercropping, Legume, Cereal Weed control.

Maize (*Zea mays* L.) is one of the most important peed and food crops in Egypt. In Egypt, the cultivated maize area is 2 million fed with an annual production of 6 million tons which is not enough (Agricultural Statistics, 2007). Therefore, efforts are focused to increase its productivity to fill the gap between the local production and human consumption through many factors as cropping systems, fertilizer, cultivar selection, seeding ratios weed controls etc. The cropping systems are included crop rotation, relay cropping and intercropping of annual cereals with legumes. In cereal-legume rotation or intercrop systems the cereal benefits from the nitrogen fixed by the legume and the decomposition of the nutrient-rich biomass, root and nodules of the legume and the reason for increased seed yield in maize may be attributed to nitrogen fixing ability of legumes and extensive root system of cereals (Chen *et al.,* 2004) which help to increase soil organic matter levels (Gregorich *et al.,* 2001), as well as strategies reducing weed population density and biomass production (Liebman & Dyck, 1993). Several researchers reported that cereal yields superiority after legume crop have been attributed to less N-uptake by the legume and increasing residual organic matter.

Ahlawet *et al.*(1981) showed that grain legumes increased mean plant height, length and diameter of cob, grains/ cob, grain yield/ cob and 1000 grain of maize compared with wheat and fallow. Grain and stover of maize grown after legumes were increased by 18.8 and 15.3% and 29.6 and 21.0% more than fallow or wheat, respectively. Abou-Keriasha *et al.* (1998) showed that grain yield of maize grown after berseem or faba bean was significantly higher than that grown after wheat by 35.4 and 43.0%, respectively. Similar results were observed by Shams (2000) El-Douby (2002), Toaima & Saleh (2003) and Zohry (2005).

Crop rotation helps in reducing the weed population by interrupting their life cycle and suppressing their growth development and dispersion. Because the plant characteristics growth habits and cultural practices vary with the different crops grown, conditions change frequently are enough to prevent any group of weeds from becoming a menace (Anderson, 2004). Shafshak *et al.* (1983) found that maize after clover contained 76% of the total fresh weight of weeds in maize after wheat. Total weed population reduced by 13% after clover compared with after wheat as a preceding winter crop for maize. Altieri & Liebman (1988) noted that cropping patterns selected in management systems can also act to reduce weed densities and cause shifts in composition, density and spatial distribution of weed species in fields. Singer *et al.* (2000) reported that weed densities in corn averaged 6.3 and 9.9 weeds $m^2$ in the soybean-wheat /red clover-corn cropping system, compared with 1.7 and 1.0 weeds $m^2$ on continuous corn at two of the four sites under sites under study. Teasdale *et al.* (2004) found that seed banks of smooth pigweed (*Amaranthus hybrids*) and common lamsquarters (*Chenopodium album*) in maize were usually lower following the 4-year rotation of the 3-year rotation than the 2-year rotation. Zohry (2005) concluded that berseem as a preceding crop reduced weeds in summer crops followed by faba bean compared with that grown after wheat.

Several researchers on intercropping systems found that yield of one or all of the crops in the intercrop were lower than that of the total of pure stands, but the combined yield from the intercrop was higher than total yield of any of crops as pure stand. The reduction in intercropped maize yield ranged from 10 to 15% of pure stand compared with a higher reduction ranged from 45 to 67% in legume crops (bean and cowpea) pure stands (Fininsa, 1997 and Abou Keriasha *et al.*, 2009). Whereas Reddy *et al.* (1992), Lima (2000), Okpara (2000), Khan *et al.* (2002) and Yilmaz *et al.* (2007) showed that cereal crops grain yield was increased or not affected by intercropping systems compared with the sole crop, but legume crops were decreased. Okpara (2000) stated that intercropping significantly increased plant height in both crops and grain yield of maize in first season and reduced in the second season, but cowpea yield was reduced in the two seasons. Abou-Keriasha *et al.* (2009) found that the highest land equivalent ratio (LER) recorded 1.29 and monetary 1874.52 while total actual yield loss (AYL) was positive. Similar results were published by Padhi (2001) and Khan *et al.* (2002).

Intercropping is known as the system that could reduce weeds in the field. Cover crop efficiency is achieved by a rapid occupation of the open space between the main crop rows, preventing weed seed germination and reducing weed seeding growth and development (Hollander *et al.*, 2007). Camel *et al.* (1983) reported that intercropping corn and soybean on the same ridges provided 24.000 corn plants and 24.000 soybean plants/ fed and decreased weed growth in times of dry weight at all samplings compared with alternate ridges of corn and soybean. Zougmore *et al.*(2000) showed that sorghum, cowpea intercropping reduced weeds manifest by 20-30% compared to a sorghum monoculture. Odhiambo & Ariga (2001) and Massawe *et al.* (2001) observed that intercropping maize and bean in the same hole had the lower weeds (*Striga* sp.) than solid planting.

## Material and Methods

Two field experiments were carried out at Mallawi Agric. Res. St. (Middle Egypt) during the two summer seasons of 2008 and 2009. The objective of this study was to investigate the effect of preceding crops and intercropping maize with cowpea on productivity and associated weeds. A randomized complete block design (RCBD) in a split-plot with three replications was used in both seasons. The main plots were devoted to the three preceding winter crops (wheat faba bean and berseem) whereas the sub-plots were allocated for three solid planting namely: solid maize (variety T.W.C 310), solid cowpea (variety Cream) cut after two months (forage) and solid cowpea left without cutting (seeds), as well as two intercropping treatments namely maize + cowpea (forage) and maize + cowpea without cut (seeds). The sub plot area was 10.5 $m^2$ (1/400 fed) containing 5 ridges, each of 3.0 m in length and 0.70 m in width.

Maize (solid or intercropping) was grown on one side of ridge with one plant/hill, 30 × 70 cm between. Solid cowpea was grown on one side of ridges with two plants/hill 30 cm apart and 70 cm and when intercropping on maize were sown on the other side of all maize ridges with two plants/hill 30 cm apart.

Maize and solid cowpeas were sown in the last week of May while intercropped cowpea was sown three weeks after maize sown in the two seasons. Calcium superphosphate (15.5% $P_2O_2$) at rate of 150 unit/fed was added during soil preparation. Nitrogen fertilizer for maize was used at the rate 120 unit/fed in the form of ammonium nitrate (33.5%) which was applied in the three equal doses just before the first, second and the third irrigations of maize. Nitrogen fertilizer for cowpea was added at the rate 20 unit/fed after thinning. Potassium fertilizer (potassium sulfate, 48% $K_2O$) was added at the rate 24 unit $K_2O$ / fed.

First cut of cowpea was done after two months (solid and intercropped) and the second cut (in solid only) was at two months after first cut. Harvesting for maize and cowpea (solid and intercropped) was during the first week of October in both seasons.

Ten maize plants were chosen randomly from each sub-plot to determine yield components of maize (plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of grains/ row, grain weight of ear (g), 100 weight of grain (g) and shelling percentage). Grain yield of maize (ardab/fed, ardab=140kg), green forage (ton/fed) or seeds yield of cowpea was estimated from the whole sub-plot area (kg/plot) and it was calculated per feddan.

Weed studies (broad leaves) were hand pulled from each sub plot before first and second hoeing (30 and 45 days after sowing).

*Competitive relationships*

*Land equivalent ratio (LER)*

When LER is greater than 1, the intercropping favors the growth and yield of the species. In contrast, when LER is lower than 1, the intercropping negatively affects the growth and yield of plants grown in mixtures.

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

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

where: Yaa is pure stand yield of crop a, Ybb is pure stand yield of crop b, Yab is mixture yield of a (when combined with b) and Yba yield of b (when combined with a).

*Aggressivity ( Agg )*

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

$$\text{Aga} = \frac{yab}{yaa \times zab} - \frac{yba}{ybb \times zba}, \quad \text{Agb} = \frac{yba}{ybb \times zba} - \frac{yab}{yaa \times zab}$$

An aggressivity value of zero indicates that the intercropped 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.

*Competitive ratio (CR)*

The CR gives more desirable competitive ability for the crops and is also advantageous as an index over AYL**.** The CR represents simply the ratio of individual LERs of the 2 component crops and takes into account the proporation of the crops in which they are initially sown. Then, the CR index was calculated using following formula as given by Willey & Rao (1980).

$$\text{CRa} = \left\{\left(\frac{LERa}{LERb}\right) \times \left(\frac{Zba}{Zab}\right)\right\},$$

$$\text{CRb} = \left\{\left(\frac{LERb}{LERa}\right) \times \left(\frac{Zab}{Zba}\right)\right\}$$

where: LERa and LERb represent relative yield of a and b intercrops, respectively. Since the CR values of the two crops will be the reciprocals of each other. CRa, CRb are the competitive ratio for intercrop where Zab representing the sown proportion of intercrop a (legume crops) in combination with b (maize) and Zab the sown proportion of intercrop (maize) in combination with a (legume crops).

*Area time equivalent ratio (ATER)*

A concept that considers the time factor along with land area is ATER proposed by Hiebsch (1978). 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 intercropping 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 the myriad processes that take place in green plants (Hiebsch & McCollum, 1987).

*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, suggested by Willey (1979):

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

The average market price of 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.

Data for each experiment were then analyzed by MSTATC (1980) software for comparison of the mean values of the two seasons by LSD test at the 5% level. Response equations were calculated according to Snedecor & Cochran (1988).

## Results and Discussion

*Maize*

*Effect of preceding winter crops on maize grain yield, its components and associated weeds*

The data in Table 1 indicated a significant effect of preceding winter crops (wheat, faba bean and berseem) on yield, yield components and associated weeds of maize except plant height, ear height and shelling percentage in the both seasons and the combined, ear length in the first season, and number of grains in the second season.

Maize preceded by faba bean was superior in most studied characters, while the lowest values were observed when it was grown after wheat. These results held true in both seasons and the combined season. The superiority may be attributed to the high level of soil fertility which due to N fixation and decomposition after legume crops (faba bean or berseem). The results are in agreement with those obtained by Shams (2000) and Zohry (2005).

Planting maize after faba bean resulted in an increased by 10.2% for ear diameter, 11.8% for number of grains/row, 15.3% for weight of 100 grains, 7.5% for grain weight/ear and 10.8% for grain yield/fed compared with those preceded by wheat (combination of the two seasons). Similar results were reported by Abou-Keriasha *et al*. (1998) and Zohry (2005).

The results also show that fresh weight of associated weeds (*Corohorus olitorius, Portulaca oleracea, Xanthium strumarium and Panicum spp*.) was significantly affected by preceding crops. The weed density in maize sequenced after faba bean and berseem least than this grown in maize sequenced by wheat. Significant difference in fresh weight of associated weeds due to crop sequence that causes unstable environments for weeds by varying patterns of resource, competition, allelopathic interference, soil disturbance or mechanical damage appear to be the most successful for weed suppression (Altieri & Liebman, 1988). These results are in agreement with that obtained by Zougmore *et al*.(2000) and Zohry (2005).

TABLE 1. Effect of preceding winter crops on growth, yield, yield components of maize and associated weeds in both seasons and Combined data.

| Characters / Preceding crop | Plant height (cm) | Ear height (cm) | Ear length (cm) | Ear diameter (cm) | No grains/ row | Grain wt /ear (g) | 100-grain wt. (g) | Shelling % | Grain yield ardab/fed | Wt of weeds kg/subplot |
|---|---|---|---|---|---|---|---|---|---|---|
| **First season** | | | | | | | | | | |
| Wheat | 273.20 | 182.30 | 21.33 | 3.70 | 42.60 | 245.66 | 35.03 | 84.80 | 21.57 | 3.42 |
| Faba bean | 275.40 | 184.20 | 21.57 | 4.08 | 51.90 | 258.90 | 42.23 | 85.10 | 23.27 | 2.99 |
| Berseem | 278.40 | 185.30 | 21.70 | 3.66 | 50.20 | 255.00 | 37.20 | 82.80 | 23.07 | 2.86 |
| **LSD** | NS | NS | NS | 0.29 | 1.62 | 6.17 | 3.54 | NS | 2.60 | 0.15 |
| **Second season** | | | | | | | | | | |
| Wheat | 274.10 | 184.40 | 23.40 | 3.73 | 47.94 | 259.47 | 37.13 | 80.43 | 21.40 | 3.54 |
| Faba bean | 279.70 | 185.10 | 23.10 | 4.09 | 49.50 | 284.30 | 41.10 | 82.23 | 23.80 | 3.12 |
| Berseem | 279.90 | 185.20 | 21.23 | 3.78 | 48.00 | 288.20 | 38.20 | 81.33 | 23.70 | 2.93 |
| **LSD** | NS | NS | 1.59 | 0.18 | NS | 15.14 | 1.33 | NS | 2.14 | 0.12 |
| **Combined of the two seasons** | | | | | | | | | | |
| Wheat | 273.70 | 183.40 | 22.36 | 3.70 | 45.3 | 252.56 | 36.08 | 82.60 | 21.41 | 3.48 |
| Faba bean | 277.60 | 184.60 | 22.34 | 4.80 | 50.68 | 271.64 | 41.60 | 83.60 | 23.60 | 3.05 |
| Berseem | 279.40 | 185.30 | 21.48 | 3.72 | 49.10 | 271.60 | 37.70 | 82.00 | 23.70 | 2.86 |
| **LSD** | NS | NS | 0.67 | 0.15 | 0.88 | 4.88 | 1.74 | NS | 1.15 | 0.26 |

*Effect of intercropping on yield, yield components of maize and associated weed*

Data in Table 2 show significant differences in all studied characters except ear length in both seasons and ear diameter in the first season. The results clearly show that intercropping system resulted in taller maize plants than in solid planting. The highest value of maize plant height was observed when intercropped cowpea for produced dry seeds (without cutting) followed by when cowpea was cut in the both seasons. The results also proved that the yield and yield components were decreased under intercropping condition. The lowest values were observed when cowpea left to produce seeds (without cutting). The reduction in maize grain yield and yield components were 4.1% for ear diameter, 8.0% for number of grains/row, 13% for grain weight of ear, 10.6% for weight of 100 grains, 4.4% for shelling percentage and 4.7% for grain yield/fed in the combined two seasons. The reduction in yield and yield components of intercropped maize due to increased shading effect of plants, hence a high competition for intercepted light. Higher yield components of maize were recorded under sole cropping compared to intercropping indicating that crops in sole plots suffered less from competition**.** These results are agreement with those obtained by Reddy *et al.* (1992), Okpara (2000) and Abou-Keriasha *et al.* (2009).

Intercropping system effect on weed weight (*Corohorus olitorius, Portulaca oleracea, Xanthium strumarium and Panicum* spp.), was observed in both seasons (Table 2). The highest values of weed weight were observed in solid planting; while the lowest values were observed in intercropping. The reduction in weed weight was 72.8% when intercropped cowpea which was cut, (after two months) while this reduction was 72.0% when intercropped cowpea was left without cutting (combination of the two seasons). Thus in maize-legume intercrops the decrease in available light for weeds led to a reduction of weed density and dry matter compared to sole crops (Liebman & Dyck, 1993 and Dimitrios *et al*., 2010). Similar results were obtained by Camel *et al.* (1983) and Zohry (2005).

*The interaction effects*

There was no significant interaction between the effects of the preceding crops and cropping system on yield components of maize which means the effects of preceding crops and cropping system on maize yield components were generally additive (Table 3). The plant height of maize reached the maximum values when cowpea seeds and sequenced after wheat, while the minimum values were recorded in solid planting and sequenced after wheat. The maximum values of yield components (ear length, number of grains, weight of grains/ear and weight of 100 grain) were observed in solid planting and sequenced after faba bean, whereas, the minimum values were observed when cowpea was seeds and sequenced after wheat except weight of grains/ear and grain yield/fed were when grown after wheat and cowpea was (seeds). These results indicated that maize grown after legume crops (faba bean or berseem) and intercropped cowpea was cut after two months (short period) has a beneficial effect on yield and yield components than when intercropped cowpea was left without cutting (five months). These results are in agreement with Abou-Keriasha *et al.* (1998) and Zohry (2005).

**TABLE 2. Effect of cropping systems on yield, yield components in maize and associated of weed in both seasons and the combined data.**

| Preceding crop | Plant height (cm) | Ear height (cm) | Ear length (cm) | Ear diameter (cm) | No grains/ row | Grain wt/ear (g) | 100-grain wt (g) | Shelling % | Grain yield ardab/ fed | wt of weeds kg/subplot |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **First season** | | | | |
| Solid | 262.60 | 174.40 | 22.03 | 3.70 | 50.10 | 276.60 | 40.60 | 86.20 | 23.78 | 6.00 |
| Cowpea with cut | 278.50 | 186.40 | 21.60 | 3.80 | 49.20 | 257.40 | 37.90 | 83.90 | 23.27 | 1.63 |
| Without cutting | 286.50 | 191.00 | 20.93 | 3.80 | 45.20 | 225.60 | 35.80 | 82.70 | 20.85 | 1.66 |
| **LSD** | 6.30 | 9.20 | NS | NS | 2.42 | 14.16 | 1.81 | 1.98 | 1.28 | 0.13 |
| | | | | | | **Second season** | | | | |
| Solid | 266.90 | 175.20 | 23.30 | 4.02 | 49.86 | 286.10 | 40.57 | 83.20 | 24.76 | 6.16 |
| Cowpea with cut | 276.90 | 187.40 | 22.50 | 3.89 | 48.70 | 278.80 | 39.00 | 82.20 | 23.07 | 1.67 |
| Without cutting | 286.90 | 192.70 | 21.80 | 3.68 | 46.80 | 264.30 | 36.80 | 79.20 | 20.53 | 1.75 |
| **LSD** | 5.28 | 4.63 | NS | 0.18 | 1.44 | 9.45 | 1.33 | 2.52 | 1.30 | 0.89 |
| | | | | | | **Combined of the two seasons** | | | | |
| Solid | 264.8 | 174.8 | 22.70 | 3.86 | 50.00 | 281.40 | 40.60 | 84.73 | 24.27 | 6.08 |
| Cowpea with cut | 277.7 | 186.3 | 22.07 | 3.84 | 48.90 | 268.17 | 38.40 | 83.06 | 23.17 | 1.65 |
| Without cutting | 286.7 | 191.8 | 21.40 | 3.70 | 46.11 | 244.90 | 36.30 | 80.96 | 20.70 | 1.70 |
| **LSD** | 3.88 | 4.14 | 0.74 | 0.12 | 1.34 | 8.10 | 1.04 | 1.52 | 1.00 | 0.17 |

**TABLE 3. Effect of interaction between preceding crops and cropping systems on yield, yield components of maize and associated weed in the two seasons (combined of the two seasons).**

| Characters | | Plant height (cm) | Ear height (cm) | Ear length (cm) | Ear diameter (cm) | No. grains/ row | Grain wt /ear (g) | 100-grain wt (g) | Shelling % | Grain yield ardab/fed | Wt. of weeds kg/ subplot |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Preceding crop** | **Cropping system** | | | | | | | | | | |
| Wheat | Solid | 260.30 | 191.60 | 22.90 | 3.81 | 51.40 | 266.20 | 39.20 | 85.00 | 22.75 | 6.44 |
| | Maize /cowpea (cutting) | 271.70 | 185.00 | 22.20 | 3.70 | 50.10 | 259.00 | 37.20 | 82.50 | 21.60 | 1.95 |
| | Maize /cowpea (seeds) | 289.00 | 173.50 | 21.90 | 3.55 | 45.70 | 229.50 | 36.50 | 80.60 | 20.08 | 2.02 |
| Faba bean | Solid | 267.80 | 198.70 | 23.10 | 3.80 | 52.00 | 291.60 | 45.80 | 83.80 | 25.30 | 6.06 |
| | Maize /cowpea (cutting) | 278.10 | 184.90 | 22.40 | 3.65 | 51.50 | 269.10 | 43.10 | 83.50 | 24.50 | 1.50 |
| | Maize /cowpea (seeds) | 286.80 | 175.35 | 21.50 | 3.60 | 48.70 | 253.50 | 38.50 | 82.30 | 20.90 | 1.60 |
| Berseem | Solid | 268.60 | 191.00 | 22.00 | 4.20 | 46.50 | 285.80 | 41.30 | 85.30 | 24.70 | 5.75 |
| | Maize /cowpea (cutting) | 283.20 | 189.10 | 21.50 | 4.10 | 45.00 | 273.40 | 37.50 | 83.50 | 24.30 | 1.48 |
| | Maize /cowpea (seeds) | 288.70 | 175.60 | 20.80 | 4.30 | 44.00 | 251.60 | 36.65 | 79.80 | 21.10 | 1.46 |
| **LSD** | | NS | NS | NS | NS | NS | NS | 1.80 | NS | NS | 0.35 |

The results show also, the maximum of weeds weight (6.44 kg/plot) were observed in solid planting and sequenced after wheat, while the minimum values (1.46 kg/plot) was observed when intercropped cowpea was left without cutting for produced seeds and sequenced by berseem. Weed density in maize-legume intercropping and sequenced after legume crops (faba bean and berseem) was more reduced (25% of solid) than those grown in maize-legume intercropping and sequenced after wheat (30% of solid). It is clear that the effect of intercropping maize with cover crop on weed density is higher than the effect of crop sequence. Similar result was observed by Hollander *et al.* (2007).

*Cowpea*

Data presented in Table 4 show that forage and seeds yield of cowpea were affected by preceding crops and intercropping in both seasons and the combined the two seasons. The maximum values of forage and seed yield were observed in solid planting and sequenced after wheat, while the minimum values were observed when intercropped on maize and grown after berseem in the both seasons and the combined data. Forage and seed yields of cowpea sequenced after wheat were higher than those grown after legume crops (faba bean and berseem) in both seasons.

**TABLE 4. Effect of preceding crops and cropping system on forage yield and seeds of cowpea in the first, the second seasons and the combined data.**

| Preceding crop (A) | Cropping system (B) | Forage yield (ton/fed.) | | | Seeds yield (kg/fed) | | |
|---|---|---|---|---|---|---|---|
| | | First season | Second season | Combined | First season | Second season | Combined |
| Wheat | Solid | 26.30 | 25.00 | 25.65 | 831.66 | 810.00 | 820.83 |
| | Intercropped | 13.10 | 11.90 | 12.50 | 220.33 | 221.66 | 220.99 |
| | M | 19.70 | 18.45 | 19.00 | 526.00 | 515.80 | 520.90 |
| Faba bean | Solid | 24.00 | 23.00 | 23.50 | 806.60 | 786.60 | 796.60 |
| | Intercropped | 11.33 | 10.50 | 10.91 | 196.66 | 149.60 | 198.13 |
| | M | 17.66 | 16.75 | 17.20 | 501.63 | 468.10 | 497.31 |
| Berseem | Solid | 23.33 | 22.30 | 22.81 | 766.66 | 783.60 | 774.98 |
| | Intercropped | 11.00 | 10.50 | 10.75 | 194.66 | 194.30 | 194.48 |
| | M | 17.16 | 16.40 | 16.78 | 480.66 | 488.90 | 484.73 |
| Cropping system | Solid | 24.54 | 23.43 | 23.96 | 801.64 | 793.30 | 797.47 |
| | Intercropped | 11.81 | 10.96 | 11.38 | 203.88 | 205.18 | 204.53 |
| LSD | Preceding crop (A) | 0.69 | 0.79 | 0.54 | 7.43 | 6.62 | 3.60 |
| | Cropping system (B) | 1.57 | 1.41 | 0.62 | 234.67 | 5.26 | 5.17 |
| | Interaction A × B | 2.23 | 24.50 | 1.08 | 406.47 | 9.11 | 8.95 |

These results also show that forage and seeds were more decreased under intercropping conditions. The reduction in forage and seed yields were high (52.2 and 74.3%) compared with solid planting, respectively. This reduction in cowpea yield might be due to more shading effect of taller maize plants on shorter cowpea plants and adverse low of the intercepted light competition for nutrients, carbon dioxide might have had reflect adverse effect on growth of cowpea and thereby reduce their yields. Similar results were by Reddy *et al.* (1992) and Abou-keriasha *et al.* (2009).

*Competitive relationships and yield advantages*

*Land equivalent ratio (LER)*

Data in Table 5 indicates that land equivalent ratio (LER), area time equivalent ratio (ATER), Aggressivity (Ag), Competitive ratio (CR) and monetary advantage index (MAI) varied considerably due to the effect of preceding crops and intercrop in the combined data of the two seasons. Their results revealed that the yield of maize and cowpea were decreased. The highest values of maize Rym (0.98) was observed when grown after berseem and cowpea was forage, while the lowest values (0.82) was observed when maize grown after faba bean and cowpea was left without cutting. Whereas the highest values of relative yield cowpea (0.48) was observed when grown after wheat or berseem and cowpea which cutting after two months. The lowest value (0.25) was observed when grown after faba bean or berseem and seeds.

Land equivalent ratio (LER) values were greater than one. It could be concluded that the actual productivity was higher than the expected productivity. The highest LER value (1.46) was observed when sequenced by berseem and cowpea was cut after two months, while the lowest value (1.07) was observed when sequenced by faba bean and cowpea was left without cutting.

*Area time equivalent ratio (ATAR)*

The values of area time equivalent ratio (ATAR) were higher than one; this refers to advantage of the intercropping cowpea with maize. The higher values ATER (1.19) was observed when sequenced by berseem and cowpea was forage. The lowest value (1.03) was observed when sequenced by faba bean and cowpea was left without cutting.

*Aggressivity (Ag)*

Data of aggressivity revealed that value of Ag for maize was positive, while cowpea was negative. It means that maize was the dominant and cowpea was dominated.

*Competitive ratio (CR)*

Data on competitive ratio which expresses the exact degree of competitivity indicates that the main crop (maize) was more competitive than cowpea under intercropping conditions; it is indicating the dominance of maize on cowpea. The competitive degree of maize was increased when cowpea was for seeds while competitive degree of cowpea was decreased when cowpea was cut (forage).

**TABLE 5. Effect of preceding crops and intercropping on competitive relationships and yield advantages of combined data.**

| Preceding crop | Cropping system | Yield | | | LER | | | CR | | | Agg | | ATER | MAI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Maize | Cowpea | | Lm | Lc | LER | CRm | CRc | Total | Agm | Agc | | |
| | | | forage | seed | | | | | | | | | | |
| Wheat | Solid | 22.75 | 25.65 | 820.53 | | | | | | | | | | |
| | Maize/cowpea (cutting) | 21.60 | 12.50 | - | 0.95 | 0.48 | 1.43 | 1.98 | 0.50 | 2.48 | +0.47 | -0.47 | 1.16 | 1674.90 |
| | Maize/cowpea (seeds) | 20.10 | - | 221.00 | 0.88 | 0.27 | 1.15 | 3.26 | 0.30 | 3.56 | +0.61 | -0.61 | 1.08 | 639.65 |
| Mean | | | | | 0.91 | 0.37 | 1.28 | 2.62 | 0.40 | 3.02 | +0.53 | -0.53 | 1.12 | 1157.26 |
| Faba bean | Solid | 25.30 | 23.50 | 796.90 | | | | | | | | | | |
| | Maize/cowpea (cutting) | 24.50 | 10.75 | - | 0.97 | 0.45 | 1.42 | 2.15 | 0.46 | 2.61 | +0.52 | -0.52 | 1.16 | 1767.95 |
| | Maize/cowpea (seeds) | 20.90 | - | 198.10 | 0.82 | 0.25 | 1.07 | 3.28 | 0.30 | 3.58 | +0.57 | -0.57 | 1.03 | 325.30 |
| Mean | | | | | 0.89 | 0.35 | 1.24 | 2.71 | 0.38 | 3.09 | +0.54 | -0.54 | 1.08 | 1046.28 |
| Berseem | Solid | 24.70 | 22.81 | 774.90 | | | | | | | | | | |
| | Maize/cowpea (cutting) | 24.30 | 10.91 | - | 0.98 | 0.48 | 1.46 | 2.04 | 0.49 | 2.53 | +0.50 | -0.50 | 1.19 | 1874.65 |
| | Maize/cowpea (seeds) | 21.10 | - | 194.48 | 0.85 | 0.25 | 1.10 | 3.40 | 0.29 | 3.69 | +0.60 | -0.60 | 1.06 | 4543.56 |
| Mean | | - | - | - | 0.91 | 0.36 | 1.28 | 2.72 | 0.39 | 3.11 | +0.55 | -0.55 | 1.12 | 1164.51 |

*Monetary advantage index (MAI)*

Similar trend to that of LER, ATER, Ag and CR was also observed for MAI, the MAI, which is an indicator of the economic feasibility of intercropping systems. These values were positive due to LER or ATER was greater than one. The highest MAI value (1874.657) was observed when sequenced by berseem and cowpea was forage. While the lowest (325.297) was observed when sequenced by faba bean and cowpea was left without cutting (seeds). Similar results were observed by Padhi (2001) and Abou-Keriasha *et al.* (2009).

The results indicate that intercropping maize with cowpea was favored for growth yield of both crops particularly and beneficial when sequenced after berseem and cowpea which was (forage).

## Conclusion

Finally, it could be concluded that planting maize after legume crops (faba bean and berseem) resulted increased maize grain yield/fed by 7.4% and decreased weed density by 15.0% compared with this preceding by wheat. The intercropping maize with cowpea resulted in decreased maize grain yield/fed by 4.7% and weed density by 72.4% compared with solid maize. The forage and seeds of intercropped cowpea were more decreased (52.2 and 74.3%) compared with solid planting, respectively.

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(*Received* 24/ 1/ 2011;
*accepted* 7 / 9 / 2011)

## تأثير المحاصيل السابقة والتحميل على إنتاجية كل من الذرة الشامية ولوبيا العلف والحشائش المصاحبة لهما

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أقيمت تجربتان حقليتان بمحطة بحوث ملوى (مصر الوسطى) خلال الموسم الصيفى لعامى ٢٠٠٨ و ٢٠٠٩ بهدف دراسة تأثير المحاصيل السابقة والتحميل على إنتاجية كل من الذرة الشامية ولوبيا العلف والحشائش المصاحبة لهما واستخدم تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات خلال الموسمين٠ والقطع الرئيسية وزعت عليها المحاصيل الشتوية السابقة (القمح – الفول البلدى – البرسيم) بينما فى القطع الشقية شملت ثلاث نظم زراعة منفردة وهى ذرة شامية منفردة ، لوبيا العلف منفرد حشت بعد شهرين من الزراعة (علف) ، لوبيا علف منفرد تركت بدون حش (بذور) وبجانب معاملتين تحميل هما ذرة شامية + لوبيا علف حشت بعد شهرين من الزراعة (علف) وذرة شامية + لوبيا علف تركت بدون حش (بذور)٠

وأوضحت النتائج ان الذرة الشامية المسبوقة بالفول البلدى كانت متفوقة فى جميع الصفات المدروسة بينما الذرة الشامية بعد القمح كانت أقلهم٠

وكانت كثافة الحشائش النامية فى الذرة الشامية المسبوقة بالمحاصيل البقولية أقل من النامية فى الذرة الشامية المسبوقة بالقمح٠

أنخفض المحصول ومكوناته للذرة الشامية تحت ظروف التحميل مقارنة بالزراعة المنفردة٠ انخفض المحصول عندما كانت لوبيا العلف المحملة بدون حش لإنتاج البذرة وكان مقدار النقص فى محصول الحبوب ٤,٧٪ مقارنة بالزراعة المنفردة (التحليل التجميعى للموسمين)٠

كان النقص فى وزن الحشائش ٧٢,٨٪ عندما كانت لوبيا العلف (علف) و ٧٢,٠٪عندما كانت لوبيا العلف المحملة لانتاج البذور٠

انخفض المحصول الأخضر للعلف ومحصول البذور للوبيا العلف المحملة كثيرا تحت ظروف التحميل وهذا الانخفاض كان ٥٢,٢٪ فى محصول العلف الأخضر و ٧٤,٤٪ فى محصول البذور مقارنة بالزراعة المنفردة (متوسط التحليل التجميعى للموسمين)٠

ولوحظت القيم الأعلى للقياسات التنافسية لكل من LER (١,٤٦) ، ATAR (١,١٩)، MAI (١٨٧٤,٦٦) عندما كانت الذرة الشامية مسبوقة بالبرسيم ومحملة مع لوبيا العلف (علف)٠