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ABSTRACT

A field experiment was conducted during the 2009-2010 and 2010-2011 seasons in the Regional Agriculture Research Station; New valley governorate to study the effect of different intercropping system (T1a : Sole tomato, T1b : Sole garlic, T2 (1 tomato plant : 1 garlic plant), T3 (1 tomato plant : 2 garlic plants), T4 (1 tomato plant : 3 garlic plants). This experiment was laid out in randomized complete block design (RCBD) with three replicates. The obtained results in the two growing seasons revealed that the highest tomato and garlic yields were produced by T1a and T1b (27.4 and 9.6 ton/feddan for sole tomato and garlic, respectively in the first season, being 28.5 and 9.9 in the second season in the same order) while the lowest tomato and garlic yields (25.6 and 0.8 ton/feddan for tomato and garlic, respectively in the first season, being 26.4 and 0.8 ton/feddan in the second season in the same order) were produced by T2 (1 tomato:1 garlic). On the other hand, T4 treatment (1 tomato plant: 3 garlic plants) produced the second highest values in this respect. Intercropping evaluation parameter and aggressiveness suggested that tomato was dominant crop. The land equivalent ratio (LER) of tomato/garlic intercropping was more than unit. Also, Land equivalent coefficient (LEC) was the same for both seasons. Moreover, the highest net profit was obtained from T4 (1 tomato plant: 3 garlic plants) but the lowest net profit was obtained from sole garlic (T1b).

Key words: Intercropping, tomato, garlic, land equivalent ratio, land equivalent coefficient, aggressiveness and net profit

Introduction

Intercropping has been identified as a promising system that results in an effective use of land and other resources (Remison, 1982), efficient utilization of water and soil nutrients (Sharma et al., 1979) and reduction in the cost of production (Bijay et al., 1978). Intercropping if properly managed and looked after can go a long way to solve the problems of low productivity per unit area and sustainability of a production system (Ahmad and Saeed, 1998). It helps in maintaining the soil fertility and making efficient use of nutrients (Aggarwal et al., 1992) and ensures economic utilization of land, labor and capital resources (Moris and Garrity, 1993). Using intercrop system is one of providing nutrition by using from exist equipment. Intercropping is from plants pattern of natural sustainable like intact forest that shows, always combination of genius prefer than single genus (Preston, 2003). Nahid (2012) stated that it is economical to have lettuce and garlic in a green leaf stage intercropping. By having two garlic rows of lettuce with simultaneous planting and harvesting lettuce and garlic in green stage in the province. Considering that the productivity of a crop is limited by the amount of resources and is mainly determined by how efficiently the crop can use them, the species composing an intercropping should be contrasting in some of their agro-botanical characteristics, such as size, architecture, cycle, growth rate, demand for nutrients, demand for light, etc. Tomato and garlic are of great economic importance in Egypt vegetable market. They were chosen for this study because they match the very important, and perhaps the most important, criterion for achieving success under intercropping conditions. Thus, one of the reasons for this choice of crops was to exploit their temporal and/or spatial complementarities. So, the aim of this study to evaluate of yield and yield components of tomato – garlic intercrop in New Valley government and make economic study for this.

Materials and Methods

An experiment was conducted during two successive winter growing seasons (2009-2010 and 2010-2011) in the Regional Agriculture Research Station; New Valley, El-Kharga. The soil texture is sandy loam (Table 1 and 2).

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Table 1: Chemical soil analysis of the experimental site.

<table>
<thead>
<tr>
<th></th>
<th>CaCO3</th>
<th>P (ppm)</th>
<th>N (ppm)</th>
<th>SO4 meq/L</th>
<th>Cl meq/L</th>
<th>HCO3 meq/L</th>
<th>K meq/L</th>
<th>Na meq/L</th>
<th>Mg meq/L</th>
<th>Ca meq/L</th>
<th>PH</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.05</td>
<td>12.50</td>
<td>60</td>
<td>8.0</td>
<td>7.0</td>
<td>0.45</td>
<td>1.96</td>
<td>4.48</td>
<td>1.65</td>
<td>6.58</td>
<td>7.90</td>
<td>1.55</td>
<td></td>
</tr>
</tbody>
</table>

This experiment was conducted to assess yield and its component of tomato (main crop) and garlic (secondary crop). This experiment was conducted in randomized complete block design (RCBD) with three replicates. Plot size was 10.5 m$^2$ (1m x 10.5 m long). Five treatments are used in this study as follow:

- **T1 (a):** Sole tomato (8400 plant / feddan)
- **T1 (b):** Sole garlic (100800 plant/ feddan)
- **T2:** (1 tomato plant : 1 garlic plant), (8400 tomato plants: 8400 garlic plants/ feddan)
- **T3:** (1 tomato plant : 2 garlic plants), (8400 tomato plants: 16800 garlic plants/ feddan)
- **T4:** (1 tomato plant : 3 garlic plants), (8400 tomato plants: 25200 garlic plants/ feddan)

In this experiment, seeds of the tomato cultivar ‘Supper strain B’ were planted in nursery at August 15th in first and second seasons, then seedlings were transplanted in permanent field on 4th October in both seasons in hills 50 cm apart and 1m between laterals. Whereas tomato plants were planted in right side of lateral and garlic cloves were in opposite side in intercropping treatment while each single crops in sole treatments were cultivated in the same site of lateral. The distance between garlic clove and its others were 10 cm, and the distance between the tomato and garlic 15 cm.

Secondary crop (garlic) Strain Sids 40 derived from Chinese variety in Horticulture Research Institute was planted using cloves in front of tomato in 4th October in both seasons. Cloves were soaked in water for 12-16 hours in running water in burlap sacks then soaked in micronic sulfer solution 5 g / liter of water for 1/2 hour. All other cultural practices were applied as recommended for tomato production (main crop). The irrigation was done using drip irrigation system. The laterals spaced 1m from each other and also the drippers spaced 50 cm from each other.

**Measured traits of tomato:** Plant height, number of branches per plant, number of fresh fruits per plant, fresh fruit weight per plant (kg), average fruit weight (g), number of fresh fruits per kg and the total fruit yield (ton per feddan) were calculated. These traits were determined using random sampled of ten plants per plot. The fruities were collected in about eight times in each season.

**Measured traits of garlic:** Number of cloves per bulbs, weight of single clove, bulb diameter, weight of single bulb and total yield ton per feddan and the following parameters were recorded using ten randomly sampled plants per plot.

**Intercropping Efficiency Parameters:**

Land Equivalent Ratio (LER) was determined according to Willey (1979) where,

$$\text{LER} = \frac{\text{Intercropping yield of main crop}}{\text{Pure stand yield of main crop} + \text{Intercropping yield of secondary crop}}$$

Land equivalent coefficient (LEC) = LAxLB, Where, LA = LER of main crop and LB = LER of intercrop (Adetiloye et al., 1983). Aggressiveness values were determined according to McGilchrist (1965), where

- Aggressiveness for main crop = (intercropping yield of main crop/expected yield of main crop) - (intercropping yield of secondary crop/expected yield of secondary crop) and
- Aggressiveness for secondary crop = (intercropping yield of secondary crop/expected yield of secondary crop)-(intercropping yield of main crop/ expected yield of main crop);

The expected yield = yield of sole crop X the fraction of the area occupied (1.0 for tomato and 0.5 for secondary crop in the presently used cropping system (garlic).

**Net profit:**

The net profit of tomato and garlic yield was calculated using the followed formula:

$$\text{NP} = [(Y \times P) - T_c]$$

Where NP is the net profit ($ feddan$^{-1}$), Y the yield (ton feddan$^{-1}$), P the yield price ($ ton$^{-1}$), and $T_c$ is the total costs ($ feddan$^{-1}$) (Younis et al., 1991). The costs were 163.93 $ and 409.84 $ per feddan for tomato and garlic, respectively (Agricultural Statistics Bulletin 2009/2010).
Statistical Analyses and Mean Separation Procedure:

All collected data were subjected to analysis of variance (ANOVA) procedure using the MSTAT-C Statistical Software Package (Michigan State University, 1983) and means were separated using the least significant differences method (LSD) at 5% level of significance, Gomez and Gomez (1984), only when a significant "F" test was obtained.

Results and Discussion

Yield parameter of tomato:

Data presented in (table 3) revealed that the intercropping had a significant influence on all studied traits in the two growing seasons. T4 treatment produced the tallest tomato plants (65.9 and 68.6cm in first and second seasons, respectively) while the shorter plants (54.9 and 57.2 cm in first and second seasons, respectively) were obtained from T2. Plants grow in dense vegetations at the risk of being out-competed by neighbors. To increase their competitive power, plants display adaptive responses, such as rapid shoot elongation (shade avoidance) to consolidate light capture (Keuskamp et al. 2010). Here too, the T4 treatment gave the highest mean values of number of branches plant \(^{-1}\)(7.4 and 7.7 branch plant \(^{-1}\)in first and second seasons, respectively). This is to be expected since the same treatment was gained the tallest plants and consequently number of nodes and branches. Also, the illustrated data focused that the high significant effect of intercropping system on number of fruits plant \(^{-1}\). Solid tomato treatment and T4 intercropping treatments gained the highest mean values (67.7 and 70.9 in first and second seasons, respectively) and the differences between the mentioned treatments were not significant at 0.05 level. This is logic since the T4 and T1 treatments produced the maximum values concerning of number of branches plant \(^{-1}\) and consequently high number of fruits plant \(^{-1}\). Also, T4 (1 tomato plant: 3 garlic plants) gained the highest mean values of fruit weight and fruits weight plant \(^{-1}\)(63.9 g and 4.4 kg for fruit weight and fruits weight plant \(^{-1}\) in the first season being 67.2g and 4.6 kg in second season in the same order). The highest weight of fruits plant \(^{-1}\) as resulted to the highest fruit weight produced by T4 treatment. But, the reverse was true with regard to number of fruit kg \(^{-1}\) whereas the T4 treatment gave the lowest number of fruit kg \(^{-1}\) in both seasons of study. This is logic since the same treatment gained the heaviest fruit weight and consequently produced the lowest number of fruit in kg. Moreover, the present data indicated that the maximum fruit yield feddan \(^{-1}\) (27.4 and 28.5 ton/ feddan in the first and second seasons, respectively) was obtained from solid treatment followed by T4 treatment which produced 26.7 and 28.0 ton / feddan in the same order. While the minimum fruit yield feddan \(^{-1}\) was gained by T2 treatment. Similar trend was obtained by Pilatti et al. (1994) and sayed et al, 2008.

Yield parameter of garlic:

Data presented in Table 4 revealed that the intercropping system had a significant effect on the all studied traits in the two growing seasons. T4 produced the highest values of number of cloves head \(^{-1}\) (17.0 and 16.6 cloves head \(^{-1}\) in the first and second seasons, respectively) while the lowest mean values in this respect (13.00 and 12.5 cloves head \(^{-1}\) in the first and second seasons, respectively) were obtained by T1b and T2 in the first and second seasons, respectively. Also, the data revealed that clove weight was affected significantly by the treatments in both seasons. The lowest values of clove weight were obtained from T4 treatment (3.4 and 3.3 g clove \(^{-1}\) in first and second seasons, respectively). The reduction in clove weight in crowded planting system (T4) was due to the competition between plants for nutrients, light, water and soil which led to the previous result. Here too, the present data show that the bulb diameter reacted significantly to treatment studied in both seasons. The minimum mean values of bulb diameter (3.4 and 3.3 cm in the first and second seasons, respectively) were obtained from T4 treatment. This may be due to the lowest size of cloves in T4 treatment. Moreover, the T2 treatments gave the highest mean value of bulb weight (94.9 g) in the first season while the highest value of bulb weight (95.1 g) in the second seasons was obtained from T1 (sole). On the other hand the lowest mean values in this respect were obtained by T4. This is logic since the same treatment gained the lowest values with regard to clove weight. Here too, the maximum fresh yield means values (9.6 and 9.9 ton feddan \(^{-1}\) in the first and second seasons, respectively) were obtained from T1b treatment (sole) while the lowest mean values in this respect were obtained from T2 treatment (1tomato plant : 1 garlic plant). These increases in fresh yield in solid garlic planting system could explain by the increases in number of plants and bulb weight in the T1b treatment.

Intercropping efficiency:

The measures of intercrop efficiency determined in the study follow similar trend for both seasons (Table 5). For tomato, the highest partial LER value was obtained from T1 and T4 treatments (1tomato plant : 2 garlic
plants and 1 tomato plant: 3 garlic plants, respectively). For garlic, the highest partial LER value was also obtained at T3 and T4 (1 tomato plant: 2 garlic plants and 1 tomato plant: 3 garlic plants, respectively).

Total Land Equivalent Ratio (LER) value was greater than unit in all treatments in both seasons, thus intercropping in all treatments increased the efficiency of soil use and demonstrate yield advantages for the intercropped plots.

In particular, 1 tomato plant : 3 garlic plants (T3) gave the highest LER of 1.12 in both seasons, implying that 12% more land would be used as compared sole crops to produce the yield obtained under intercropping situations.

LEC values followed a trend similar to that of LER. This is consistent with findings of Ofori and Stern (1987), Susan and Mini (2005) and Kabura et al. (2008).

The values of aggressiveness suggested that the main crop (tomato) dominated over secondary crop (garlic) in this study.

The effect of tomato-garlic intercropping on total cost, total return and net profit $ per feddan over two years is shown in table 6. T1b (sole garlic) had the lowest net profit compared to intercropped 1 tomato: 3 garlic plants (T4) which had the highest net profit followed by T1 (1 tomato plant : 2 garlic plants), sole tomato (T1a) and 1 tomato plant : 1 garlic plant (T2).

### Table 3: Yield attributes of tomato as influenced by intercropping

<table>
<thead>
<tr>
<th>Traits</th>
<th>Plant height (cm)</th>
<th>No. of branches/plant</th>
<th>Fruits No./plant</th>
<th>Fruits weight plant (kg)</th>
<th>Fruit weight (g)</th>
<th>No. of fruits per kg</th>
<th>Fruits yield ton/feddan</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1a: Sole tomato</td>
<td>64.1</td>
<td>66.7</td>
<td>6.6</td>
<td>7.0</td>
<td>67.7</td>
<td>70.5</td>
<td>3.9</td>
</tr>
<tr>
<td>T1b: 1 tomato:1 garlic</td>
<td>54.9</td>
<td>57.2</td>
<td>6.5</td>
<td>6.6</td>
<td>45.0</td>
<td>46.4</td>
<td>2.8</td>
</tr>
<tr>
<td>T2: 1 tomato:2 garlic</td>
<td>62.2</td>
<td>64.8</td>
<td>6.4</td>
<td>6.8</td>
<td>65.7</td>
<td>68.4</td>
<td>3.8</td>
</tr>
<tr>
<td>T3: 1 tomato:3 garlic</td>
<td>65.9</td>
<td>68.6</td>
<td>7.4</td>
<td>7.7</td>
<td>67.5</td>
<td>70.9</td>
<td>4.4</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>0.9</td>
<td>0.8</td>
<td>0.1</td>
<td>0.1</td>
<td>0.7</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

### Table 4: Yield attributes of garlic as influenced by intercropping

<table>
<thead>
<tr>
<th>Traits</th>
<th>Number of cloves</th>
<th>Clove weight (g)</th>
<th>Bulb diameter</th>
<th>Bulb weight (g)</th>
<th>Fresh yield ton/feddan</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1b: Sole garlic</td>
<td>13.0</td>
<td>12.6</td>
<td>7.2</td>
<td>7.3</td>
<td>5.3</td>
</tr>
<tr>
<td>T2: 1 tomato:1 garlic</td>
<td>13.0</td>
<td>12.5</td>
<td>7.3</td>
<td>7.1</td>
<td>5.3</td>
</tr>
<tr>
<td>T3: 1 tomato:2 garlic</td>
<td>14.0</td>
<td>13.8</td>
<td>6.0</td>
<td>6.1</td>
<td>4.5</td>
</tr>
<tr>
<td>T4: 1 tomato:3 garlic</td>
<td>17.0</td>
<td>16.6</td>
<td>3.4</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>0.6</td>
<td>1.7</td>
<td>1.1</td>
<td>0.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>

### Table 5: Effect of intercropping on land equivalent ratio, land equivalent coefficient and aggressiveness in tomato based cropping system.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Partial LER Tomato</th>
<th>Total LER Tomato</th>
<th>Partial LEC Tomato</th>
<th>Total LEC Tomato</th>
<th>AGGRESSIVENESS Tomato</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2: 1 tomato:1 garlic</td>
<td>0.93</td>
<td>0.08</td>
<td>1.01</td>
<td>0.93</td>
<td>0.08</td>
</tr>
<tr>
<td>T3: 1 tomato:2 garlic</td>
<td>0.97</td>
<td>0.15</td>
<td>1.12</td>
<td>0.97</td>
<td>0.14</td>
</tr>
<tr>
<td>T4: 1 tomato:3 garlic</td>
<td>0.97</td>
<td>0.15</td>
<td>1.12</td>
<td>0.98</td>
<td>0.14</td>
</tr>
</tbody>
</table>

### Table 6: Effect of Tomato-garlic intercropping on total cost, total return and net profit $ per feddan over two years.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total cost</th>
<th>Total return</th>
<th>Net profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1a: Sole tomato</td>
<td>726.9</td>
<td>4576.6</td>
<td>3849.7</td>
</tr>
<tr>
<td>T1b: 1 tomato:1 garlic</td>
<td>847.5</td>
<td>3988.9</td>
<td>3141.4</td>
</tr>
<tr>
<td>T2: 1 tomato:2 garlic</td>
<td>759.7</td>
<td>4580.1</td>
<td>3820.4</td>
</tr>
<tr>
<td>T3: 1 tomato:3 garlic</td>
<td>792.5</td>
<td>5016.0</td>
<td>4223.5</td>
</tr>
<tr>
<td>T4: 1 tomato:3 garlic</td>
<td>825.2</td>
<td>5064.1</td>
<td>4238.9</td>
</tr>
</tbody>
</table>

### References


