Effects of Intercropping System of Tomato and Common Bean on Growth, Yield Components and Land Equivalent Ratio in New Valley Governorate

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ABSTRACT

Two field experiments were conducted during 2010/2011 and 2011/2012 seasons in sandy soil under drip irrigation system at the Regional Agricultural Research Station, New Valley, El-Kharga Governorate, Egypt. The objectives of this study were to determine: (1) Whether the yield and its components of tomato are reduced when they are interplant with different plant population density of common bean. (2) The appropriate planting ratio that would give high yields of tomato and common bean and (3) Ascertain monetary returns from tomato/common bean intercrops. The efficiency of different cropping systems can be evaluated by land equivalent ratio which was determined as an index of intercropping advantage and economic net income. Tomato (Lycopersicon esculentum Mill cv. Super Strain B) as a main crop was intercropped with different plant population density of common bean (Phaseolus vulgaris L. cv. Bronco) as intercrop. All crops were grown also in pure stands. Treatments consisted of combinations of three densities of common bean for each tomato plant (1 tomato plant: 1 or 2 or 3 common bean plants) in a randomized complete block design. Results of this study showed that yield response of tomato due to different intercropping systems was insignificant. Also, results showed that different intercropping system compared to sole did not affect yield and some component of tomato. This indicated also that tomato plant can be tolerating common bean plants without adverse effect on yield. Common bean yield of intercropping systems increased as number of plants associated with tomato increased. Data showed a high additional increase in profits over the each cost for one plant tomato: three common bean plants. The highest LER (Land Equivalent Ratios) was found 1 tomato plant: 3 common bean plants as 1.26 and 1.25 in 1st and 2nd seasons, respectively. It is recommended to use this pattern to improve farmer’s income and LER under New Valley conditions.

Key words: Cropping systems, tomato, common bean, yield, yield components, land equivalent ratio (LER), income

INTRODUCTION

Various cropping systems are used worldwide to increase food production. One example is intercropping which is the simultaneous planting of two or more crops in the same field. (Ofori and Stern, 1987; Nassef and Abd El-Gaid, 2012). While growing crops in monoculture is easier regarding planting, weeding and harvesting, it has the disadvantage of faster pest and
disease growth than mixed crops (Li et al., 2003; Zhang and Li, 2003). Insects need more time to find their host plants in fields with different crops. Thus, there are less pest and disease outbreaks in intercropped fields (Li et al., 2001). Also the soil is more efficiently used when different crops are planted leaving less area for weeds (Francis, 1989). Intercropping better exploits environmental resource, so improving soil fertility and increasing crop yield (Shen and Chu, 2004; Javanmard et al., 2009; Dhamardeh et al., 2010; Addo-Quaye et al., 2011).

Studies which have demonstrated advantages of intercropping with legumes include, tomato or okra with cowpea (Olasantan, 1991). Cabbage with bean (Poniedziałek et al., 1989), watermelon with soybean (Sharaiha and Hattar, 1993) and chilli with bean (Costa and Perera, 1998). Intercrops gave complementary effects in the previous studies.

The objective of this investigation was to study the effect of intercropping system between tomato and common bean on growth parameters, yield components and LER under drip irrigation system and it could be concluded that intercropping of 1 tomato plant and 3 common bean plants could provide economically profitable options for farmers under New Valley governorate conditions.

MATERIALS AND METHODS

Two field trials were conducted in 2010/2011 and 2011/2012 in the Regional Agricultural Research Station, New Valley, El-Kharga Governorate, Egypt to determine the effect of tomato (main crop) – common bean (secondary crop) intercropping system on growth, yield components and Land Equivalent Ratio (LER). The experimental design was a Randomized Complete Block Design (RCBD) with three replicates. The experimental unit area was 10.5 m² (1 m × 10.5 m long). Five intercropping treatments were used in this study as following:

- **T₁₁**: 1 plant of tomato (8400 plant fed⁻¹)
- **T₁₂**: 1 plant of common bean (8400 plant fed⁻¹)
- **T₁₃**: 1 plant of tomato and 1 plant of common bean (8400 plant fed⁻¹ and 16800 plant fed⁻¹)
- **T₁₄**: 1 plant of tomato and 3 plants of common bean (8400 plant fed⁻¹ and 25200 plant fed⁻¹)

Drip irrigation system was used as a source of irrigation. The laterals distances were 100 cm apart and dripper 50 cm within laterals. The dripper discharge 4 L h⁻¹. Tomato (cv. Super Strain B) was planted in nursery at 1st August in both seasons then the seedlings were transplanted in permanent field on 15th September in both seasons in hills 50 cm apart and 1 m between laterals. Common bean (cv. Bronco) plants were also sown in 15th September in both seasons. The distance between common bean and its others were 10 cm and the distance between tomato and common bean was 15 cm. Tomato plants were spaced 50 cm apart in the laterals of drip irrigation without common beans. Common bean plants were sown 10 cm apart hills. Drip irrigation system one hour day after day was used to cover plants water demand. All others agricultural practices needed for tomato and common bean plants were done in the two growing seasons.

Ten tomato plants were chosen randomly from each experimental unit then the following measurements were taken: Plant height (cm), branches plant⁻¹, fruit weight (g), No. of fruit plant⁻¹, weight of fruits plant⁻¹ (g), No. of fruits kg⁻¹ and total fruits yield (ton feddan⁻¹).
Also, ten common bean plants were chosen randomly from each experimental unit then the follows measurements were taken: Plant height (cm), pod length (cm), pod width (cm) and fresh yield (ton feddan\(^{-1}\)) were measured.

**Land equivalent ratio:** LER was determined according to the following equation:

\[
LER = \frac{Y_{sa}}{Y_{sa}} + \frac{Y_{tb}}{Y_{tb}}
\]

where, \(Y_{sa}\) and \(Y_{ta}\) are the individual crop yield in intercropping and \(Y_{sa}\) and \(Y_{tb}\) are their yields as sole crop (Willey, 1979).

To determine tomato (as main crop) intercropping farming feasibility analysis was carried out on cost structure and revenue using the partial budget analyses. The analyses were done for the total cost and cash cost using a price level and wage rate prevailing at the location. Farming is financially and economically feasible if the gross B/C value is more than one. Formulation of the gross B/C is as follows:

\[
B/C = \frac{P \times Q}{B_i}
\]

where, \(P\) is tomato and common bean price (LE/ton), \(Q\) is tomato and bean yield, \(B_i\) is the production cost (Hoagland and Williamson, 2000).

Tomato yield equivalent was calculated as follows (Prasad and Srivastava, 1991):

\[
\text{Tomato equivalent yield} = \frac{\text{Yield of tomato in intercropping system} + \text{Yield of common bean} \times \text{Market price of common bean}}{\text{Market price of tomato}}
\]

**Statistical analysis:** All experiment were performed twice. Analysis of variance were carried out using MSTAT-C (1991) program version 2.10. Least Significant Difference (LSD) was employed to test for significant difference between treatments at \(p<0.05\) (Gomez and Gomez, 1984).

**RESULTS AND DISCUSSION**

**Tomato:** Illustrated data in Table 1 indicated that intercropping system of tomato with common bean affected significantly \((p<0.05)\) tomato plant height in both seasons. The highest mean values of plant height \((63.96 \text{ and } 66.58 \text{ cm in the first and second seasons, respectively})\) were obtained from intercropping treatment \(T_4\). This may be due to the competition occur between tomato and common bean plants for light in order to increase plant density led to the previous result. The shortest plants resulted from \(T_3\) combination. The remained three treatments \((T_1, T_3 \text{ and } T_4)\) were statistically similar.

The data in Table 1 revealed that No. of branches plant\(^{-1}\) reacted significantly to intercropping system second season only. The highest mean values \((7.19 \text{ and } 7.47 \text{ branches plant}^{-1} \text{ in the first and second seasons, respectively})\) were recorded from \(T_4\). This could be due to the nitrogen fixation effect of legume crop that increase soil fertility under this treatment and encourage plant growth and branching process. Portes (1984) and Carruthers et al. (2000) reported that, increased yield of intercropping of legume and non legume crops may be due to the fact that
Table 1: Effects of tomato-common bean intercropping systems on yield and some yield components of tomato

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>No. of branches plant^{-1}</th>
<th>No. of fruits plant^{-1}</th>
<th>Fruit weight (g)</th>
<th>Weight of fruits plant^{-1} (kg)</th>
<th>No. of fruits (kg^{-1})</th>
<th>Fruit yield (ton feddan^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_{4} (sole tomato)</td>
<td>64.00</td>
<td>60.05</td>
<td>6.40</td>
<td>6.40</td>
<td>48.20</td>
<td>48.80</td>
<td>67.40</td>
</tr>
<tr>
<td>T_{3} (1 tomato: 1 common bean)</td>
<td>53.34</td>
<td>55.51</td>
<td>6.29</td>
<td>6.40</td>
<td>50.00</td>
<td>50.00</td>
<td>62.00</td>
</tr>
<tr>
<td>T_{2} (1 tomato: 2 common bean)</td>
<td>60.33</td>
<td>62.86</td>
<td>6.30</td>
<td>6.60</td>
<td>52.00</td>
<td>53.00</td>
<td>61.00</td>
</tr>
<tr>
<td>T_{4} (1 tomato: 3 common bean)</td>
<td>63.96</td>
<td>66.58</td>
<td>7.19</td>
<td>7.47</td>
<td>58.00</td>
<td>55.00</td>
<td>54.00</td>
</tr>
<tr>
<td>LSD for 0.05</td>
<td>6.37</td>
<td>6.08</td>
<td>ns</td>
<td>0.63</td>
<td>ns</td>
<td>ns</td>
<td>7.26</td>
</tr>
</tbody>
</table>

T refers to intercropping treatments used in this study.
legumes fix nitrogen in the soil which is needed by non legume crops. Also, the presented data in Table 1 revealed that No. of fruits plant\textsuperscript{-1} were influenced not significantly (p<0.05) by intercropping tomato/common bean plant densities in the two growing seasons. \(T_4\) produced the highest mean values of fruits plant\textsuperscript{-1} (58.00 and 55.00 fruit plant\textsuperscript{-1} in the first and second seasons, respectively), while the lowest mean values in this respect (48.20 and 48.80 fruits plant\textsuperscript{-1} in the first and second seasons, respectively) were obtained from \(T_{1b}\). This is expected since the intercropping system \(T_4\) produced the highest No. of branches plant\textsuperscript{-1} which increased the flowering No. and consequently No. of fruits plant\textsuperscript{-1}. Furthermore, the obtained results indicated that intercropping systems had a significant (p<0.05) effect on fruit weight (g) in the first growing season only. The highest value (67.40 g) was obtained from sole (\(T_{1b}\)) in the first season. Also, the presented data in Table 1 revealed that the significant differences between treatments in relation to weight of fruits plant\textsuperscript{-1} were found in second season only. The maximum mean values of fruits plant\textsuperscript{-1} (3.99 kg plant\textsuperscript{-1} in second season) was obtained from \(T_5\) (1 tomato plant: 2 common bean plants).

Also, the No. of fruits kg\textsuperscript{-1} of tomato was not significantly affected when intercropped with different plant population density of common bean in seasons 2010/2011 and 2011/2012 (Table 1). The highest No. of fruits kg\textsuperscript{-1} was obtained from \(T_4\) (17.24 and 18.80 fruits kg\textsuperscript{-1} in the both seasons, respectively).

Moreover, the yield of tomato was not significantly affected when intercropped with different plant population density common bean in both seasons (Table 1). These findings concord with the results of Brown \textit{et al.} (1985) in tomato-cabbage intercropping system. Barker and Blamey (1985) and Singh \textit{et al.} (1986) found that the total yield can often be increased by intercropping legume with non-legume. The maximum fruits yield feddan\textsuperscript{-1} (27.10 and 28.20 ton feddan\textsuperscript{-1}, in the first and second seasons, respectively) were obtained from \(T_{1b}\) (sole tomato). The differences between \(T_{1b}\) and other treatments did not reached the significant level at 5%.

**Common bean:** Common bean Table 2 showed that the intercropping, different plant population density of common bean with tomato application significantly affected all the characters investigated except pod length (cm). The highest plant height (56.00 and 58.00 in the first and second season, respectively) was obtained from \(T_4\). The lowest plant height was obtained from \(T_{1b}\) and \(T_5\) in both seasons. Also, the tallest pod (12.00 and 11.90 cm in the first and second seasons, respectively) were recorded from \(T_4\). This may be due to the complement occur between tomato and common bean plants on light in order to increase plant density led to the previous result. On the other hand, the data in Table 2 revealed that the widest pods (8.40 mm) were obtained from

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Pod length (cm)</th>
<th>Pod width (mm)</th>
<th>Fresh yield (ton feddan\textsuperscript{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(T_{1b}) (Sole tomato bean plants)</td>
<td>50.00</td>
<td>51.00</td>
<td>11.00</td>
<td>11.10</td>
</tr>
<tr>
<td>(T_4) (1 tomato: 1 common bean)</td>
<td>50.00</td>
<td>51.00</td>
<td>11.00</td>
<td>11.10</td>
</tr>
<tr>
<td>(T_{1a}) (1 tomato: 2 common bean)</td>
<td>56.00</td>
<td>57.00</td>
<td>11.50</td>
<td>11.60</td>
</tr>
<tr>
<td>(T_5) (1 tomato: 3 common bean)</td>
<td>56.00</td>
<td>58.00</td>
<td>12.00</td>
<td>11.50</td>
</tr>
<tr>
<td>LSD for 0.05</td>
<td>3.24</td>
<td>4.57</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(T\) refers to intercropping treatments were used in this study.
Table 3: Land equivalent ratio (LER) as affected by tomato-common bean cropping systems

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_1 ) (1 tomato : 1 common bean)</td>
<td>0.96</td>
<td>0.12</td>
<td>1.08</td>
<td>0.99</td>
<td>0.13</td>
<td>1.06</td>
</tr>
<tr>
<td>( T_2 ) (1 tomato : 2 common bean)</td>
<td>0.95</td>
<td>0.24</td>
<td>1.19</td>
<td>0.93</td>
<td>0.24</td>
<td>1.17</td>
</tr>
<tr>
<td>( T_3 ) (1 tomato : 3 common bean)</td>
<td>0.93</td>
<td>0.33</td>
<td>1.25</td>
<td>0.94</td>
<td>0.31</td>
<td>1.23</td>
</tr>
</tbody>
</table>

\( T \) refers to intercropping treatments were used in this study.

Table 4: Effect of intercropping tomato-common bean on tomato equivalent yield

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total yield ton fed(^{-1}) in both crops</th>
<th>Tomato equivalent yield fed(^{-1})</th>
<th>B/C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_1 ) (1 tomato : 1 common bean)</td>
<td>25.66</td>
<td>26.82</td>
<td>27.44</td>
</tr>
<tr>
<td>( T_3 ) (1 tomato : 2 common bean)</td>
<td>26.64</td>
<td>27.17</td>
<td>28.35</td>
</tr>
<tr>
<td>( T_4 ) (1 tomato : 3 common bean)</td>
<td>25.52</td>
<td>27.20</td>
<td>28.50</td>
</tr>
</tbody>
</table>

\( T \) refers to intercropping treatments were used in this study. B/C: Benefit:Cost, B/C: P/Q, Bi P is tomato and common bean price (LE/tom), Q is tomato and bean yield, Bi is the production cost.

\( T_2 \) and \( T_{1b} \) in the first and second season, respectively. Moreover, the data in Table 2 showed that the maximum values of fresh yield (3.61 and 3.67 ton fed\(^{-1}\) in the first and second seasons, respectively) were obtained from \( T_{1b} \) (sole common bean). This is logic since the sole common bean treatment doesn’t suffer any competition with tomato plants and out yielded the other intercropping systems.

**Intercropping efficiency:** If the values of Land Equivalent Ratio (LER) become over the unity under intercropping system, this revealed that the superiority of this system over the sole cropping system (Table 3) (Vandermeer, 1992). Yildirim and Guvenc (2005) reported that the Land Equivalent Ratios as an indicator of biological efficiency intercropping system were always greater than with intercropping in their research. In the present study the highest value of LER was obtained from \( T_0 \) and gave a LER of 1.26 and 1.25 in the 1st and 2nd seasons, respectively.

The lowest LER values were obtained in 1 plant tomato: 1 plant common bean (\( T_3 \)) treatment as 1.08 and 1.06 in the 1st and 2nd seasons, respectively. Yildirim and Guvenc (2005) also concluded that intercropping, based on cauliflower with Cos lettuce, leaf lettuce, radish, onion and snap bean not only efficiently uses limited areas for crop production but also increases income for small farmers with limited resources. Also, Table 4 show a high additional increase in profits over the cash (7.20 and 7.40) for \( T_4 \) in the 1st and 2nd seasons, respectively, comparing the other intercropping treatments.

Higher returns under intercropping systems explained the suitability of intercropping systems to be adopted on a commercial scale (Table 4). The positive effect of intercropping on net income B/C in the present study was agreement with the results of Erdogan and Karatas (2000) in cucumber: Pepper and tomato; Lettuce, Abidin et al. (1989) in garlic: Bean, Quayyum and Akanda (1990) in cabbage: Bean, Prabhakar and Shukla (1990) in Okra: Bean intercrops.

The highest tomato equivalent yield was 28.6 and 29.5 in the first and second season, respectively, were obtained from treatment 4 (1 tomato plant: 3 common bean plants).

**CONCLUSION**

It could be concluded that different intercropping system compared to sole did not affect yield and some component of tomato. This indicated also that tomato plant can be tolerating common
bean plants without adverse effect on yield. Also, intercropping of 1 tomato plant: 3 common bean plants could provide economically profitable options for farmers under New Valley governorate conditions.

REFERENCES