Asian Journal of Crop Science

ISSN 1994-7879

science alert
http://www.scialert.net

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Crop Science 6 (3): 254-261, 2014
ISSN 1994-7879 / DOI: 10.3923/ajcs.2014.254.261

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

[1]M.A. Abd El-Gaid, [2]M.H. Al-Dokeshy and [2]Dalia M.T. Nassef
[1]Department of Vegetable Research, Horticultural Research Institute, Agriculture Research Center, Egypt
[2]Department of Horticultural, Faculty of Agriculture, Assiut University, Assiut, Egypt

Corresponding Author: M.A. Abd El-Gaid, Department of Vegetable Research, Horticultural Research Institute, Agriculture Research Center, Egypt

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 diffirent 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 cop 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 affected 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; Dahmardeh *et al*., 2010; Addo-Quaye *et al*., 2011).

Studies which have demonstrated advantages of intrcropping with legumes include, tomato or okra with cowpea (Olasantan, 1991). Cabbage with bean (Poniedzialek *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 trails 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 m^2 (1 m × 10.5 m long). Five intercropping treatments were used in this study as following:

- T_{1a} = Sole tomato (8400 plant fed^{-1})
- T_{1b} = Sole common bean (112000 plant fed^{-1})
- T_2 = One tomato plant: one common bean plant (8400 tomato plants: 8400 common bean plant fed^{-1})
- T_3 = One tomato plant: two common bean plants (8400 tomato plants: 16800 common bean plant fed^{-1})
- T_4 = One tomato plant: three common bean plants (8400 tomato plants: 25200 common bean 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. Sole tomato plants were spaced 50 cm apart in the laterals of drip irrigation without common beans. Sole common beans 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 follows 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:

$$\text{LER} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

where, Y_{ab} and Y_{ba} are the individual crop yield in intercropping and Y_{aa} and Y_{bb} 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, Bi is the production cost (Hoagland and Williamson, 2000).

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

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

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 and 66.58 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_2 combination. The remained three treatments (T_1, T_3 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 and 7.47 branches plant^{-1} 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

Treatments	Plant height (cm)		No. of branches plant^{-1}		No. of fruits plant^{-1}		Fruit weight (g)		Weight of fruits plant^{-1} (kg)		No. of fruits (kg^{-1})		Fruit yield (ton feddan^{-1})	
	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12
T_{1a} (Sole tomato)	64.00	63.05	6.49	6.40	48.20	48.80	67.40	60.37	3.23	3.23	14.85	16.64	27.10	28.20
T_2 (1 tomato: 1 common bean)	53.34	55.51	6.29	6.40	50.00	50.00	62.00	63.00	3.10	2.98	16.13	15.90	26.12	26.36
T_3 (1 tomato: 2 common bean)	60.33	62.86	6.30	6.60	52.00	53.00	61.00	62.00	3.17	3.99	16.40	16.10	25.78	26.34
T_4 (1 tomato: 3 common bean)	63.96	66.58	7.19	7.47	58.00	55.00	54.00	56.00	3.13	3.10	17.24	18.80	25.18	26.05
LSD for 0.05	6.37	6.08	ns	0.63	ns	ns	7.28	ns	ns	0.24	ns	ns	ns	ns

T refers to intercropping treatments were 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^{-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^{-1} (58.00 and 55.00 fruit plant^{-1} in the first and second seasons, respectively), while the lowest mean values in this respect (48.20 and 48.80 fruits plant^{-1} in the first and second seasons, respectively) were obtained from T_{1a}. This is expected since the intercropping system T_4 produced the highest No. of branches plant^{-1} which increased the flowering No. and consequently No. of fruits plant^{-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_{1a}) 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^{-1} were found in second season only. The maximum mean values of fruits plant^{-1} (3.99 kg plant^{-1} in second season) was obtained from T_3 (1 tomato plant: 2 common bean plants).

Also, the No. of fruits kg^{-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^{-1} was obtained from T_4 (17.24 and 18.80 fruits kg^{-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 concur with the results of Brown *et al.* (1985) in tomato-cabbage intercropping system. Barker and Blamey (1985) and Singh *et al.* (1986) found that the total yield can often be increased by intercropping legume with non-legume. The maximum fruits yield feddan^{-1} (27.10 and 28.20 ton feddan^{-1}, in the first and second seasons, respectively) were obtained from T_{1a} (sole tomato). The differences between T_{1a} 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_2 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 2: Effects of tomato-common bean intercropping systems on yield and some yield components of fresh common bean

	Plant height (cm)		Pod length (cm)		Pod width (mm)		Fresh yield (ton feddan^{-1})	
Treatments	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12	2010/11	2011/12
T_{1b} (Sole tomato bean plants)	50.00	51.00	11.00	11.10	8.30	8.40	3.61	3.67
T_2 (1 tomato: 1 common bean)	50.00	51.00	11.00	11.10	8.40	8.30	0.44	0.46
T_3 (1 tomato: 2 common bean)	56.00	57.00	11.50	11.60	8.00	8.10	0.86	0.87
T_4 (1 tomato: 3 common bean)	56.00	58.00	12.00	11.90	7.10	7.20	1.14	1.15
LSD for 0.05	3.24	4.57	ns	ns	0.67	0.34	0.74	0.42

T refers to intercropping treatments were used in this study

Table 3: Land equivalent ratio (LER) as affected by tomato-common bean cropping systems

	2010/2011			2011/2012		
Treatments	Tomato	Common bean	LER	Tomato	Common bean	LER
T_2 (1 tomato : 1 common bean)	0.96	0.12	1.08	0.93	0.13	1.06
T3 (1 tomato : 2 common bean)	0.95	0.24	1.19	0.93	0.24	1.17
T_4 (1 tomato : 3 common bean)	0.93	0.33	1.26	0.94	0.31	1.23

T refers to intercropping treatments were used in this study

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

	Total yield ton fed^{-1} in both crops		Tomato equivalent yield fed^{-1}		B/C ratio	
Treatments	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
T_2 (1 tomato : 1 common bean)	26.56	26.82	27.44	27.74	6.80	6.90
T3 (1 tomato : 2 common bean)	26.64	27.17	28.36	28.95	7.04	7.00
T_4 (1 tomato : 3 common bean)	26.32	27.20	28.60	29.50	7.20	7.40

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/ton), 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_4 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_2) 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 affected 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

Abidin, Z., R. Subhan and R.S. Basuki, 1989. The experiment of multiple cropping of garlic, red bean and red pepper. Bul. Penel. Hort., 13: 1-8.

Addo-Quaye, A.A., A.A. Darkwa and G.K. Ocloo, 2011. Growth analysis of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. ARPN J. Agricu. Biol. Sci., 6: 34-44.

Barker, C.M. and F.P. Blamey, 1985. Nitrogen fertilizer effects on yield and nitrogen uptake of sorghum and soybean growth in sole and intercropping systems. Field Crops Res., 12: 233-240.

Brown, J.E., W.E. Splittstoesser and J.M. Gerber, 1985. Production and economic returns of vegetable intercropping systems. J. Am. Soc. Hortic. Sci., 110: 350-353.

Carruthers, K., B. Prithiviraj, Q. Fe, D. Cloutier, R.C. Martin and D.L. Smith, 2000. Intercropping of corn with soybean, lupin and forages: Silage yield and quality. J. Agron. Crop Sci., 185: 177-185.

Costa, W.A.J.M. and M.K.K.W. Perera, 1998. Effects of bean population and row arrangement on the productivity of chilli/dwarf bean intercropping in Sri Lanka. J. Agron. Crop Sci., 180: 53-58.

Dahmardeh, M., A. Ghanbari, B.A. Syahsar and M. Ramrodi, 2010. The role of intercropping maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* L.) on yield and soil chemical properties. Afr. J. Agric. Res., 5: 631-636.

Erdogan, H. and A. Karatas, 2000. An investigations on intercropping production of tomato, cucumber and pepper together with crisp head and coos lettuce in heated glasshouse by geotermal energy. Proceeding of the Vegetable Symposium, September 11-13, 2000, Isparta, Turkey, pp: 296-302.

Francis, C.A., 1989. Biological efficience in multiple cropping systems. Adv. Agron., 42: 1-42.

Gomez, A.K. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Willy and Sons, New York, USA.

Hoagland, W.H. and L. Williamson, 2000. Feasibility studies. Department of Agricultural Economics, University of Kentucky. http://www.uky.edu/Ag/AgEcon/pubs/ext_other/feasibility_study.pdf.

Javanmard, A., A.D.M. Nasab, A. Javanshir, M. Moghaddam and H. Janmohammadi, 2009. Forage yield and quality in intercropping of maize with different legumes as double-cropped. J. Food Agric. Environ., 7: 163-166.

Li, L., J. Sun, F. Zhang, X. Li, S. Yang and Z. Rengel, 2001. Wheat/maize or wheat/soybean strip intercropping: I. Yield advantage and interspecific interactions on nutrients. Field Crop Res., 71: 123-137.

Li, L., F.S. Zhang, X.L. Li, P. Christie, J.H. Sun, S.C. Yang and C. Tang, 2003. Interspecific facilitation of nutrient uptake by intercropped maize and faba bean. Nutr. Cycling Agroecosyst., 65: 61-71.

MSTAT-C, 1991. A Software Program for the Design, Management and Analysis of Agronomic Research Experiments. Michigan State University, East Lansing, MI.

Nassef, D.M.T. and M.A. Abd El-Gaid, 2012. Evaluation of yield and its components of intercropped tomato-garlic in New Valley Governorate. Res. J. Agric. Biol. Sci., 8: 256-260.

Ofori, F. and W.R. Stern, 1987. Cereal-legumes intercropping system. Adv. Agron., 40: 41-80.

Olasantan, F.O., 1991. Response of tomato and okra to nitrogen fertilizer in sole cropping and intercropping with cowpea. Hortic. Sci., 66: 191-199.

Poniedzialek, M., A. Zacharias, E. Kunucki and R. Suchodolska, 1989. Effect of cabbage, french bean and snap bean intercropping on the level and quality of yield. Folia Hortic., 1: 37-51.

Portes, T.D.A., 1984. Profile of light interception and yields of six bean (*Phaseolus vulgaris* L.) cultivars of different growth habits intercropped with maize (*Zea mays* L.). Field Crop Abst., 37: 491-491.

Prabhakar, B.S. and V. Shukla, 1990. Crop land use efficiency in sequential intercropping systems with vegetables. Ind. J. Hortic., 47: 427-430.

Prasad, K. and V.C. Srivastava, 1991. Pigeon pea (*Cajanus cajan*) and soybean (*Glycine max*) intercropping system under rainfed situation. Indian J. Agr. Sci., 61: 243-246.

Quayyum, M.A. and M.E.M. Akanda, 1990. Productivity and profitability of cabbage intercropped vegetables. Hort. Abst., 60: 7201-7201.

Sharaiha, R.K. and B. Hattar, 1993. Intercropping and poultry manure effects on yields of corn, watermelon and soybean grown in a calcareous soil in the Jordan Valley. J. Agron. Crop Sci., 171: 260-267.

Shen, Q. and G. Chu, 2004. Bi-directional nitrogen transfer in an intercropping system of peanut with rice cultivated in aerobic soil. Boil. Fertil. Soils, 40: 81-87.

Singh, N.B., P.P. Singh and K.P.P. Nair, 1986. Effect of legume intercropping on enrichment of soil nitrogen, bacterial activity and productivity of associated maize crops. Exp. Agric., 22: 339-344.

Vandermeer, J., 1992. The Ecology of Intercropping. Univercity of Cambridge, Cambridge.

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

Yildirim, E. and I. Guvenc, 2005. Intercropping based on cauliflower: More productive, profitable and highly sustainable. Eur. J. Agron., 22: 11-18.

Zhang, F.S. and L. Li, 2003. Using competitive and facilitative interactions in intercropping systems enhances crop productivity and nutrient-use efficiency. Plant Soil, 248: 305-312.