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PROTECTION OF TOMATO PLANTS AGAINST COLD AND FROST CONDITIONS BY INTERCROPPING UNDER SOHAG GOVERNORATE

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ABSTRACT

Two field trials were carried out through two years, i.e. 2009/2010 and 2010/2011 winter seasons at Shandaweel Agriculture Research Station, Sohag Governorate (Upper Egypt). The aim of this study to investigate intercropping three field crops (wheat, faba bean and onion) in three plant densities as a companion crops with tomato, aiming to protect it from cold and frost, as well as, wind. A split plot design with three replications was used in both seasons. Keeping the three field crops in the main plot and plant densities (one, two and three rows) in the sub plots. The obtained results indicated that the intercropping tomato plants with the mentioned crops resulted in protective producer against the low cold temperature and wind which led to decrease percentage of injured plants and flowers as compared with the solid planting. The yield and yield components of tomato were decreased under intercropping condition. The reduction was estimated 15.5% for fruit set percentage, 25.3% for average fruit weight, 14.5% for number of tomato fruits/plant and 15.8% for yield/fed as compared with solid planting. Intercropping tomato with wheat recorded the lowest values of injured and dead plants percentage. The reduction in yield and yield components was lesser than with onion. The results also show clearly that the high plant density (three rows) had more protective against cold temperature which led to earliness flowering and reduced the percentages of both injured and dead plants as compared with low density. The reduction in yield and yield components of tomato under high density were higher as compared with low density. Intercropped crops (wheat, faba bean and onion) were affected by plant density under intercropping condition. The yield components of the three crops were increased especially under low density (one row) which had wide distance between plants as compared with solid planting. However, the seed and bulb yield/fed were more decreased especially under low density (7.4% for wheat, 57.0% for faba bean and 70.1% for onion). The highest values of land equivalent ratio (1.48), monetary advantage index (12292.2) and net return (32738.0 L.E/fed) were observed when intercropping with onion. In general, under intercropping, the damage of tomato fruits was decreased and marketable yield was increased. These could be attributed to plant height and plant density of intercropped crops. This density must be low (1-2 rows) in tall crops, wheat and faba bean; and the opposite in short crop (onion).

Keyword: Intercropping, tomato, wheat, faba bean, onion, density.

INTRODUCTION

The climate in Upper Egypt is very hot in the summer and very cold in winter at night with dry conditions. Meteorological data indicated that the maximum air temperature is 23.8-25.4 C° in winter and the minimum is

between 9.4-15.5 C° (December and January), maximum air temperature is 39.4 C° in summer (July and August). The average air temperature is 24.6 C° and 39.4, respectively, while, the averages for soil temperature are 13.3 C° and 41.3 C° in winter and summer, respectively. Average relative humidity is 63.4 % in summer and 78.0% in winter. Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops grown in large areas in Egypt through the year for local market, processing and exportation. If temperature decrease below 5-8 C°, it cause cold injury, i.e. burning leaves, no growth, curly bushy plants (Gent, 1990 and May, 1991).

Flowering and fruit setting of tomato are influenced by air and soil temperature during autumn and winter seasons in Upper Egypt. Thus, tomato cultivations require protection against cold weather to improve fruit setting under these unfavorable conditions. Many investigators studied the effect of plastic tunnels as a method for tomato protection and to provide an opportunity for early harvest (Gent, 1990 and Salah, 1992). Stumiatie (1989) compared tomato grown under rice straw or black plastic mulch, shaded or un-shaded with transparent plastic. He obtained high yield with plastic mulch treatments compared with rice straw mulch.

To reduce cost, increase land utilization rate and adding additional income to farmers, intercropping tomato with other field crops is suggested. Higher monetary return and more stable income also give additional advantages of the associated cropping system as compared to mono-crop cultures. However, several researchers have conducted trails on the effect of intercropping some field crops to protect tomato plants. Schuerger (1994) showed that mean fruit weight was slightly lower (12%) for intercropped than monocultured tomato plants. The number of tillers per plant was slightly lower (7%) for wheat, and grain weight per plant and mean seed dry weight were slightly higher 14% and 15%, respectively for intercropped than for monocultured plants. Abd El-Aal and Zohry (2004) found that intercropping tomato with faba bean maximized utilization of irrigation water quantity by saving 31% compared to solid treatment. Also, tomato fruit yield and marketable fruits yield were increased by intercropping. Obadoni *et al*., (2005) observed that the highest stand yield were in the slope crops of cowpea and tomato. Highest yields when intercropping cowpea with tomato were recorded by the mixtures containing 33/67 and 50/50, respectively. Ibrahim *et al*., (2010) found that highest yield of intercropped tomato with faba bean (cold-protected) was 20.19 ton/fed. compared to 14.8 ton/fed. for solid tomato (un-protected). The total income of tomato in all intercropping treatments was evidently higher than in solid. The maximum value of total land equivalent ratio (2.21), and total income (18650 LE) were obtained when four rows of faba bean were grown on both sides of tomato beds. Upadhyay *et al*., (2010) observed that the average benefit cost ratio for intercrops vs. sole crops was 109:1 individually, the benefit cost ratios were 305:1 and 104:1 for the sole tomato and corn, respectively. The land equivalent ratio was 1.78 for baby corn-tomato intercropping. Ibrahim *et al*., (2011) found that yield of intercropped tomato with wheat was higher (22.28 ton/fed) than tomato solid plant (12.25 ton/fed). The average grain yield of wheat was 23.2 ardab/fed. Maximum value of equivalent ratio (2.66), total income (24843 LE)

and net return (19340 LE) were obtained when wheat cv. Giza 68 was intercropped with tomato at November 15 plantation.

Wheat (*Triticum aestivum* L.) and faba bean (*Vicia faba* L.) as main crops has bean considered the first strategic food in Egypt. However, there is a great gap between our local consumptive and production. Intercropping wheat, faba bean and onion with other crops is one of solutions for increasing productivity through maximize the utilization of available resources of the environmental resource with minimum competition, especially for light, land and water. Radwan (1993) showed that plant height, spike length, number of grains/spike, weight of 1000 grain and straw yield/fed of wheat and faba bean were increased by intercropping system. El-Habbak *et al*., (1993) showed that land equivalent ratio (LER) was greater than one under intercropping cotton with onion and reached to 1.44 and 1.70 when plant density was 50 and 100% of solid, respectively. Toajma (2006) revealed that plant height, bulb diameter, bulb weight and bulb yield/fed recorded higher values with onion pure stand compared to intercropped onion with fodder beet. Abou-Keriasha *et al*., (2011) noticed that the reduction in intercropped cowpea yield when intercropping with maize (taller plant) might be due to more shading effect of taller maize plants on shorter cowpea plants and a verse low of the intercepted light; and competition for nutrients, water and carbon dioxide. Farghly *et al*., (2003) and Gadallah *et al*., (2006) recorded that different intercropping of wheat with sugar beet resulted in higher gross return per unit area than pure stand.

The objective of this investigation was to evaluate the intercropping of three crops (wheat, faba bean and onion) at three plant densities as a companion crops with tomato, aiming to protect it from cold and frost under Sohag Governorate conditions.

MATERIALS AND METHODS

Field trials were carried out at Shandaweel Agriculture Research Station, (Sohag Governorate) during 2009/10 and 2010/11 winter seasons to evaluate the intercropping of three crops (wheat, faba bean and onion) at three plant densities as a companion crops with tomato as a method to protect it from cold and frost under Sohag Governorate conditions. The experiments were laid out in a split plot design with three replicates. Keeping the three field crops (wheat, faba bean and onion) in the main plots and plant densities (one, two and three rows) in the sub plots. Solid plots of tomato and the three field crops were also included in each replication for comparison and determination of land equivalent ratio and to calculate the yield advantage of crops, total income and net return/fed.

Tomato cv. Super strain-B was transplanted at a distance of 35 cm apart between plants on the one side of beds, 120 cm width on November 15th in two successive seasons, (in both solid and intercropping), while, the harvesting started on the February 15th and stopped May 15th for solid tomato, but the harvesting started on the February 1st and finished at May 15th in intercropping pattern. Wheat Sids-12 and faba bean Giza-843 were

sowing November 15th in rows (one, two and three) at a distance of 20 cm on the others side of tomato beds. Onion Shandaweel-1 was transplanted November 15th at a distance of 20 cm between rows and 10 cm between plants. Solid planting of wheat, faba bean and onion were sowing as recommended for each crop.

The plot size was 7.2 m^2 including 2 beds of 120 cm width and 300 cm length. All cultural practice for wheat, faba bean and onion were applied as recommended. Air and soil temperatures were recorded during the two growing seasons as presented in Table (1).

Table 1: Minimum and maximum values of air and soil temperature and relative humidity (R.H%) as means through 2009/2010 and 2010/20111 seasons.

Months	2009/2010 season						2010/2011 season					
	Air temp. C°		Soil temp. C°		R.H %		Air temp. C°		Soil temp. C°		R.H %	
	Maxi. temp.	Mini. temp.	Maxi. temp.	Mini. temp.	Maxi.	Mini.	Maxi. temp.	Mini. temp.	Maxi. temp.	Mini. temp.	Maxi.	Mini.
November	27.2	14.7	34.2	13.3	70.3	32.3	30.8	17.3	38.3	16.0	69.0	29.3
December	23.8	12.2	30.7	10.5	69.2	32.6	24.8	12.4	30.8	10.6	70.1	32.9
January	25.4	9.4	31.9	10.3	68.5	30.2	19.4	4.7	19.4	14.0	78.0	39.6
February	27.5	13.2	34.7	11.5	66.1	30.1	18.3	10.6	18.3	15.1	71.5	43.5
March	29.8	13.7	37.0	12.2	65.3	29.1	26.5	7.8	26.5	19.8	67.0	29.0
April	32.9	14.7	41.5	13.1	62.5	26.5	28.0	9.8	28.0	21.9	63.9	27.7
May	35.7	15.5	44.3	13.9	62.4	26.0	34.5	17.4	34.5	28.1	63.4	28.2

Data recorded:

1-Tomato:

Plant growth measurements:

Dry weight of tomato branches and leaves as well as total dry weight of plants were determined after 45, 60, 75 and 110 days from transplanting in both seasons.

Cold tolerance measurements:

Cold tolerance of tomato characters i.e., slightly injured (purple colour leaves), moderately injured (50% damage of leaves, stem and regrowing) and dead plants (full damage) percent from total plants were determined after 30 and 60 days from transplanting in both seasons.

Flowering characters:

a. Earliness, i.e. number of days from transplanting till flowering of 25% tomato plants.
b. Four plants in each plot were labeled and the flowering data were recorded;

Number of clusters/plant, number of flowers/cluster, number of fruits/cluster and fruit set percentage.

Yield and yield components:

Tomato fruits were picked at 4 days intervals and the following data were obtained:

1. Average fruit weight (g) at sixth pickings. A random sample of 20 fruits/plot was taken and average fruit weight was determined.
2. Number of fruits/plant.

3. Total yield (ton/fed).

2- Wheat:

Plant height (cm), number of spikles/m, weight of seeds/plot (g), weight of 100 seeds (g) and seed yield (ard./fed).

3- Faba bean:

Plant height, number of branches/plant, number of pods/plant, number of seeds/pod, weight of seeds/plot (g), weight of 100 seeds (g) and seed yield (ard./fed).

4- Onion;

Average bulb weight (g), weight of exportable bulbs (ton/fed.), weight of culls bulb (ton/fed), single bulb percentage, double bulb percentage and total yield (ton/fed.).

The statistical analysis was carried out for each crop separately according to Snedecor and Cochran (1988), using MSTATC computer V4 (1986). LSD at 0.05 level of probability was used to compare between treatment means.

Competitive relationships, yield advantages and economic evaluation:

1- Land equivalent ratio (LER)

LER was described by Willey and Osiru 1972. Land equivalent ration LER was determined according to the following formula:

$$LER \quad \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa and Ybb were pure stand of crop a and b respectively. Yab is mixture yield of a and Yba is mixture yield of b crop.

2- Competitive ratio (CR) was calculated by the following formula as advocated by **Willey and Rao (1980)**.

$$CRa = \frac{LERa}{LERb} \times \frac{Zba}{Zab} \quad \& \quad CRb = \frac{LERb}{LERa} \times \frac{Zab}{Zba}$$

Where:

LERa and LERb represent relative yield of a and b intercrops, respectively. Since the CR values of the two crops will in fact be reciprocals of each other. CRa, CRb are the competitive ratio for intercrop. Zab representing the sown proportion of intercrop a (wheat, faba bean and onion) in combination with b (tomato). Zba is the sown proportion of intercrop b crop (tomato) in combination with a crop (wheat, faba bean and onion).

3- 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).

$$MAI = \frac{\text{Value of combined intercrops x LER -1}}{LER}$$

4- Net return/fed:

Net return/fed = total return –(fixed cost of tomato+variable cost of other crops)

Total income/fed = price tomato yield + price intercropped crops yield.

The market price for wheat grain, faba bean seeds, onion bulbs and tomato fruit was 400 LE/aradab., 550 LE/aradab, 1000 LE/ton and 1000 LE/ton, respectively. as an average for the two seasons.

RESULTS AND DISCUSSION

I- Tomato crop:

1- Intercropped crops effect:

1-1. Dry weight of stem and leaves:

Data in Table (2) indicated that intercropped crops (wheat, faba bean or onion) had significant effect on dry weight of stem and leaves of tomato plants during the four stages in both seasons and the combined. The dry weight of stem and leaves on intercropped tomato plants at 45 days after transplanting were higher, but it is lesser at 30 and 110 days after transplanting compared with solid planting in both seasons and the combined. These results showed clearly that intercropping tomato plants with other crops (wheat, faba bean or onion) had the protective producers by raising the air and soil temperature as well as protection from winds, which offered favorable conditions for tomato growth during cold months (45-75 days after transplanting). Similar results were observed by Stumiatie (1989), May (1991) and Ibrahim *et al*., (2011). The results, also, show that the highest values of dry weight of stem and leaves of tomato plants were observed when intercropping with wheat followed by faba bean, while, the lowest values were recorded by onion in the two seasons and the combined. It is clear that intercropping tomato with taller plants as wheat or faba bean was more protective for tomato plants than short plants (onion).

Table 2: Effect of intercropping of some crops on dry weight (g) of tomato plants during 2010/2011 and 2011/2012 seasons.

	Days from transplanting							
	45 days		60 days		75 days		110 days	
Intercropped crops	stem	leaves	stem	leaves	stem	leaves	stem	leaves
	2010/2011 season							
Wheat	2.53	2.21	2.94	5.18	7.72	11.09	43.28	34.00
Faba bean	2.07	1.71	2.52	4.68	5.96	10.66	42.70	30.36
Onion	1.82	1.59	2.32	4.22	7.02	10.39	48.06	32.74
LSD	**0.06**	**0.04**	**0.09**	**0.34**	**1.26**	**0.20**	**4.95**	**1.20**
Solid	**1.27**	**1.21**	**3.41**	**3.72**	**5.39**	**3.94**	**55.22**	**37.9**
	2011/2012 season							
Wheat	2.47	2.17	2.90	4.79	7.98	11.03	46.02	33.59
Faba bean	2.03	1.65	2.46	4.57	5.85	10.61	42.17	30.26
Onion	1.77	1.56	2.24	4.19	7.34	10.38	48.03	32.76
LSD	**0.07**	**0.05**	**0.20**	**0.31**	**1.21**	**0.14**	**4.68**	**1.14**
Solid	**1.26**	**1.17**	**3.37**	**3.71**	**6.35**	**3.95**	**55.19**	**37.35**
	Combined analysis							
Wheat	2.50	2.19	2.92	4.99	7.85	11.06	44.65	33.86
Faba bean	2.05	1.68	2.49	4.63	5.91	10.63	42.44	30.31
Onion	1.79	1.58	2.28	4.21	7.18	10.38	48.04	32.75
LSD	**0.04**	**0.02**	**0.09**	**0.35**	**0.52**	**0.10**	**3.25**	**0.67**
Solid	**1.27**	**1.19**	**3.39**	**3.72**	**5.87**	**3.95**	**55.21**	**37.63**

1-2. Cold tolerance percentage:

The obtained results of cold tolerance percentage (slightly and moderately injured and dead plants) at 30 and 60 days after transplanting appeared significant affect with intercropped crops (wheat, faba bean or onion) except slightly injured percentage at 60 days after planting (Table 3) in both seasons and their combined. The results illustrated that the moderately injured and dead plants under intercropping condition were more less as compared with solid planting. The moderately injured percentage at 30 and 60 days after transplanting was 15.4 and 24.2% of solid planting, respectively. While, the dead plants percentage was more decreased (3.6 and 3.4%) of solid, respectively (combined analysis). Whereas, the slightly injured percentage was higher than solid planting. These results show that intercropping tomato plants with other crops resulted in protective producers from raised the cold temperature and wind which led to decrease in injured and dead plants percentage. The results, also, show that intercropping tomato with wheat recorded the lowest values of moderately injured and dead plants percentage followed by faba bean at 30 and 60 days after transplanting. The moderately injured and dead planting percentage when intercropping with wheat were 11.3 and 2.5% at 30 days and 14.3 and 2.4% at 60 days after transplanting as compared with solid planting (combined). While, the percentage of moderately injured and dead plants when intercropping with onion were higher (18.6 and 4.8% at 30 days) and (31.6 and 4.6% at 60 days) as compared with solid planting. The high decreasing in injured and dead plants percentage when intercropping with wheat or faba bean is due to that the plant height of wheat or faba bean plants were more taller than onion plants which induced effective protection against cold weather.

Table 3: Effect of intercropping of some crops on cold tolerance of tomato plants during 2010/2011 and 2011/2012 seasons (percent from total plants).

Intercropped crops	Days from transplanting					
	30 days			60 days		
	Slightly injured	Moderately injured	Dead plants	Slightly injured	Moderately injured	Dead plants
	2010/2011 season					
Wheat	17.33	5.69	0.87	13.56	7.77	0.84
Faba bean	25.22	8.33	1.18	16.00	15.31	1.09
Onion	32.22	9.33	1.62	15.56	17.59	1.52
LSD	**2.61**	**0.99**	**0.32**	**NS**	**3.60**	**0.39**
Solid	**15.67**	**51.33**	**33.00**	**10.00**	**57.00**	**33.00**
	2011/2012 season					
Wheat	17.78	5.74	0.79	14.22	8.51	0.79
Faba bean	26.33	8.32	1.13	17.00	15.53	1.13
Onion	33.56	9.56	1.56	16.44	18.22	1.56
LSD	**1.54**	**1.38**	**0.36**	**NS**	**2.85**	**0.36**
Solid	**17.67**	**50.00**	**32.33**	**10.00**	**56.33**	**33.67**
	Combined analysis					
Wheat	17.56	5.72	0.83	13.89	8.64	0.82
Faba bean	25.78	8.33	1.16	16.50	15.42	1.11
Onion	32.89	9.44	1.59	16.00	17.91	1.54
LSD	**1.24**	**0.69**	**0.20**	**1.88**	**1.87**	**0.22**
Solid	**16.67**	**50.67**	**32.67**	**10.00**	**56.67**	**33.34**

1-3. Yield and yield components:

Data in Table (4) indicated that the intercropped crops (wheat, faba bean or onion) had significant effect on earliness flowering (days), yield and yield components of tomato except no. of flowers/cluster, no. of fruits/cluster and fruit set percentage in both seasons and the combined. The earliness in flowering was 18.3 days when intercropping with wheat, 13.5 days with faba bean and 7.8 days with onion as compared with solid planting. This might be due to that the intercropped crops had the protective producers which raised the temperature of winds which offered favorable conditions for tomato growth. Similar results were observed by Abd El-Aal and Zohry (2004) and Ibrahim *et al*., (2011). The results also indicate that the yield and yield components of tomato were decreased under intercropping conditions as compared with solid planting, except for number of cluster/plant. The reduction was estimated by 6.0% for no. of flowers/cluster, 20.0% for no. of clusters/plant, 15.5% for fruit set percentage, 25.3% for average weight one tomato fruit, 14.5% for no. of tomatoes/plant and 15.8% for yield (ton/fed) as compared with solid planting (combined analysis). This reduction in yield and yield components of tomato due to increase shading effect of intercropped crops plants, hence a high competition for intercepted light which lead to a decrease in availability of light for crops which decreased the growth rate (Abou Kerasha *et al*., 2011).

Table 4: Effect of intercropping of some crops on earliness of flowering, yield and yield components of tomato plants during 2010/2011 and 2011/2012 seasons.

Traits / Intercropped crops	arliness o flowering (day)	No. of clusters /plant	No. of flowers /cluster	No. of fruits /cluster	Fruit set%	Avg. Wt. one tomato fruit (g)	No. of tomato fruit /plant	Yield (ton/fed)
	2010/2011 season							
Wheat	68.89	14.22	7.44	3.67	49.60	100.22	32.22	25.602
Faba bean	71.33	13.33	7.44	3.78	51.19	96.11	27.00	20.546
Onion	79.33	11.89	7.67	3.44	45.44	111.00	36.00	31.863
LSD	**1.92**	**0.85**	**NS**	**NS**	**NS**	**4.25**	**1.47**	**2.15**
Solid	**87.67**	**8.67**	**8.00**	**4.33**	**54.17**	**135.7**	**37.33**	**30.35**
	2011/2012 season							
Wheat	65.11	13.22	7.33	4.22	57.74	103.96	34.89	29.02
Faba bean	72.33	12.44	7.00	4.33	58.93	88.13	28.44	19.88
Onion	75.78	12.56	7.33	3.78	51.78	106.98	37.22	31.66
LSD	**2.38**	**0.98**	**NS**	**NS**	**NS**	**2.18**	**1.71**	**1.48**
Solid	**83.00**	**9.33**	**7.67**	**5.33**	**69.64**	**136.5**	**39.00**	**31.94**
	Combined analysis							
Wheat	67.00	13.72	7.39	3.94	53.67	102.09	33.56	27.31
Faba bean	71.83	13.00	7.39	4.06	55.05	92.12	27.72	20.21
Onion	77.56	11.67	7.50	3.61	48.61	108.99	26.81	31.76
LSD	**1.76**	**0.53**	**NS**	**NS**	**NS**	**1.98**	**0.92**	**1.07**
Solid	**85.34**	**9.00**	**7.84**	**4.83**	**61.91**	**136.1**	**38.17**	**31.15**

The results in Table (4) showed that the reduction in yield and yield components of tomato when intercropped with wheat was lower while with onion was higher as compared with solid planting. The reduction in yield and

yield components of tomato when intercropping with wheat was 20.0% for no. of tomatoes/plant, 13.0% for average weight of one tomato fruit and 2.0% for yield (ton/fed). While, this reduction when intercropping with onion was 32.3% for no. of tomatoes/plant, 21.5% for average weight one tomato friut and 36.3% for yield (ton/fed) (combined analysis). These results indicate that the taller crops (wheat or faba bean) has an advantage for protection against cold weather to improve the yield over than the shorter crop (onion).

2- Effect of intercropped crops density:

2-1. Dry weight of stem and leaves:

Data presented in Table (5) indicated that all characters studied i.e., dry weight of leaves after 45 days from transplanting, dry weight of leaves after 75 days from transplanting, dry weight of leaves after 110 days from transplanting, dry weight of stem after 45 days from transplanting, dry weight of stem after 60 days from transplanting, and dry weight of stem after 110 days from transplanting was significantly affected by plant density of the intercropped crops in both seasons and combined. The results show that dry weight of both stem and leaves at 45, 60 and 75 days after transplanted was higher than solid planting, while at 110 days was less in both seasons. The highest values were observed when tomato was intercropping with high density (three rows). While, the lowest values were observed when intercropping with low density (one row) in both seasons and combined. This might be due to that the intercropping with high plant density was more protective producers which raised the temperature and offered favorable conditions for tomato growth (Gent, 1990 and May, 1991).

Table 5: Effect of intercropped crop density on dry weight (g) of tomato plants during 2010/2011 and 2011/2012 seasons.

Plant density	Days of transplanting							
	45 days		60 days		75 days		110 days	
	stem	leaves	stem	leaves	stem	leaves	stem	leaves
	2010/2011 season							
One ridges	2.07	1.76	2.44	4.83	7.08	10.65	48.51	34.00
Two ridges	2.14	1.84	2.76	4.65	7.14	10.72	42.12	32.04
Three ridges	2.21	1.92	2.58	4.59	6.48	10.77	43.41	31.19
LSD	0.06	0.04	0.04	NS	0.11	0.06	1.23	0.54
Solid	1.27	1.21	3.41	3.72	5.39	3.94	55.22	37.9
	2011/2012 season							
One ridges	2.00	1.71	2.40	4.42	6.80	10.61	47.63	33.48
Two ridges	2.11	1.81	2.66	4.59	7.11	10.71	45.31	32.01
Three ridges	2.16	1.86	6.54	4.54	7.09	10.70	43.27	31.10
LSD	0.03	0.03	0.14	NS	0.06	0.07	0.90	0.63
Solid	1.26	1.17	3.37	3.71	6.35	3.95	55.19	37.35
	Combined analysis							
One ridges	2.03	1.74	2.42	4.63	7.03	10.63	48.07	33.74
Two ridges	2.12	1.83	2.71	4.62	7.13	10.71	43.72	32.03
Three ridges	2.18	1.89	2.56	4.57	6.78	10.74	73.34	31.15
LSD	0.03	0.03	0.07	NS	NS	0.04	2.80	0.39
Solid	1.27	1.19	3.39	3.72	5.87	3.95	55.21	37.63

2-2. Cold tolerance percentage of tomato plants:

The obtained results of cold tolerance percentage (slightly injured, moderately injured and dead plants) at 30 and 60 days after transplanting were significantly affected by plant density of the intercropped crops as shown in (Table 6) in both seasons and the combined analysis. The results indicate that the moderately injured and dead plants percentage at 30 and 60 days after transplanting were more least compared to the solid planting. The percentage of moderately injured and dead plants when intercropping with high plant density (three rows) were estimated by 11.3 and 3.0% of solid at 30 days and 20.2 and 43.5 of solid at 30 days, respectively (combined analysis). Whereas, the percentage of moderate injured and dead plant when intercropping with low density (one row) were estimated by 19.2 and 4.23% of solid at 30 days and 27.8 and 0.6% of solid at 60 days after transplanting. These results indicated that intercropping tomato with high plant density (three rows) was more protective against cold temperature and wind than with low plant density.

Table 6: Effect of intercropped crop density on cold tolerance of tomato plants during 2010/2011 and 2011/2012 seasons (percent from total plants).

	Days of transplanting					
	30 days			60 days		
Plant density	Slightly injured	Moderately injured	Dead plants	Slightly injured	Moderately injured	Dead plants
	2010/2011 season					
One ridges	25.78	9.69	1.40	15.89	15.70	1.32
Two ridges	25.78	7.87	1.24	16.22	14.35	1.17
Three ridges	23.22	5.80	1.02	13.00	11.63	0.97
LSD	**1.58**	**0.68**	**0.18**	**1.17**	**1.18**	**0.19**
Solid	**15.67**	**51.33**	**33.00**	**10.00**	**57.00**	**33.00**
	2011/2012 season					
One ridges	26.89	9.83	1.37	16.89	15.89	1.37
Two ridges	26.78	8.08	1.18	17.11	14.52	1.18
Three ridges	24.00	5.71	0.93	13.67	11.86	1.93
LSD	**1.85**	**1.04**	**0.17**	**1.04**	**1.16**	**0.17**
Solid	**17.67**	**50.00**	**32.33**	**10.00**	**56.33**	**33.67**
	Combined analysis					
One ridges	26.33	9.76	1.38	16.39	15.80	1.34
Two ridges	26.28	7.97	1.21	16.67	14.43	1.17
Three ridges	23.61	5.76	0.98	13.33	11.74	0.95
LSD	**1.15**	**0.59**	**0.12**	**0.74**	**0.78**	**0.12**
Solid	**16.67**	**50.67**	**32.67**	**10.00**	**56.67**	**33.34**

2-3. Yield and yield components:

Data in Table (7) showed that the highest plant density of intercropped crops had significant effect on earliness of flowering (days), yield and yield components of tomato, except no. of clusters/plant, no. of flowers/cluster, no. of fruits/cluster and fruit set percentage in both seasons and the combined analysis. The plant density of intercropped crops affect positively on earliness of flowering as compared with solid planting. The earliness on flowering reached to 14 days under high plant density (three rows) and to 11.8 days

with low plant density (one row) as compared with solid planting. These results may be due to that the highest plant density had more protective against the cold temperature and winds and offered favorable conditions for tomato growth as compared to low plant density (one row).

The results, also, indicate clearly that the yield and yield components were decreased by intercropping, except no. of clusters/plant as compared with solid planting. The reduction in yield and yield components of intercropped tomato was due to the effect of competition between the field crops and tomato plants especially under high plant density, hence a high competition for intercepted light. The reduction in yield/fed was high when intercropping with high plant density, while, the reduction with low plant density was least.

Table 7: Effect of intercropped crop density on earliness of flowering, yield and yield components of tomato plant during 2010/2011 and 2011/2012 seasons.

Traits / Plant density	arliness o flowering (day)	No. of clusters /plant	No. of flowers /cluster	No. of fruits /cluster	Fruit set%	Avg. Wt. one tomato fruit (g)	No. of tomato fruit /plant	Yield (ton/fed)
	2010/2011 season							
One ridges	74.11	13.22	7.67	3.56	46.82	117.89	30.22	28.61
Two ridges	72.11	13.11	7.44	3.56	51.19	107.67	31.22	27.01
Three ridg	73.33	13.11	7.67	3.78	45.44	81.78	33.78	22.39
LSD	**1.58**	**NS**	**NS**	**NS**	**NS**	**3.79**	**0.99**	**1.13**
Solid	**87.67**	**8.67**	**8.00**	**4.33**	**54.17**	**135.7**	**37.33**	**30.35**
	2011/2012 season							
One ridges	72.89	12.33	7.33	4.11	55.95	119.20	32.78	31.55
Two ridges	71.00	12.44	7.33	4.11	56.35	101.82	32.89	26.98
Three ridg	69.33	12.56	7.00	4.00	56.15	78.04	34.89	22.03
LSD	**1.80**	**NS**	**NS**	**NS**	**NS**	**2.60**	**1.26**	**1.20**
Solid	**83.00**	**9.33**	**7.67**	**5.33**	**69.64**	**136.5**	**39.00**	**31.94**
	Combined analysis							
One ridges	73.50	12.78	7.50	3.83	51.39	118.54	31.50	30.08
Two ridges	71.56	12.78	7.39	3.83	52.28	104.74	32.06	26.99
Three ridg	71.33	12.83	7.39	3.94	53.67	79.91	34.33	22.21
LSD	**1.14**	**NS**	**NS**	**NS**	**NS**	**2.18**	**0.76**	**0.78**
Solid	**85.34**	**9.00**	**7.84**	**4.83**	**61.91**	**136.10**	**38.17**	**31.15**

3. The interaction effect:

There were significant interaction effect between intercropping some crops and plant density in all studies characters of tomato, except number of fruits/cluster (Tables 8, 9 and 10). The highest values of dry weight of stem and leaves of tomato plants were observed when intercropping with three rows of wheat (high density) at 45, 60 and 75 days after transplanting, while, the lowest values were recorded when intercropping with one row of onion

(Table 8). Data in Table (9) showed also that the minimum values of cold tolerance percentage (slightly and moderately injured and dead plants) at 30 and 60 days after transplanting were observed when intercropping with high density of wheat (3 rows). The maximum values were observed with low density of onion (one row).

Concerning to the interaction effect on earliness, data in (Table 10) showed that earliness of flowering in tomato as a main crop was observed when intercropping with taller plants (wheat) and high density, while, the latest flowering was notice with onion. These results indicate clearly that intercropping tomato plants with taller plants (wheat) and high density (3 rows) resulted in protective produces which raised the cold tolerance against cold temperature and wind which led to decreased injured, dead plants percentage and has send earliness of flowering (**Gent, 1999 and May, 1991**).

The results of yield and yield components of tomato (Table 10) showed that the highest values of average fruit weight for one tomato, number of tomatoes per plant and yield (ton/fed) were observed when intercropping with onion and low density (one row) followed by wheat with one row as compared with solid planting and other treatments, while, the lowest values were observed by faba bean with high density (3 rows).

The reduction in tomato yield when intercropping with taller crop plants might be due to more protection effect of taller plants on shorter tomato plants and adverse effect of low intercepted light, and also the competition for nutrients, carbon dioxide may be reflected on adverse effect on growth of tomato which reduce their yield.

Table 8: Interactions effect on dry weight of stem and leaves of tomato plant during 2010/2011 and 2011/2012 seasons (percent from total plants).

Traits	Dry weight after 45 days (stem) (g)			Dry weight after 45 days (leaves) (g)			Dry weight after 60 days (stem) (g)			Dry weight after 60 days (leaves) (g)		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	2.35	1.97	1.78	2.05	1.65	1.51	2.90	2.30	2.06	5.27	4.53	4.09
Two ridges	2.53	2.06	1.78	2.21	1.67	1.58	2.90	2.55	2.67	4.82	4.63	4.42
Three ridges	2.62	2.11	1.82	2.31	1.73	1.65	2.95	2.63	2.10	4.86	4.72	4.11
LSD	0.06			0.04			0.12			0.54		
Solid	1.27			1.19			3.39			3.72		
Traits	Dry weight after 75 days (stem) (g)			Dry weight after 75 days (leaves) (g)			Dry weight after 110 days (stem) (g)			Dry weight after 110 days (leaves) (g)		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	7.83	6.06	7.20	10.81	10.76	10.33	51.01	45.90	47.30	36.89	31.26	33.08
Two ridges	8.00	5.96	7.42	11.10	10.66	10.38	41.39	41.27	48.48	33.43	29.86	32.78
Three ridges	7.72	5.71	6.93	11.29	10.49	10.44	41.54	40.13	48.35	31.25	29.81	32.38
LSD	0.67			0.08			4.85			0.68		
Solid	5.87			3.95			55.21			37.63		

Table 9: Interactions effect on cold tolerance of tomato plant during 2010/2011 and 2011/2012 seasons (percent from total plants).

Traits	Cold tolerance after 30 days slightly			Cold tolerance after 30 days moderately			Cold tolerance after 30 days dead plants		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	17.83	26.83	34.33	7.45	9.50	12.33	1.03	1.30	1.82
Two ridges	20.17	27.00	31.67	5.38	8.70	9.83	0.77	1.13	1.73
Three ridges	14.67	23.00	32.67	4.32	6.78	6.17	0.68	1.03	1.22
LSD	1.99			1.02			0.21		
Solid	16.67			50.67			32.67		
Traits	Cold tolerance after 60 days slightly			Cold tolerance after 60 days moderately			Cold tolerance after 60 days dead plants		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	14.33	16.83	18.00	9.89	17.83	19.67	1.02	1.27	1.75
Two ridges	16.00	17.17	16.83	9.04	15.24	19.02	0.77	1.08	1.67
Three ridges	11.33	15.50	13.17	7.00	13.20	15.03	0.67	0.98	1.20
LSD	1.28			1.36			0.21		
Solid	10.00			56.67			32.83		

Table 10: Interactions effect on earliness, yield and yield components of tomato plant during 2010/2011 and 2011/2012 seasons (percent from total plants)

Traits	Earliness flowering			No. of clusters /plant			No. of flowers /cluster			No. of fruits /cluster		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	70.17	73.67	76.67	13.67	13.00	11.67	7.50	7.50	7.50	4.00	4.00	3.50
Two ridges	66.67	70.00	78.00	13.50	13.00	11.83	7.17	7.50	7.50	4.00	4.00	3.50
Three ridges	64.17	71.83	78.00	14.00	13.00	11.50	7.50	7.17	7.50	3.83	4.17	3.83
LSD	1.97			0.83			0.54			NS		
Solid	85.34			9.00			7.84			4.83		
Traits	Fruit set%			Avg. Wt. one tomato (g)			No. of tomatoes /plant			Yield (ton/fed)		
Crops / Plant density	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion	Wheat	Faba bean	Onion
One ridges	53.57	53.57	47.02	123.2	108.1	124.4	33.00	26.83	34.67	32.59	23.16	34.50
Two ridges	55.95	53.57	47.32	104.8	99.7	109.7	33.00	26.50	36.67	27.65	21.13	32.19
Three ridges	51.49	58.03	51.49	78.3	68.6	92.9	34.67	29.83	38.50	21.70	16.34	28.59
LSD	7.53			3.77			1.31			1.35		
Solid	61.91			136.1			38.17			31.15		

II- Intercropped crops:

1- Wheat :

Data in Table (11) indicated a significant effect of density on yield and yield components of wheat, except 100-seed weight in first season and plant

height in second season. The highest values were observed with one row, while, the lowest value was observed with high density (3 rows). Number of spikes/m^2 of intercropped wheat was lesser than in solid planting. This reduction due to that the density of intercropped wheat was more less compared to solid. While, the 100-seed weight was high in both density one and two rows and decreased in three rows density. The reduction in 100-seed weight under three rows condition might due to the intra-interspecific competition effect between tomato plants and wheat plants. Grain yield of intercropped wheat was more decreased as compared with solid planting. This reduction was estimated by 67.4, 53.3 and 43.1% for one, two and three rows, respectively (combined analysis). This reduction due to the low plant density of intercropped wheat as compared to solid planting and competition with tomato plants. Similar results were observed by Schuerger (1994) and Ibrahim *et al*., (2011).

Table 11: Effect of intercropped wheat density with tomato on growth, yield and yield components of wheat during 2010/2011 and 2011/2012 seasons and the combined.

Traits / Plant density	Plant height (cm)	No. of spikes/m	100-seeds weight (g)	Seed yield (ard/fed)
	2010/2011 season			
One ridges	112.33	305.33	10.29	4.98
Two ridges	108.67	404.67	9.86	7.63
Three ridges	106.33	476.00	9.73	9.02
LSD	**1.07**	**16.80**	**NS**	**0.64**
Solid	**104.3**	**538.0**	**8.93**	**12.62**
	2011/2012 season			
One ridges	104.0	283.33	12.94	5.92
Two ridges	106.0	407.33	12.16	7.97
Three ridges	102.7	522.67	10.73	10.08
LSD	**NS**	**5.23**	**0.13**	**0.73**
Solid	**106.3**	**571.0**	**12.93**	**20.80**
	Combined			
One ridges	108.17	294.33	11.61	5.45
Two ridges	107.33	406.00	11.01	7.80
Three ridges	104.50	499.33	10.23	9.55
LSD	**3.38**	**34.56**	**0.39**	**0.48**
Solid	**105.3**	**554.5**	**10.93**	**16.71**

2- Faba bean :

Data in Table (12) show that all studied characters i.e., plant height (cm), number of branches/plant, number of pods/plant, number of seeds/pod, 100-seeds weight (g) and seed yield (ard/fed), were significantly affected by plant density (first, second seasons and the combined). The plant height was significantly reduced as compared to solid planting. The yield components (no. of branches, no. of seeds/pod and 100-seed weight) of intercropped faba bean were higher than solid planting especially under low density (one or two rows). This increasing in yield components might due to wide distance between plants under intercropping condition. However, the seed yield/fed attained more reduction as compared with solid planting. The reduction was

estimated by 57% for one row, 37% for two rows and 22% for three rows. This reduction due to that the density of intercropped faba bean were less than solid (17% for one row, 34% for two rows and 50% for three rows of solid density). Similar results were observed by **Ibrahim *et al*., (2010)**.

Table 12: Effect of intercropped faba bean density with tomato on growth, yield and yield components of faba bean during 2010/2011 and 2011/2012 seasons and the combined.

Traits / Plant density	Plant height (cm)	No. of branches	No. of pods /plant	No. of seeds/pod	100-seeds weight (g)	Seed yield (ard/fed)
	2010/2011 season					
One ridges	99.00	4.00	16.00	4.00	89.95	6.20
Two ridges	103.33	3.53	13.67	3.73	87.41	9.03
Three ridges	106.33	3.20	11.00	3.30	84.54	11.11
LSD	**1.28**	**0.14**	**0.86**	**0.10**	**0.76**	**0.92**
Solid	**108.7**	**3.27**	**10.33**	**3.23**	**85.87**	**14.50**
	2011/2012 season					
One ridges	99.33	3.60	14.00	3.93	85.23	5.38
Two ridges	106.67	3.27	14.00	3.60	80.38	7.93
Three ridges	104.00	3.10	10.33	3.23	76.63	9.90
LSD	**0.84**	**0.05**	**0.69**	**0.05**	**0.91**	**0.66**
Solid	**107.7**	**3.30**	**10.00**	**3.27**	**80.83**	**12.62**
	Combined					
One ridges	99.17	3.80	15.00	3.97	87.59	5.79
Two ridges	102.83	3.40	13.83	3.67	83.90	8.48
Three ridges	105.17	3.15	10.67	3.27	80.59	10.50
LSD	**3.01**	**0.29**	**2.09**	**0.22**	**2.33**	**0.57**
Solid	**108.2**	**3.29**	**10.17**	**3.25**	**83.35**	**13.56**

3- Onion :

Significant differences were observed in all studied characters, except percentage of single bulbs and double bulbs in both seasons and combined as shown in (Table 13).

The results showed that all studied characters were decreased under intercropping system, except average bulb weight when intercropped with one or two rows and double bulb percentage with two or three rows (combined analysis).

|Intercropping with one or two rows of onion produced heavy bulbs as compared with solid planting. This increasing in bulb weight is due to wide distance between hills in low density plants (one or two rows). The increasing was estimated by 46% with one row and 15.2% with two rows (combined analysis), while, the average bulb weight when intercropping with three was decreased (11.6%).

The total bulb yield/fed attained more decrease under intercropping system as compared with solid planting. The reduction in bulb yield is due to the severe competition between tomato and onion plants for light, water and nutrient elements. The low density (one row onion) had the highest values of average bulb weight, but bulb yield/fed was more decreased as compared with solid planting. This reduction in bulb yield was estimated by 70.1, 50.0 and 40.5% for one, two and three rows, respectively. This reduction in bulb

yield is due to low density of onion plants (25% of solid planting). Similar results were reported by El-Habbak *et al*., (1993) and Toaima (2006).

Data in Table (13) show also that the weight of exportable bulbs (ton/fed) and weight of culls bulbs (ton/fed) were affected by plant density under intercropping conditions. The weight of both exportable and culls bulb (ton/fed) were decreased when intercropping with one row or two rows and increased by three rows compare to sold planting. The weight of exportable and culls yields were estimated by 48.6 and 55.2% for one row, 84 and 88.1%for two rows and 99.5 and 105% for three rows, respectively.

The effect of plant density on percentage of single and double bulbs was insignificant, however, the low density (one row) had high percentage of single bulbs and low percentage for double bulbs.

Table 13: Effect of intercropped onion density with tomato on growth, yield and yield components of onion during 2010/2011 and 2011/2012 seasons and the combined.

Traits / Plant density	Avg. bulb weight (g)	Weight of exportable bulbs (ton/fed)	Weight of culls bulb (ton/fed)	Single bulbs (%)	Double bulbs (%)	Total yield (ton/fed)
	2010/2011 season					
One ridges	110.53	3.21	0.447	88.18	8.07	3.65
Two ridges	77.23	5.27	0.742	85.59	12.36	6.01
Three ridges	61.20	6.01	0.848	87.68	11.30	6.86
LSD	**13.16**	**1.64**	**0.32**	**NS**	**NS**	**1.02**
Solid	**67.23**	**6.64**	**0.797**	**89.08**	**9.68**	**10.88**
	2011/2012 season					
One ridges	107.17	3.47	0.394	89.70	6.88	4.00
Two ridges	94.54	6.26	0.620	87.24	11.20	6.86
Three ridges	70.65	7.66	0.704	89.70	9.02	8.34
LSD	**8.64**	**1.07**	**0.29**	**NS**	**NS**	**0.56**
Solid	**81.90**	**7.07**	**0.719**	**90.25**	**8.13**	**14.73**
	Combined					
One ridges	108.85	3.34	0.421	88.94	7.47	3.83
Two ridges	85.89	5.76	0.671	86.42	12.36	6.43
Three ridges	65.93	6.83	0.801	88.69	10.16	7.60
LSD	**17.13**	**0.98**	**0.30**	**NS**	**NS**	**0.58**
Solid	**74.57**	**6.86**	**0.76**	**89.67**	**8.91**	**12.81**

III- Competitive relationships, yield advantage and economic evaluation:

Data in Table (14) indicated that land equivalent ratio (LER), competitive ratio (CR), Monetary advantage index (MAI) and Net return varied considerably due to the effect of intercropped crops and plant density in the combined data of the two seasons.

1- Land Equivalent Ratio (LER):

The highest values of tomato RYt (1.02) was observed when intercropped with onion, while, the lowest value (0.64) was by faba bean. Whereas, the highest values of intercropped crops (0.61) was observed when intercropped with faba bean and the lowest value (0.45) was observed by wheat.

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 (1.53) was observed when intercropping tomato with two rows of faba bean, while, the lowest value (1.17) was observed by one row of faba bean. Similar results were observed by Abd Aal and Zohry (2004) and Ibrahim *et al*., (2010 and 2011).

2- Competitive ratio (CR):

The CR values of intercropped crops were greater than the CR of tomato. It is indicating that intercropped crops were dominant crop and more competitive than tomato crop.

3- Monetary advantage index (MAI):

The MAI values were positive in all cases, these positive of MAI values were due to LER and CR were greater than one. There was similar trend to that of LER and CR, it is a indicator of the economic feasibility for intercropping systems. The highest MAI value (13342.0) was observed when intercropping with two rows of onion. While, the lowest value (4939.35) was observed when intercropping with three rows of wheat. The results indicated that the value of MAI was superior when intercropping tomato with onion followed by intercropping tomato with wheat.

4- Net return:

The financial return of intercropping some crops (wheat, faba bean or onion) with tomato plants as compared with solid tomato planting is presented in Table (14).

Table 14: Effect of intercropping of some crops (wheat, faba bean and onion) with tomato under three densities on competitive relationship, yield advantages and net returns (combined data).

Intercropped crops	No. of row	LER			CR		MAI	Total income and net return		
		RYt	RYc	Total	CRt	CRc		Total cost	Total income	Net return
Wheat	One	1.05	0.32	1.37	0.53	1.87	9393.14	4730.0	34780.0	30050.0
	Two	0.88	0.46	1.34	0.63	1.57	7807.56	4930.0	30770.0	25840.0
	Three	0.70	0.57	1.27	0.61	1.62	4939.35	5200.0	25520.0	20320.0
	Mean	0.87	0.45	1.32	0.59	1.68	6380.00	4953.3	30353.3	25400.0
Faba bean	One	0.74	0.43	1.17	0.93	2.32	3828.63	4700.0	26350.0	21650.0
	Two	0.68	0.62	1.30	0.55	1.82	5952.46	4930.0	25794.0	20864.0
	Three	0.52	0.77	1.29	0.51	1.97	4971.59	5200.0	22115.0	16915.0
	Mean	0.64	0.61	1.25	0.66	2.04	4917.50	4943.3	17014.8	12071.5
Onion	One	1.11	0.30	1.41	0.93	1.08	11145.6	4715.0	38330.0	33615.0
	Two	1.03	0.50	1.53	1.03	0.97	13347.0	4900.0	38630.0	33730.0
	Three	0.92	0.60	1.52	1.15	0.88	12384.2	5280.0	36200.0	30920.0
	Mean	1.02	0.47	1.48	1.03	0.97	122292.2	4981.6	37720.0	32738.4
Solid tomato	Mean	---	---	---	---	---	---	4466.5	31150.0	26683.5

In general, intercropping tomato with three winter crops under three plant density (one, two and three rows) resulted in an increase in total income and net return as compared with solid tomatoes. The highest values of total revenue and net returns (38630.0 and 33730.0 L.E/fed) were observed when

intercropping with two rows of onion, while, the lowest values (22115.0 and 16915.0 L.E/fed) were observed when intercropping with three rows faba bean, respectively. The financial return showed the intercropping tomato with onion was more profitable for farmers than solid tomato.

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حماية نباتات الطماطم من أضرار البرد والصقيع بواسطة التحميل تحت ظروف محافظة سوهاج

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أقيمت تجربتان حقليتان فى محطة بحوث جزيرة شندويل (محافظة سوهاج)، خلال موسمى ٢٠١٠/٢٠٠٩ و٢٠١١/٢٠١٠ وذلك بهدف دراسة تأثير تحميل ثلاثة محاصيل حقلية (القمح والفول البلدى والبصل) بثلاث كثافات زراعة مع محصول الطماطم، على حماية نباتات الطماطم من البرد والصقيع والرياح. وقد تم استخدام تصميم القطاعات المنشقة داخل زراعات الطماطم، وذلك باستخدام ثلاث مكررات. وقد تم وضع الثلاثة محاصيل (القمح والفول البلدى والبصل) فى القطع الرئيسية بينما تم وضع الثلاث كثافات نباتية (خط وخطان وثلاثة خطوط) فى القطع الشقية.

وقد اوضحت النتائج أن تحميل بعض المحاصيل الحقلية على الطماطم أدت إلى حماية نباتات الطماطم من البرودة العالية ومن الرياح وبذلك فإنها أدت إلى تقليل حدوث أضرار للنباتات أو الأزهار وذلك مقارنة بالزراعة المنفردة للطماطم. وقد أدى التحميل على الطماطم إلى نقص فى المحصول ومكوناته. حيث كان النقص ١٥.٥% فى نسبة العقد و٢٥.٣% لمتوسط وزن ثمرة الطماطم و١٤.٥% لعدد ثمار الطماطم على النبات، و١٥.٨% لمحصول الفدان، وذلك مقارنة بالزراعة المنفردة للطماطم. وأدى تحميل القمح على الطماطم إلى إعطاء أقل نسبة من النباتات المتضررة بالصقيع ومن النباتات الميتة، وقد كان النقص فى محصول الطماطم أقل من مثيله فى حالة البصل.

أوضحت النتائج أن الكثافة العالية لمحاصيل التحميل (ثلاث خطوط) كان لها تأثير أكبر فى الحماية لمحصول الطماطم من درجات الحرارة المنخفضة، حيث أدت إلى التبكير فى الازهار، كما أدت الى تقليل نسبة النباتات المتضررة بالصقيع والنباتات الميتة، وذلك مقارنة بالكثافات المنخفضة.

وقد كان النقص فى المحصول ومكوناته فى الطماطم عالياً عند التحميل بالكثافة المرتفعة وذلك مقارنة بالكثافة المنخفضة.

أوضحت النتائج أن صفات المحاصيل المحملة (القمح والفول البلدى والبصل) قد تأثرت بالكثافة النباتية عند التحميل. حيث إزدادت صفات مكونات المحصول تحت الكثافة المنخفضة وبصفة خاصة عند تحميل خط واحد من المحاصيل المحملة، وذلك نتيجة لزيادة المسافة بين النباتات وذلك مقارنة بالزراعة المنفردة. ومع ذلك فإن المحصول الكلى للفدان لهذه المحاصيل قد إنخفض بصورة كبيرة نتيجة للتحميل، وبصفة خاصة عند الكثافة المنخفضة (٧.٤% للقمح و ٥٧.٠% للفول البلدى و ٧٠.١% للبصل). تم الحصول على أعلى قيمة من معدل كفاءة إستغلال الأرض (١.٤٨) ودليل الفائدة النقدية (١٢٢٩٢.٢) والعائد الكلى (٣٢٧٣٨.٠ جنية مصرى) عند تحميل البصل على الطماطم.

وبوجه عام فإنه تحت ظروف التحميل قد حدث نقص فى الأضرار الحادثة لثمار الطماطم وقد إزداد المحصول التسويقى، ويعود ذلك الى طول وكثافة المحاصيل المحملة، ويجب التحميل بكثافة منخفضة فى حالة المحاصيل الطويلة (الفول البلدى والقمح)، والعكس فى حالة المحصول القصير (البصل).

قام بتحكيم البحث

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