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Effect of Sunflower Intercropping on some Barley Cultivars under Salt-affected Soil Conditions

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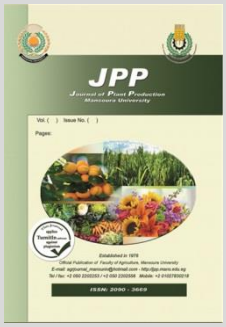

ABSTRACT

During the 2020/2021 and 2021/2022 growing seasons, a field experiment was conducted at the Experimental Station Farm, Faculty of Agriculture, Kafr El-Sheikh University, Egypt, to examine the productivity of both barley and sunflower under saline soil conditions, as well as their competitive dynamics and economic valuation. A split-plot design was used for the field experiment in three replications. Barley cultivars (Giza-123, Giza-126 and Giza-127) were assigned to the main-plots. The sub-plots were divided into three intercropping systems; the recommended plant density for barley cultivars was used; the recommended plant densities for sunflower cultivars were 25%, 37%, and 50%. Giza-123 cultivar provided the highest values of all examined sunflower features as well as the greatest values of plant height, number of grains/spike, weight of grains/spike, grain yield/fed, straw yield/fed, biological yield/fed, and harvest index of barley. The highest values of all tested barley attributes came from sowing barley cultivars at recommended plant densities, and the highest values of all analyzed sunflower features came from sowing sunflower at 25.0% of recommended plant densities. Under the saline soil conditions of Kafr El-Sheikh Governorate, Egypt, it could be concluded that the maximum total income and economic return were obtained by sowing barley Giza-123 cultivar with the recommended plant density on top of the bed, 120 cm apart, and sowing sunflower on one side of the bed in hills, 20 cm apart (50.0% of the recommended plant density).

Keywords: Sunflower and barley, yield, LER, AGG and RCC.

INTRODUCTION

One of the most significant cereal crops in Egypt's and the world's arid and semi-arid regions is barley (*Hordeum vulgare* L.). To make a decoction that is a nourishing and demulcent drink in febrile conditions and in catarrhal affections of the respiratory and urinary organs, barley grains can be ground into a flour and used as a cereal in baking bread, making porridge, etc. Barley water is used to dilute cow's milk for young infants; it prevents the formation of hard masses of curd in the stomach. Considering that barley can tolerate salinity and drought, it can take the position of wheat as the main crop.

The sunflower (*Helianthus annuus* L.) is growing in importance as a source of edible vegetable oil worldwide due to its good nutritional qualities, lack of cholesterol, high amount of unsaturated fatty acids, and high concentration of linoleic acid (Seiler, 2007). Sunflower is essential crop, not only due to its quality and quantity have good rank among the oilseed crops, but also adopt to highly warm season and drought, high temperature and moisture limited conditions (Unger, 1990). Sunflower just takes up a relatively little portion of Egypt's crop structure. To close the gap between our production and consumption of edible oils, it is crucial to expand the area under oil seed crops.

Due to differences in resource use, intercropping crops can increase growth rate, reduce weeds, pests, and diseases, and make better use of resources (Willey, 1995). Additionally, intercropping has complementing effects amongst its elements, increasing productivity as a result of lessened competition (Willey, 2000). Since there is a significant difference in the amount of edible oil produced and consumed in Egypt, intercropping sunflower with other crops may offer a chance to make up for some of the shortage Additionally, it might aid in lessening competition between oil crops and other critical crops that present in the old lands (Hefny et al., 2020). Sowing the suitable cultivar is important factor to enhance growth, grain yield and grain quality of barley. In this connection, many investigators reported that there are significant differences due to barely genotypes in growth, yield, yield components and quality due to the differences in genetic structure and their interaction with environmental condition prevailing during growing season (Abido and Seadh, 2015). Ahmed et al. (2017) found that Giza 123 cultivar outperformed Giza 129 and Giza 130 cultivars and acquired the highest mean values for grain yield/fed, number of spikes/m2, and plant height, whereas Giza 129 cultivar produced the tallest plants and the most spikes/m2. Barley cultivars have a considerable impact on growth characteristics, yield, and yield components, according to Agwa and Mohamed (2020). With the exception of 1000-grain weight, which was raised by Giza 131 cultivar, Giza134 cultivar had the highest values of all the attributes given. Moustafa et al., (2021) stated that 39% of the grain yield from the studied genotypes showed that some of them performed better than others, indicating a stronger ability for adaptation. In comparison to Giza 132, Giza 133, and Giza 135 cultivars, Seadh et al. (2022) reported that Giza 134 cultivar generated the highest levels of plant height, number of spikes/m2, spike length, number of grains for each spike, weight of grains for each spike, and grain and straw yields for each fed.

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Numerous studies have shown that plant density and planting pattern have a significant impact on the viability of intercrops. Numerous studies have demonstrated that intercrop components may more effectively make use of various edaphic and climatic growth resources, maintaining a large number of plants, and producing an optimal plant density that is higher than that of sole crops (Ofori and Stern, 1987).The secret to reducing intraspecific rivalry among sunflower plants, which will allow their foliage to receive an optimum quantity of solar radiation and boost the final production of both crops, is proper plant distribution. 2012 Sangoi et al. According to Mohammed and Abd El Zaher (2013), the conditions that produced the highest values of land equivalent ratio (LER), area time equivalent ratio (ATER), and net income were 100% sugar beet plant density plus 80% sunflower plant density with 50% defoliation of sunflower leaves Hefny et al. (2020) demonstrated that the intercropping pattern of 100% watermelon pulp + 25% sunflower produced the highest yield of watermelon pulp and its attributes, as well as the highest values of land equivalent ratio, total return, and monetary advantage index. In contrast, the intercropping pattern of 100% watermelon pulp + 50% sunflower followed the opposite trend and produced the lowest values. As a result, this project is intended to examine how intercropping some barley cultivars with sunflowers affects the productivity of both the barley and the sunflower, as well as how it affects farmers' and overall revenue under the salty soil conditions of Kafr El-Sheikh Governorate in Egypt.

MATERIALS AND METHODS

A field experiment was executed at the Experimental Research Station Farm, Faculty of Agriculture, Kafr El-Sheikh University, Egypt, during the two winter growing seasons of 2020/2021 and 2021/2022 to study the effect of sunflower intercropping on some barley cultivars under saline soil conditions on productivity of both barley and sunflower as well as competitive relationships and economic evaluation.

Three different barley cultivars received main-plot allocations (Giza-123as six-row, Giza-126 as six-row and Giza-127 as two-row). The examined barley cultivars and the sunflower Sakha-53 cultivar utilized in this study were received from the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt, and the Barley and Oil Crops Research Sections, respectively. The sub-plots were divided into three intercropping systems for barley and sunflower, with the barley cultivars being sown on top of the bed at the recommended plant density, 120 cm apart, and the sunflower cultivars being sown on one side of the bed in hills, 40, 30 and 20 cm apart (25.0%, 37.5%, and 50.0% of the recommended plant density, respectively). After reaching the flowering stage, 50.0% of the plant's total leaves were lost from sunflower plants.

Three beds, each measuring 1.2 meters wide and 4.8 meters long, made up each basic experimental unit (sub-plot), totaling 17.28 m^2. Rice (Oryza sativa L.) and maize (Zea mays L.) were the previous summer crops in the first and second seasons, respectively. The soil in the experimental field, where samples were taken at random from the soil surface (between 0 and 30 cm), during soil preparation in both growing seasons, was classified as saline soil. Then, using the procedure outlined by Page et al. (1982), chemical analyses and the particle size distribution were permitted. The results are shown in Table 1.

Table 1. The experimental field particle size distribution and chemical soil properties during 2020/2021 and 2021/2022 seasons.

Properties		2020/2021season	2021/2022season
A: Particle size distribution:			
Sand %		18.53	18.53
Silt %		31.52	31.52
Clay %		49.95	49.95
Texture		clayey	Clayey
B: Chemical soil properties :			
pH		7.95	7.90
EC ds/m^2		8.70	6.90
Organic matter (g kg^{-1})		12.00	12.05
Total N %		0.09	0.08
Total carbonate %		4.90	4.95
CEC meq/100 g soil		34.16	33.95
SP %		78.00	77.30
SAR		6.80	6.63
Available mg/kg	N	38.83	35.16
	P	5.80	5.90
	K	316.00	320.00
Soluble cationsmeq/L	Zn	1.08	1.11
	Mn	1.86	1.90
	Ca^{++}	25.00	14.91
	Mg^{++}	17.20	11.04
	Na^{+}	44.22	41.52
	K^{+}	1.47	1.35
Soluble anions meq/L	CO_3^{-}	0.00	0.00
	HCO_3^{-}	4.00	3.00
	CL^{-}	36.48	29.21
	SO_4^{-}	47.41	43.17

The experimental field was properly prepared by thorough leveling, compaction, ridging, and good orthogonal ploughing (with 120 cm between beds) (17.28 m2). During soil preparation, mono-calcium super-phosphate fertilizer (15.5% P2O5) was administered in a single dosage to all plots at a rate of 150 kg/fed. Using the aforementioned intercropping systems, barely was intercropped with sunflower on December 13 and December 10 of the first and second seasons, respectively. Barley cultivars were sown on top of the bed with the recommended plant density, and sunflower was sown on one side of the bed in hills, 40, 30 and 20 cm apart (25%, 37%, and 50% of the recommended plant density of sunflower).

Due to the recommendations for each crop, sunflower and barely were both grown separately. Each sub-plot received two equal applications of ammonium nitrate (33.5%) at 80 kg N/fed, just prior to the first and second irrigations. Each sub-plot received a 50 kg/fed application of potassium sulfate (48% K2O) along with the first dose of nitrogen fertilizer. According to each crop's instructions, the other agricultural operations for sorghum and barely were carried out as usual.

Harvesting was accomplished on April15th and May 5th in the first season and on April 10th and May1stin the second season for sunflower and barely, respectively.

Recorded data:

1. Barley characters:

At harvest time, one square meter was randomly chosen from each sub-plot to estimate the characteristics listed below. Plant height (cm) was calculated as the average of 10 plants, measured from the soil's surface to the top of the main stem spike. By counting the number of active tillers per square meter, the number of spikes/m2 was calculated. The average length of ten spikes was used to calculate the spike length (cm), which is the distance from the primary spike's base to its top. The amount of grains per spike was calculated by counting the average number of grains across ten spikes. By weighing complete, extracted grains of spike as an average of 10 spikes, grains weight/spike (g) was calculated. Weighing 1000 grains of each

sample yielded the 1000-grain weight (g). Each sub-complete plot's plants were harvested, air dried, threshed, and the grains were weighed in kg to determine the grain yield (kg/fed). The straw from the previous sample was weighed in kilograms/plot and then converted to kg per feddan. This is known as the straw yield (kg/fed By weighing complete plants that had been air dried and collected from each subplot in kg/plot, the biological yield (kg/fed) was obtained. It was then translated to kg per feddan. The harvest index (HI%) measures the physiological effectiveness and capacity of the barley crop to convert the entire dry matter into economic yield. HI was determined using the formula shown below: Harvest 2 characteristics Each sub-two plot's outer raised beds were bagged with paper bags at the conclusion of the full flowering stage in order to prevent bird damage.

$$\textbf{Harvest Index} = \frac{\textbf{Grain yield (kg/fed)}}{\textbf{Biological yield (kg/fed)}} \times 100$$

2. Sunflower traits:

When it was time for harvest, five guarded plants were randomly selected from each sub-two plot's outside beds, harvested separately, bagged, and cleared of any remaining straw and debris. Then, the parameters of plant height (in cm), stem diameter (in cm), head diameter (in cm), 100-seed weight (in g), seed yield (in g/plant), and seed yield (in kg/fed) were noted. According to A.O.A.C. (2007), seed oil percentage (%) was calculated using the Soxhlet apparatus Seed yield per feed and seed oil % were multiplied to determine oil yield (kg/fed).

3. Competitive relationships:

a- Land equivalent ratio (LER) was determined according to the following formula described by Willey and Rao (1980):

$$\textbf{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Yaa and Ybb were a pure stand of the crop, a (barley) and b(sunflower), respectively. Yab is the mixture yield of (a) crop, and Yba is the mixture yield (b) crop.

b- Aggressively (Ag) was calculated according to Mc-Gilchrist (1965) as the following formula:

- **For crop (a),**

$$A_{ab} = \frac{Y_{ab}}{Y_{aa}\ x\ Z_{ab}} - \frac{Y_{ba}}{Y_{bb}\ x\ Z_{ba}}$$

- **and for the crop (b),**

$$A_{ba} = \frac{Y_{ba}}{Y_{bb}\ x\ Z_{ba}} - \frac{Y_{ab}}{Y_{aa}\ x\ Z_{ab}}$$

Where:
Aab = aggressively value for the component a (barley).
Aba = Aggressively value for the component b(sunflower).
Yab is the intercrop yield of barley ,Zab is the percentage of the area occupied by sunflower.

c- Relative crowding coefficient (RCC) or K was calculated according to De-Wit (1960) as follows:

$$\textbf{K = Kab × Kba}$$

$$Kab = \frac{Yab\ x\ Zba}{(Yaa - Yab)Zab} \qquad Kba = \frac{Yba\ x\ Zab}{(Ybb - Yba)Zba}$$

Where: a is barley, and b is the sunflower, respectively. Zab is the percentage of the area occupied by barley and Zba is the area occupied by sunflower.

4. Economic evaluations:

Total income from each treatment was calculated in Egyptian pounds (L.E.) from market prices of barley grains were 5.8and 6.0 L.E./kg, barley straw were 1.20 and 1.32 L.E./kg and sunflower seed were 10 and 12L.E./kg in 2020/2021 and 2021/2022 seasons, respectively.

Net return = Total income – Total costs

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by Gomez and Gomez (1984) using the "MSTAT-C" software package. In addition, treatment means were compared by using least significant of difference (LSD) method at 5 % level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Effect of barley cultivars performance:

The obtained results of this study indicate that all studied characters of both barley *i.e.* plant height, number of spikes/m^2, spike length, number of grains/spike, grains weight/spike (Table 2), 1000-grain weight, grain yield/fed, straw yield/fed, biological yield/fed and harvest index (Table 3)and sunflower *i.e.* plant height, stem diameter, head diameter, 100-seed weight (Table 4), seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed (Table 5) were significantly affected due to various studied barley cultivars *i.e.* Giza-123 as six-row, Giza-126 as six-row and Giza-127 as two-row in both seasons.

Table 2. Plant height, number of spikes/m^2, spike length, number of grains/spike and grains weight/spike of barley intercropped with sunflower as affected by barley cultivars, intercropping systems and their interaction throughout 2020/2021 and 2021/2022 seasons.

Characters		Plant height (cm)		Number of spikes/m^2		Spike length (cm)		Number of grains/spike		Grains weight/spike (g)	
Treatments		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A. Barley cultivars:											
Giza-123		102.01	103.51	406.6	410.2	8.07	8.27	61.82	62.75	3.13	3.19
Giza-126		91.56	92.91	397.8	401.0	6.96	7.18	55.20	56.26	2.74	2.79
Giza-127		86.88	88.24	478.9	482.1	9.06	9.24	25.41	26.40	1.38	1.45
LSD at 5 %		0.68	0.71	2.0	1.7	0.08	0.05	0.38	0.42	0.14	0.13
B. Intercropping systems (ratio from the recommended plant density of sunflower):											
25.0 %		95.54	96.88	431.1	434.9	8.17	8.43	48.79	49.83	2.50	2.55
37.5 %		93.34	94.71	427.8	431.3	8.05	8.23	47.18	48.13	2.39	2.46
50.0 %		91.57	93.06	424.4	427.2	7.88	8.03	46.46	47.46	2.36	2.41
LSD at 5 %		0.49	0.51	2.0	2.0	0.06	0.04	0.39	0.40	0.05	0.04
Interaction:											
	25.0 %	104.60	105.93	410.7	414.4	8.23	8.48	63.93	64.87	3.31	3.33
Giza-123	37.5 %	101.40	102.73	406.8	411.6	8.04	8.28	61.18	61.99	3.06	3.15
	50.0 %	100.03	101.86	402.4	404.5	7.96	8.07	60.37	61.41	3.03	3.09
	25.0 %	93.33	94.73	400.4	404.2	7.04	7.37	56.15	57.45	2.76	2.83
Giza-126	37.5 %	91.63	92.96	397.7	400.7	6.97	7.17	55.28	56.25	2.74	2.78
	50.0 %	89.73	91.03	395.2	398.3	6.89	7.00	54.16	55.09	2.72	2.76
	25.0 %	88.70	90.00	482.2	486.0	9.26	9.46	26.30	27.16	1.43	1.50
Giza-127	37.5 %	87.00	88.43	478.9	481.6	9.13	9.24	25.08	26.14	1.38	1.45
	50.0 %	84.96	86.30	475.7	478.8	8.80	9.02	24.86	25.90	1.34	1.40
LSD at 5 %		NS	NS	NS	NS	NS	NS	0.68	0.70	0.09	0.07
Solo barley		105.0	107.0	485.2	489.4	9.45	9.59	64.00	65.55	3.45	3.55

Table 3. 1000-grain weight, grain yield/fed, straw yield/fed, biological yield/fed and harvest index (HI %) of barley intercropped with sunflower as affected by barley cultivars, intercropping systems and their interaction throughout 2020/2021 and 2021/2022 seasons.

Characters		1000-grain weight (g)		Grain yield (kg/fed)		Straw yield (kg/fed)		Biological yield (kg/fed)		Harvest index (HI %)	
Treatments		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A. Barley cultivars:											
Giza-123		52.34	52.77	1869.8	1875.8	4137.0	4147.4	6006.8	6023.2	31.13	31.14
Giza-126		49.20	49.63	1721.8	1727.2	4031.3	4044.1	5753.0	5771.2	29.92	29.92
Giza-127		54.18	54.59	1753.9	1759.5	4098.1	4109.9	5852.0	5869.3	29.96	29.97
LSD at 5 %		0.30	0.28	28.4	28.2	24.5	24.2	28.0	27.6	0.41	0.40
B. Intercropping systems (ratio from the recommended plant density of sunflower):											
25.0 %		53.11	53.54	1803.5	1809.5	4131.8	4144.5	5935.3	5953.9	30.37	30.38
37.5 %		51.61	51.99	1791.4	1796.3	4087.5	4097.9	5878.9	5894.2	30.46	30.46
50.0 %		51.00	51.46	1750.6	1756.7	4047.0	4058.9	5797.6	5815.6	30.18	30.19
LSD at 5 %		0.25	0.26	19.1	19.4	20.4	20.0	22.0	21.5	NS	NS
Interaction:											
	25.0 %	53.92	54.30	1882.2	1888.9	4212.0	4223.9	6094.2	6112.9	30.88	30.90
Giza-123	37.5 %	51.81	52.19	1872.6	1878.0	4104.2	4115.5	5976.7	5993.5	31.33	31.33
	50.0 %	51.29	51.83	1854.8	1860.5	4094.7	4102.7	5949.5	5963.2	31.17	31.20
	25.0 %	49.96	50.47	1739.3	1744.5	4048.2	4062.4	5787.5	5806.9	30.05	30.04
Giza-126	37.5 %	48.98	49.35	1718.7	1722.5	4033.7	4045.5	5752.4	5768.1	29.87	29.86
	50.0 %	48.66	49.07	1707.3	1714.4	4012.0	4024.3	5719.3	5738.7	29.85	29.87
	25.0 %	55.44	55.86	1789.1	1794.9	4135.3	4147.1	5924.3	5942.0	30.20	30.21
Giza-127	37.5 %	54.03	54.44	1782.9	1788.3	4124.6	4132.8	5907.5	5921.1	30.18	30.20
	50.0 %	53.06	53.47	1689.8	1695.2	4034.3	4049.7	5724.1	5744.9	29.52	29.50
LSD at 5 %		0.44	0.50	33.1	33.7	35.5	24.7	38.9	27.5	NS	NS
Solo barley		55.51	56.41	1895.3	1899.5	4229.8	4242.55	6125.2	6142.1	30.94	30.92

It could be noticed that barley cultivar Giza-123 surpassed other studied cultivars (Giza-126 and Giza-127) and resulted in the highest values of plant height, number of grains/spike, grains weight/spike, grain yield/fed, straw yield/fed, biological yield/fed and harvest index of barley as well as the highest values of plant height, stem diameter, head diameter, 100-seed weight, seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed of sunflower under saline soils conditions and intercropping with sunflower in both seasons. Nevertheless, Giza 127 cultivar produced the highest number of spikes/m^2, spike length and 1000-grain weight of barley and the lowest values of plant height, number of grains/spike and grains weight/spike of barley and plant height, stem diameter, head diameter, 100-seed weight, seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed of sunflower under saline soils conditions and intercropping with sunflower in the first and second seasons. However, Giza 126 cultivar came as the second best cultivars concerning plant height, number of grains/spike and grains weight/spike of barley and all studied characters of sunflower besides resulted in the lowest values of number of spikes/m^2, spike length, 1000-grain weight, grain yield/fed, straw yield/fed, biological yield/fed and harvest index of barley in both seasons.

The variation among barley cultivars under salt-affected soils conditions and intercropping with sunflower may be due to the genetic factors and genetic makeup of the studied barley cultivars. These results are in agreement with those reported by Abido and Seadh (2015), Ahmed *et al.* (2017), Agwa and Mohamad (2020), Moustafa *et al.* (2021) and Seadh *et al.* (2022).

Table 4. Plant height, stem diameter, head diameter and 100-seed weight of sunflower intercropped with barley as affected by barley cultivars, intercropping systems and their interaction throughout 2020/2021 and 2021/2022 seasons.

Characters		Plant height (cm)		Stem diameter (cm)		Head diameter (cm)		100-seed weight (g)	
Treatments		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A. Barley cultivars:									
Giza-123		140.7	147.4	2.88	2.93	22.55	23.50	5.85	5.96
Giza-126		135.5	143.6	2.71	2.83	22.08	22.94	5.79	5.88
Giza-127		132.6	139.8	2.56	2.65	21.11	22.15	5.59	5.74
LSD at 5 %		4.5	5.0	0.06	0.08	0.78	0.77	0.05	0.06
B. Intercropping systems (ratio from the recommended plant density of sunflower):									
25.0 %		133.6	139.7	2.84	2.89	23.85	24.59	5.90	5.97
37.5 %		136.7	143.8	2.73	2.83	22.01	23.06	5.75	5.90
50.0 %		138.5	147.3	2.57	2.68	19.89	20.94	5.58	5.71
LSD at 5 %		2.3	2.4	0.06	0.07	0.63	0.66	0.06	0.05
Interaction:									
	25.0 %	136.3	141.0	2.97	2.98	25.51	26.27	6.05	6.15
Giza-123	37.5 %	141.7	147.4	2.90	2.95	21.98	23.06	5.81	5.97
	50.0 %	144.0	153.7	2.78	2.87	20.17	21.16	5.70	5.76
	25.0 %	133.4	141.5	2.89	2.95	23.73	24.40	5.91	5.98
Giza-126	37.5 %	136.0	143.8	2.73	2.88	22.64	23.49	5.78	5.90
	50.0 %	137.2	145.5	2.51	2.65	19.86	20.95	5.67	5.78
	25.0 %	131.1	136.6	2.68	2.76	22.31	23.11	5.75	5.79
Giza-127	37.5 %	132.3	140.3	2.55	2.66	21.41	22.63	5.66	5.84
	50.0 %	134.3	142.6	2.44	2.53	19.63	20.70	5.37	5.60
LSD at 5 %		NS	NS	NS	NS	1.20	1.14	0.09	0.09
Solo sunflower		155.3	156.2	2.99	3.05	26.90	26.99	6.22	6.30

Table 5. Seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed of sunflower intercropped with barley as affected by barley cultivars, intercropping systems and their interaction throughout 2020/2021 and 2021/2022 seasons.

Characters		Seed yield (g/plant)		Seed yield (kg/fed)		Seed oil (%)		Oil yield (kg/fed)	
Treatments		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A. Barley cultivars:									
Giza-123		57.25	60.57	433.4	440.9	40.67	41.46	175.8	182.5
Giza-126		55.14	59.09	416.4	424.6	40.40	41.23	167.9	174.8
Giza-127		51.20	55.41	400.5	409.1	39.91	40.57	159.4	165.6
LSD at 5 %		0.81	0.79	5.5	5.4	0.32	0.27	3.1	2.9
B. Intercropping systems (ratio from the recommended plant density of sunflower):									
25.0 %		57.24	64.55	354.8	362.3	41.29	41.68	146.5	151.0
37.5 %		54.76	56.75	416.9	425.2	40.52	41.35	169.0	175.8
50.0 %		51.59	53.76	478.7	487.1	39.17	40.23	187.6	196.1
LSD at 5 %		0.45	0.41	3.8	3.1	0.21	0.19	2.0	1.6
Interaction:									
	25.0 %	60.30	65.83	372.5	378.6	41.66	42.00	155.2	159.0
Giza-123	37.5 %	57.25	60.43	429.7	437.3	40.89	41.64	175.7	182.1
	50.0 %	54.20	55.44	498.1	506.8	39.47	40.75	196.6	206.5
	25.0 %	57.20	64.26	350.9	359.0	41.20	41.77	144.5	149.9
Giza-126	37.5 %	56.60	58.07	414.2	422.7	40.39	41.42	167.3	175.1
	50.0 %	51.61	54.96	484.1	492.0	39.61	40.52	191.8	199.3
	25.0 %	54.21	63.57	340.9	349.4	41.01	41.29	139.8	144.2
Giza-127	37.5 %	50.43	51.77	406.8	415.5	40.30	41.00	163.9	170.3
	50.0 %	48.97	50.89	453.8	462.5	38.44	39.43	174.4	182.4
LSD at 5 %		0.81	0.72	5.6	5.3	0.38	0.34	3.0	2.8
Solo sunflower		61.00	66.00	1140.0	1150.0	41.70	42.00	542.1	567.0

2. Intercropping systems effects:

The data appearance in this study revealed that the effect of intercropping systems of barley and sunflower (where barley cultivars were sown with the recommended plant density and sunflower sown with 25.0% , 37.5% and 50.0 % of the recommended plant density on both barley traits *i.e.* plant height, number of spikes/m^2, spike length, number of grains/spike, grains weight/spike (Table 2), 1000-grain weight, grain yield/fed, straw yield/fed and biological yield/fed (Table 3) and sunflower traits *i.e.* plant height, stem diameter, head diameter, 100-seed weight (Table 4), seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed (Table 5)in both seasons was significant under saline soils conditions, with the exception of harvest index of barley in both seasons.

It could be affirmed that the first intercropping system of barley and sunflower *i.e.* sown barley cultivars with the recommended plant density on top of the bed, 120 cm apart, and sown sunflower on one side of the bed in hills, 40 cm apart (25.0 % of the recommended plant density clearly resulted in the highest values of barley traits *i.e.* plant height, number of spikes/m^2, spike length, number of grains/spike, grains weight/spike, 1000-grain weight, grain yield/fed, straw yield/fed and biological yield/fed as well as stem diameter, head diameter, 100-seed weight, seed yield/plant and seed oil percentage of sunflower intercropped with barley as compared with other studied intercropping systems under saline soils conditions in both seasons.

However, the second intercropping system of barley and sunflower *i.e.* sown barley cultivars with the recommended plant density and sown sunflower on one side of the bed in hills, 30 cm apart (37.5 % of the recommended plant density) was ranked secondly after the first intercropping system of barley and sunflower under saline soils conditions in the two growing seasons. While, the third intercropping system of barley and sunflower *i.e.* sown barley cultivars with the recommended plant density and sown sunflower on one side of the bed in hills, 20 cm apart (50.0 % of the recommended plant density) registered the highest values of plant height, seed yield/fed and oil yield/fed of sunflower as well as the lowest values of the rest studied characters of both barley and sunflower under saline soils conditions in both seasons.

These increases in all yield and yield attributes of intercropped barley with sunflower and individual traits of sunflower plants due to the lowest plant density of sunflower (25.0 % of the recommended plant density) under saline soils conditions might be attributed to reduce competition and mutual shading among barley plants and sunflower plants, which affects the growth, yield and its attributes of intercropped barley and sunflower. These results are in partial agreement with those reported by Sangoi *et al.* (2012), Mohammed and Abd El Zaher (2013) and Hefny *et al.* (2020).

3. Interaction effects:

The interaction between barley cultivars and intercropping systems as ratio from the recommended plant density of sunflower had significant effects on number of grains/spike, grains weight/spike (Table 2), 1000-grain weight, grain yield/fed, straw yield/fed and biological yield/fed (Table 3) of barley intercropped with sunflower as well as head diameter, 100-seed weight (Table 4), seed yield/plant, seed yield/fed, seed oil percentage and oil yield/fed (Table 5) of sunflower intercropped with barley, with the exception of plant height, number of spikes/m^2, spike length and harvest index of barley and plant height and stem diameter of sunflower under saline soils conditions in both seasons.

The suggested treatment that produced the highest values of number of grains/spike, grains weight/spike, grain yield/fed, straw yield/fed, biological yield/fed of barley as well as head diameter, 100-seed weight, seed yield/plant and seed oil percentage of sunflower was sown barley Giza-123 cultivar with (25.0 % of the recommended plant density) under saline soils conditions in both seasons as illustrated in Tables 2, 3, 4 and 5. Even as, the highest values of 1000-grain weight of barley were produced from sown barley Giza-127 cultivar with (25.0 % of the recommended plant density)under saline soils conditions in both seasons. Though, the highest values of seed yield/fed and oil yield/fed were produced from sown barley Giza-123 cultivar (50.0 % of the recommended plant density) under saline soils conditions in both seasons.

4. Competitive relationships:

Land equivalent ratio:

The data obtained in (Table 6) demonstrated that, in comparison to planting barley and sunflowers in a pure stand in both seasons, all treatments of the interaction between some barley cultivars and intercropping systems as a ratio from the recommended plant density of sunflower increased land productivity. The optimum treatment involved planting barley Giza-123 cultivar under saline soil conditions with (50.0% of the recommended plant density of sun flower), increasing land use by 41% in both seasons. The least effective treatment was simultaneously sown barley Giza-126 cultivar in saline soils at 25.0% of the recommended plant density. In the first and second seasons, this therapy was used 26% and 25%, respectively. It is clear from this that barley contributed more to LER in all treatments across both seasons.

Aggressivity (A):

Due to interactions between some barley cultivars and intercropping systems as a ratio from the optimal plant density, the data acquired and reported in (Table 6) showed that sunflower is the dominant crop in all treatments in both seasons. It is clear that a sunflower crop outperformed barley in terms of competitiveness. Whereas, sunflower was intercropped with barley by 25.0% of its pure stand, and barley was planted at a rate of 100% of its original stand.

Table 6. Land equivalent ratio (LER), aggressively (Ag) and relative crowding coefficient (RCC) of intercropping barley with sunflower as affected by as affected by the interaction between barley cultivars and intercropping systems as ratio from the recommended plant density of sunflower throughout 2020/2021 and 2021/2022 seasons.

Character		Land equivalent ratio (LER)			Aggressively (Ag)		Relative crowding Coefficient (RCC)			Land equivalent ratio (LER)			Aggressively (Ag)		Relative crowding Coefficient (RCC)		
		Lb	Ls	LER	Ag b	Ag s	Kb	Ks	K	Lb	Ls	LER	Ag b	Ag s	Kb	Ks	K
Treatments		2020/2021 season								2021/2022 season							
Giza-123	25.0 %	0.99	0.33	1.32	-1.30	+1.30	0.49	194.1	95.7	1.00	0.33	1.32	-1.31	+1.31	0.52	196.3	102.6
	37.5 %	0.98	0.38	1.35	-1.00	+1.00	0.15	161.3	24.4	0.98	0.38	1.36	-1.00	+1.00	0.15	163.6	24.8
	50.0 %	0.97	0.44	1.41	-0.86	+0.86	0.17	155.2	26.3	0.97	0.44	1.41	-0.87	+0.87	0.17	157.6	26.3
Giza-126	25.0 %	0.94	0.31	1.25	-1.22	+1.22	0.04	177.9	7.6	0.95	0.31	1.26	-1.24	+1.24	0.04	181.5	7.9
	37.5 %	0.94	0.36	1.30	-0.96	+0.96	0.06	152.2	8.8	0.94	0.37	1.31	-0.97	+0.97	0.06	155.0	9.0
	50.0 %	0.93	0.42	1.36	-0.84	+0.84	0.07	147.6	10.4	0.93	0.43	1.36	-0.85	+0.85	0.07	149.5	10.6
Giza-127	25.0 %	0.97	0.30	1.27	-1.19	+1.19	0.07	170.6	12.6	0.97	0.30	1.27	-1.21	+1.21	0.07	174.6	13.0
	37.5 %	0.96	0.36	1.32	-0.94	+0.94	0.10	148.0	15.1	0.96	0.36	1.33	-0.95	+0.95	0.10	150.9	15.2
	50.0 %	0.93	0.40	1.33	-0.79	+0.79	0.07	132.3	9.4	0.94	0.40	1.34	-0.79	+0.79	0.07	134.5	9.7

b = barley, s = sunflower.

Relative crowding coefficient (RCC):

The results gathered in (Table 6) demonstrated that the interplay of the two elements under investigation-barley cultivars and intercropping systems-as a ratio from the advised plant density- achieved favourable yield in all treatments during both seasons. The barley Giza-123 cultivar was sown with the appropriate plant density (25.0% of the recommended plant density of the sun flower) under saline soil conditions (95.7 and 102.6, respectively), in the first and second seasons, and this resulted in the best yield advantage. In contrast, the treatment of sown barley Giza-126 cultivar with (25.0% of the recommended plant density of sun flower) under saline soils conditions (7.6 and 7.9 in the first and second seasons, respectively, demonstrated the lowest yield advantage.

5. Economic evaluation:

The data obtained and displayed in (Table 7) showed that all interactions between specific barley cultivars and intercropping systems as a ratio from the recommended plant density under saline soil conditions exceeded total income and net return compared to cultivation of barley or sunflower alone in both seasons. The barley Giza-123 cultivar was sown under saline soil conditions in the first and second seasons, and the maximum values of total income (20652.5 and 22660.2 LE) and economic return (9902.5 and 11285.2 LE) were obtained, respectively On the other hand, the barley Giza-126 cultivar was sown under saline soil conditions in the first and second seasons, and the lowest values of total revenue (18454.8 and 20137.4 LE) and echoic return (8329.8 and 9447.4 LE), respectively, were obtained.

Table 7. Effect of the interaction between barley cultivars and intercropping systems on economic evaluation of intercropping barley with sunflower throughout the two winter seasons of 2020/2021 and 2021/2022 seasons.

Treatments		Economic evaluation											
		2020/2021 season						2021/2022 season					
Barley cultivars	Intercr-opping systems	Actual barley grain yield (LE/fed)	Actual barley straw yield (LE/fed)	Actual sunflo-wer seed yield (LE/fed)	Total income (LE/ fed)	Total cost (LE/ fed)	Net return (LE/ fed)	Actual barley grain yield (LE/fed)	Actual barley straw yield (LE/fed)	Actual sunflo-wer seed yield (LE/fed)	Total income (LE/ fed)	Total cost (LE/ fed)	Net return (LE/ fed)
Giza-123	25.0 %	10916.8	5054.4	3725.0	19696.2	10125	9571.2	11333.4	5575.5	4543.2	21452.1	10690.0	10762.1
	37.5 %	10861.1	4925.0	4297.0	20083.1	10383	9700.1	11268.0	5432.5	5247.6	21948.1	10920.0	11028.1
	50.0 %	10757.8	4913.6	4981.0	20652.5	10750	9902.5	11163.0	5415.6	6081.6	22660.2	11375.0	11285.2
Giza-126	25.0 %	10087.9	4857.8	3509.0	18454.8	10125	8329.8	10467.0	5362.4	4308.0	20137.4	10690.0	9447.4
	37.5 %	9968.5	4840.4	4142.0	18950.9	10383	8567.9	10335.0	5340.1	5072.4	20747.5	10920.0	9827.5
	50.0 %	9902.3	4814.4	4841.0	19557.7	10750	8807.7	10286.4	5312.1	5904.0	21502.5	11375.0	10127.5
Giza-127	25.0 %	10376.8	4962.4	3409.0	18748.1	10125	8623.1	10769.4	5474.2	4192.8	20436.4	10690.0	9746.4
	37.5 %	10340.8	4949.5	4068.0	19358.3	10383	8975.3	10729.8	5455.3	4986.0	21171.1	10920.0	10251.1
	50.0 %	9800.8	4841.2	4538.0	19180.0	10750	8430.0	10171.2	5345.6	5550.0	21066.8	11375.0	9691.8
Solo barley		10992.7	5075.8	-	16068.5	9500.0	6568.5	11397.0	5600.2	-	16997.2	10000.0	6997.2
Solo sunflower		-	-	11400.0	11400.0	2500.0	8900.0	-	-	13800.0	13800.0	2750.0	11050.0

CONCLUSION

It was determined that the barley Giza-123 cultivar was sown with the recommended plant density (50.0% of the recommended plant density) under saline soil conditions under the environmental conditions of Kafr El-Sheikh Governorate, Egypt, and that the maximum total income and economic return were obtained from intercropping barley with sunflower.

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تأثير تحميل دوار الشمس على بعض أصناف الشعير تحت ظروف الأراضى المتأثرة بالأملاح

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الملخص

تم تنفيذ تجربة حقلية في المزرعة البحثية بكلية الزراعة، جامعة كفر الموسمين 2021/2020 و 2022/2021، لدراسة تأثير تحميل دوار الشمس على بعض أصناف الشعير تحت ظروف الأراضى المتأثرة بالأملاح على إنتاجية كل من الشعير ودوار الشمس وكذلك العلاقات التنافسية والتقييم الاقتصادي. وكان التصميم المستخدم للقطع المنشقة مرة واحدة فى ثلاث مكررات. تم تخصيص القطع الرئيسية لأصناف الشعير (جيزة 123، جيزة 126 وجيزة 127). بينما تم تخصيص القطع الشقية لأنظمة التحميل، حيث تم زراعة أصناف الشعير على ظهر المصطبة (عرض المصطبة 120 سم)، بينما تم زراعة دوار الشمس فى جور على ريشة واحدة من جانبى المصطبة على مسافات 40، 30 و20 سم بين الجور، أى بنسبة 25.0 % و 37.5 % و 50.0٪ على الترتيب. أشارت النتائج المتحصل عليها أن صنف الشعير جيزة 123 أنتج أعلى القيم لصفات إرتفاع النبات، عدد الحبوب/السنبلة، وزن حبوب/سنبلة، محصول الحبوب/فدان، محصول التبن/فدان، المحصول البيولوجي/فدان ودليل الحصاد للشعير. وأعطى أعلى القيم لجميع صفات دوار الشمس المدروسة وقطر الساق و القرص ووزن 100 بذرة ومحصول البذور/نبات ونسبة الزيت ببذور دوار الشمس تحت ظروف الأراضى المتأثرة بالأملاح. من النتائج المتحصل عليها من هذه الدراسة يمكن إستنتاج أنه للحصول على الحد الأقصى لإجمالى دخل المزارع وكذلك صافى العائد الإقتصادي يوصى بزراعة الشعير صنف جيزة 123 بالكثافة النباتية على ظهر المصطبة مع زراعة دوار الشمس فى جور على ريشة واحدة من المصطبة على مسافات 20 سم بين الجور (50.0٪ من الكثافة النباتية) تحت ظروف الأراضى المتأثرة بالأملاح بمحافظة كفر الشيخ، مصر.

الكلمات الدالة: دوار الشمس ، الشعير، معدل استغلال الارض، العدوانية، الحشد النسبى