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Effect of Intercropping Sunflower Cultivars and Defoliation Time on Sugar Beet Yield and Quality

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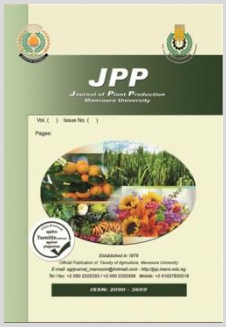

ABSTRACT

A field trial was carried out during 2021/2022 and 2022/2023 seasons at Itay El-Baroud, Research Station, El Behaira Governorate, Field Crop Research Institute, to study the effect of intercropping 25% plant density of sunflower (Sakha 53, Giza 102 and Giza 120) with sugar beet and four treatments of 50% defoliation for sunflower cultivars as follow at flowering stage (L1), 15 days after flowering stage (L2), 30 days after flowering stage (L3) and without defoliation leaves (L4), on sugar beet and sunflower. Results showed that when sowing sunflower Giza 102 with sugar beet in both seasons, yield, its components, and quality of sugar beet recorded the greatest values. The greatest values were obtained for all sugar beetroot character traits during the defoliation treatment (L1) in both seasons. The interaction between sunflower Giza 102 and (L1) produced the highest values for root length, root diameter, and root yield/fed in one season and TSS% in both seasons. The greatest values for all sunflower characters were found in Giza 120. The defoliation treatment (L4) had the greatest values across all sunflower character traits across both seasons. The highest values on sunflower characters were recorded in interactions between Giza 120 and (L4) over both seasons.. The Giza 102 and (L1) defoliation treatments with sugar beetroot plantings in seasons, respectively, produced the greatest LER values (1.23 and 1.31). When sugar beet root and sunflower Giza 102was intercropped with (L1) defoliation treatment in both seasons, the increases in net return were 22855.10 and 27256.59 L.E., respectively.

Keywords: intercropping, production, sucrose%, LER, net income.

INTRODUCTION

The sugar business relies on the sugar beetroot *(Beta vulgaris L.)*, which is a significant crop around the world. It is the second sugar crop grown in Egypt after sugarcane. The Egyptian government buys a lot of sugar each year to help close the gap in sugar availability. The Ministry of Agriculture and Land Reclamation estimates that sugar beetroot production in the 720000 region reached 1409160 tons in 2021.

Sunflower having features such as suitable oil cake, high quality of the oil, suitable climate adaptation, grown in soils variations, short growth duration, is considered as the most oil production (Tavakoli, 2013).

One of the main problems associated with the Egyptian agricultural system is the small area of cultivated land per farmer. A large percentage of farmers, 42.9%, work in a field area not exceeding one feddan (4200 m^2) (Ahmed *et al*., 2009). This led to an increased need to maximize land usage to enhance farmers' income. The need to follow such as intercropping, which is a very important in this context. The intercropping system contributes significantly to crop production through its efficient use of environmental resources compared to the monoculture system (Zhang and Li, 2003). Currently, this system is interestingly increasing in low-input crop production systems and is being extensively investigated. Badraoui *et al*. (2003) intercropped wheat-sugar beet or sunflower and recommended sugar beet and sunflower as companion crops. El-Dessougi *et al*. (2003) reported that sugar beet with oil seed crops produced higher economics than other companion crops.

Defoliating of sunflower works to reduce the shading, increase the access of light and carbon dioxide into sugar beet plants, which increase production and income of the unit area. So, intercropping sunflower at 25% of its pure stand with 100% sugar beet achieve the highest root yield per fed and monetary return (Sheha *et al*., 2017). Intercropping pattern of 100% sugar beet + 76% sunflower of plant density and 75% defoliation of sunflower gave the highest yield of sugar beet root fed^{-1}. The highest total return was recorded when sugar beet intercropped with sunflower at 80% of the recommended plant density at 50% of sunflower leaves defoliated (Wafaa and Abd El-Zaher, 2013). El Yamani (2010) compare between of two defoliation leaves (50 and 75%) of sunflower intercropped with soybean, he reported that the highest sunflower yield was obtained when alone with no leaf defoliation, whereas the lowest value was achieved when sunflower was intercropped with soybean with 75% leaf defoliation. Sunflower was obtained the highest yield with no defoliation and sequenced by 25% leaf defoliation, while the lowest seed yield was achieved when 75% of leaves were of sunflower leaves at milky ripe stage (Mohammed , 2006).

The present investigation was planned to study the effect of intercropping of some sunflower varieties with sugar beet under some sunflower defoliation treatments on productivity of sugar beet and sunflower, to obtain the best land usage and net return for farmer as well as increase oil productivity.

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MATERIALS AND METHODS

A field experiment was carried out at Itay El-Barud Experimental Station in El-Behaira Governorate, Agriculture Research Center, Egypt during 2021/2022 and 2022/2023 seasons, the sugar beet was sown on 15th and 19th September. in the first and second seasons. Sunflower was sown on 16th and 17th October in both seasons, respectively. All other practices for sugar beet and sunflower production were undertaken as recommended to study the effect of four defoliation treatments of three sunflower cultivars on growth, yield and yield component characters and quality characteristics of sugar beet (*Beta vulgaris L.)* Kawemira cv. and sunflower cultivars. The preceding crop was maize in both seasons.

The experiment included 12 treatments as follow:

1- Three sunflower cultivars (Sakha 53, Giza 102 and 120).

2- Four treatments of 50% defoliation for sunflower cultivars as follow: at the flowering stage, according to the flowering time of each cultivar (L1), 15 days after flowering stage (L2) 30 days after flowering stage (L3) and no leaves removed (L4). And cultivation of both sugar beet and sunflower are alone as recommended of each crop in both seasons.

A split-plots arrangement in randomized complete block design (RCBD) was used with three replications. Sunflower cultivars were set up at a random in the main-plots and sunflower leaf defoliation treatments were in the sub- plots. The experimental area was 10.80 m^2 (1/389 fed) included 3 ridges, each ridge was 3 m long and 1.20 m wide.

Soil samples were taken at 30 cm depth one week before sowing to determine the mechanical and chemical characteristics of the experimental soil in Table 1. That done by Water and Soil Research Institute, A.R.C. using the methods as described by Jackson (1958) and Chapman and Pratt (1961).

Table 1. Physical and chemical analysis of experimental soil during 2021/2022 and 2022/2023 seasons.

Soil properties	Soil texture	Sand %	Silt %	Clay %	PH	Organic matter%	Available N (ppm)	Available P (ppm)	Available K (ppm)	EC (m mhos) cm^{-1} (1;5)
2019/20	Clay	7.08	32.53	60.39	7.71	2.10	17.06	10.3	220.87	1.5
2020/21	Clay	7.09	32.96	59.95	7.79	2.14	16.64	11.2	301.01	1.6

Table 2. Weather conditions during the 2021/2022 and 2022/2023 growing seasons.

Month	Temperature (°C)				Relative humidity(%)	
	Season					
	2021/22		2022/23		2021/22	2022/23
	Min	Max	Min	Max		
Set	22.24	29.87	23.75	30.87	68	67
Oct	19.69	27.15	20.46	28.75	67	66
Nov	13.83	23.33	13.9	23.7	63	63
Dec	12.49	21.22	12.54	21.89	63	64
Jan	10.44	18.87	10.22	17.9	61	62
Feb	11.60	21.12	11.22	21.83	56	57
Mar	12.92	24.33	12.63	23.81	55	56
Apr	16.27	26.26	16.17	27.5	49	50

Meteorological records of Central Laboratory for Agriculture Climate (Source: Etay El-Baroud Research Station) El-Beheira Governorate Agriculture Research Center, Egypt, 2021/2022 and 2022/2023.

Flowering time:

Sakha 53 was flowered after 85 days form sowing date, Giza 102 was flowered after 72 days form sowing date and Giza 120 was flowered after 75 days form sowing date.

Sugar beet was planted on ridges 120 cm width on the two sides in hills with 20 cm apart to realize the recommended planting density (35000 plants fad^{-1}) and sunflower was grown on the middle of the same ridge, 40 cm between hills and one plant $hill^{-1}$ (8750 plants fad^{-1}) to achieve 100% sugar beet + 25% sunflower.

All plots received phosphoric fertilizer in the form of super phosphate (15.5% P_2O_5) at a rate of 150 kg fed^{-1} during land preparation. Potassium sulphate (48% K_2O) was added at a rate of 100 kg/fed before first irrigation. Nitrogen fertilizer was applied at a rate 80 kg fed^{-1} for sugar beet + 7.5 kg fed^{-1} on all treatments in the form of ammonium nitrate (33.5% N) in two equal doses, just before the first and second irrigation.

Recorded data:

A. Sugar beet.

Root length (cm), root diameter (cm), root weight (g), root yield (ton fed^{-1}) and top yield (ton fed^{-1}).

Sugar yield (tons fed^{-1}) was determined according to the method of Delta Sugar Company where approximately 3.07% of the sucrose percentage is considered as a loss during industrial practices.

Sugar yield (tons fed^{-1}) = root yield (tons fed^{-1}) x sucrose%.

Quality characters:

Fresh sugar beet samples were taken representing each treatment to estimate the following:

a- Percentage of total soluble solid (TSS %) was measured by using refract meter according to A. O. A. C. (1984).

b- Sucrose% by using Saccharemeter according to Le-Docte (1927).

c- Juice purity% was calculated according to the method describing by Carruthers and Old Field (1961).

$$\textbf{Purity (\%)} = \frac{Sucrose\%}{TSS\%}\ x\ 100$$

B. Sunflower characters.

Plant height (cm), head diameter (cm), number of seeds $head^{-1}$, 100-seed weight (g), seed weight $head^{-1}$ (g) , seed yield (ton fed^{-1}) ,oil content and oil yield/ fed.

C. Competition relationships:

1- Land equivalent ratio (LER).

The ratio of area needs under solid cropping to that of intercropping, at same management level, to produce an equivalent yield, according to Andrews and Kassam (1976):

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

Where, Y_{aa} and Y_{bb} are the solid crop yields of crops Sugar beet a and Sunflower b, respectively, Y_{ab} is the intercrop yield of crop a, and Y_{ba} is the intercrop yield of crop b. When the values of LER were greater than1, there is a yield advantage; when LER equal to 1, as less than 1, there is a disadvantage.

2- Relative crowding coefficient (RCC): From Dewit (1960).

$$\textbf{K} = (K_{ab} \times K_{ba}), \text{ where } K_{ab} = \frac{Yab \times Zba}{(Yaa - Yab)\, x\, Zab} \text{ and } K_{ba} = \frac{Yba \times Zab}{(Ybb - Yba)\, x\, Zba}$$

Where Z_{ab} and Z_{ba} were the proportions of Sugar beet a and Sunflower b in the intercropping, respectively.

3- Aggressivity (A) which is often used to determine the competitive relationship between two crops used in mixed cropping (Mc-Gilchrist, 1965).

$$A_a = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}, \text{ and } A_b = \frac{Yba}{Ybb \times Zba} - \frac{Yab}{Yaa \times Zab}$$

If $A_a = 0$, both crops are equally competitive, if A_a is positive, then the a is dominant, if A_a is negative, then the a is dominated.

Economic evaluation.

The difference between the total net returns from intercropping and solid crops was used to compute the farmer's benefit (L.E.). For sugar beet root, the cost per ton of roots as reported by (Bulletin of Statistical Cost production and Net return, 2022 and 2023) was used 1245 and 1450 E.L. ton-1 in both seasons, while the yield of the tops was 200 and 250 E.L. ton-1 in accordance with the local market. In all seasons, sunflower seeds cost between 12.500 and 15000 E.L. per ton. While net returns were calculated by deducting the total of the fixed costs of the sugar beet and the variable costs of the sunflower in accordance with the intercropping method, income was calculated by adding the price of the sugar beet yield and the price of the sunflower yield.

Statistical analysis.

The data were analyzed according to Snedecor and Cochron (1988). The treatments means were compared by using the least significant differences (LSD) at 5% and 1% levels of probability. The analysis of variance (ANOVA) was computed using CoStat V 6.4 (2005) .

RESULTS AND DISCUSSION

A: Sugar beet:

1- Effect of sunflower cultivars on sugar beet:

Data given in Table 3. showed that root length and root weight, two sugar beet yield character traits, were strongly influenced by several sunflower cultivars, although root width was not significantly influenced in either season. The Giza 102 cultivar and Giza 120 cultivar had the highest levels of these features, whereas the Sakha 53 cultivar had the lowest values. The Giza 102 cultivar, which had the shortest plant height, was followed by the Giza 120 cultivar and the Sakha 53 cultivar, which had the maximum plant height. Therefore, the interspecific competition between sugar beet and sunflower had an impact on these sugar beet characteristics. According to sunflower plant heights, plants for light caused an increase in shadowing, especially at higher sunflower cultivars in terms of plant height and leaf area. The same outcomes were noted by Abdel-Motagally and Osman (2010). Results of sugar beet yields/fed *i.e*., top yield, root yield and sugar yield, revealed that root and sugar yield were significantly affected by sunflower cultivars in both seasons and top yield was significantly affected in the second season as shown in Table 3. The same trend of yield component features was seen for top, root, and sugar yields/fed in both seasons. The sugar beetroot planted under the Giza 102 sunflower cultivar produced the highest top, root and sugar yields/fed (15.36, 16.03, and 3.11 tons, respectively) in the first season and (14.86, 16.11, and 3.18 tons, respectively) in the second season. However, when produced sunflower under the Sakha 53 sunflower cultivar, the lowest values of these features were (14.90, 14.80, and 2.74 tons) in the first season and (13.83, 15.21, and 2.89 tons) in the second season, respectively. The Giza 102 cultivar, which was followed by the Giza 120 cultivar and Sakha 53, which was the highest, had the shortest plant height and growth season, which may account for these results. These sugar beet traits were thus influenced by the interspecific competition between sugar beet and sunflower plants for light, which resulted in increased shade, particularly at higher sunflower cultivars in height plant and leaf area, in accordance with sunflower plant heights. The same outcomes were noted by Abdel-Motagally and Osman (2010).

Table 3. Effects of sunflower varieties on yield and yield components of sugar beet as well as its quality characters during 2021/2022 and 2022/2023growing seasons.

Cultivar	Character								
	Root length(cm)	Root diameter(cm)	Root weight(g)	Top yield (ton fed^{-1})	Root yield (ton fed^{-1})	Sugar yield (ton fed^{-1})	TSS %	Sucrose %	Purity %
Sunflower cultivars				2022/2023					
Sakha53 (V1)	23.63	5.41	404.91	14.90	14.80	2.74	20.85	18.43	84.93
Giza102(V2)	24.83	6.02	470.97	15.36	16.03	3.11	22.56	19.32	85.26
Giza 20(V3)	24.11	5.78	431.38	14.93	15.22	2.96	22.08	19.35	87.60
LSD . at 5%	0.78	N.S.	6.99	N.S.	0.48	0.28	0.52	0.79	N.S.
Sugar beet solid	26.36	6.21	577.13	15.60	20.30	3.72	22.76	18.33	83.32
Sunflower cultivars				2022/2023					
Sakha53 V1)	24.62	5.56	420.17	13.83	15.21	2.89	22.24	18.90	85.12
Giza102 V2)	25.53	6.08	475.92	14.86	16.11	3.18	23.16	19.80	85.44
Giza120(V3)	25.09	5.88	446.36	14.19	15.34	3.08	23.09	19.83	85.79
LSD . at 5%	0.71	N.S.	16.24	0.86	0.59	0.14	0.67	0.55	N.S.
Sugar beet solid	26.11	6.14	569.76	15.11	19.01	3.65	22.50	19.18	84.24

The data in Table 3. showed that whereas purity% was not considerably influenced, total soluble solids% and sucrose% were both significantly impacted by sunflower cultivars in both seasons. Data showed that there were no appreciable variations for TSS% and sucrose% in either season between Giza 102 and Giza 120. Additionally, by intercropping various sunflower kinds with sugar beetroot in Pure stand for both seasons, chemical characteristics were increased. These outcomes are a result of shade brought on by the various sunflower types' varying plant heights. According to Panhwar *et al.* (2017), there is a significant variation in plant height between different sunflower cultivars.

2- Effect of sunflower defoliation dates on sugar beet:

As shown in Table 4. sugar beet yield components i.e. root length, and root weight were significantly affected by sunflower defoliation dates in both seasons, while root diameter was significantly affected by sunflower defoliation dates in the first season, only. Defoliation In both seasons, 50% of sunflower leaves at flowering outperformed other treatments. Non-defoliation then recorded the lowest values

for those traits, followed by 15 days after flowering, after 30 days from flowering, and then 50% of sunflower leaves at flowering. This outcome might be the result of reduced interspecific rivalry between sugar beet and sunflower plants for light and the opportunity for sugar beet roots to grow more rapidly than either after 30 days or without defoliation. These findings are consistent with those made by Wafaa and Abd El-Zaher (2013), Sheha *et al*. (2017), and Raza *et al*. (2019), among others.

With respect to sugar beet yields /fed, data indicated that top, root and sugar yields /fed were significantly influenced by 50% defoliation dates of sunflower leaves in both seasons. Data showed that 50% defoliation of the leaves at blooming, followed by 15 and then 30 days, produced the highest values for these features, while no defoliation during either season produced the lowest values. When sunflower leaves were defoliated at flowering, after 15 days, and after 30 days from the flowering date compared to non-defoliation (L4) in the first season, the increase in root and sugar yields/fed were (18.27 and 32.31%), (12.57 and 21.36%), and (6.39 and 8.30%), respectively. In the second season, the increases were (17.97 and 33.69%), (12.62 and 23.31%), and (5.89 and 5.30%). These findings agreed with those of Sheha *et al*. (2017) and Wafaa and Abd El-Zaher (2013).

According to Table 4. defoliation treatments had a substantial impact on total soluble solids%, sucrose%, and purity% in both seasons. The behavior of these individuals followed the same pattern for sugar beetroot yields per feed in both seasons. Compared to sugar beetroot pure stand, these features were boosted by defoliation treatments in both seasons. These characteristics may have decreased because of delaying root and top growth and storage, which in turn changed the chemical characters produced, as well as non-defoliation treatments applied 15 or 30 days after blooming. Similar findings were published in 2013 by Wafaa and Abd El Zaher. 2013).

Table 4. Effects of leaf removal dates of sunflower on sugar beet during 2021/2022 and 2022/2023seasons.

Defoliation date	Character									
	Root length (cm)	Root diameter(cm)	Root weight(g)	Top yield (ton fed^{-1})	Root yield (ton fed^{-1})	Sugar yield (ton fed^{-1})	TSS %	Sucrose %	Purity %
	2021/2022								
At flowering (L1)	25.61	6.09	484.36	16.01	16.97	3.59	23.19	21.16	86.68
15 days after lowering(L_2)	25.26	5.86	462.08	15.75	15.73	3.09	22.80	19.65	86.18
30days after flowering(L_3)	23.18	5.60	406.73	14.71	14.84	2.65	20.84	17.82	85.55
No leaves removed (L4)}	22.71	5.40	389.82	13.77	13.87	2.43	20.50	17.49	85.30
LSD . at 5%	0.57	0.30	14.21	0.66	0.46	0.13	0.63	0.58	0.55
Sugar beet solid	26.36	6.21	577.13	12.60	20.30	3.72	22.76	18.33	83.32
	2022/2023								
At flowering (L1)	26.89	6.17	490.48	14.95	17.14	3.77	25.32	21.86	86.33
15 days after lowering(L_2)	26.23	6.00	487.01	14.86	16.09	3.26	23.61	20.24	85.73
30days after flowering(L_3)	23.88	5.73	413.77	13.99	14.94	2.64	21.40	18.16	85.05
No leaves removed (L4)}	23.32	5.60	398.66	13.37	14.06	2.50	20.97	17.77	84.68
LSD . at 5%	0.71	N.S.	22.34	0.63	0.57	0.14	0.32	0.47	0.67
Sugar beet solid	26.11	6.14	569.76	12.11	19.01	3.65	22.50	19.18	84.24
Interaction: 1st= the first season	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
and 2nd= the second season	0.99 ns	ns Ns	23.61 ns	Ns ns	0.79 Ns	Ns ns	1.08 0.77	ns ns	ns Ns	

3- Interaction effects.

The interaction between sunflower cultivars and various defoliation dates of 50% sunflower leaves had a substantial impact on root length, root weight, and root yield/fed in the first season as well as total soluble solids% in both seasons, as shown in Table 5.

Table 5. Effect of the interaction between intercropping sunflower cultivars with sugar beet and sunflower defoliation dates during 2021/2022 and 2022/2023 seasons.

Treatment	Root Length (cm)	Root weight (g)	Root yield (ton fed^{-1})	T.S.S.%	
	2021/2022	2021/2022	2021/22	2021/22	2022/23
		Sakha 53 (V1)			
At flowering (L1)	24.33	471.22	16.56	20.40	24.48
15 days after lowering(L_2)	24.70	421.15	14.92	22.50	23.16
30 days after flowering(L_3)	23.00	379.81	14.34	20.50	21.00
No leaves removed (L4)}	22.50	347.46	13.39	20.01	20.31
		Giza 102 (V2)			
At flowering (L1)	26.47	509.87	17.68	24.67	25.75
15 days after lowering(L_2)	26.33	496.79	16.54	23.00	23.63
30 days after flowering(L_3)	23.33	441.86	15.44	21.50	21.85
No leaves removed (L4)}	23.20	435.35	14.47	21.09	21.39
		Giza 120 (V3)			
At flowering (L1)	26.03	471.98	16.67	24.49	25.74
15 days after lowering(L_2)	24.75	468.29	15.72	22.90	24.03
30 days after flowering(L_3)	23.21	398.52	14.75	20.51	21.36
No leaves removed (L4)}	22.43	386.71	13.76	20.40	21.21
LSD. at 5%	0.99	23.61	0.731	1.08	0.77

The highest values for these traits were observed for the sunflower Giza 102 cultivar and 50% defoliation of sunflower leaves at flowering (L1), while the lowest values were obtained for the sunflower Sakha 53 cultivar and non-defoliation of sunflower leaves. These outcomes might be explained by the fact that the Giza 102 cultivar flowered 72 days after planting, as opposed to other sunflower types, which flowered more than 80 days after planting. However,

compared to other defoliation treatments, 50% defoliation of sunflower leaves at blooming allows sugar beet roots to grow more and reduces inter-species competition between sugar beet and sunflower plants for light. Similar findings reported by Jun *et al.* (2017) revealed that defoliation of the entire leaf or a portion of the leaf above the three ear-leaves at flowering greatly increased photo synthetically active radiation (PAR) at the ear and interception of PAR (IPAR) from the ear to middle of the ear and soil surface. Additionally, Liu *et al.* (2020) noted a substantial relationship between years, cultivars, and leaf defoliations and grain yield and yield components. The effects of leaf removal on the two cultivars were therefore examined separately.

B- Sunflower

1- Effect of sunflower cultivars:-

According to data in Table 6. there were significant differences between sunflower cultivars in both seasons for plant height, head diameter, number of seeds head-1, seed weight head-1, 100-seed weight, and seed yield fed-1, as well as oil content and oil yield/fed. Compared to other sunflower cultivars, the Giza 120 cultivar had taller plants in both pure stands and intercropping situations with sugar beetroot. The variations reflecting genetic make-up may be the cause of the variations in plant height across sunflower cultivars. This outcome was consistent with those of Rodrigues Pereira (1978), Schelotto and González (1980) and Abdel-Motagally and Osman (2010).

The results in Table 6. clearly showed that Giza 120 had the highest values, followed by Sakha 53, while Giza 102 had the lowest values for head diameter, number of seeds per head, weight of seeds per head, and seed yield/fed in both pure stands and intercropping with sugar beetroot. Due to its excellence in terms of growth and yield component features, Giza120 and Sakha 53 cultivars have improved in these traits. Data on 100-seed weight showed that Giza 102 cultivar had the highest 100-seed weight and oil content in both seasons. On the other hand, Sakha 53 cultivar showed the least weight and oil content in both seasons. Data showed that sunflower cultivars' yield characteristics increased under sugar beetroot intercropping by 25% of their plant densities compared to pure stands for these kinds in both seasons. Therefore, even though sunflower plant density was only 25% of its pure stand fed^{-1} seed production for sugar beet intercropping for sunflower varieties was virtually equal to 50% of its pure in both seasons. These findings are a strong indication that sugar beetroot is not a rival for the types of sunflower being studied, and that intra-specific rivalry is far less intense between the two species than inter-specific competition. Tichy *et al.* (2001), Wafaa and Abd El-Zaher (2013), and Sheha *et al.* (2017) all produced similar findings.

Table 6. Effects of different sunflower varieties on yield and yield components of sunflower during 2021/2022 and 2022/2023 seasons.

Sunflower cultivar		Plant height(cm)	Head diameter(cm	No. of seeds head^{-1}	Seeds weight head^{-1}(g)	100-seed weight (g)	oil content	oil yield/ fed	Seed yield (ton fed^{-1})
2021/2022									
Sakha 53 (V1)		154.05	23.12	1111.05	75.63	6.41	34.58	0.171	0.495
Giza 102 (V2)		145.06	22.02	1004.61	72.03	6.66	36.34	0.166	0.457
Giza 120 (V3)		159.47	23.15	1119.94	76.03	6.60	35.45	0.180	0.507
LSD . at 5%		3.47	0.57	26.67	3.17	0.08	0.558	0.001	0.003
	Sakha 53 (V1)	159.78	17.01	851.16	45.00	5.20	35.45	0.452	1.277
Solid	Giza 102 (V2)	156.25	16.50	757.28	41.33	5.61	37.22	0.412	1.107
	Giza 120 (V3)	166.16	17.21	855.46	45.17	5.55	35.74	0.449	1.259
2022/2023									
Sakha 53 (V1)		155.42	23.81	112.31	76.84	6.38	34.37	0.178	0.518
Giza 102 (V2)		145.75	22.89	1025.23	73.11	6.96	36.23	0.177	0.513
Giza 120 (V3)		159.25	23.69	1131.69	78.43	6.81	35.32	0.181	0.513
LSD . at 5%		5.63	0.75	19.73	0.95	0.12	0.076	0.002	0.006
	Sakha 53 (V1)	166.13	17.83	875.66	46.67	5.33	35.11	0.433	1.234
Solid	Giza 102 (V2)	160.13	17.08	779.45	43.67	5.77	37.15	0.419	1.128
	Giza 120 (V3)	170.03	17.90	864.25	46.91	5.73	35.69	0.460	1.289

2- Effect of sunflower defoliation dates.

Results shown in Table 7. showed that 50% defoliation of sunflower leaves at various times considerably influenced all examined characteristics of sunflower. According to the data, defoliation of sunflower leaves prior to blooming offered the highest value, followed by defoliation of sunflower leaves 30 days after flowering and then 15 days after flowering, while defoliation of sunflower leaves on flowering day produced the lowest value. These are absolutely accurate for plant height, head diameter, and seed number. Head-1, 100-seed weight, seed yield, oil content, and oil yield, fed in both seasons. This conclusion makes sense when taking into account the fact that maximal leaf area development is required for full interception and conversion of solar radiation to efficient photosynthetic activity and dry matter accumulation in order to maximize productive development and seed generation. Regarding this issue, Abbaspour *et al.* (2001), Muro *et al.* (2001), Mohammed and Wafaa (2006), and El-Yamni *et al.* (2010) all made mention of it.

3- Effect of the interaction:-

Data in Table 8. showed that the interaction between sunflower cultivars and their defoliation dates significantly affected plant height, 100-seed weight and seed yield/fed, oil content, and oil yield/fed in both seasons. In one season, the interaction also significantly affected the number of seeds and seed weight head$^{-1.}$ Except for 100-seed weight and oil content, which showed with Giza 102 cultivar and without leaves defoliation, Giza 120 and Sakha 53 cultivars did not reach to 5% level of significance in all of the most studied characters. Giza120 cultivar and without leaves defoliation treatment recorded the highest values for these characters.

Table 7. Effect of defoliation sunflower dates on yield and yield components of sunflower during 2021/2022 and 2022/2023 seasons.

Defoliation date		Plant height (cm)	Head diameter (cm)	No. of seeds Head^{-1}	100-seed weight (g)	Seeds weight Head^{-1} (g)	oil content	oil yield / fed	Seed yield (ton fed^{-1})
2021/2022									
At flowering (L1)		148.61	20.28	1005.25	6.21	67.87	34.78	0.146	0.418
15 days after lowering(L_2)		151.57	22.22	1055.61	6.28	73.29	35.30	0.153	0.431
30 days after flowering(L_3)		152.51	23.60	1099.79	6.69	77.13	35.58	0.187	0.529
No leaves removed (L4)}		158.76	24.19	1153.49	7.05	79.96	36.16	0.202	0.558
LSD . at 5%		1.96	0.49	23.42	0.09	1.10	0.083	0.001	0.009
Sunflower alone	Sakha 53 (V1)	159.78	17.01	851.16	5.20	45.00	34.58	0.171	0.495
	Giza 102 (V2)	156.25	16.50	757.28	5.61	41.33	36.34	0.166	0.457
	Giza 120 (V3)	166.16	17.21	855.46	5.55	45.17	35.45	0.180	0.507
2022/2023									
At flowering (L1)		149.55	21.74	1025.450	6.39	69.45	34.72	0.152	0.438
15 days after lowering(L_2)		150.22	22.67	1072.30	6.62	74.69	35.14	0.167	0.479
30 days after flowering(L_3)		154.11	24.14	1114.38	6.78	79.30	35.40	0.195	0.541
No leaves removed (L4)}		160.00	25.29	1161.46	7.07	81.41	35.97	0.201	0.562
LSD . at 5%		2.32	0.53	14.19	0.13	0.98	0.121	0.002	0.010
Sunflower alone	Sakha 53 (V1)	166.13	17.83	875.66	5.33	46.67	34.37	0.178	0.518
	Giza 102 (V2)	160.13	17.08	779.45	5.77	43.67	36.23	0.177	0.5139
	Giza 120 (V3)	170.03	17.90	864.25	5.73	46.91	35.32	0.181	0.5139

Interaction: 1st = the first season and 2nd= the second season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	3.4	4.01	ns	Ns	ns	24.67	0.15	0.22	ns	1.70	0.119	0.173	0.0020	0.0042	0.0051	0.0058
	3.4	4.01	ns	Ns	ns	24.67	0.15	0.22	ns	1.70	0.119	0.173	0.0020	0.0042	0.0051	0.0058

Table 8. Effect of interaction between intercropping sunflower cultivars with sugar beet and defoliation dates of sunflower on sunflower during 2021/2022 and 2022/2023 seasons.

Treatment	Plant height (cm)		No. of seed Head^{-1}	100-seed weight(g)		Seed weight Head^{-1}(g)	oil content		oil yield/ fed		Seed yield (ton fed^{-1})	
	2021/22	2022/23	2022/23	2021/22	2022/23	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Sakha 53 (V1)												
At flowering (L1)	147.33	153.33	1052.13	5.92	6.12	70.01	34.07	33.94	0.147	0.153	0.433	0.451
15 days after lowering(L_2)	155.00	154.66	1103.44	6.22	6.33	74.17	34.32	34.11	0.155	0.167	0.453	0.490
30 days after flowering(L_3)	153.16	151.66	1146.81	6.64	6.32	80.83	34.53	34.33	0.182	0.192	0.529	0.559
No leaves removed (L4)}	160.66	162.00	1190.87	6.88	6.77	82.33	35.4	35.13	0.199	0.200	0.564	0.570
Giza 102 (V2)												
At flowering (L1)	144.00	141.00	954.73	6.34	6.39	66.12	35.19	35.21	0.139	0.151	0.397	0.431
15 days after lowering(L_2)	143.00	143.33	1003.62	6.28	6.95	72.11	36.24	36.13	0.142	0.162	0.392	0.449
30 days after flowering(L_3)	143.03	148.33	1046.01	6.77	7.04	75.89	36.61	36.46	0.185	0.199	0.505	0.546
No leaves removed (L4)}	150.25	150.33	1096.56	7.27	7.43	78.34	37.32	37.12	0.199	0.197	0.534	0.531
Giza 120 (V3)												
At flowering (L1)	154.45	154.33	1069.64	6.38	6.45	71.22	35.09	35.01	0.152	0.152	0.435	0.436
15 days after lowering(L_2)	156.70	152.66	1109.84	6.34	6.80	77.78	35.35	35.2	0.163	0.172	0.463	0.490
30 days after flowering(L_3)	161.37	162.33	1150.33	6.65	6.98	81.17	35.60	35.42	0.195	0.196	0.550	0.554
No leaves removed (L4)}	165.37	167.66	1196.94	6.99	7.01	83.56	35.76	35.65	0.208	0.205	0.579	0.575
LSD. at 5%	3.40	4.01	25.67	0.15	0.22	1.70	0.119	0.173	0.002	0.004	0.0051	0.0058

Conversely, the Giza 120 cultivar showed the lowest values for plant height, number of seeds head-1, seed weight head-1, and seed yield fed-1 when 50% of the leaves were defoliated at flowering. oil output/fed Sakha 53 cultivar, however, results in a drop in 100-seed weight.

This is the same pattern as Rodrigues Pereira (1978), Schelotto and González (1980), Abdel-Motagally and Osman (2010) and Sheha *et al*. (2017) reported.

C- Competitive Relationships and yield advantages of intercropping:

1-Land equivalent ratio (LER):

Results in Table 9. demonstrated that intercropping sunflower varieties at a 25% plant density with sugar beetroot and defoliating 50% of sunflower leaves at flowering consumed more land in both seasons than one treatment alone.

The Giza 102 variety and leaves defoliation at blooming date, which recorded 1.23 and 1.31 in the first and second seasons, respectively, had the best results in both seasons. Sugar beetroot varieties with sunflower varieties by 25% plant density and 50% of its varieties being defoliated after flowering date gave better yields than expected where Lsug or Lsun exceeded 0.50% in all systems in both seasons.

The findings showed that sugar beetroot is a good component in sunflower types under these studies under various defoliation dates because its yields exceeded those anticipated. Sahoo *et al*. (2003), Mohammed and Wafaa (2006), and El Yamani *et al*. (2010) all reported similar findings.

2- Relative crowding coefficient (RCC):-

Results in Table 9. showed that planting both species under various treatments resulted in advantages for all treatments during both seasons.

The treatment using the Giza 102 variety with leaves defoliated at blooming in the first and second seasons

produced the best results, with K values reaching 3.75 and 8.41 in the first and second seasons, respectively. The findings clearly show that both component coefficients, Ksug and Ksum, were more than one in all treatments and that Ksum contributed more to K than Ksug did in both seasons. This data makes it quite evident that sunflower was the best treatment-related contributor. Similar findings were made by Verma *et al*. (2005), Olanite *et al*. (2002), and Nagangoud, *et al*. (2005).

3- Aggressivity (A):-

Results in Table 9. revealed that sugar beet root predominated in all treatments during both seasons and sunflower was the dominating intercrop component. The data showed that by delaying the date of leaves defoliation, "A" values for all sunflower types increased, and the highest values for "A" were obtained without leaves defoliation for sunflower varieties in both seasons. The current findings clearly demonstrate that sugar beetroot, the "understory" component, lacks sunflower's "overstory" intercrop's superior competitive capabilities. The findings of Long *et al*. (2001), Ghosh *et al*. (2006), Egbe (2010), and Koji *et al*. (2016) agree with one another.

Table 9. Relative yield, land equivalent ratio (LER), relative crowding coefficient (K) and Aggressivity (A) of intercropped sugar beet and sunflower as influenced by different sunflower cultivars and some. defoliation dates treatments during 2021/2022 and 2022/2023 seasons.

Treatment		LER			K			A		LER			K			A	
		L_{sug}	L_{sun}	LER	K_{sug}	K_{sun}	K	A_{sug}	A_{sun}	L_{sug}	L_{sun}	LER	K_{sug}	K_{sun}	K	A_{sug}	A_{sun}
		2019/2020								2020/2021							
Sakha 53	L1	0.82	0.34	1.16	1.11	2.02	2.24	-0.66	+0.66	0.89	0.36	1.25	1.94	2.28	4.42	-0.71	+0.71
	L2	0.73	0.35	1.08	0.69	2.13	1.47	-o.82	+0.82	0.83	0.40	1.23	1.24	2.64	3.28	-0.95	+0.95
	L3	0.71	0.42	1.13	0.60	2.84	1.70	-1.19	+1.19	0.76	0.45	1.21	0.80	3.25	2.60	-1.29	+1.29
	L4	0.66	0.44	1.10	0.49	3.15	1.55	-1.38	+1.38	0.72	0.46	1.18	0.64	3.42	1.19	-1.41	+1.41
Giza 102	L1	0.87	0.36	1.23	1.69	2.22	3.75	-0.69	+0.69	0.93	0.38	1.31	3.41	2.44	8.41	-0.73	+0.73
	L2	0.82	0.37	1.19	1.10	2.31	2.54	-0.81	+0.81	0.88	0.40	1.28	1.80	2.73	4.91	-0.89	+0.89
	L3	0.76	0.46	1.22	0.79	3.37	2.66	-1.33	+1.33	0.82	0.45	1.27	1.11	3.45	3.83	-1.25	+1.25
	L4	0.71	0.48	1.19	0.62	3.63	2.25	-1.49	+1.49	0.77	0.47	1.24	0.81	3.69	2.99	-1.40	+1.40
Giza 120	L1	0.82	0.34	1.16	1.15	2.08	2.39	-0.70	+0.70	0.89	0.34	1.23	1.96	2.07	4.05	-0.59	+0.59
	L2	0.77	0.35	1.12	0.86	2.42	2.08	-0.92	+0.92	0.83	0.39	1.22	1.20	2.51	3.01	-0.54	+0.54
	L3	0.73	0.44	1.17	0.66	3.10	2.05	-1.28	+1.28	0.78	0.43	1.21	0.89	3.03	2.70	-1.18	+1.18
	L4	0.68	0.46	1.14	0.53	3.45	1.83	-1.47	+1.47	0.73	0.45	1.18	0.69	3.33	2.30	-1.36	+1.36
Pure		1.00	1.00	….	1.00	1.00	….	…	…	1.00	1.00	….	1.00	1.00	….	…	…

D- Economic evaluation:-

Data from Table 10. showed that, in both seasons, all treatments outperformed sugar beetroot alone in terms of total income and net return. In comparison to seeding sugar beets in a monoculture crop in the second season, all intercropping treatments saw an increase in total income and net return. The results indicated that the Giza 102 variety and the defoliation treatment at flowering date (L1) produced the highest values for total income, which were 30199.10 and 35995.95 L.E. in the first and second seasons, respectively.

The Sakha 53 sunflower cultivar was planted with sugar beetroot and without leaves defoliation (L4) in the first season, and these conditions resulted in the lowest values for total income and net return, which were 26452.05 and 19108.05 L.E., respectively. The lowest values, 30564.50 and 21825.14 L.E., were recoded for these characters in the second season when sugar beetroot was produced as a monoculture crop. The increases in net return when the Giza 102 variety was grown with sugar were 2925.60 and 5431.45 L.E.

Table 10. Total income (L.E.) and net return (L.E.) of intercropped sugar beet and sunflower as influenced by different sunflower cultivars and defoliation dates treatments during 2021/2022 and 2022/2023 seasons.

Treatment		Total income (L.E.)		Net return (L.E.)	
		2021/2022	2022/2023	2021/2022	2022/2023
Sakha 53	At flowering (L_1),	29119.20	34708.00	21775.20	25968.64
	15days after flowering(L_2)	27253.40	34028.50	19909.40	25289.14
	30days after flowering(L_3)	27374.30	32608.50	20030.30	23869.14
	No leaves removed (L_4)	26452.05	31623.00	19108.05	22883.64
Giza 102	At flowering (L_1)	30199.10	35995.95	22855.10	27256.59
	15days after flowering(L_2)	28852.80	34716.95	21508.80	25977.59
	30days after flowering(L_3)	28571.80	33874.50	21227.80	25135.14
	No leaves removed (L_4)	27416.65	32525.50	20072.65	23786.14
Giza 120	At flowering (L_1)	29347.65	34767.00	22003.65	26027.64
	15 days after flowering(L_2)	28630.90	33935.50	21286.90	25196.14
	30 days after flowering (L_3)	28142.75	33328.50	20798.75	24589.14
	No leaves removed (L_4)	27120.70	32318.00	19776.70	23578.64
Sugar beet pure stand		27273.50	30564.50	19929.50	21825.14
Sunflower alone (average of the three varieties)		15179.17	18255.00	9036.17	10753.82

CONCLUSION

It could be concluded that to obtain the maximum value for productivity, total income, net return, and LER of must be intercropping with sugar beet with Giza 102 sunflower cultivar and defoliation 50% form sunflower

leaves at flowering date, under environmental circumstances of EL- Beheria Governorate, Egypt

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تأثير تحميل أصناف دوار الشمس وميعاد توريقها على محصول وجودة بنجر السكر

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الملخص

أقيمت تجربة حقلية خلال الموسمين ٢٠٢٢/٢٠٢١ و٢٠٢٣/٢٠٢٢ بمحطة البحوث الزراعية –إيتاي البارود – البحيرة – مركز البحوث الزراعية , لدراسة تأثير تحميل ٢٥% من الكثافة النباتية لدوار الشمس "سخا ٥٣, جيزة ١٠٢و جيزة ١٢٠" مع بنجر السكر وتوريق ٥٠% لتلك الأصناف كالآتي "عند مرحلة الإزهار (L_1), بعد الإزهار بـ١٥ يوم (L_2), بعد الإزهار بـ٣٠يوم (L_3), وبدون توريق (L_4)" على بنجر السكر ودوار الشمس. سجل المحصول, ومكوناته والجودة لبنجر السكر أعلى قيم مع صنف دوار الشمس جيزة ١٠٢ خلال موسمي الزراعة. وحققت معاملة توريق ٥٠% من أوراق دوار الشمس عند التزهير أعلى القيم لكل صفات بنجر السكر خلال موسمي الزراعة, اعلى قيم لطول الجذر وقطر الجذر ومحصول الفدان في موسم واحد وصفة المواد الصلبة الكلية% في الموسمين بالتفاعل بين دوار الشمس جيزة ١٠٢ومعاملة التوريق(L1) . سجل الصنف جيزة ١٢٠ أعلى قيم على كل قيم دوار الشمس في كلا الموسمين. سجلت معاملة التوريق (L4) أعلى قيم لكل صفات دوار الشمس خلال موسمي الدراسة. التفاعل بين جيزة ١٢٠ وعدم التوريق (L4) سجل اعلى قيم خلال الموسمي. أعلى قيم لمعامل الحشد النسبى (١,٢٣, ١,٣١) عندما زرع جيزة ١٠٢ وتوريقهُ (L1) خلال موسمي الزراعة. زاد صافي العائد١٠,٢٢٨٥٥, ٢٧٢٥٦,٩٥جنية بتحميل دوار الشمس جيزة ١٠٢وتوريقهُ (L1) مع بنجر السكر عن زراعة بنجر السكر منفرد في كلا الموسمين.