Middle East Journal of Agriculture Research
Volume: 11 | Issue: 02| April – June| 2022

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2022.11.2.27
Journal homepage: www.curresweb.com
Pages: 474-484

Response of Watermelon Pulp to Intercropping With Some Summer Oil Crops Under Different Sowing Dates

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Received: 20 March 2022 **Accepted:** 05 May 2022 **Published:** 15 May 2022

ABSTRACT

A field trial was carried out at Gemmiza Agricultural Research Station, A.R.C, Egypt during 2019 and 2020 seasons to obtain the advantage of intercropping oil crops (sunflower, soybean and sesame) and its suitable sowing date (15 days before sowing watermelon pulp [D1], sowing both crops simultaneously [D2] and 15 days after sowing watermelon pulp [D3]) for intercropping with watermelon pulp to increase land equivalent ratio and farmer's income. Oil crops allocated to the main plots and sowing dates arranged in the sub-plots in split-plot design with three replications. Results indicated clearly that no. of seeds fruit^{-1}, seed weight fruit^{-1}, 100-seed weight, seed weight plant^{-1} and seed yield fed^{-1} of watermelon pulp affected significantly by interaction between the type of associated oil crop and its sowing date. Results also indicated clearly that all traits of oil crops affected significantly by sowing dates except plant height trait for all oil crops in both seasons. The highest seed yield values for oil crops associated with watermelon pulp were recorded when sowing any of oil crops 15 days before planting watermelon pulp in both seasons. The highest values of LER (1.26 and 1.26) were recorded when sowing soybean simultaneously with planting watermelon pulp, whereas, highest values of gross income of the farmer (31,282 and 30,158 LE) were recorded when sowing soybean after 15 days from planting watermelon pulp in first and second seasons, respectively. This intercropping technique adds an additive income of 1,982 and 1,808 LE to gross income of the watermelon pulp farmers. It could be recommended that soybean should be planted 15 days after watermelon pulp planting to obtain the highest farmer's gross income.

Keywords: Sunflower, soybean, sesame, Land Equivalent Ratio, Economic evaluation.

1. Introduction

Watermelon pulp (*Citrullus Colocynthoides*) has been cultivated since the early times in Egypt where it is known as gurma melon. It is the important vegetable crops in Egypt, which can be exported to other countries. Spread cultivation of watermelon pulp in the recent period due to higher income for farmers, limited period of their stay in the ground. It has been widely cultivated especially in Northern Regions of Egypt. Its importance is due to its tolerance to drought and salinity, so it's a good crop for the new reclaimed lands. It has been grown as alone crop or intercropped with some other crops such as maize crop. However, its production has been confined to one variety. The seeds of this locally cultivated variety usually are obtained from ripening fruit.

Sunflower, soybean and sesame are the most important oil summer crops in Egypt. The large gap (89.5%) between the production and consumption of edible oil in Egypt (CAPMAS, 2018) due to low farmer profitability of oil crops sole cultures, encourage farmers to use intercropping technique of oil crops with other crops, which could provide an opportunity to overcome low farmer profitability and some of the deficiency of edible oil production. Moreover, it could also help in reducing competition exists in the old lands between oil crops and other strategic crops.

Sowing dates encouraged scientists to study its effect on yield of oil crops under sole culture. Hamza and Safina (2015) planted sunflower at beginning of each month all over the year and they reported that the highest seed yield was obtained when sowing sunflower in March, then seed yield

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decreased gradually with delaying sowing date till the end of the year. Kandil *et al*. (2012) they planted soybean in four sowing dates 20th April, 5th May, 20th of May and 5th June and they investigated that the highest seed yield recorded when sowing soybean at 5th May and the seed yield decreased significantly with delaying sowing date to 5th June. Hamza and Abd El-Salam (2015) planted sesame in four sowing dates (i.e., 20th March, 9th April, 29th April and 19th May) and they reported that the highest seed yield of sesame was recorded with the second sowing date then decreased delaying sowing date.

Appropriate sowing date is the key for decreasing the inter-specific competition between intercropped oil crops and watermelon pulp plants, which enabling their foliage to receive an appropriate amount of solar radiation and increase the final yield of both crops (Sangoi *et al*., 2012).

Therefore, the present study was established to investigate the suitable sowing date for oil crops when intercropped with watermelon pulp, increase edible oils production as well as farmer total income.

2. Materials and Methods

Field trial was carried out at Gemmiza Agricultural Research Station, Agricultural Research Center, (Lat. 30° 47' 27" N, Long. 30° 59' 53" E, 22 m above sea level), Egypt, during 2019 and 2020 summer seasons to study the advantage of intercropping oil crops i.e., (sunflower, soybean and sesame) and its suitable sowing dates i.e., (15 days before sowing watermelon pulp [D1], sowing both crops simultaneously [D2] and 15 days after sowing watermelon pulp [D3]) with watermelon pulp. Oil crops allocated to the main plots and sowing dates arranged in the sub-plots in split-plot design with three replications. Local variety of watermelon pulp (*Citrullus Colocynthoides* L) was planted on one side of the raised beds (1.8m width) in hills (one plant/hill^{-1}) at 20cm apart (100% of sole culture) where sowing sunflower cv Giza 102 and sesame cv Shandwil 3 were in one line on the other side of the raised bed in hills (one plant/hill^{-1}) at 20 and 10cm apart (33% of sole culture), respectively. Whereas sowing of soybean cv Giza 111 was in two lines on the other side of the raised bed in hills (one plant/hill^{-1}) at 10cm apart (33% of sole culture). Each sub plot including 3 raised beds with 1.8m width and 3m length= 16.2 m^2 plot area. Watermelon pulp was planted at 15th and 16th May in the first and second seasons, respectively. Fertilization was added as recommended for watermelon pulp, beside of pure stands for each of watermelon pulp, sunflower, soybean and sesame as recommended. The preceding winter crop was wheat in both seasons. Physical and chemical analysis of the soil (0 − 30 cm) was analyzed by Water and Soil Research Institute, ARC (Table, 1).

Table 1: Soil physical and chemical analysis of the experimental site during 2019 and 2020 summer seasons.

	2019 Season	2020 Season
Physical analysis		
Clay (%)	57.1	55.4
Silt (%)	22.3	23.7
Sand (%)	20.6	20.9
Texture grade	Clay	Clay
Chemical analysis		
pH	7.4	7.3
EC (dS m^{-1})	0.8	0.9
Available N (mg Kg^{-1})	22.9	24.0
Available P (mg Kg^{-1})	9.0	11.0
Available K (mg Kg^{-1})	350	360

2.1. Data Recorded:

At harvest time, random samples of ten guarded plants were taken from each sub-plot to determine the following characters:

A. Watermelon pulp characters:

Number of fruits plant^{-1}, number of seeds fruits^{-1}, seeds weight fruits^{-1} (g), 100-seed weight (g) and seed weight plant^{-1} (g). Seeds yield fed^{-1} (Kg) was estimated from the whole sub-plot area (kg plot^{-1}) and it was adjusted per fed.

B. Sunflower characters:

Plant height (cm), no. of seeds head^{-1}, 1000-seed weight (g) and seed weight plant^{-1} (g). Seed yield fed^{-1} (kg) was estimated from the whole sub-plot area (kg plot^{-1}) and it was adjusted per fed.

C. Soybean characters:

Plant height (cm), no. of seeds plant^{-1}, 100-seed weight (g) and seed weight plant^{-1} (g). Seed yield fed^{-1} (kg) was estimated from the whole sub-plot area (kg plot^{-1}) and it was adjusted per fed.

D. Sesame characters:

Plant height (cm), no. of capsules plant^{-1}, 1000-seed weight (g) and seed weight plant^{-1} (g). Seed yield fed^{-1} (kg) was estimated from the whole sub-plot area (kg plot^{-1}) and it was adjusted per fed.

E. Competitive relationships:

1. Land equivalent ratio (LER):

LER defines as the ratio of area needed under sole cropping to one of intercropping at the same management level to produce an equivalent yield (Mead and Willey, 1980). It is calculated as follows: LER = Relative Yield (RY_a) for crop a (watermelon pulp) + Relative Yield (RY_b) for crop b (oil crop), $RY_a = (Y_{ab}/Y_{aa})$, $RY_b = (Y_{ba}/Y_{bb})$, where Y_{aa}= Pure stand yield of crop a (watermelon pulp), Y_{bb}= Pure stand yield of crop b (oil crop), Y_{ab}= Intercrop yield of crop a (watermelon pulp) and Y_{ba}= Intercrop yield of crop b (oil crop). The values of LER were estimated by using data of recommended sole cultures of both crops. When LER of more than unity indicates yield advantage, equal to unity indicates no gain or no loss and less than unity indicates yield loss (Vandermeer, 1989).

2. Aggressivity (A):

Aggressivity represents a simple measure of how much the relative yield increase in one crop is greater than the other in an intercropping system (Willey, 1979) was calculated as follows: $A_{ab}=[Y_{ab} / (Y_{aa} \times Z_{ab})]-[Y_{ba} / (Y_{bb} \times Z_{ba})]$; $A_{ba}=[Y_{ba} / (Y_{bb} \times Z_{ba})]-[Y_{ab} / (Y_{aa} \times Z_{ab})]$. where Z_{ab} is the sown proportion of watermelon pulp in intercropping with oil crops and Z_{ba} the sown proportion of oil crops in intercropping. Aggressiveness tests the disparity in competitive ability of crops under intercropping. Positive signs of aggressivity indicates the dominant crop and the negative sign indicates the dominated crop. Higher numerical aggressiveness values signify a greater difference in competition as well as a greater difference in both crops between real and predicted production.

3. Competitive Ratio (CR):

As proposed by Willey and Rao (1980) gives the exact degree of competition by indicating the times in which one crop is more competitive than the other. Competition Ratio CR is calculated according to the following equation:

$CR = (LER_a / LER_b)(Z_{ba} / Z_{ab})$. Where LER_a and LER_b represent relative yields of a and b intercrops, respectively. Since the CR values of the two crops will in fact be reciprocals of each other.

4. Land Equivalent Coefficient (LEC):

LEC is a measure of interaction concerned with the strength of relationship for a two-crop mixture, the minimum expected productivity co-efficient (PC) is 25%, that is, a yield advantage was obtained if LEC value was exceeded 0.25. (Adetiloye *et al*., 1983). It is calculated as follows: LEC = La × Lb, where: La = relative yield of crop a (watermelon pulp) and Lb = relative yield of crop b (oil crops).

5. System Productivity Index (SPI):

SPI indicating higher productivity and stability of intercrops than solid culture. SPI was calculated as (Odo, 1991). It was calculated as follows:

$SPI=[(S_A/L_B) \times L_b]+S_a$, where S_A and L_B are the yield of watermelon pulp and oil crops in sole cropping, S_a and L_b are the yield of watermelon pulp and oil crops in intercropping.

F. Economic Evaluation:

1. Farmer gross income: Farmer gross income of intercropping cultures as compared to recommended sole culture of watermelon pulp were calculated as follows:

Farmer total income (LE fed^{-1}) = (seed yield of watermelon pulp × unit price) + (seed yield of oil crop × unit price).

2. Monetary advantage index (MAI): Suggests that the economic assessment should be assessed on the basis of the rentable value of this land. MAI was calculated according to the formula suggested by Willey (1979). The higher the MAI value the more profitable.

MAI = Value of combined intercrops × (LER-1/LER)

The market prices of seeds for watermelon pulp, sunflower, soybean and sesame were 50000, 8000, 8500 and 20000 LE ton^{-1}, respectively, as an average for the two seasons (Bulletin of Statistical Cost Production and Net Return, 2019).

2.3. Statistical Analysis

Analysis of variance of the obtained data of each season was performed. The measured variables were analyzed by ANOVA using MSTAT-C statistical package (Freed, 1991). Mean comparisons were performed using the least significant differences (LSD) test with a significance level of 5% (Snedecor and Cochran, 1988).

3. Results and Discussion

3.1. Watermelon pulp

3.1.1. Effect of associated oil crop:

Effect of associated oil crops on watermelon pulp traits in intercrop was presented in Table (2). Results obtained that there were increases in all traits of watermelon pulp, namely, no. of fruits $plant^{-1}$, no. of seeds $fruit^{-1}$, seed weight $fruit^{-1}$, 100-seed weight, seed weight $plant^{-1}$ and seed yield fed^{-1} when soybean intercropped with watermelon pulp followed by sesame whereas sunflower recorded lowest values in both seasons. Increases were significant among the treatments imposed in both seasons, except in case of 100-seed weight where differences failed to reach 5% level of significance. It could be noted that the lowest yield and its attributes of watermelon pulp traits were recorded when sunflower intercropped with watermelon pulp reflecting the negative effect of shading intensity on watermelon pulp when the tallest oil crop was associated. These results are also supported by Hefny *et al*. (2020) and Sheha *et al*. (2020).

3.1.2. Effect of sowing dates of oil crops:

Results in Table (2) indicated that no. of fruits $plant^{-1}$, no. of seeds $fruit^{-1}$, seed weight $fruit^{-1}$, 100-seed weight, seed weight $plant^{-1}$ and seed yield fed^{-1} significantly affected by sowing date of associated oil crop. The highest values of watermelon pulp were recorded when oil crops intercropped 15 days after sowing watermelon pulp and sowing date at simultaneously occupied the second rank, while the lowest values of watermelon pulp were recorded when oil crops intercropped 15 days before sowing watermelon pulp. These results may be due to the late date of intercropping oil crops with watermelon pulp resulted less inter-specific competition, which reflected in high yield of watermelon pulp, the reverse was true in both seasons. Gbaraneh (2018) they stated that in case of intercropping maize (over-story crop) with egusi melon, entry of maize should be delayed to 4 weeks after egusi sowing to allow the full expression of egusi melon (under-story crop).

3.1.3. Interaction effect:

Results in Table (2) indicated that the interaction between oil crops and sowing dates significantly affected no. of seeds $fruit^{-1}$, seed weight $fruit^{-1}$, seed weight $plant^{-1}$ and seed yield fed^{-1} in both seasons while no. of fruits $plant^{-1}$ and 100-seed weight were insignificantly affected in both seasons. The highest values of watermelon pulp recorded when soybean intercropped 15 days after sowing watermelon pulp, while the lowest values of watermelon pulp recorded when sunflower intercropped 15 days before sowing watermelon pulp. It could be due to that species sown first may have exploited nutrients in successive horizons in advance of the later introduced species (Gbaraneh

Table 2: Effect of intercropping sunflower, soybean or sesame and its sowing dates on watermelon pulp during 2019 and 2020 summer seasons.

Trait		No. of fruits plant^{-1}		No. of seeds fruit^{-1}		Seed weight fruit^{-1} (g)		100-seed weight (g)		Seed weight plant^{-1} (g)		Seed yield fed^{-1} (kg)	
Treatment		**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Oil crop:													
Sunflower		1.2	1.1	360.4	350.6	36.5	34.2	9.4	9.2	40.2	38.0	434.1	397.2
Soybean		1.4	1.3	396.2	388.6	41.0	38.0	9.7	9.6	48.3	45.9	521.9	502.4
Sesame		1.3	1.3	379.9	372.4	39.8	37.0	9.6	9.3	47.1	44.7	514.6	493.0
LSD at 0.05%		0.12	0.08	4.03	3.19	3.21	2.71	NS	NS	3.00	4.02	15.24	12.17
Sowing date:													
D1		1.1	1.1	343.6	335.9	35.4	33.6	9.1	8.9	38.1	34.7	415.0	388.4
D2		1.3	1.3	384.7	369.8	40.2	37.0	9.5	9.3	46.0	43.6	509.8	483.3
D3		1.4	1.4	408.3	405.9	41.5	38.6	10.1	9.9	51.4	50.3	545.7	520.9
LSD at 0.05%		0.09	0.12	3.11	2.53	2.36	1.88	0.22	0.41	4.48	4.87	12.94	7.34
Interaction:													
	D1	1.1	1.0	325.7	315.3	29.6	28.8	9.0	8.7	30.5	28.4	313.6	293.3
Sunflower	**D2**	1.2	1.1	364.7	349.7	39.0	36.5	9.3	9.1	42.9	39.1	484.3	433.1
	D3	1.3	1.3	391.0	386.7	40.7	37.4	9.8	9.7	47.1	46.5	504.5	465.2
	D1	1.2	1.2	358.0	350.0	39.2	36.2	9.2	9.2	42.2	38.5	474.3	441.2
Soybean	**D2**	1.4	1.4	405.3	392.3	41.1	37.6	9.7	9.5	48.1	46.0	523.3	515.8
	D3	1.5	1.5	425.3	423.3	42.6	40.2	10.2	10.0	54.7	53.1	568.0	550.3
	D1	1.1	1.1	347.0	342.3	37.5	35.8	9.1	8.8	41.7	37.2	457.1	430.9
Sesame	**D2**	1.4	1.3	384.0	367.3	40.6	36.9	9.5	9.3	47.1	45.8	521.9	500.9
	D3	1.5	1.4	408.7	407.7	41.1	38.3	10.2	9.9	52.5	51.2	564.7	547.1
LSD at 0.05%		NS	NS	5.38	4.38	4.09	3.26	NS	NS	7.76	8.44	22.41	12.71

2018). These results are in accordance with those obtained by Hefny *et al*. (2020) and Sheha *et al*. (2020).

3.2. Oil crops:

3.2.1. Sunflower:

Sunflower traits i.e., plant height, no. of seeds head^{-1}, 1000-seed weight, seed weight plant^{-1} and seed yield fed^{-1} presented in Table (3). No. of seeds head^{-1}, 1000-seed weight, seed weight plant^{-1} and seed yield fed^{-1} traits were significantly affected by sowing date in both seasons, while plant height insignificantly affected in both seasons. The highest values of sunflower yield components traits were recorded when sunflower planted 15 days before sowing watermelon pulp these may be due to inter-specific competition between sunflower and watermelon pulp plants for light, water and nutrients was lower than simultaneously sowing date or after 15 days from watermelon pulp sowing date. These results are in accordance with those obtained by Hamza and Safina (2015).

3.2.2. Soybean:

Results in Table (4) showed that soybean traits i.e., no. of seeds plant^{-1}, 100-seed weight, seed weight plant^{-1} and seed yield fed^{-1} were significantly affected by sowing date while plant height was insignificantly affected by sowing date. The highest values of soybean yield and its components were obtained when soybean intercropped 15 days before sowing watermelon pulp, whereas the lowest values were obtained when soybean planted 15 days after sowing watermelon pulp. These results were supported by Kandil *et al*. (2012) and Gbaraneh (2018).

3.2.3. Sesame:

Results in Table (5) indicated clearly that no. of capsules plant^{-1}, 1000-seed weight, seed weight plant^{-1} and seed yield fed^{-1} of sesame were significantly affected by sowing date while plant height was not significantly affected in both seasons. The highest values of sesame yield and its component were obtained when sesame planted 15 days before sowing watermelon pulp followed by at simultaneously sowing date, whereas the lowest values were obtained when sesame planted 15 days after sowing watermelon pulp (Hamza and Abd El-Salam, 2015 and Gbaraneh 2018).

3.3. Competitive relationships and yield advantage:

3.3.1. Land equivalent ratio (LER):

Results in Table (6) indicate interesting trends of relative yields of oil crops with watermelon pulp under different sowing dates. Relative yields of watermelon pulp (under-story crop) were higher than those of oil crops (over-story crop), indicating light competitive pressure of oil crops.

All LER values exceed the unit except when sunflower planted 15 days before sowing watermelon pulp in both seasons. The highest LER values (1.26 and 1.26) were recorded when soybean simultaneously planted with watermelon pulp in both seasons. Whereas the minimum LER values (0.95 and 0.92) were recorded when sunflower planted 15 days before sowing watermelon pulp in both seasons. These results are in accordance with those obtained by Hefny *et al*. (2020) whom reported decline in LER with increasing sunflower percent in the triple combination from 25% up to 50% with 100% watermelon pulp under orange trees.

3.3.2. Aggressivity (A):

Results in Table (6) showed that oil crops were the dominant crop and watermelon pulp was the dominated crop when oil crops planted 15 days before watermelon pulp in both seasons. The reverse was true when oil crops planted 15 days after watermelon pulp in both seasons. Sunflower and soybean were the dominant crops when planted simultaneously with watermelon pulp and watermelon pulp was the dominated crop, whereas sesame was dominated crop when planted simultaneously with watermelon pulp and watermelon pulp was the dominant crop in both seasons. These results are in accordance with those obtained by Gbaraneh (2018).

3.3.3. Competitive Ratio (CR):

Results in Table (6) showed that the highest value of CR for watermelon pulp was recorded when sesame planted 15 days after planting watermelon pulp, whereas the lowest value of CR was recorded

Table 3: Effect of sowing date on yield and its component of sunflower during 2019 and 2020 summer seasons.

Trait	Plant height (cm)		No. of seeds head^{-1}		1000-seed weight (g)		Seed weight plant^{-1} (g)		Seed yield fed^{-1} (kg)	
Sowing date	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
D1	261.7	253.0	850.3	838.0	62.3	61.3	50.9	46.9	468.1	429.6
D2	247.3	238.8	812.3	804.3	56.8	55.1	46.9	44.7	402.8	376.0
D3	258.1	245.0	762.0	744.7	50.7	50.0	42.8	42.5	317.7	275.5
LSD at 0.05%	NS	NS	28.49	38.16	5.15	4.39	0.96	0.80	86.14	67.25

Table 4: Effect of sowing date on yield and its component of soybean during 2019 and 2020 summer seasons.

Trait	Plant height (cm)		No. of seeds plant^{-1}		100-seed weight (g)		Seed weight plant^{-1} (g)		Seed yield fed^{-1} (kg)	
Sowing date	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
D1	112.7	107.3	139.0	125.7	17.3	17.2	24.3	23.4	507.1	466.2
D2	113.3	113.0	123.3	110.7	16.4	16.3	21.6	21.2	477.3	441.7
D3	110.7	105.7	94.7	93.7	15.6	15.4	19.2	18.1	339.1	310.9
LSD at 0.05%	NS	NS	13.71	15.76	0.56	0.12	1.39	3.86	42.54	38.97

Table 5: Effect of sowing date on yield and its component of sesame during 2019 and 2020 summer seasons.

Trait	Plant height (cm)		No. of capsules plant^{-1}		1000-seed weight (g)		Seed weight plant^{-1} (g)		Seed yield fed^{-1} (kg)	
Sowing date	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
D1	142.0	134.7	87.3	85.0	4.8	4.6	14.1	13.2	260.1	253.2
D2	134.0	129.0	82.0	71.0	4.3	4.1	10.9	9.7	198.1	187.6
D3	131.3	128.7	74.5	69.2	3.7	3.7	7.4	6.6	132.4	118.9
LSD at 0.05%	NS	NS	5.57	4.45	0.33	0.49	3.28	2.29	21.74	25.71

Table 6: Effect of intercropping oil crops in different sowing dates with watermelon pulp on competitive relationships in 2019 and 2020 seasons.

Treatment	Trait	Land Equivalent Ratio (LER)			Aggressivity (A)		Competitive Ratio (CR)		Land Equivalent Coefficient (LEC)	System Productivity Index (SPI)
		RY_a	RY_b	LER	A_a	A_b	CR_a	CR_b		
2019 Season										
Sunflower	**D1**	0.54	0.41	0.95	-0.95	+0.95	0.43	2.33	0.22	556.71
	D2	0.83	0.36	1.18	-0.33	+0.33	0.77	1.30	0.30	693.50
	D3	0.86	0.28	1.14	+0.02	-0.02	1.02	0.98	0.24	669.50
Soybean	**D1**	0.81	0.39	1.20	-0.49	+0.49	0.69	1.45	0.32	703.77
	D2	0.89	0.37	1.26	-0.28	+0.28	0.81	1.24	0.33	739.28
	D3	0.97	0.26	1.23	+0.24	-0.24	1.23	0.81	0.25	721.45
Sesame	**D1**	0.78	0.33	1.11	-0.30	+0.30	0.78	1.29	0.26	653.04
	D2	0.89	0.25	1.15	+0.17	-0.17	1.17	0.86	0.23	671.05
	D3	0.96	0.17	1.13	+0.60	-0.60	1.89	0.53	0.16	664.29
2020 Season										
Sunflower	**D1**	0.52	0.40	0.92	-0.93	+0.93	0.43	2.34	0.21	522.30
	D2	0.76	0.35	1.12	-0.40	+0.40	0.72	1.39	0.27	633.52
	D3	0.82	0.26	1.08	0.06	-0.06	1.06	0.95	0.21	612.05
Soybean	**D1**	0.78	0.37	1.15	-0.45	+0.45	0.70	1.44	0.29	652.55
	D2	0.91	0.35	1.26	-0.20	+0.20	0.86	1.16	0.32	716.04
	D3	0.97	0.25	1.22	0.30	-0.30	1.30	0.77	0.24	691.25
Sesame	**D1**	0.76	0.35	1.11	-0.37	+0.37	0.73	1.36	0.26	626.68
	D2	0.88	0.26	1.14	+0.15	-0.15	1.15	0.87	0.23	645.96
	D3	0.96	0.16	1.13	+0.64	-0.64	1.98	0.50	0.16	639.04

Sole culture yields were 586 and 567 Kg fed^{-1} for watermelon pulp, 1128.3 and 1063.7 Kg fed^{-1} for sunflower, 1295.0 and 1250.7 Kg fed^{-1} for soybean and 778.3 and 733.3 Kg fed^{-1} for sesame in 2019 and 2020 respectively.

when sunflower planted 15 days before planting watermelon pulp in both seasons. Results also evidenced that the highest value of CR for oil crops was recorded when sunflower planted 15 days before planting watermelon pulp, whereas the lowest value of CR was recorded when sesame planted 15 days after planting watermelon pulp in both seasons. These results could be due to negative shading effect of sunflower compared to soybean and sesame, which affect watermelon pulp plants to benefit solar radiation to produce more dray matter. These results were supported by Gbaraneh (2018) whom add that each crop was more competitive when planted before the other.

3.3.4. Land Equivalent Coefficient (LEC):

LEC was affected by oil crops under sowing dates in both seasons (Table 6). All LEC values were exceeded 0.25 reflecting a yield advantage was obtained whereas LEC values were not exceeded 0.25 when planting oil crops after sowing watermelon pulp also when sunflower was planted 15 days before sowing watermelon pulp or when sesame was planted simultaneously with sowing watermelon pulp in both seasons.

The advantage of the highest LEC when planted soybean simultaneously with watermelon pulp in both seasons probably due to the low interspecific competition between soybean and watermelon pulp for above and underground environmental conditions which reflected to higher economic yield of both species per unit area compared with other oil crops.

3.3.5. System productivity index (SPI):

Means of SPI values (Table, 6) varied from 556.71 and 522.30 by intercropping sunflower 15 days before watermelon pulp to 739.28 and 716.04 when intercropping soybean simultaneously with watermelon pulp in the first and second seasons, respectively. This result implies a relatively stable productivity by intercropping both soybean and watermelon pulp simultaneously.

3.4. Economic Evaluation:

3.4.1. Farmer gross income:

Results in Table (7) provided gross income from intercropping oil crops with watermelon pulp under different sowing dates to sole culture of watermelon pulp. It is clearly evidenced that planting all oil crops 15 days before sowing watermelon pulp decreases farmers income compared with the sole culture of watermelon pulp also, no economic advantages were recorded when planting sunflower simultaneously or 15 days after sowing watermelon pulp. The highest values of gross income (31,282 and 30,158 LE) were obtained when soybean was planted simultaneously with sowing watermelon pulp in the first and second seasons, respectively. This technique adds an additive income of 1,982 and 1,808 LE to gross income for watermelon pulp farmers with increases of 6.8 and 6.4% in the first and second seasons, respectively compared with sowing watermelon pulp in sole culture.

3.4.2. Monetary advantage index (MAI):

All values of MAI in Table (7) were positive except in one intercropping case when sowing sunflower 15 days before planting watermelon pulp, which showed a negative MAI value in both seasons. The positive values reflecting a yield advantage compared with negative value under this study.

The highest values of MAI were obtained when soybean was planted it with 15 days after watermelon pulp planting and reached 6266 and 6150 in the first and second seasons, respectively.

4. Conclusion

It could be concluded that the current study recommended when sowing watermelon pulp on one side of raised bed (1.8m width) in hills (one plant/hill^{-1}) at 20cm apart (100% of sole culture) to intercrop soybean cv Giza 111 at 33% of its sole culture as two lines on the other side of the watermelon pulp raised beds in hills (one plant/hill) at 10cm apart after 15 days from sowing watermelon pulp. This intercropping technique obtaining the highest seed yield (97%) of watermelon pulp (the main crop) in addition to 26% of soybean seed yield as averages of its sole cultures, increasing LER by 23% and adds an average additive income of 1,895 LE to gross income of the watermelon pulp farmer.

Table 7: Effect of intercropping oil crops in different sowing dates with watermelon pulp on farmer gross income and monetary advantage index in 2019 and 2020 seasons.

Treatment	Trait	Seed yield fed^{-1} (Kg)		Farmer income (LE)			Monetary advantage index (MAI)
		Watermelon pulp	Oil crop	Watermelon pulp	Oil crop	Gross	
2019 Season							
Sunflower	**D1**	313.6	468.1	15,680	3,745	19,425	-1,022
	D2	484.3	402.8	24,215	3,222	27,437	4,253
	D3	504.5	317.7	25,225	2,542	27,767	3,463
Soybean	**D1**	474.3	507.1	23,715	4,310	28,025	4,690
	D2	523.3	477.3	26,165	4,057	30,222	6,266
	D3	568.0	339.1	28,400	2,882	31,282	5,873
Sesame	**D1**	457.2	260.1	22,860	5,202	28,062	2,881
	D2	521.9	198.1	26,095	3,961	30,056	3,810
	D3	564.6	132.4	28,230	2,648	30,878	3,639
Watermelon pulp (Sole Culture)		586.0	-	29,300	-	29,300	-
2020 Season							
Sunflower	**D1**	**293.3**	**429.6**	14,665	3,437	18,102	-1,549
	D2	**433.1**	**376.0**	21,655	3,008	24,663	2,590
	D3	**465.2**	**275.5**	23,260	2,204	25,464	1,874
Soybean	**D1**	**441.2**	**466.2**	22,060	3,963	26,023	3,412
	D2	**515.8**	**441.7**	25,790	3,754	29,544	6,150
	D3	**550.3**	**310.9**	27,515	2,643	30,158	5,421
Sesame	**D1**	**430.9**	**253.2**	21,545	5,063	26,608	2,534
	D2	**500.9**	**187.6**	25,045	3,751	28,796	3,520
	D3	**547.1**	**118.9**	27,355	2,377	29,732	3,352
Watermelon pulp (Sole Culture)		**567.0**	**-**	28,350	-	28,350	-

Market prices of seeds were 50000, 8000, 8500 and 20000 LE ton^{-1} for watermelon pulp, sunflower, soybean and sesame, respectively as an average of both seasons.

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