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MATERIAL AND METHODS

Four field experiments were conducted at Sakha Agricultural Research Station, Agriculture Research Center (ARC), Egypt, during 2010/11 and 2011/12 seasons, to study the effect of intercropping wheat (*Tritium aestivum*, L.) cv. Sakha 93 and faba bean (*Vicia faba*, L) cv. Giza 843 with sugar beet (*Beta Vulgaris*, l.) cv. Diamond on the productivity of these crops and farmers benefit. There was no preceding summer crop in both seasons.

Representative soil samples were taken from each site at the depth of 0-15 cm and 0-30 cm from the soil surface. Samples were air-dried then ground to pass through a two mm sieve and well mixed. Mechanical and chemical analysis of soil was determined in Soil Research Institute, ARC, according to **Jackson, 1967**.

The experimental field was fertilized with 31 kg P_2O_5/feddan in the form of superphosphate fertilizer (15.5 % P_2O_5) and 24 kg K_2O/feddan in the form of potassium sulphate (48% K_2O) during soil preparation.

A split plot design with four replications was used for each experiment. The main plots were assigned to two planting patterns and the sub-plot to six intercropping systems as follows :

A- <u>Planting pattern</u> (main plots):

   1. Ridges 60 cm apart.

   2. Beds 120 cm apart.

B- <u>Intercropping system (sub plots)</u>:

   1. Pure-stand of sugar beet was sown in hills 20 cm apart on one side of 60 cm ridges or two sides of 120 cm beds to achieve 35.000 plants per feddan after thinning.

2. Pure-stand of wheat or faba bean were sown in hills 20 cm apart on the two sides of 60 cm ridges or four rows on the top of 120 cm beds at the rate of 15-20 seeds/hill for wheat and two seeds/hill for faba bean.

3. Intercropping wheat or faba bean in hills 20 cm apart with sugar beet (100% sugar beet + 50% wheat or faba bean).

4. Intercropping wheat or faba bean in hills 40 cm apart with sugar beet (100% sugar beet + 25% wheat or faba bean).

5. Intercropping wheat or faba bean in hills 60 cm apart with sugar beet (100% sugar beet + 16.6% wheat or faba bean).

6. Intercropping wheat or faba bean in hills 80 cm apart with sugar beet (100% sugar beet + 12.5% wheat or faba bean).

Wheat or faba bean was sown on the other side of beet ridge and two rows on top of bed at all intercropping systems. The plot size was 34.56 m^2 (4.8 × 7.2 m). Each plot included 8 ridges 60 cm apart or 4 beds 120 cm apart and 7.2 m long.

Sowing of sugar beet took place on 26 and 21 October in 2010 and 2011 seasons, respectively. Seeds of multigerm sugar beet cultivar "Diamond" were sown in hills at rate of 3-4 seed balls per hill. Thirty five days after sowing, thinning to one plant per hill was done. Then seeds of wheat or faba bean were sown in hills with the mentioned spaces on 2nd December, 28th November in 2010 and 2011 seasons, respectively. Sugar beet plants in all plots were fertilized by side-dressing one-half of 90kg N / feddan in form of urea (46% N) and irrigated immediately. The other half of 90 N/feddan for sugar beet was added just before the second irrigation. All other practices were applied as recommended for each crop in the region.

Economic evaluation from crop intensification perspective :

Economic evaluation from perspective of the crop intensification made by using MELER equation to evaluate all simultaneous intercropping patterns under the study. MELER equation has been established by **El-Hawary ,2011** as follows:

$$MELER = A/O + B/O + C/O \quad .$$

Where:

A: First or major crop. B: Secondary crops.

O: Monoculture crop (traditional crop or compared crop).

$$A = \left(\sum_{L=1}^{m^-} Y_{aL} \, Pr_{aL} \right) \quad , \quad C = (C_o - C_1)$$

$$B = \left(\sum_{K=1}^{n} \left(\sum_{L=1}^{n^-} Y_{bkL} \, Pr_{bkL} \right) \right) \quad , \quad O = \left(\sum_{L=1}^{m} Y_{oL} \, Pr_{oL} \right)$$

n , m^- , n^- and m : Number of secondary crops , number of main and by-products together of first or major crop , secondary crop and monoculture crop (or substituted by intercropping crops), respectively. (where : $n^- = nk$)

Y_{aL} , Y_{bkL} and Y_{oL} : Yield /F. of main and by products of first or major crop , secondary crop (s) and monoculture crop (or substituted by intercropping crops) , respectively .

Pr_{aL} , Pr_{bkL} and Pr_{oL} : Prices of production unit of main and by products of first or major crop , secondary crop (s) and monoculture crop (or substituted by intercropping crops) , respectively .

C_o and C_1: Total costs of monoculture crop (or substituted by intercropping crops) and the intercropping crops, respectively.

The application of MELER equation on this study is as follows:

n =1 (one secondary crop, wheat or Faba bean).

m- = 2 , n- = 2 and m =2 (major crop , secondary crop and monoculture crop , respectively ,each one of them has one main product and one by-product) .

A= (Major crop (SB) intercropped) = (Root yield t/f. x price L.E./t.) + (Top yield t/f x price L.E./t) .

B= (Secondary crop intercropped (WH or FB)) = (Grains (or seeds)yield t/f x price L.E /t) + (Straw yield t/f. x price L.E./t) .

O= (Monoculture crop or compared crop in this study was SB) = (Root yield t/f. x price L.E. /t.)+ (Top yield t/f x price L.E./t) .

C= C o (Cost of monoculture or compared crop) $- C_1$ (cost of major crop + cost of secondary crop).

The computation of the intercropping advantage net return is as follows:

=Gross income of the compared crop x (MELER value (of the treatment) -1)

The computation of the total net return is as follows:

= (Gross income of the compared crop – cost) + (Net return of the intercropping advantage of the treatment) .

MELER formula values are relative to yield of the traditional crop or compared crop, where the yield of the traditional crop is considered 100%.

Also, web application on the website "www.elhawary.net " was used for applying the previous formula.

The economic evaluation has been made according to the official prices given for the concerned season by the Ministry of Agriculture and Land Reclamation, Agriculture Economic Institute, of the same duration of the study.

Total cost of each crop included fixed (land rent) and variable costs (labor , fertilizers , weed control, pesticides and seeds   …etc.).

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Results and discussion

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IV. Economic evaluation from crop intensification perspective .

IV.I. Modified economic land equivalent ratio (MELER).

Among the factors that farmers take into account are the economic factors in terms of the price of seeds, fertilizers, insecticides and fungicides as well as the selling price of the crops to be able to choose the appropriate system for use, compared with the traditional systems.

Therefore equation   have been established by El-Hawary, 2011, for the economic evaluation of simultaneous intercropping systems on the bases of biological yield and economic parameters from perspective of the crop intensification. Modified Economic Land Equivalent Ratio (MELER) equation (EL-Hawary, 2011) has included the factors that affect the final production of the system and also the economic return of the land. The economic returns of such systems compared with the traditional methods used by farmers are the reference to the profit or loss and thus the success or failure of the proposed system. One of the features proposed equation that can predict the success or failure of the proposed system through the price policy of inputs on the market. So it can monitor the spread of the implementation of the proposed programs through the market prices   .

All data that needed to apply MELER equation were illustrated in Table (1). Solid sugar beet   cultivated on ridges was chosen to be the compared crop , because it had been substituted by intercropping system and at the same time it is considered the farmer̕ s traditional crop .So , the yields of all solid sugar beet planted on ridges treatments with wheat and faba bean as well as the two seasons had been gathered to take the average to become a treatment control or a

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compared treatment with the others treatments. The same happened with sole sugar beet planted on beds to be an ordinary treatment.

Data of 100% sugar beet planted on ridges as a compare crop and treatment of 100%SB + 50% wheat planted on ridges from the Table (1) will be used to apply MELER equation as an example as follows:

MELER value = $[(21.00 \times 324.5 + 8.6 \times 90) + (2.29 \times 2300 + 3.408 \times 400) + (4460 - 5015)](31.9 \times 348.21 + 12.087 \times 90)^{-1} = 1.1203$

MELER value of 100% SB+50% wheat (1.1203) was relative to the yield of the traditional crop or the compared crop.

MELER values of 100% SB+50% wheat as percentage = 112.03 % of yield of 100% SB planted on ridges.

MELER values of 100SB+50% wheat = +12.03% yield over the yield of the compared crop (100 % SB planted on ridges).

The computation of the intercropping advantage net return =

$$= 12195.75 \quad \times \quad 02103 = 1467.97 \text{ LE/F}$$

The computation of total net return =

$$= (12195.75 - 4460) + 1467.97 = 9203.72 \text{ LE/F.}$$

MELER values were computed for all intercropping patterns and summarized in Table (2) . From results obtained, it can be seen that the cultivation of 100% solid sugar beet on beds gave yield lower by 7.12% (as an average of two seasons) than yield of solid sugar beet cultivated on ridges.

Concerning intercropping wheat with sugar beet planted on ridges, the treatment of 100% SB + 12.5% Faba bean showed the highest net return compared with the other treatments under the study, which gave 30.67% yield over the yield of the 100% SB planted on ridges (130.67% yield of the compared crop) followed by the treatment of 100% SB + 16.5% FB planted on ridges (126.23 % yield of compared treatment). While the treatment of 100%SB + 12.5% WH

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planted on ridges occupied the third position by 124.22% yield of compared treatment. The first treatment planted on beds which occupied the seventh position in the rank was 100% SB+25% WH by 117.55 % yield of the compared crop. The lowest   MELE R value was 105.62 % yield of the compare crop (5.62% yield over the yield of the compared crop) showed by 100% SB+50% FB planted on beds.

Values of intercropping advantage net return and total net return of all intercropping patterns were illustrated in Table (3).The highest value of net return was gave by the treatment of 100% SB + 12.5% Faba bean planted on edge which showed 3740.70 LE/F and 11476.44 LE/F for NR of intercropping advantage and total NR , respectively . While The first treatment planted on beds was 100%

SB+25% WH showed 2094.47 LE/F and 9830.20LE/F for NR of intercropping advantage and total net return , respectively. The lowest NR was mentioned with the treatment of 100% SB+50% FB planted on beds .However , it was over the NR of both solid treatments .

Table (1): Total costs (LE/f), Yield (t/f) and price (LE/f) of sugar beet, wheat and faba bean under different intercropping patterns.

Intercropping patterns	Costs	Intercropping wheat with sugar beet							
		Sugar beet				wheat			
		Root		Top		Grains		Straw	
	LE/F	Yield T/F	Price LE/T	Yield T/F	Price LE/T	Yield T/F	Price LE/T	Yield T/F	Price LE/T
100% SB on ridges	4460	31.900	348.21	12.08	90	-	-	-	-
100% SB on beds	4460	29.655	345.12	10.64	90	-	-	-	-
Average of two seasons									
Ridges									
100%SB+ 50% WH	5015	21.00	324.5	8.6	90	2.29	2300	3.408	400
100%SB+ 25%WH	4738	24.75	340.58	10.6	90	1.88	2300	2.871	400
100%SB+ 16.6 %WH	4644	26.75	344.3	11.3	90	1.66	2300	2.652	400
100%SB+ 12.5 %WH	4599	28.75	351.31	12.1	90	1.38	2300	2.316	400
Beds									
100%SB+ 50% WH	5015	19.15	304.69	8.2	90	2.37	2300	3.708	400
100%SB+ 25%WH	4738	26.6	324.49	9.9	90	1.71	2300	2.713	400
100%SB+ 16.6 %WH	4644	26.1	330.68	10.2	90	1.41	2300	2.361	400
100%SB+ 12.5 %WH	4599	27.65	335.63	11.05	90	1.38	2300	2.451	400
		Intercropping faba bean with sugar beet							
		Sugar beet				Faba bean			
		Root		Top		Seeds		Straw	
Ridges									
100%SB+ 50% FB	5028	21.36	319.55	9.025	90	0.902	7000	2.856	280
100%SB+ 25%FB	4743	25.11	330.68	9.585	90	0.782	7000	2.440	280
100%SB+ 16.6 %FB	4648	27.87	334.39	9.865	90	0.685	7000	2.074	280
100%SB+ 12.5 %FB	4601	30.06	341.82	10.785	90	0.617	7000	1.831	280
Beds									
100%SB+ 50% FB	5028	19.41	314.6	8.355	90	0.835	7000	2.648	280
100%SB+ 25%FB	4743	20.16	324.495	9.195	90	0.742	7000	2.246	280
100%SB+ 16.6 %FB	4648	22.72	328.21	9.615	90	0.674	7000	1.804	280
100%SB+ 12.5 %FB	4601	24.84	336.87	9.785	90	0.581	7000	1.545	280

Table (2): MELER values of intercropping patterns treatments (as average of two seasons) in descending ranks.

Intercropping patterns	MELER values		
	Ratio relative to yield of traditional crop	As percentage of yield of traditional crop	% yield over 100% yield of traditional crop
100% SB solid on ridges (Traditional crop)	1.0000	100.00	00.00
100% SB + 12.5% FB on ridges	1.3067	130.67	30.67
100% SB + 16.5% FB on ridges	1.2623	126.23	26.23
100% SB + 12.5% WH on ridges	1.2432	124.22	24.22
100% SB + 25% FB on ridges	1.2335	123.35	23.35
100% SB + 16.5% WH on ridges	1.2236	122.36	22.36
100% SB + 25% WH on ridges	1.1953	119.53	19.53
100% SB + 25% WH on beds	1.1755	117.55	17.55
100% SB + 12.5% WH on beds	1.1717	117.17	17.17
100%SB + 50 % FB on ridges	1.1628	116.28	16.28
100%SB + 50 % WH on ridges	1.1203	112.3	12.03
100%SB + 12.5% FB on beds	1.1160	111.60	11.60
100% SB + 16.5% WH on beds	1.1112	111.12	11.12
100% SB + 50% WH on beds	1.0956	109.56	9.56
100%SB + 50% WH on ridges	1.0626	106.26	6.26
100% SB + 25 % FB on beds	1.0886	108.86	8.86
100% SB + 50 % FB on beds	1.0562	105.62	5.62
100% SB on beds	0.9288	-7.12	----

Table (3) : Net return of the intercropping advantage and the total net return of intercropping patterns .

Intercropping patterns	Net return of intercropping advantage. LE/F	Total net return LE/F.
100% SB solid on ridges (Traditional crop)	----	7735.729
100% SB + 12.5% FB on ridges	3740.70	11476.44
100% SB + 16.5% FB on ridges	3199.56	10935.3
100% SB + 12.5% WH on ridges	2954.83	10690.56
100% SB + 25% FB on ridges	2844.76	10580.49
100% SB + 16.5% WH on ridges	2726.09	10461.83
100% SB + 25% WH on ridges	2382.15	10117.88
100% SB + 12.5% WH on beds	2094.47	9830.20
100% SB + 25% WH on beds	2067.03	9802.76
100%SB + 50 % FB on ridges	1991.28	9727.01
100%SB + 50 % WH on ridges	1467.97	9203.70
100%SB + 12.5% FB on beds	1414.87	9150.60
100% SB + 16.5% WH on beds	1356.55	9092.28
100% SB + 50% WH on beds	1166.81	8902.54
100%SB + 50% WH on ridges	756.38	8492.11
100% SB + 25 % FB on beds	715.14	8450.87
100% SB + 50 % FB on beds	686.12	8421.84
100% SB on beds	---	6732.13