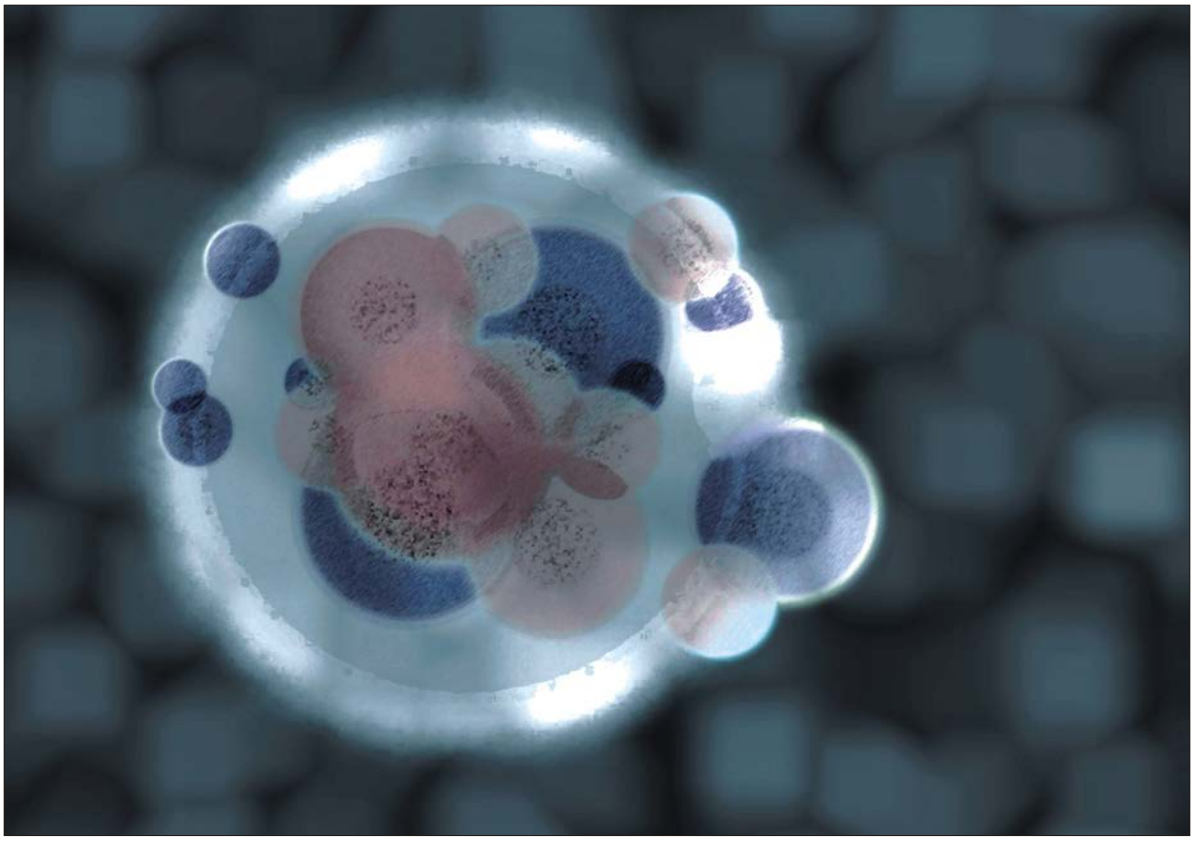

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Relay Intercropping Wheat and Cotton Studies: II-Effect of Sowing Dates and Ridge Width on Cotton

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Abstract: Intercropping cotton and wheat is a new farming system in Egypt. The main objective of this research was to investigate the response of sole and relay intercropping cotton and wheat to the effect of sowing dates and ridge width on cotton yields in Abo Hussein Village, Abo Kebeer district, Sharkia Governorate, Egypt. The experiment was carried out in a strip plot design with four replications. The vertical plots were occupied with three sowing dates. The horizontal plots were assigned to three ridge width. Sowing on 15th March significantly affected ($p<0.05$) number of days to first flower opening and plant height of sole and relay intercropping cotton and number of fruiting branches/plant, number of opened bolls/plant, boll weight, seed cotton yield per plant and feddan and lint cotton yield/fed of sole cotton and resulted in the highest values in both seasons. Sowing relay intercropping cotton on 1st April significantly affected ($p<0.05$) number of fruiting branches/plant, number of opened bolls/plant, boll weight, seed cotton yield per plant and feddan and lint cotton yield/fed and produced the highest values in both seasons. Sowing sole or relay intercropping cotton on wide ridges significantly affected all studied traits and produced the highest values in both seasons. It can be concluded that, in order to maximize seeds and lint cotton yields/fed of sole cotton, it must be sown in 15th March on ridges with width of 100 cm. However, for maximization of seeds and lint cotton yields/fed of relay intercropping cotton, it must be sown in 1st April on ridges with width of 100 cm.

Key words: Cotton, relay intercropping, sowing dates, ridge width

INTRODUCTION

Intercropping cotton with wheat helps in increasing the total production from the limited cultivation area. Cotton growers, during last decades suffered much from rapidly increasing costs of production which has not been matched by an equal increase in price policy. Moreover, predominant deterioration of cotton productivity was a cogent reason for farmers to avoid cotton planting. On this basic ground, farmers tried hardly to seek a new farming system which might allow them a new multiple cropping system in cotton rotation, in order to achieve maximum land utilization with higher gross income. Hence, the inclusion of some long duration winter crops such as wheat becomes a hope to achieve this goal. This of course results in a drop in cotton yield due to delaying cotton planting, therefore it become necessary to use intercropping as one of the most suitable way for increasing cotton area without any shortage of wheat area to meet raising demands and to overcome the problem of delaying cotton planting (Mohamed *et al*., 1999; Hussein and Samira, 2005).

Sowing dates means the effect of climatic factors and all environmental conditions in large scale on growth and yield of all field crops, which differ widely from region to another. Moreover, sowing dates is considered the most important factor for all field crops generally and cotton specially. It has a vital role for germination, growth, yield and fiber quality of cotton. In this regard, El-Nour *et al*. (2000) found that early sowing increased the yield components and yield of seed cotton, while it decreased plant height and internodes length, but it delayed the first flower appearance. They added that sowing dates had no effect on boll weight, lint percentage and seed index. El-Zik *et al*. (2000) found that lint yield and fiber quality traits were markedly affected by sowing date. The third sowing date on 9th April produced the highest lint yield and fiber quality. Ali and El-Sayed (2001) reported that delaying cotton sowing date to the end of April reflected inverse effect on most of flowering and earliness parameters assembled herein as shorter period to first flower appearance or boll opening. Makram *et al*. (2001) showed that early sowing of cotton (March, 25) exceeded late sowing (April, 25) in number of buds, total bolls and open bolls/plant. The highest yield components and yield per feddan was produced from early sowing (March, 25), where the cotton plants received the highest number of heat units, through the growing season as compared to

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late sowing. Makram and Ali (2001) showed that late sowing of cotton increased final plant height due to the increase of air temperature. Whereas, early sowing delayed the appearance of first flower with lower number of days degrees units. They added that early sowing exceeded late sowing in yield components, yield and the efficiency use of thermal units by cotton plants. Saleh *et al.* (2004) found that early sowing date 20th March reflected significant increase in each of: days to first flower appearance, open boll numbers/plant, boll weight, seed cotton yield/plant, seed cotton yield/fed, lint % and lint cotton yield/fed. However, sowing on 20th April increased plant height and boll shedding. Toaima (2004) stated that sowing cotton on 1st March reduced all cotton growth characters and components and seed cotton yield per plant and feddan. Whereas, sowing cotton on 15th March was significantly higher in number of fruiting branches/plant, number of open bolls/plant, boll weight, seed index, seed cotton yield/plant and seed cotton yield/fed as compared with the other two sowing dates (1st March and 1st April).

Ridge width and plant distribution were the most affective factors for increasing yield and its components of cotton. In this respect, Hussain *et al.* (2000) reported that the 30 cm hill spacing increased plant height, boll numbers/plant and boll weight compared with those of 10 or 20 cm hill spacing. However, highest seed cotton yield/ha was produced from the narrow hill spacing of 10 cm. Maitra *et al.* (2000) showed that highest seed yield/ha (1502 kg ha^{-1}) was produced from using plant spacing of 60×45 cm compared with other plant spacings. Mert *et al.* (2006) suggested that Ridge-Tillage (RT) planting system with 17 cm intra-row spacing can be used in cotton production instead of Conventional Tillage (CT) planting system in the Eastern Mediterranean Region of Turkey.

Therefore, this investigation was established to investigate the response of sole and relay intercropping cotton to the effect of sowing dates and ridge width on yield and its attributes of cotton under the environmental conditions of Sharkia Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were carried out at a farm in Abo Hussein Village, Abo Kebeer district, Sharkia Governorate, during the two successive summer seasons of 2006 and 2007 to study the response of sole and relay intercropping cotton (Giza 86 cultivar) to the effect of sowing dates and ridge width on yield and its attributes of cotton.

Treatments and experimental design: The experiments were carried out in a s trip plot design with four replications. The vertical plots were occupied with three times of sowing dates of cotton (15th March, 1st April and 15th April). The horizontal plots were assigned to three ridge width (80, 90 and 100 cm between ridges).

Each experimental basic unit included four ridges, width as previously mentioned and length was 4.0 m, resulted an area of 12.8, 14.4 and 16.0 m^2, respectively. The preceding winter crop before cotton in sole system was Egyptian clover (*Trifolium alexandrinum* L.) in both seasons. The experiments were carried out in a clay soil with medium fertility as shown in Table 1.

Agricultural practices: Cotton seeds were sown under wheat plants according to the usual dry method at aforementioned dates on two sides of the ridge in hills. The distance between hills was 42.0, 37.3 and 33.6 cm, of each ridge width 80, 90 and 100 cm, respectively, each hill received five seeds. Plants were thinned to leave the best healthy two plants/hill (to obtain 50000 plants/fed for all treatments of ridge width) before second irrigation in both seasons. The other normal agricultural practices of growing cotton were kept the same as practice in the area as recommended by Ministry of Agriculture. Picking of the seed cotton yield was conducted on two pickings; first one was done after 185-188 days from planting and the second picking was done after 15 days from the first one in both seasons.

Characteristics studied: During the vegetative growth period, five plants in each plot were taken randomly and labeled. The following characters were estimated:

- Number of days to first flower opening
- Plant height (cm)
- Number of fruiting branches/plant

Table 1: Mechanical and chemical soil characteristics at the experimental sites during first and second growing years

	First year		Second year	
Soil analysis	Clover	Wheat	Clover	Wheat
Mechanical				
Sand (%)	26.96	26.33	27.77	28.56
Silt (%)	16.86	18.05	22.31	22.82
Clay (%)	56.18	55.62	49.92	48.62
Soil texture class	Clay	Clay	Clay	Clay
Chemical				
Available N (ppm)	32.15	32.74	35.65	33.61
Available P (ppm)	7.41	7.93	7.51	7.82
Exchangeable K (mg/100 g)	108.00	107.00	111.00	106.00
Ca^{++} (meq L^{-1})	25.00	27.00	20.00	24.00
Mg^{++} (meq L^{-1})	12.00	13.00	9.00	11.00
Na^{+} (meq L^{-1})	221.60	317.80	491.90	511.60
K^{+} (meq L^{-1})	98.65	95.14	93.80	98.32
Cl^{-} (meq L^{-1})	71.00	62.10	44.38	41.50
HCO_3^{-} (meq L^{-1})	152.50	142.09	137.20	134.80
SO_4 (meq L^{-1})	133.70	162.10	433.10	364.20
EC (dS m^{-1})	1.56	1.62	1.37	1.31
pH	7.08	7.14	7.13	7.05

- Number of opened bolls/plant
- Boll weight (g)
- Seed cotton yield/plant (g): This trait was estimated by collecting all opening bolls on the single plants and weight was recorded in grams
- Seed cotton yield (Kentar/fed): This trait was measured as the total seed cotton yield of each plot at harvest time, determined in kg/plot and converted to Kentar/fed (1 Kentar = 157.5 kg seed cotton and 1 feddan = 4200 m^2)
- Lint cotton yield (Kentar/fed): This trait was measured as the total lint cotton of each plot and then converted to Kentar/fed. (1 Kentar = 50 kg lint cotton)

Competitive relationships: In order to have knowledge about the nature and degree of competition between wheat and cotton the following parameters were calculated:

Land equivalent ratio (LER): Determined according to De Wit and van den Bergh (1965):

$$LER = L_{wheat} + L_{cotton}$$

Where:

L_{wheat} = Intercropping grain yield of wheat/Sole grain yield of wheat

L_{cotton} = Intercropping seed cotton yield /Sole seed cotton yield

Area time equivalent ratio (ATER): Determined according to Hiebsch and McCollum (1987):

$$ATER = \frac{(RYw \times tw) + (RYc \times tc)}{T}$$

Where, Ry_w, RY_c are Relative yield of wheat and cotton, respectively i.e., (Yield of intercrop/fed)\(Yield of sole/fed) Intercropping grain yield of wheat/Sole grain yield of wheat. t_w, t_c are Duration (days) for wheat and cotton from sowing to harvesting, respectively. T is Duration (days) of intercropping pattern.

Statistical analysis: All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip plot design as published by Gomez and Gomez (1984), using "MSTAT-C" Computer software package. Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Effect of sowing dates: The statistical analysis of obtained results that presented in Table 2 and 3 showed that number of days to first flower opening, plant height, number of fruiting branches/plant, number of opened bolls/plant, boll weight, seed cotton yield/plant, seed cotton yield/fed and lint cotton yield/fed of both sole and relay intercropping cotton were significantly affected ($p = 0.05$) Sowing to different sowing dates of cotton (15th March, 1st and 15th April) in both seasons Sowing cotton on 15th March gave the highest values of number of days to first flower opening (76.03, 76.08, 76.72 and 76.60) and plant height (166.1, 157.9, 164.1 and 155.5 cm) of sole and relay intercropping cotton in the first and second seasons, respectively as well as number of fruiting branches/plant (11.07 and 10.72), number of opened bolls/plant (18.87 and 18.15), boll weight (1.97 and 1.93 g), seed cotton yield/plant (33.06 and 31.06 g), seed cotton yield/fed (8.72 and 8.47 Kentar/fed) and lint cotton yield/fed (10.25 and 9.75 Kentar/fed) of sole cotton in the first and second seasons, respectively. However, sowing relay intercropping cotton on 1st April produced the highest values of number of fruiting branches/plant (10.66 and 10.36), number of opened bolls/plant (18.88 and 18.23), boll weight (1.97 and 1.96 g), seed cotton yield/plant (29.83 and 27.65 g), seed cotton yield/fed (8.37 and 7.55 Kentar/fed) and lint cotton yield/fed (10.03 and 8.86 Kentar/fed) in the first and second seasons, respectively.

The desirable effect of sowing sole cotton on earliest date (15th March) might be ascribed to the seasonable environmental conditions during this period such as temperature, relative humidity, day length and light intensity which allow to good establishment, vegetative growth and development consequently increasing dry matter accumulation, yields and its components. However, the increases in cotton yields of relay intercropping cotton with the intermediate sowing date (1st April) may be attributed to suitable environmental conditions during this period for growing cotton, where wheat growth was reduced and onset aging. These results are in harmony with those obtained by El-Zik *et al.* (2000), Ali and El-Sayed (2001), Makram *et al.* (2001) and Toaima (2004).

Effect of ridge width: Ridge width treatments i.e., 80, 90 and 100 cm between ridges had a significant effect on number of days to first flower opening, plant height, number of fruiting branches/plant, number of opened bolls/plant, boll weight, seed cotton yield/plant, seed

Table 2: Effect of sowing dates and ridge width during 2006 and 2007 seasons on flowering and fruiting

Characters	Number of days to first flower opening				Plant height (cm)				Number of fruiting branches/plant				Number of opened bolls/plant			
	Sole		Relay intercropping		Sole		Relay intercropping		Sole		Relay intercropping		Sole		Relay intercropping	
seasons																
treatments	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Sowing dates																
15th March	76.03	76.08	76.72	76.60	166.1	157.9	164.1	155.5	11.07	10.72	9.93	9.89	18.87	18.15	14.84	14.52
1st April	74.98	73.00	75.35	73.50	165.7	155.1	163.8	153.4	10.75	10.22	10.66	10.36	17.91	16.86	18.88	18.23
15th April	72.66	71.75	73.17	72.34	159.8	151.5	156.4	149.6	10.35	9.89	9.45	9.13	17.19	14.95	16.15	15.87
F test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5%	0.18	0.16	0.20	0.18	0.4	0.3	1.0	0.6	0.08	0.07	0.06	0.09	0.06	0.13	0.10	0.11
Ridge width (cm)																
80	74.70	73.92	75.17	74.52	164.7	155.1	162.2	153.2	10.58	10.13	9.93	9.77	17.77	16.47	16.52	15.98
90	74.52	73.74	75.11	74.18	164.0	154.7	161.3	152.7	10.72	10.29	10.05	9.78	17.98	16.65	16.66	16.20
100	74.45	73.16	74.97	73.74	162.9	154.6	160.8	152.6	10.87	10.40	10.07	9.84	18.22	16.84	16.70	16.44
F test	*	*	ns	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5%	0.09	0.19	-	0.22	0.3	0.2	0.9	0.5	0.07	0.09	0.08	0.05	0.10	0.05	0.11	0.05

*Significant test at 5% level of significance, ns: Nonsignificant

Table 3: Effect of by sowing dates and ridge width during 2006 and 2007 seasons on boll, seed and lint yield

Characters	Boll weight (g)				Seed cotton yield/plant (g)				Seed cotton yield (Kentar/fed)				Lint cotton yield (Kentar/fed)			
	Sole		Relay intercropping		Sole		Relay intercropping		Sole		Relay intercropping		Sole		Relay intercropping	
seasons																
treatments	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Sowing dates																
15th March	1.97	1.93	1.86	1.83	33.06	31.06	25.28	21.67	8.72	8.47	6.72	5.68	10.25	9.75	7.08	6.27
1st April	1.87	1.84	1.97	1.96	29.61	27.10	29.83	27.65	8.23	7.43	8.37	7.55	9.66	8.44	10.03	8.86
15th April	1.83	1.76	1.88	1.88	27.54	22.43	27.67	24.44	7.54	6.10	7.64	6.35	8.96	6.71	8.95	7.11
F test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.02	0.01	0.01	0.01	0.29	0.26	0.22	0.38	0.02	0.05	0.16	0.08	0.12	0.07	0.26	0.10
Ridge width (cm)																
80	1.88	1.83	1.89	1.87	29.32	26.34	27.46	23.50	8.02	7.13	7.44	6.28	9.35	7.99	8.41	7.04
90	1.89	1.84	1.90	1.89	30.09	26.83	27.55	25.05	8.15	7.31	7.47	6.64	9.65	8.28	8.62	7.53
100	1.91	1.86	1.91	1.90	30.79	27.42	27.76	25.22	8.32	7.55	7.82	6.66	9.86	8.62	9.03	7.67
F test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5%	0.01	0.01	0.01	0.01	0.22	0.13	0.26	0.37	0.09	0.03	0.15	0.12	0.08	0.04	0.21	0.18

*Significant test at 5% level of significance

cotton yield/fed and lint cotton yield/fed of both sole and relay intercropping cotton in the two growing seasons of this experimentation, excluding number of days to first flower opening of relay intercropping cotton in the first season as shown from data in Table 2 and 3.

Sowing sole or relay intercropping cotton on wide ridges (100 cm between ridges) produced the highest values of number of fruiting branches/plant (10.87, 10.40, 10.07 and 9.84), number of opened bolls/plant (18.22, 16.84, 16.70 and 16.44), boll weight (1.91, 1.86, 1.91 and 1.90 g), seed cotton yield/plant (30.79, 27.42, 27.76 and 25.22 g), seed cotton yield/fed (8.32, 7.55, 7.82 and 6.66 Kentar/fed), lint cotton yield/fed (9.86, 8.62, 9.03 and 7.67 Kentar/fed) of sole and relay intercropping cotton in the first and second seasons, respectively. Contrary, the lowest values of number of fruiting branches/plant (10.58, 10.13, 9.93 and 9.77), number of opened bolls/plant (17.77, 16.47, 16.52 and 15.98), boll weight (1.88, 1.83, 1.89 and 1.87 g), seed cotton yield/plant (29.32, 26.34, 27.46 and 23.50 g), seed cotton yield/fed (8.02, 7.13, 7.44 and 6.28 Kentar/fed), lint cotton yield/fed (9.35, 7.99, 8.41 and 7.04 Kentar/fed) were obtained as a result of sowing sole or relay intercropping cotton on narrow ridges (80 cm between ridges) in the first and second seasons, respectively. However, the highest values of studied growth characters i.e.., number of days to first flower opening (74.70, 73.92, 75.17 and 74.52) and plant height (164.7, 155.1, 162.2 and 153.2 cm) were resulted from sowing sole or relay intercropping cotton on narrow ridges (80 cm between ridges) in the first and second seasons, respectively.

The increases in yields of sole and relay intercropping cotton due to sowing on wide ridges, it may be attributed to sowing on ridge width is considered more suitable for low competition between plants that increased in photosynthesis rate and developed productivity.

Table 4: Land equivalent ratio (LER) and area time equivalent ratio (ATER) as affected by times of two last irrigations of wheat and sowing dates of cotton and ridge width of both wheat and cotton as well as their interaction during 2005/2006 and 2006/2007 growing seasons

Characters	LER		ATER	
treatments	2005/2006	2006/2007	2005/2006	2006/2007
Times of irrigations				
15th March and 1st April and 15th March	1.776	1.669	0.882	0.826
1st and 15th April and 1st April	2.030	2.043	1.015	1.022
15th April and 1st May and 15th April	2.081	2.075	1.039	1.038
F test	*	*	*	*
LSD at 5%	0.033	0.013	0.015	0.007
Ridge width (cm)				
80	1.993	1.924	0.993	0.959
90	1.987	1.947	0.992	0.971
100	1.907	1.917	0.951	0.955
F test	*	ns	*	ns
LSD at 5%	0.074	-	0.035	-

*Significant at 5 % level of significance, ns: Non-significant

Similar results were in coincidence with those fixed by Hussain *et al.* (2000), Maitra *et al.* (2000) and Mert *et al.* (2006).

Competitive relationships

Times of two last irrigations of wheat and sowing dates of cotton: There were significant differences between times of two last irrigations of wheat and sowing dates of cotton on Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) in the two growing seasons of study (Table 4).

The highest values of Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) were resulted from performing fourth and fifth irrigations of wheat at 15th April and 1st May, respectively and sowing cotton on 15th April in both seasons. The corresponding results were 2.081 and 2.075 as well as 1.039 and 1.038 in the first and second seasons, respectively. On the other side, the lowest means of LER (1.776 and 1.669) and ATER (0.882 and 0.826) were obtained from carrying out fourth and fifth irrigations of wheat at 15th March and 1st April, respectively and sowing cotton on 15th March in both seasons.

The results of competitive relationships i.e., Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) due to times of two last irrigations of wheat and sowing dates of cotton are in partial accordance with those found by Hussein and Samira (2005).

Ridge width of both wheat and cotton: Ridge width treatments of both wheat and cotton had a significant effect on Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) in the first season, vice versa in the second season (Table 4).

Sowing both wheat and cotton on ridges with width of 80 cm was the most favorable treatment that produced the highest average of LER (1.993) and ATER (0.993) in the first second. However, sowing both wheat and cotton on ridges with width of 100 cm was resulted in the lowest average of LER (1.907) and ATER (0.951) in the first second.

CONCLUSION

From obtained data, it can be concluded that in order to maximize seeds and lint cotton yields/fed of sole cotton, it must be sown in 15th March on ridges with width of 100 cm. However, for maximize seeds and lint cotton yields/fed of relay intercropping cotton, it must be sown in 1st April on ridges with width of 100 cm under the environmental conditions of Sharkia Governorate, Egypt.

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