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Maximizing Productivity, Profitability and Land Use Efficiency by Relay Intercropping Watermelon with some Wheat Cultivars under Drip Irrigation System

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ABSTRACT

A field experiment was carried out in Ismailia Experiment Station, ARC, Ismailia Governorate, Egypt, during 2016/2017 and 2017/2018 seasons, to study the effect of planting dates (1st, 10th and20th March) of watermelon relay intercropping with wheat and wheat cultivars (Misr 1, Gemmiza 11and Sakha 93) on productivity, land use efficiency and profitability per unit area. A split-plot design was used with three replications. Results indicated that growth, yield and its attributes of wheat were insignificant effect by watermelon planting dates. Contrary, planting dates of watermelon relay with wheat significantly affected watermelon traits. Early planting date on 1st March of watermelon had highest values of growth, yield and yield components. On the other hand, late planting date of watermelon decreased growth, yield and its components. Wheat cultivars varied significantly in all studied traits. Misr 1 cultivar had the highest grain yield/fad compared to Gemmiza 11 and Sakha 93. However, watermelon relay intercropping with wheat cultivar Sakha 93 significantly increased branches number/plant, number of fruits/plant, mean fruit weight and fruit yield/fad of watermelon. Relay intercropping watermelon with wheat Sakha 93 cultivar on 1st March had 15.41ardab/fad of grain wheat + 25.29 t/fad fruits of watermelon and increased land equivalent ratio (LER), area time equivalent ration (ATER) and total income compared to solid watermelon culture had 26.15 t/fad of fruits and 57920 L.E/fad, respectively. Therefore, this study suggested watermelon relay intercropping with wheat to share land resources and production inputs as well as increased wheat production and grower profitability in watermelon cultivated areas.

Keywords: Relay intercropping, wheat cultivars, watermelon planting dates, LER, ATER

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in terms of area and production. Also, wheat is considered as the first leading cereal crop in the world, due to its position as a staple food for the majority of the world population. However, there are gap between the national needs and the local wheat production. Therefore, crop intensification and food grains efforts are continually looking for ways to increase productivity of wheat to minimize gap between the Egyptian production and consumption, and increased profitability as well as land use efficiency in Egypt. This can be achieved through an effective use of modern techniques by the proper choice of intercropping date and suitable wheat cultivars.

Watermelon (*Citrullus lanatus* Thumb.) is one of the important vegetables crops in Egypt. The fruits are nutritionally important as a natural source of citrulline and carotenoids such as lycopene and βcarotene, a precursor of vitamin A (Setiawan *et al*., 2001; Edwards *et al*., 2003 and Collins *et al*., 2007). In Egypt, watermelon cultivation area was 109335 Fadden in 2018, which produced 1483255 tons with average 13.57 t/fad (FAO, 2020). About 50-53% of watermelon cultivation area during that period was cultivated in new reclaimed land using drip irrigation. Due to wider spacing between the watermelon plants and the large unutilized inter-space can be exploited for growing inter and mixed crops successfully to increase land use efficiency, farmers income, food security, reduction of soil erosion, pest, disease and weed control(Munisse *et al.*, 2012).

Cash crops have been increasingly used in intercropping system by local farmers in developing countries to provide increased economic returns and food production from limited land resources, *e.g.* intercropping watermelon with cereal crops(Olasantan and Babalola, 2007), relay intercropping wheat with cotton (Sherif*et al.*, 2011)watermelon/garlic (Chowdhury et al., 2015), wheat-maize/watermelon (Huang *et al.*, 2015), wheat/watermelon (Xu *et al.*, 2015) and watermelon/cotton (Miller and Greene, 2018). Potential benefits of intercropping include increased water, nutrient, and light efficiency and reduced pest and disease pressure (Machado, 2009 and Sullivan, 2003), also may provide insurance against crop failure (Lithourgidis*et al.*, 2011),higher efficient use of arable land and increase profitability per hectare for growers (Kahn, 2010 and Lithourgidis*et al.*, 2011). When crops are produced in an intercropping system, the yield of each species is usually lower than that obtained in sole crop production, even if the sum of relative yields is often greater than one (Sherif*et al.*, 2011; Yu *et al.*, 2015 and Martin-Guay*et al.*, 2018).

Largely, intercropping benefits are usually greater when the growth duration between the component crops differs widely (suggesting temporal effects) than when the crops durations are similar (suggesting spatial effects) (Fukai and Trenbath, 1993 and Yahuza, 2011). There was

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no relevance between time of seeding cotton (on15th and 30th March) and the growth and yield of wheat under relaying cotton with wheat system (Kamel*et al.*,1992). Dua *et al.* (2007) evaluated wheat-potato relay intercropping system and concluded that yield of potato was not influenced by relay intercropping but highest grain yield was obtained in sole wheat crop. Mkamilo (2004) found that simultaneous planting of maize and sesame caused reductions in maize grain yield, of an average 27%. These reductions decreased with delayed inter-seeding times. Conversely, delayed seeding led to significant reductions in sesame yield, caused by a direct effect of planting time and an increased competitiveness of maize. Similarly, late planting of watermelon led to greater melon yield and its components reduction than early planting in monocropping or intercropping systems, with greater effect occurring in intercropping in both years, while intercropping did not reduce the growth and yields of maize or cassava, irrespective of the planting date (Olasantan and Babalola, 2007).Sherif*et al.* (2011) found that the effect of planting dates of cotton relay intercropping with wheat on growth, yield and yield components of wheat was insignificant in both seasons, while cotton yield and its components significantly affected by cotton planting date.

Increasing wheat yield per unit area could be attained by cultivating high-yielding cultivars. Yield performance of wheat differs among cultivars due to variation in maturity duration, plant height, number of spike m-2, number of grain spike-1, 1000-grain weight, harvest index and grain yieldfad-1 (Fayed *et al.,* 2015; Kandil*et al.,* 2016 and EL Hag and Shahein 2017). However, cultivars suitable for intercropping system are difficult to find, because most plant breeding programs focus on sole crop systems with much larger cultivated areas and more complicated variety × cropping system interactions in intercropping systems than in sole crop systems (Hauggaard-Nielsen and Jensen, 2001). A number of studies indicated major differences in cultivar performance under different agronomic systems such as intercropping (Yadav and Yadav, 2001). On the other hand, Sherif*et al.* (2001) reported that wheat cultivars had no significant effect on growth, yield and its attributes of cotton. Therefore, the evaluation of the genetic material developed for monoculture may be insufficient to identify suitable genotypes for intercropping (Francis and Smith, 1985).

Thus, this research was implemented to find the best planting date of relayed intercropped watermelon with the suitable wheat cultivar to maximize productivity and profitability per unit area of the two crops under sandy soil conditions.

MATERIALS AND METHODS

Experimental site:

The present research was carried outat Ismailia Agricultural Experiments and Research Station, ARC, Ismailia Governorate, Egypt, during two seasons of 2016/2017 and 2017/2018 to find the best planting date of relayed intercropped watermelon with the suitable wheat cultivar to maximize productivity and profitability per unit area of the two crops under sandy soil conditions. The preceding crop was peanut in both seasons. The experimental soil was sand texture; it had 5.16 percent clay, 4.20 percent silt and 90.64 percent sand,0.56 percent organic matter and 7.82 pH as average of both seasons,according to standard methods described by Piper (1950). Drip irrigation system was used in both growing season.

Experimental design and treatments:

Treatments were arranged in a split-plot in a complete randomized block design with three replicates. Three planting dates of watermelon *cv.* Sakata hybrid (1st March, 10th March and 20th March) occupied main plots whereas wheat cultivars (Misr-1, Gemmiza-11 and Sakha-93) were arranged in the sub-plots. Experimental unit area was 36 m^2, it consisted from 3 raised beds (5.0 m length and 2.40 m in width). Variability between studied wheat cultivars are presented in Table 1.

Table 1. Variation among wheat cultivars in yield, plant height, growth region and maturity.

Cultivars	Yield ($kg\ ha^{-1}$)	Plant height (cm)	Growth Region
Sakha 93	6500	Short (90 cm)	All Egypt and salinity soils
Misr 1	8600	Medium (110 cm)	All Egypt
Gemmeiza 11	8200	Long (120 cm)	Delta, Nubaria, Fayum

Crop management:

The land was first cleaned and then disc ploughed, harrowed, leveled and then divided into raised beds 2.40 m width and 5 m length. Planting of wheat cultivars was done on 15th and 13rd November in the first and second seasons, respectively under sole and intercropping system.Wheat seeds were planting in 12 rows on the top of the raised bed at 20 cm between rowsin sole culture, while seeds of intercropped wheat were planting in 8 rows on the top of beds at 20 cm apart (wheat pant density is 67 % of its recommended). Seedlings of watermelon plant in stage of 3-4 trueleaves were transplanted on 1st March under sole culture, while transplanted in intercropping system conducted on 1st, 10th and 20th March in both seasons in ditch rows. The distances between the plants were 75 cm and 240 cm between beds.

The sources of nitrogen, potassium and phosphorus fertilizers were ammonium nitrate (33.5% N), potassium sulphate (48% K_2O) and calcium superphosphate (15.5% P_2O_5) and phosphoric acid, respectively. Calcium superphosphate at 200 kg /fad was applied during soil preparation, while poultry manure at 20m^3/fad was added in ditch rows for watermelon a month before planting watermelon. Both crops were fertilized with ammonium nitrate, phosphoric acid and potassium sulphate as fertigation as recommended for each crop. The harvest date for wheat wason 20th April and 17th April and watermelon on 23rd July and 25th July in the first and second seasons, respectively. Recommended cultural practices for growing each crop were used according to the instruction laid down by the Egyptian Ministry of Agriculture.

The drip irrigation network was distributed on the raised bed,put on each bed 3 laterals (16 mm diameter). Two laterals established on the top of the bed to irrigate wheat plants at 80 cm spaced, while the third lateral staying on the one side of the bed for watermelon. Drippers spacing were 40 and 75 cm for wheat and watermelon, respectively.

Recorded data:

Wheat traits:

At harvest, number of spikes/m^2 for each experimental unit was recorded, then ten guarded stems were taken randomly from each experimental unit and the following traits were measured; plant height (cm), spike length (cm), spikelets number/spike, grains number/spike and 1000-grain weight (g). Grain yield (kg/fad) was measured as all harvested plants from each experimental unit were weighted then threshed to assess grain yield/fad.

Watermelon traits:

Harvesting was carried out upon fruit maturity symptoms. Five fruits from each sub-plot were collected to measure; main branch length (cm), branch number/plant, fruit number/plant and fruit weight (kg) and total yield t/fad.

Intercropping indices:

Land equivalent ratio (LER)

Defined as the ratio of area needed under sole crop to intercropping at the same conditions to gain an equivalent yield (Willey, 1979). LER was determined according to the following formula:

$$\mathbf{(LER = (Yab / Yaa) + (Yba / Ybb}$$

Where; Yaa = Pure stand yield of crop a (water melon), Ybb = Pure stand yield of crop b (wheat), Yab = Intercrop yield of crop a (water melon) and Yba = Intercrop yield of crop b (wheat).

Area Time Equivalent Ratio (ATER): Area time equivalent ratio provides more realistic comparison of the yield of intercropping over monocropping in terms of time taken by component crops in the intercrop according to Hiebsch (1980).

$$\mathbf{ATER= (LERa \times DCa + LERb \times DCb)/ Dt}$$

Where LER is land equivalent ratio of crop, DC is duration (days) taken by crop, Dt is days to intercropping system from planting to harvest.

Aggressivety (A)

It mean a comparison of how much relative yield increase for the intercropped crop (a) on crop (b) with the expected crop to find out which of the two crops dominated in yield according to Mc-Gilchrist, (1965).

$$\mathbf{Aab = Yab / yaa \times zab - Yba/ ybb \times zba.}$$

The result of this equation is similar value for the main and the intercropped crops with either negative or positive signs. If the aggressivity is high for the dominant crop, the sign will be positive. The opposite occurs if the sign is negative, thus the crop is dominated. The greater numerical value of (Agg), gave greater difference in competitive abilities and hence the larger difference between actual and expected yield.

Total return/fad:

The total return per faddan was calculated for each treatment in Egyptian pounds, using the average market price for both years. The farm prices were 400 and 450L.E/ardab for grain wheat and 2000 and 2500 L.E / ton for watermelon in 2016/2017 and 2017/2018 seasons, respectively.

The Statistical analysis:

Data were analyzed according to Gomez and Gomez (1984). Treatment means were compared using least significant differences (LSD) test at 0.05 level of probability (Waller and Duncan, 1969). Statistical analysis was performed using analysis of variance technique of MSTATC statistical package (Freed, 1991).

RESULTS AND DISCUTION

1. Wheat characteristics:

1. Effect of relay intercropping date of watermelon with wheat:

Data in Table 2 showed that plant height, number of spikes/m^2, spike length, number of spikelets and grains/spike, 1000-grain weight and grain yield/fad of wheat were insignificant effect by planting date of watermelonin both seasons. This may be due to that watermelon was planted when the wheat plants reached later growth stage, and growth of watermelon plants became slow at the begging of its growing season.

Table 2. Effect of planting dates of watermelon intercropping with some wheat cultivars on wheat traits in both seasons.

Trait Treatment	Plant height (cm)	No. of spike/m^2	Spike length (cm)	No. of spikelets/spike	No. of grains/ spike	1000- grain weight (g)	Grain yield (ard./fad)
				First season			
1st March	100.18	368.44	11.29	20.36	44.11	39.53	15.87
10th March	100.11	364.22	11.23	20.45	43.65	39.65	15.84
20th March	99.91	360.89	11.15	20.37	43.36	39.68	15.80
LSD at 0.05	NS	NS	NS	NS	NS	NS	NS
				Second season			
1st March	103.15	373.00	11.75	21.07	44.42	40.25	16.76
10th March	103.16	370.11	11.81	21.08	44.50	40.21	16.73
20th March	102.87	374.44	11.80	21.15	44.61	40.34	16.80
LSD at 0.05	NS	NS	NS	NS	NS	NS	NS

Ardab (ard.)= 150 kg, fad= 4200m^2

Thus wheat crop reached full maturity before watermelon plants become a strong competitor for wheat plants. Intercropping benefits are usually greater when the growth duration between the component crops differs widely than when the crops durations are similar (Fukai and Trenbath, 1993 and Yahuza, 2011). There was no relevance between time of seeding cotton (on15th and 30th March) and the growth and yield of wheat under relaying cotton with wheat system (Kamel *et al.*, 1992). Relay intercropping of watermelon with maize or cassava did not reduce the growth and yields of maize or cassava, irrespective of the planting date of watermelon (Olasantan and Babalola, 2007).These results are in accordance with those obtained bySherif *et al.* (2011) they found that the effect of planting date of cotton on growth, yield and yield components of wheat was not pronounced.

2. Wheat cultivars performance:

Table 3 clearly indicated that growth, yield and yield components of wheat varieties variedsignificantly in the two growing seasons. Results indicated that wheat cultivar Misr 1 had the highest grain yield/fadcompared toGemmiza 11 and Sakha 93 by4.53 and 11.16% in first season and 4.57 and 11.24 % in second season, respectively. These results may be attributed to Misr 1had the greater number of spikes/m^2, which outnumbered that of Gemmiza11 and

Sakha 93 by 4.41%and6.52%,respectively, as an average of both seasons. On the otherhand, Sakha 93had the lowest value of grain yield/ faddan. Thismay be due to it had the least number of spikes/m^2 and number of spikelets/spike (Table 3). Yield performance of wheat differs among cultivars due to variation in growth, yield components and maturity duration. In this concern, Fayed et al., 2015; Kandil*et al.*, 2016 and EL Hag and Shahein 2017, reported similar conclusion.

The same table showed that wheat cultivarsunder solid culture outyielded the samerespective cultivar in the intercrop. The increases in grain yield/fad of solid wheat cultivars over those in the intercrop were17.68, 17.72 and 17.91 % in the first season and were 12.15, 12.83 and 15.22% inthe second season, respectively, for Misr 1, Gemmiza 11 and Sakha 93. This reduction could be attributed to plant density of wheat in intercropping culture reached 67% of sole culture. When crops are produced in an intercropping system, the yield of each species is usually lower than that obtained in sole crop production (Sherif*et al*., 2011;Yu*et al*. 2015 and Martin-Guay*et al.,* 2018).

Table 3. Effect of wheat cultivars intercropping with watermelon on wheat traits in both seasons.

Trait Treatment	Plant height (cm)	No. of spike/m^2	Spike length (cm)	No. of spikelets/spike	No. of grains/ spike	1000- grain weight (g)	Grain yield (ardab/fad)
				First season			
Misr 1	100.81	379.33	10.28	21.03	41.53	37.73	16.63
Gemmiza 11	105.06	360.56	12.42	21.99	36.81	41.85	15.91
Sakha 93	94.33	353.67	10.97	20.30	37.78	39.28	14.96
LSD at 0.05	3.61	6.88	0.23	0.31	1.32	1.03	0.06
Sole Misr 1	103.43	371.00	10.00	20.13	39.13	38.65	19.57
Sole Gemmiza 11	107.50	349.00	11.37	20.47	36.00	41.06	18.73
Sole Sakha 93	98.07	351.67	10.40	19.40	25.90	39.06	17.64
				Second season			
Misr 1	104.11	384.00	10.81	21.03	41.92	38.02	17.61
Gemmiza 11	109.53	370.55	12.75	21.98	36.83	42.75	16.84
Sakha 93	95.55	363.00	11.80	20.30	39.77	40.03	15.83
LSD at 0.05	4.98	6.13	0.34	0.31	0.54	0.3	0.05
Sole Misr 1	106.20	390.67	10.50	20.80	40.77	37.33	19.75
Sole Gemmiza 11	113.47	380.33	11.33	21.40	36.77	40.77	19.00
Sole Sakha 93	99.30	376.67	10.63	19.80	37.70	38.67	18.24

Ardab (ard.)= 150 kg, fad= 4200m^2

3. The interaction effect:

The interaction effect of planting date of watermelon and wheat cultivars was insignificant on all the studied traits of wheat in both seasons. These data show that each of these two factors act independently on all the studied traits of wheat, meaning that wheat cultivars responded similarly to different planting dates of watermelon as a relay intercrop with wheat and the planting date of watermelon had no significant effect on wheat performance irrespective the cultivar in both seasons (Table 4).These results are confirmed with those obtained by Sherif*et al.* (2011) they found that wheat characters were not affected by planting date of cotton x wheat cultivars in both seasons.

Table 4. Interaction effect of planting dates of watermelon intercropping with some wheat cultivars on wheat traits in both seasons.

Trait Treatment		Plant height (cm)	No. of spike/m^2	Spike length (cm)	No. of spikelets/spike	No. of grains/ spike	1000- grain weight (g)	Grain yield (ard./fad)
					First season			
1st March	Misr 1	101.00	383.00	10.40	20.16	41.60	37.36	16.66
	Gem. 11	104.87	360.33	12.40	21.13	38.20	41.65	15.95
	Sakha 93	94.67	362.00	11.06	19.80	37.53	39.58	14.99
10th March	Misr 1	100.73	380.33	10.20	20.26	41.40	37.73	16.63
	Gem. 11	105.17	359.00	12.43	21.13	36.70	42.05	15.91
	Sakha 93	94.43	353.33	11.06	19.96	37.86	39.18	14.98
20th March	Misr 1	100.70	374.67	10.23	20.33	41.60	38.10	16.60
	Gem. 11	105.13	362.33	12.43	21.06	35.53	41.86	15.87
	Sakha 93	93.90	345.67	10.80	19.73	37.96	39.07	14.93
LSD at 0.05		NS	NS	NS	NS	NS	NS	NS
					Second season			
1st March	Misr 1	103.80	385.33	10.76	21.03	41.93	38.06	17.61
	Gem. 11	110.00	367.00	12.63	21.86	36.73	42.60	16.84
	Sakha 93	95.66	366.67	11.86	20.33	39.60	40.10	15.83
10th March	Misr 1	104.50	380.00	10.76	21.03	41.90	37.93	17.58
	Gem. 11	109.46	371.66	12.83	22.00	37.03	42.86	16.81
	Sakha 93	95.53	358.66	11.83	20.23	39.56	39.90	15.79
20th March	Misr 1	104.03	386.66	10.90	21.03	41.93	38.06	17.64
	Gem. 11	109.13	373.00	12.80	22.10	36.73	42.86	16.88
	Sakha 93	95.46	363.66	11.70	20.33	40.16	40.10	15.87
LSD at 0.05		NS	NS	NS	NS	NS	NS	NS

2. Watermelon characteristics:

1. Effect of relay intercropping date of watermelon with wheat:

Data illustrated in Table 5 showed that planting date of watermelon relay with wheat had significantly effect on length of main branches, number of branches/plant, number of fruits/plant, mean fruit weight and fruit yield/fad of watermelon in both seasons. Early planting date on 1st Marchhad the highest values of the previous mentioned traits in both seasons. On the other hand, late planting date of watermelon decreased growth, yield and its components of watermelon. Grown watermelon with wheat on 1st March slightly increased fruit yield/fad by 0.21 and 2.24% and by 1.61 and 5.03% compared with grown on 10th and 20th March in first and second seasons, respectively.The slight variation between three planting dates in fruit yield ofwatermelon may be due to simple disparity in its planting dates.Late planting date of watermelon led to greater melon yield and its components reduction than early planting in monocropping or intercropping systems, with greater effect occurring in intercropping in both years (Olasantan and Babalola, 2007). These findings are in accordance with the study made by Sherif*et al.* (2011).

Table 5. Effect of planting date of watermelon intercropping with some wheat cultivars on water- melon traits in both seasons.

Trait Treatment	Branches Length (cm)	No. of branches /plant	No. of fruit /plant	Fruit weight (kg)	Fruit yield ton/fad
	First season				
1st March	186.51	12.00	3.04	3.765	23.71
10th March	184.01	11.78	2.89	3.646	23.66
20th March	181.23	11.48	2.78	3.541	23.19
LSD at 0.05	0.46	0.23	0.10	0.109	0.07
	Second season				
1st March	187.00	11.88	3.44	3.913	25.28
10th March	183.05	11.85	3.42	3.784	24.88
20th March	181.15	11.62	3.14	3.688	24.07
LSD at 0.05	0.95	0.20	0.08	0.114	0.56

2. Effect of wheat cultivars:

The effect of wheat cultivars on growth, yield and yield components of watermelon was significant in both seasons (Table, 6). Relay intercropping of watermelon with wheat cultivar Sakha 93 had the highest values of branches number /plant, number of fruits/plant, mean fruit weight and fruit yield/fad of watermelon, while the longest main branches was produced by intercropping watermelon with Gemmiza 11 cultivar in both seasons.Thesedata may be due to Gemmiza 11 had the tallest plants (Tables 1&3), which affected negatively the response of watermelon plants to intercept more solar radiation compared to those grown with the other wheat cultivars. Also, longest maturity period of Gemmiza 11(Table, 1)prolonged competition period between watermelon and wheat. Fruit yield/fad of watermelon rely intercropping with wheat Sakha 93 significantly increased by 3.41 and 6.17% in first season and were 1.94 and 3.66% in second season compared to Misr 1 and Gemmiza 11, respectively. These results could be attributed to Sakha 93 cultivar decreased inter-specific competition between the intercrops for basic growth resources during watermelonemergence and development which reflected positively on number of branches and fruits/plant of watermelon crop. Wheat cultivar Sakha 93 that had the medium growth durationand shortest plants (Table, 1) could be allowed more solar radiation penetration to adjacent watermelon plants which reflected positively on growth and production.These results are in contrast with those obtained bySherif*et al.* (2011) they found that insignificant effect for wheat varieties on growth, yield components and yield of cotton.Results in Table 6 also indicated that growth, fruit yield and it components of watermelon relay intercropping with wheat diminished compared to solid planting,this isresult of inter-specific competition between wheat and watermelon plants.

Table 6. Effect of wheat cultivars intercropping with watermelon on watermelon traits in both seasons.

Trait Treatment	Branches Length (cm)	No. of branches /plant	No. of fruit /plant	Fruit weight (kg)	Fruit yield ton/fad
	First season				
Misr 1	184.70	11.44	2.88	3.695	23.46
Gemmeiza 11	186.44	11.28	2.50	3.357	22.85
Sakha 93	180.61	12.53	3.33	3.899	24.26
LSD at 0.05	0.63	0.09	0.10	0.080	0.04
Sole watermelon	190.46	12.75	3.44	3.968	24.87
	Second season				
Misr 1	184.69	11.46	3.39	3.781	24.72
Gemmeiza 11	186.33	11.24	3.10	3.539	24.31
Sakha 93	180.19	12.64	3.52	4.065	25.20
LSD at 0.05	0.75	0.12	0.11	0.088	0.19
Sole watermelon	194.04	12.86	3.60	4.100	26.43

3. The interaction effect

Results in Table 7 indicated that response of wheat cultivars to planting date of watermelon relay intercropping with wheat significantly effect on main branches length and number of branches/plant in first season and number of fruits/plant in second seasons, while fruit weight and fruit yield/fad were significantly in both seasons. The highest values of the previous mentioned traits were produced by relay intercropping watermelon with wheat Sakha 93 cultivar on 1st March, except length of main branch/plant. Meanwhile, the lowest values were obtained by relay intercropping watermelon with Gemmiza 11on 20th March. This is indicated that late relay intercropping date of watermelon with Gemmiza 11 unfavorable condition for growth and development of watermelon plants, which increased intra and inter-specific competition between intercrops.

Intercropping Index:

Land equivalent ratio

LER was used as a criterion for measuring efficiency of intercropping advantage by comparing the intercropped area with mono-cropping (Willey, 1979). Data presented in Table 8 pointed out the relative yield of watermelon crop was ever higher than those of the relative yield of the wheat cultivars, could be attributed to plant population of intercropped wheat was 67% of its solid planting. Data on the relative yield also revealed that relay watermelon with wheat at the first date (1st March) resulting in the highest land equivalent rations, irrespective wheat cultivar was used. The mean values of LER of the planting dates (1st March, 10th March and 20th March) achieved yield advantage of 82, 81 and 79% in the first season and 84, 82 and 79% in the second as compared with solid planting. The same table indicated that when Sakha 93 was used in the intercrop, total LER of both wheat and watermelon were higher than other two cultivars under the same respective dates of planting watermelon in both seasons. Furthermore, Sakha 93 grown with watermelon on 1st March produced the highest LER 1.84 in the first season and 1.85 in the second season. These results are in harmony with those obtained by Olasantan and Babalola, (2007);Munisse*et al.* (2012); Huang *et al.* (2015) and Miller and Greene (2018) they reported that intercropping watermelon with wheat achieved yield advantage with LER values exceeded the unit.

Table 7. Interaction effect of planting dates of watermelon intercropping with some wheat cultivars on watermelon traits in both seasons.

Trait / Treatment		Branches Length (cm)	No. of branches /plant	No. of fruit /plant	Fruit weight (kg)	Fruit yield ton/fad
		First season				
1st March	Misr 1	186.87	11.60	3.00	3.828	23.47
	Gem. 11	188.83	11.43	2.60	3.548	23.08
	Sakha 93	183.83	12.97	3.53	3.918	24.59
10th March	Misr 1	184.50	11.50	2.83	3.722	23.81
	Gem. 11	184.80	11.23	2.53	3.323	22.78
	Sakha 93	182.73	12.60	3.30	3.892	24.39
20th March	Misr 1	182.73	11.23	2.80	3.535	23.11
	Gem. 11	185.70	11.17	2.37	3.200	22.68
	Sakha 93	175.26	12.03	3.17	3.887	23.79
LSD at 0.05		1.09	0.16	NS	0.137	0.06
		Second season				
1st March	Misr 1	188.00	11.50	3.53	3.843	24.80
	Gem. 11	189.16	11.33	3.20	3.684	25.06
	Sakha 93	183.83	12.80	3.60	4.211	25.99
10th March	Misr 1	184.03	11.53	3.40	3.786	25.09
	Gem. 11	185.33	11.30	3.30	3.475	24.37
	Sakha 93	179.80	12.73	3.56	4.092	25.18
20th March	Misr 1	182.03	11.36	3.23	3.714	24.27
	Gem. 11	184.50	11.10	2.80	3.457	23.50
	Sakha 93	176.93	12.40	3.40	3.893	24.44
LSD at 0.05		NS	NS	0.19	0.152	0.32

Area time equivalent ratio

ATER provides more realistic comparison of the yield advantage of intercropping over sole cropping in terms of variation in time taken by the component crops of intercropping culture. In all the treatments, the ATER values were lesser than LER values indicating the over estimation of resource utilization.ATER followed the same trends as influence by the planting dates of watermelon and wheat cultivars (Table, 8). However, at the latest date diminished ATER to less than the unit in most cases indicating loss rather than yield advantage. In general, ATER valuesof first planting date of March were higher than the other planting date on 10th and 20th March in both seasons. With respect to wheat cultivars, area time equivalent ratio (ATER) of Sakha 93 was higher than Misr 1 and Gemmiza 11 in both seasons. As a consequence to these observations, the highest values of all land equivalent ratio were obtained when Sakha 93 was planted at first of March, whereas, the least of these values were obtained when Gemmiza11 was planted at the late date (20thMarch). Similar results were reported by Sherif*et al.* (2011).

Aggressivity (A)

It mean a comparison of how much relative yield increase for the intercropped crop (a) on crop (b) with the expected crop to find out which of the two crops dominated in yield according to Mc-Gilchrist, (1965). If the value of A is zero, both crops are equal. If the value presented in Table 8 showed that all values of aggressivity were lower than unity. Values for wheat were positive (dominant), of A is positive for a crop (a) then crop (a) is dominant over the other and vice versa. Results whereas, values for watermelon were negative (dominated) in all treatments of study, Indicated that wheat was more competitive than watermelon. The greater the numerical value, the higher is the difference in competitive abilities and the higher the differences between the actual and the expected yields. Abd El-Zaher and Ali (2012) also reported that values of aggressivity under intercrop showed that wheat was dominant and cotton was the dominated crop in the intercropping systems.

Table 8. Interaction effect of planting dates of watermelon intercropping with some wheat cultivars on competitive relationships, total income and increases% in both seasons.

Trait / Treatment		Land equivalent ratio: RY_{melon}	RY_{wheat}	LER	ATER	Aggressivity: A_{melon}	A_{wheat}	Total return LE/fad	Increase %
					First season				
1st March	Misr 1	0.94	0.87	1.81	1.09	-0.65	0.65	53604	7.70
	Gem. 11	0.93	0.87	1.79	1.08	-0.67	0.67	52540	5.56
	Sakha 93	0.99	0.85	1.84	1.10	-0.53	0.53	55176	10.86
10th March	Misr 1	0.96	0.87	1.82	1.06	-0.63	0.63	54272	9.04
	Gem. 11	0.92	0.86	1.78	1.03	-0.68	0.68	51924	4.32
	Sakha 93	0.98	0.85	1.83	1.06	-0.54	0.54	54772	10.05
20th March	Misr 1	0.93	0.87	1.79	1.00	-0.67	0.67	52860	6.20
	Gem. 11	0.91	0.86	1.77	0.99	-0.68	0.68	51708	3.89
	Sakha 93	0.96	0.85	1.80	1.01	-0.58	0.58	53552	7.59
Solid watermelon		1	-	1	-	-	-	49772	
					Second season				
1st March	Misr 1	0.94	0.89	1.83	1.09	-0.66	0.66	69925	5.84
	Gem. 11	0.95	0.89	1.83	1.09	-0.63	0.63	70228	6.30
	Sakha 93	0.98	0.87	1.85	1.10	-0.52	0.52	72099	9.13
10th March	Misr 1	0.95	0.89	1.84	1.06	-0.63	0.63	70636	6.91
	Gem. 11	0.92	0.88	1.81	1.04	-0.67	0.67	68490	3.67
	Sakha 93	0.95	0.87	1.82	1.05	-0.57	0.57	70056	6.04
20th March	Misr 1	0.92	0.89	1.81	1.01	-0.69	0.69	68613	3.85
	Gem. 11	0.89	0.89	1.78	0.99	-0.73	0.73	66346	0.42
	Sakha 93	0.92	0.87	1.79	1.00	-0.63	0.63	68242	3.29
Solid watermelon		1	-	1	-	-	-	66068	-

Total return/fad and increase %:

The evaluation of different intercropping treatments of relayed watermelon with wheat was made for the two seasons as a total return of the twocomponents and increases % of total return wascomparative with solid watermelon as a main cropaccording to marketprice as shown in Table 8.Relayed watermelon at first of March resulted in highest total income and increase % of total return compared to solid watermelon, regardless the cultivar of wheat was in the association with watermelon. On other hand, transplanting watermelon on 10th March resulted in better total income rather thandelayed to the end of March. These results hold true in both seasons relay watermelonwith wheat Sakha 93 cultivar had the highest gross return.Msir 1 ranked the second whereas Gemmiza11 ranked the third. Intercropping wheat Sakha 93 with watermelon on first of Marchmaximizinggross revenue and had increase % of total revenue by 10.86 and 9.13% over that solid watermelon in first and second season, respectively. Whereas the minimum gross revenue wasobtained when watermelontransplanting on 20 of March was relay on Gemmiza11. It is alsoevident that, relayed watermelonwith wheat under any date or cultivar of wheat exceededthe prevailing system solid watermelon.Increasing grower profits is likely the greatest benefits of intercropping. Olasantan and Babalola, 2007; Kahn, 2010; Lithourgidis*et al.,* 2011; Chowdhury *et al*., 2015andMiller and Greene, 2018are accordance with these results.

CONCLUSION

Considering the aforementioned discussion,it can be concluded that relayedintercropping watermelon with wheat cultivar Sakha 93 on first March produced 15.41ardab/fad of grain wheat,in addition to 25.29 ton/fad of watermelon fruits, which increased the gross return by 10% and increased land use by 84%,compared to solid watermelon cultivation averaged overboth seasons. It is evident that, intercropping is more profitable than the soleplanting of both crops. Thus, relay intercropping wheat with watermelon in its cultivated area seems to be a promising strategy toreducewheat food gap.

REFERENCES

Abd EL-Zaher, Sh.R. and A.M.Ali (2012). Relay intercropping of cotton with wheat under different nitrogen fertilizer levels. Egypt. J. Agron., 34 (2):283-299.

Chowdhury, M. M. U., I. S.M. Farhad, S. K. Bhowmik, A. S. M. M. R. Khan and A. K.Choudhury (2015). Inter-space utilization through garlic (*Allium sativum*) production in watermelon (*Cirullus Lanatus*) field in coastal saline area. World J. Agric. Sci., 11 (5): 285-288.

Collins, J.K., G. Wu, P. Perkins-Veazie, K. Spears, P.L. Claypool and R.A. Baker, (2007). Watermelon consumption increases plasma arginine concentrations in adults, Nutrition, 23: 261-266.

Dua, V.K., P.M. Govindakrishnan and S.S. Lal (2007).Evaluation of Wheat-Potato Relay intercropping system in the mid hills of Shimla. Indian J. Agric. Res. 41: 142-147.

Edwards, A.J., B.T. Vinyard, E.R. Wiley, E.D. Brown, J.K. Collins, P.Perkins-Veazie, R.A.Baker, B.A.Clevidence (2003). Consumption of watermelon juice increases plasma concentrations of lycopene and β-carotene in humans. J. Nutr. 133: 1043-1050.

EL Hag, D. A.A. and A. M.E.A. Shahein(2017). Effect of Different Nitrogen Rates on Productivity and Quality Traits of Wheat Cultivars. Egypt. J. Agro., 39 (3): 321 – 335.

FAO (2020).Food and Agriculture Organization of the United Nations.

Fayed ,T. B., E. I. El-Sarag, M. K. Hassanein and A. Magdy (2015). Evaluation and prediction of some wheat cultivars productivity in relation to different planting dates under North Sinai region conditions. Ann. Agric. Sci., doi.org/10.1016/j.aoas.2014.12.001

Francis, C.A. and M.E. Smith (1985).Variety development for multiple cropping systems.Crit Rev Plant Sci., 3:133-168.

Freed R.D. (1991).MSTATC Microcomputer Statistical Program.Michigan State University, East Lansing, Michigan, USA.

Fukai, S. and B.R. Trenbath (1993). Processes determining intercrop productivity and yields of component crops. Field Crops Res., 14:263–290.

Gomez K.A. and A.A. Gomez (1984).Statistical Procedures for Agricultural Research. 2nd Ed. Toronto, ON, Canada: John Willey and Sons.

Hauggaard-Nielsen, H. and E S. Jensen (2001).Evaluating pea and barley cultivars for complementarity in intercropping at different levels of soil N availability. Field Crops Res., 72, 185–196.

Hiebsch, C.K. (1980). Principles of intercropping."Effect of N fertilization and crop duration on equivalence, ratios in intercrops versus monoculture comparisons."PhD Thesis.North Carolina State Univ., Raleigh, N. C.Y., USA.

Huang, C., Q.Liu, N.Heerink, T.Stomph, B.Li, R.Liu (2015).Economic Performance and Sustainability of a Novel Intercropping System on the North China Plain.PLoS ONE 10(8):1-16.

Kahn, B.A. (2010). Intercropping for field production of peppers. Hort. Tech., 20:530–532.

Kamel, A.S., I.O. El-Said, M.S. Sleam, N.A. El-Hawary and M.A. El-Masry (1992). Relay cropping of cotton with some long duration winter crops. Proc. 5th. Conf. Agron. Zagazig, 13-15 Sept., 2: 588-596.

Kandil, A. A., A.E.M. Sharief, S.E. Seadh and D.S.K. Altai (2016) Role of humic acid and amino acids in limiting loss of nitrogen fertilizer and increasing productivity of some wheat cultivars grown under newly reclaimed sandy soil. Int. J. Adv. Res. Biol. Sci., 3(4): 123-136

Lithourgidis, A.S., C.A. Dordas, C.A. Damalas, and D.N. Vlachostergios.(2011). Annual intercrops: An alternative pathway for sustainable agriculture. Austral. J. Crop Sci. 5(4):396–410.

Machado, S. (2009). Does intercropping have a role in modern agriculture? J. Soil Water Conserv. 84:55–57.

Martin-Guay M. O., A.Paquette, J.Dupras, D.Rivest(2018). The new green revolution: sustainable intensification of agriculture by intercropping. Science of the Total Environment, 615: 767–772.

Mc-Gilchrist,C.A.(1965):Analysis of competition on experiments.Biometrics, 21: 975-985.

Miller, G. and J. Greene (2018).Intercropping seedless watermelon and cotton.Hortsci., 53(12):1799–1803.

Mkamilo, G. (2004). Maize-sesame intercropping in Southeast Tanzania : Farmers' practices and perceptions, and intercrop performance. PhD Thesis, Wageningen University, The Netherlands, 112 pp., with English and Dutch summaries.

Munisse, P., B. D. Jensen, O. A. Quilambo and S. B. Andersen (2012).Watermelon intercropped with cereals under semi-arid conditions: an on-farm study. Exper. Agric., 48 (3): 388-398.

Olasantan, F. O. and O. A. Babalola (2007).Environment and rhizosphere fungi and bacterial populations of maize and cassava.Biological Agric. &Horti. An Inter. J. for Sustain. Production Systems. (4): 415-436.

Piper, C. S. (1950).Soil and Plant Analysis. Inter. Science Publishers, Inc. New York.

Setiawan B., A.Sulaeman, D.W.Giraud, J.A.Driskell (2001). Carotenoid content of selected Indonesian fruits. J. Food Comp. Anal. 14: 169-176.

Sherif, S.A., S.T. Ibrahim and W. Kh.Mohamed (2011). Relay intercropping of cotton with wheat in reclaimed land. Egypt. J. Agron., 33(1): 51-65.

Sullivan, P. (2003). Intercropping principles and production practices. Appropriate technology transfer for rural areas. 31 Dec. 2017. http://www.attra.ncat.org>.

Waller, R. A. and D.B.Duncan (1969). A Bayes rule for the symmetric multiple comparisons problem. J. Amer. Stat. Assoc., 64:1484-1506.

Willey, R.W. (1979): Intercropping-Its importance and research needs part.1- competition and yield advantage. Field Crop Res., 32:1-10.

Xu,W.; Z.Wang and F.Wu (2015). The effect of D123wheat as a companion crop on soil enzyme ctivities, microbial biomass and microbial communities in the rhizosphere of watermelon. Frontiers in Microbiology, Volume 6, Article 899.

Yadav, R.S., O.P. Yadav (2001). The performance of cultivars of pearl millet and cluster bean under sole cropping and intercropping systems in arid zone conditions in India. Exp. Agric., 37:231-240.

Yahuza, I. (2011). Review of some methods of calculating intercrop efficiencies with particular reference to the estimates of intercrop benefits in wheat/faba bean system. Inter. J. of Biosci., 1 (5): 18-30.

Yu Y, T. J. Stomph, D.Makowski, W.van der Werf (2015). Temporal niche differentiation increases the land equivalent ratio of annual intercrops: a meta-analysis. Field Crops Res., 184, 133–144.

تغظيم الإنتاجية والربحية وكفاءة أستخدام الأرض بالتحميل المناوب للبطيخ مع بعض أصناف القمح تحت نظام الرى بالتنقيط

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أجريت دراسة حقلية بمحطة بحوث الإسماعلية- محافظة الإسماعلية – مصر، خلال موسمى ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ لدراسة تأثير ثلاثة مواعيد لزراعة البطيخ المناوب مع القمح (١ مارس- ١٠مارس- ٢٠ مارس) وثلاثة أصناف من القمح (مصر ١- جميزة ١١- سخا ٩٣)على إنتاجية كلا المحصولين وكفاءة استخدام الأرض والعائد الأقتصادى من وحدة المساحة. إستخدم تصميم القطع المنشقة فى ثلاث مكررات. وأوضحت النتائج أن صفات نمو ومحصول القمح ومساهماتة لم تتأثر معنويا بمواعيد زراعة البطيخ المناوب مع القمح فى كلا الموسمين. وعلى النقيض، أثرت مواعيد زراعة البطيخ معنويا على محصول البطيخ ومكوناتة فى كلا الموسمين. سجلت الزراعة المبكرة فى ١ مارس أعلى القيم لصفات النمو ومحصول ثمار البطيخ ومكوناتة، بينما إنخفضت تلك الصفات السابقة بتاخير زراعة البطيخ إلى ٢٠ مارس فى كلا الموسمين. تباينت أصناف القمح فى الصفات المدروسة معنويا فى كلا الموسمين. حيث سجل الصنف مصر ١ أعلى محصول حبوب/للفدان مقارنة بالصنف جميزة ١١ وسخا ٩٣. ومع ذلك حقق التحميل المناوب للبطيخ مع صنف القمح سخا ٩٣ أعلى القيم لصفة (عدد الفروع/نبات- عدد الثمار/نبات- متوسط وزن الثمرة- ومحصول ثمار البطيخ/للفدان). لم يُظهر التفاعل بين مواعيد زراعة البطيخ وأصناف القمح تأثيراً معنوياً على محصول القمح ومكوناتة فى كلا الموسمين. بينما التفاعل بين مواعيد زراعة البطيخ وأصناف القمح أظهر تأثيراً معنوياً على طول الفرع الرئيسى و عدد الفروع/نبات (بالموسم الأول)– عدد الثمار/نبات (بالموسم الثانى) – متوسط وزن الثمرة و محصول البطيخ/فدان (فى كلا الموسمين) . التحميل المناوب للبطيخ فى ١ مارس مع الصنف سخا ٩٣ حقق ١٥,١٤ أردب قمح + ٢٥,٢٩ طن ثمار بطيخ بالإضافة إلى زيادة المكافى الإرضى والزمنى وإجمالى الإيراد النقدى وكانت القيم ١,٨٤و ١,١٠ و ٦٣٦٣٧جنية/فدان ،على التوالى، مقارنة بالزراعة المنفردة للبطيخ والتى حققت ٢٦,١٥ طن ثمار بطيخ و أجمالى أيراد نقدى ٥٧٩٢٠ جنية/ للفدان، كمتوسط للموسمين. تقترح هذة الدراسة تناوب زراعة القمح والبطيخ فى مناطق زراعة البطيخ لزيادة إنتاج القمح وتقليل الفجوة الغذائية من القمح وزيادة العائد الإقتصادى وكفاءة إستخدام الأرض.