Journal of Agri-Food and Applied Sciences
Available online at jaas.blue-ap.org
©2016 JAAS Journal. Vol. 4(1), pp. 32-42, 29 February, 2016
E-ISSN: 2311-6730

Effect of some cropping systems and preceding crops on production and quality of cotton characters

Metwally, A.A.[1*], Abuldahab, A.A.[1], Shereif, M.N.[2] and Awad, M.M.[2]

1- Agronomy Department, Faculty of Agriculture, Cairo University, Giza, Egypt.
2- Crop intensification Research Department, Field crops Research Institute, Agricultural Research Center, Giza, Egypt.

Corresponding Author: Metwally, A.A

Received: 13 December, 2015 *Accepted: 14 January, 2016* *Published: 29 February, 2016*

ABSTRACT

A Two-year study was conducted at Kafr EL-Hamam Agricultural Experiments and Research Station, ARC, Sharkia governorate, Egypt during 2009/2010 and 2010/2011 seasons to study the effect of new cropping systems of growing cotton by planting cotton in relay intercropping with faba bean and wheat or solid plantings after these winter crops. The experimental treatments were laid out in a split plot design with three replications. Two cotton cultivars (Giza 86 and Giza 90) were grown in the main plots meanwhile cropping systems were devoted in sub plot as followed: cotton after Egyptian clover (E.c) at 20th March, 20thApril and 20th May. Relay intercropping cotton with faba bean and wheat at 20th March. Growing cotton seeds after faba bean and wheat at 20th April or 20th May, respectively. Faba bean was grown on one side or both sides of the ridge, meanwhile wheat was grown at two or three rows per ridge. Cotton cultivar Giza 86 had higher values for plant height, number of total and open bolls per plant, seed cotton yields per plant and per ha, and fiber technology traits than those of another cotton cultivar. Growing cotton plants as followed E.c or intercropping with faba bean crop at 20th March had the same effects of cotton traits grown solid plantings at 20th April. The late date planting cotton (20th May) as followed after Egyptian clover or wheat caused significant reductions in all the studied cotton traits as compared with those growing in the early date. Growing cotton after/with legumes had positive effect on cotton traits in comparison with those followed or intercropped with wheat. Low plant density of faba bean (one row/ridge) or wheat (two rows/ridge) decreased their effects on cotton traits under relay intercropping, meanwhile, the cotton traits was not affected by plant density of faba bean or wheat when cotton grown after these crops. Cotton cultivar Giza 90 was superior to another cultivar Giza 86 for all traits in the late date.

Keywords: Cropping systems, Wheat, Cotton cultivars, Faba bean, Egyptian clover.

INTRODUCTION

Cropping index refers to the times of sequential crop planting in the same arable land in one year, usually defined as the ratio of the total cultivated area to the arable land area (Liu, 2013). However, the indeterminate growth habit of cotton (*Gossypium barbadense* L.) plants makes them very responsive to changes in the environment and management. Cotton is the most important fiber crop in the world, the lint is used to make processed cotton which is woven into fabrics, either alone or combined with other fibers. Unfortunately, there was a reduction in the cultivated area of cotton in Egypt. It decreased from 447,175 ha in 1982 to 135,714 ha at 2012. This is a result of increasing production costs which did not match up with cotton production and decreasing net return as compared with other summer crops *i.e.* maize and rice (Bulletin of Statistical Cost Production and Net Return, 2013), also because of interesting by growing long duration cash crop in winter in confirmed growing cotton in the rotation. So, many growers find it more remunerative to grow cotton at May after winter crops such as E.c (*Trifolium alexandrinum* L.) or wheat (*Triticum aestivum* L.) and faba bean (*Vicia faba* L.). Wheat is considered as strategic cereal crop and faba bean is the main legumes in Egypt. Also, E. c is winter annual legumes for livestock production in Egypt. The cultivated area of wheat and faba bean were 1,336,788 ha and 45,362 ha, respectively, as well as, E. c had 746,787 ha (Bulletin of Statistical Cost Production and Net Return, 2014).

So, the cropping system should be an approach to maintain the cotton cultivated area in an ever-changing agricultural environment. Seed cotton yield can be increased per unit area through proper crop management practices such as cotton cultivar, cropping system. Seed cotton yield and fiber technology may be altered by genotype and agronomic practices. Cotton cultivar selection accounts for 75% of fiber length variation, whereas 51% of micronaire variation is attributed to weather and management (Meredith, 1986). Each cultivar has a unique complement of molecular templates that determine the onset and duration of individual physiological processes of boll growth and development. Cotton genotypes vary with respect to lint percentage (Moser *et al*., 2000) and fiber quality (Baloch, 2001).

Concerning for cropping system, crop species and planting date led to a renewed interest in sequential and intercropping systems. Crop species in intercropping pattern must be carefully chosen to minimize competition and enhance the efficient use of water, light and nutrients (Sayed Galal *et al*., 1983) where there was several studies reported success of relay intercropping of cotton with some field crops in Egypt such as faba bean (Hussein and Haikal, 2000 and Zohry, 2005) and wheat (Hussein, 2006 and El-Hawary, 2009). However, this necessitates searching for the optimum densities of the components in intercrops whereas Abdel-Galil (2015) showed that increasing number of wheat rows from six to eight for ped(120 cm) may be increased inter-specific competition between the component crops for light interception during seedling and growth stages of cotton. This observation confirmed the important role of border rows as a compensatory mechanism for light interception.

Also, planting date of cotton within cropping system could be played an important role in yield and yield component of cotton plant where Kumar (1988) and Kamel *et al*. (1992) found that total bolls, seed cotton yield and its components decreased with delaying in planting date. Moreover, in Pakistan Hayatullah *et al.* (2011), showed that highest seed cotton yield was recorded by 25th April during both the years, while seed cotton yield was decreased by 5.27 % and 9.16% when the crop was sown on 10th and 25th May, respectively. Furthermore, Zhao *et al.* (2012) stated that boll weight was affected significantly by planting date.

In preview, cotton cultivars and cropping systems may have impact of seed cotton yield and yield component and fiber quality so the objective of this work to search on new cropping systems of planting cotton in Egypt by growing cotton in relay intercropping with some winter crops, as well as, growing it after these crops.

MATERIALS AND METHODS

Two field experiments were conducted at kafr EL-Hamam Agricultural Experiments and Research Station, ARC, Sharkia governorate (Lat. 30 º 34′ 00″ N, Long 31º 30 ′00″ E), Egypt during 2009/2010 and 2010/2011 seasons.The main objective is to study the effect of some cropping systems for two Egyptian cotton cultivars to find out new cropping systems of planting cotton in Egypt by growing cotton in relay intercropping with some winter crops, as well as, growing it after these crops. The experiment included twenty two treatments which were the combinations between two cotton cultivars and eleven cropping systems (Table 2). The Egyptian cotton cultivars Giza 86 and Giza 90 were used. They long staple, over 1.25 inches (Table 1). The preceeding winter crops were wheat (Sakha 93), faba bean (Giza 3) and E. c (Helaly) were used in the two growing seasons. Some varietal differences of the two tested Egyptian cotton cultivars are presented in Table (1). Cropping systems of growing cotton in relay intercropping or after harvesting winter crops were illustrated in Table (2) and Figure (1).

Table 1. Some varietal differences of the two Egyptian cotton cultivars.

Cotton cultivars	Giza 86	Giza 90
Pedigree	Crossing between Giza 75 x Giza 81	Crossing between Dandra x Giza 83
Country of origin	Egypt	Egypt
Class –growing areas	North Delta	Middle and Upper Egypt (South)
The 1st node of sympodial branch	7 or 8	6 or 7
Plant height	Tall	Medium (110-140 cm)
Size of boll casings	Medium	Large ($^3/_4$ of boll size)

These data were obtained by Cotton Research Institute, F.C.R.I., A.R.C., Giza, Egypt

Table 2. Cropping systems of growing cotton in relay intercropping or after harvesting winter crops

No.	Cropping system
S_1	Cotton was planted on one side of the ridge (70 cm width) after two cuts of Egyptian clover at 20th March (control).
S_2	Faba bean was planted on one side of the ridge (70 cm width) at 15th October and cotton was intercropped with faba bean on the other side of the ridge at 20th March on the next year. This system is called 'relay intercropping cotton with faba bean'.
S_3	Faba bean was planted on two sides of the ridge (70 cm width) at 15th October and cotton was intercropped with faba bean on one side of the ridge at 20th March on the next year. Plant density of faba bean was doubled than that of cropping system S_2

S_4	Relay intercropping cotton with wheat, wheat was planted by two rows of the ridge at 15th November and cotton was planted on one side of the ridge at 20th March on the next year .
S_5	Relay intercropping cotton with wheat as that of system 4, but wheat was grown by three rows on the ridge at 15th November (with the same population/m^2)
S_6	Cotton was planted after three cuts of Egyptain clover at 20th April, as that of cropping system S_1
S_7	Planting cotton after harvesting faba bean at 20th April without tillage. Faba bean was grown as that of cropping system S_2.
S_8	Planting cotton after harvesting faba bean at 20th April without tillage. Faba bean was grown as that of cropping system S_3.
S_9	Cotton was planted after four cuts of Egyptian clover at 20th May.
S_{10}	Planting cotton after harvesting wheat at 20th May without tillage. Wheat was grown as that of cropping system S_4.
S_{11}	Planting cotton after harvesting wheat at 20th May without tillage. Wheat was grown as that of cropping system S_5.

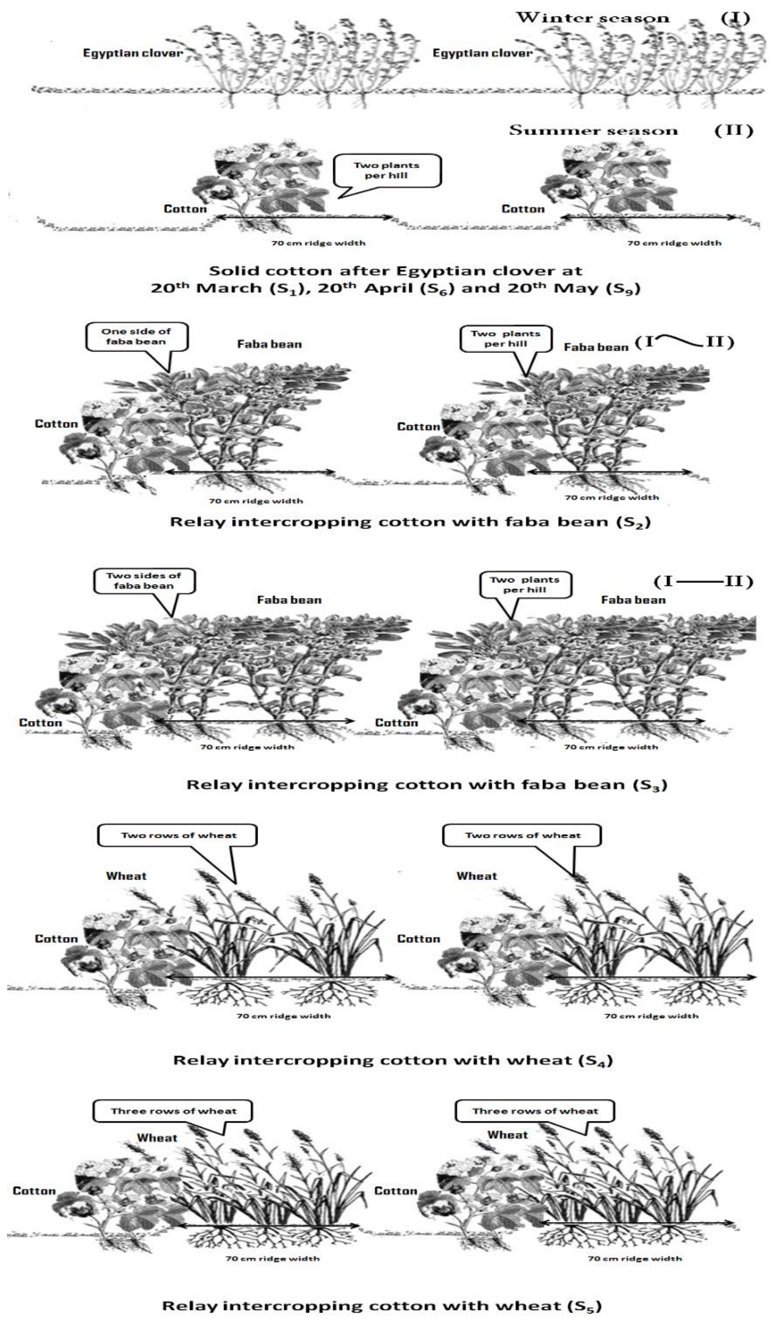

Figure 1. Cropping systems of growing cotton in relay intercropping or after harvesting winter crops

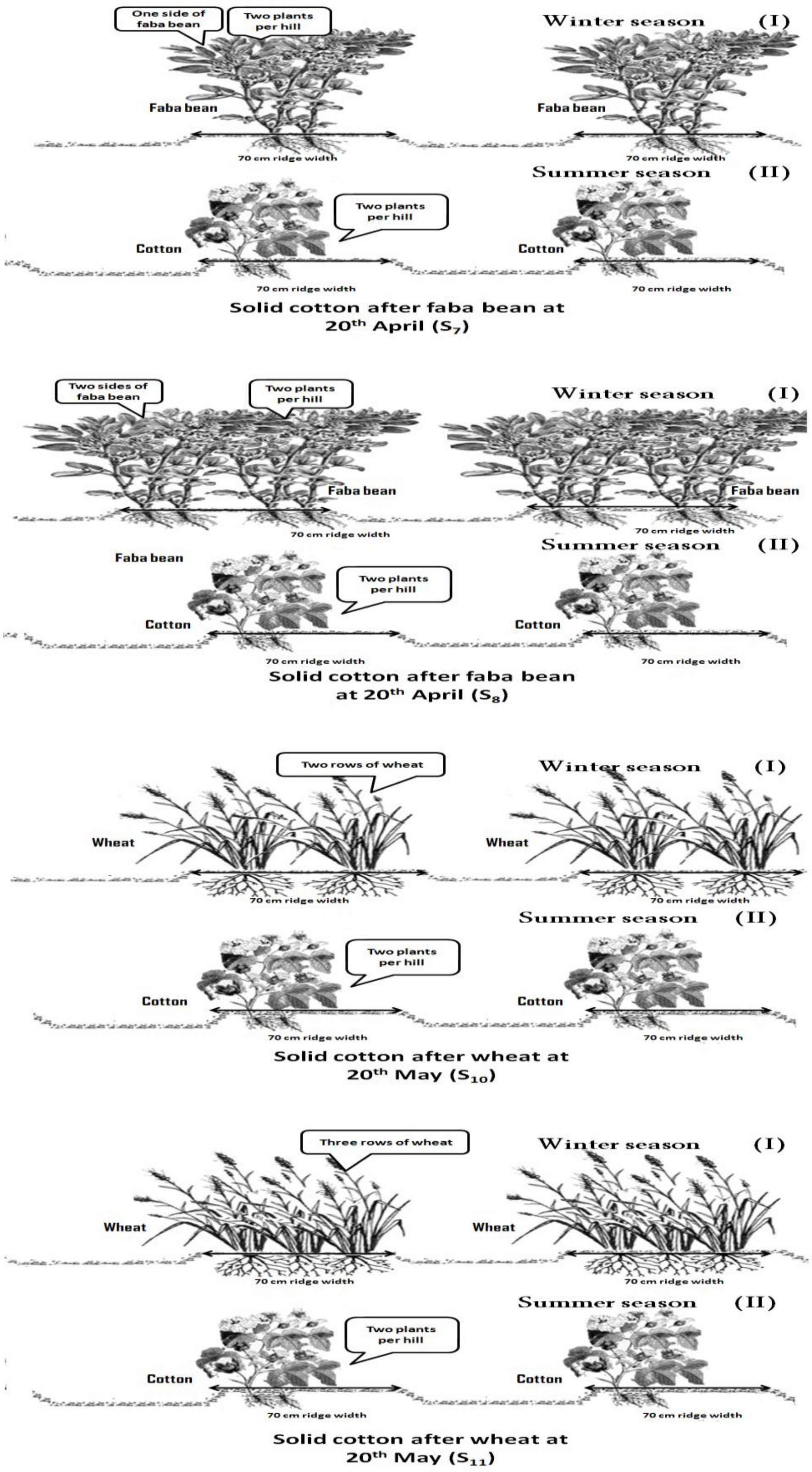

Figure 1. Continued

Solid plantings of cotton after E.c, faba bean and wheat were used to compare the performance of cotton plants under relay intercropping patterns with faba bean and wheat. The experiments were carried out in clay loam soil and the preceding crop was rice in the two seasons before growing the winter crops. Soil analysis of the experimental site are shown in Table (3).

Table 3. The physical and chemical analyses of the soil site after winter crops

Soil analysis	Preceding crops		
	Egyptian clover after 4 cuts	Faba bean	Wheat
Mechanical analysis			
Sand (%)	59.1	59.1	59.0
Silt (%)	20.0	21.0	20.0
Clay (%)	20.8	19.8	21.0
Soil texture	Clay loam	Clay loam	Clay loam
Chemical analysis			
PH 1:2.5	8.1	8.0	7.9
E.C. (dsm^{-1})	1.3	0.7	1.2
Calcium carbonate (%)	7.8	8.0	7.7
Nitrogen (ppm)	20.0	40.0	10.0
Phosphorous (ppm)	25.0	35.0	24.0
Potassium (ppm)	256.0	352.0	304.0
Magnesium (ppm)	26.0	33.8	26.0
Sodium (ppm)	106.7	153	105.6
Iron (ppm)	18.2	18.9	18.6
Mn (ppm)	14.0	13.6	13.9
Zn (ppm)	1.20	1.80	1.20
Cu (ppm)	1.20	1.74	1.10

The mechanical and chemical analyses of the soil were ocurred at ARC, Giza, Egypt. The experimental treatments were laid out in a split plot design with three replications. Cotton cultivars were randomly assigned to the main plots and cropping systems were arranged in sub plots. Each sub plot area consisted of 6 ridges (5.0 m long, 70 cm wide). The plot area was 21 m^2. Plants of cotton were thinned at two plants per hill distanced at 20 cm.

Other normal agronomic practices were practiced according to technical recommendations. Cotton cultivars were grown by 142857 plants per ha, while faba bean was planted by 285714 plants per ha in S3 and S7 but S2 and S6 was planted by 142857 plant per ha. E. c was drilled by rate of 48 kg per ha.

At harvest, ten individual guarded plants from cotton were taken randomly from each experimental unit to study plant height (cm) and yield components such as boll weight (g), number of total bolls per plant, number of open bolls per plant and seed cotton yield per plant (g). Seed cotton yield per ha was estimated as the weight of seed cotton yield was picked from the four middle ridges in sub plot, then converted to yield per ha in ton.

The measurements of fiber quality properties determined by the Cotton Technology Research Section, Cotton Research Institute, ARC, Giza, Egypt. The Digital Fibrograph Instrument was used to determine fiber length (upper half mean, UHM; mm). Fiber strength estimated by using the pressly tester (zero gauges). Micronaire (MIC) values was measured using micronaire instrument according to ASTM: D- 4604 – 05 (2005).

The homogeneity test was conducted of error mean squares and accordingly, the combined analysis of the two experimental seasons was carried out. The measured variables were analyzed by ANOVA using MSTATC statistical package (Freed, 1991). Mean comparisons were done using least significant differences (L.S.D.) method at 5 % level of probability to compare differences between the means as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Significance of mean squares of variation sources for each of plant height, total bolls/plant, boll weight, open bolls/plant, seed cotton yield/plant, seed cotton yield/ha, fiber length, pressly index and micronaire reading in combined data across 2009/2010 and 2010/2011 seasons, are presented in Table (4). All the studied traits were affected significantly by cotton cultivars except boll weight and micronaire reading. Also, all the studied traits were affected significantly by each of cropping systems and the interaction between cotton cultivars and cropping systems. But the reverse was true with the effects of years.

Cotton cultivars

Cotton cultivars were differed significantly for seed cotton yield, its attributes and fiber technology, meanwhile boll weight and micronaire reading were not differed significantly (Tables 5 and 6). Cotton cultivar Giza 86 had higher values for plant height, number of total and open bolls per plant, seed cotton yields per plant and per ha than Giza 90 cultivar. These increases were 12.90%, 11.66%, 8.26%, 17.24% and 12.60% for plant height, number of total bolls/plant, number of open bolls/plant, seed cotton yield/plant and per ha respectively. These results may be due to some varietal differances of each cultivar which formed its canopy could be interacted with the environmental conditions (Table 1). It is known that the growth and development of a plant are influenced by genetic factors, external environmental factors, and chemical hormones inside the plant. Genetic information directs the synthesis and development of enzymes which are critical in all metabolic process within the plant. Metabolic process is responsible for the three major functions that are basic to plant growth and development (photosynthesis, respiration and transpiration).

So, it may be possible that canopy architecture of Giza 86 cultivar played a major role in intercepting solar energy that reflected positively on higher dry matter accumulation in the cultivar than the other one. Differing cotton leaf shapes with varying lobing cause large alterations in the structure of the plant canopy and its ability to intercept light (Wells and Meredith, 1986). Accordingly, Giza 86 cultivar may adapted to environmental conditions of the experiment especially light intensity and temperature than another cultivar during boll formation and maturation. These results are in agreement with Hosny *et al*. (1990), Zhang *et al.* (2007), Noaman (2014) and Safina *et al.* (2014).

Also, it is important to mention that genetic information regulates the production of hormones. Boll opening is a process under the control of hormones. Ethylene is primarily responsible for triggering the process of boll opening. High auxin produced by the developing seeds counters the action of ethylene and prevents premature opening, but as the boll reaches maturity, auxin level drops and ethylene increases. Cells in a specialized layer in each suture of a boll enlarge and produce enzymes that dissolve their cell walls (Oosterhuis *et al*., 1994).

Table 4. Significance of variation sources as obtained from the combined analysis of the two seasons for some cotton traits at harvest as affected by two growing seasons, cotton cultivars, cropping systems and their interaction.

S.O.V	df	Plant height	Total bolls/plant	Boll weight	Open bolls/plant	Seed cotton yield/plant	Seed cotton yield/ha	Fiber length	Pressly index	Micronaire reading
Year (Y)	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cotton cultivars (C)	1	**	*	N.S.	**	**	**	**	**	N.S.
Y X C	1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cropping systems (S)	10	*	*	*	*	*	*	*	*	*
Y X S	10	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C X S	10	*	*	*	*	*	*	*	*	*
Y X C X S	10	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* = Significant at 5% level of probability
N.S. = Non-significant

Table 5. Seed cotton yield and its attributes as affected by cotton cultivars, cropping systems and their interactions (combined data across 2010 and 2011 seasons)

Characters / Treatments	Plant height (cm)			Total bolls/plant (no.)			Boll weight (g)		
	Giza 86	Giza 90	Mean	Giza 86	Giza 90	Mean	Giza 86	Giza 90	Mean
(S_1) Solid cotton after E.c at 20 March	147.6	127.8	137.7	19.27	15.56	17.41	2.80	2.57	2.68
(S_2)Inter.cotton with faba been (1 side) at 20 March	146.9	120.1	133.5	18.25	15.65	16.95	2.77	2.68	2.73
(S_3) Inter.cotton with faba been (2 sides) at 20 March	136.9	119.1	128.0	17.55	13.13	15.34	2.88	2.62	2.75
(S_4) Inter.cotton with wheat (2 rows) at 20 March	140.1	133.0	136.5	17.10	14.91	16.00	2.57	2.38	2.47
(S_5) Inter.cotton with wheat (3 rows) at 20 March	137.6	125.0	131.3	16.50	15.80	16.15	2.41	2.25	2.33
Average of 20th March	141.8	125.0	133.4	17.73	15.01	16.37	2.68	2.50	2.59
(S_6) Solid cotton after E.c at 20 April	136.3	122.0	1``29.1	17.63	16.98	17.3	2.58	2.42	2.50
(S_7) Solid cotton after faba been (1 side) at 20 April	137.4	123.0	130.2	17.00	14.96	15.98	2.88	2.68	2.78
(S_8) Solid cotton after faba been (2sides) at 20 April	132.4	133.0	132.7	16.91	15.03	15.97	2.90	2.75	2.82
Average of 20th April	135.3	126.0	130.6	17.18	15.65	16.41	2.78	2.61	2.70
(S_9) Solid cotton after E.c. at 20 May	108.3	101.0	104.6	16.42	13.36	14.89	1.92	2.18	2.05
(S_{10})) Solid cotton after wheat (2 rows) at 20 May	128.1	101.1	114.6	11.95	13.29	12.62	2.05	2.17	2.11
(S_{11}) Solid cotton after wheat (3 rows) at 20 May	122.0	100.3	111.1	12.65	13.60	13.12	1.91	2.16	2.03
Average of 20th May	119.4	100.8	110.1	13.67	13.41	13.54	1.96	2.17	2.06
Average of cropping systems	133.9	118.6	126.3	16.47	14.75	15.61	2.51	2.44	2.47
L.S.D. 0.05 Cotton cultivars	**			*			N.S.		
L.S.D. 0.05 Cropping systems	13.47			1.74			0.34		
L.S.D. 0.05 Interaction	19.06			1.80			0.48		

Table 5. Continued

Characters / Treatments	Open bolls/plant (no.) Giza 86	Giza 90	Mean	Seed cotton yield/plant (g) Giza 86	Giza 90	Mean	Seed cotton yield/ha (ton) Giza 86	Giza 90	Mean
(S1) Solid cotton after E.c at 20 March	15.93	15.90	15.91	40.78	36.34	38.56	3.46	3.11	3.28
(S_2)Inter.cotton with faba been (1 side) at 20 March	15.45	14.70	15.07	42.22	35.80	39.01	3.59	3.10	3.34
(S_3) Inter.cotton with faba been (2 sides) at 20 March	14.75	12.60	13.67	41.42	34.86	38.14	3.35	2.88	3.11
(S_4) Inter.cotton with wheat (2 rows) at 20 March	15.45	13.41	14.43	38.65	27.05	32.85	3.03	2.31	2.67
(S_5) Inter.cotton with wheat (3 rows) at 20 March	15.20	13.80	14.50	36.54	27.73	32.13	2.76	2.26	2.51
Average of 20th March	15.35	14.01	14.68	39.92	32.35	36.13	3.23	2.73	2.98
(S_6) Solid cotton after E.c at 20 April	14.07	13.40	13.73	32.94	30.70	31.82	2.68	2.42	2.55
(S_7) Solid cotton after faba been (1 side) at 20 April	15.15	12.25	13.70	40.45	31.10	35.77	3.15	2.76	2.95
(S_8) Solid cotton after faba been (2sides) at 20 April	14.61	12.63	13.62	39.56	31.41	35.49	3.10	2.81	2.95
Average of 20th April	14.61	12.87	13.74	37.65	31.07	34.36	2.97	2.66	2.81
(S_9) Solid cotton after E.c. at 20 May	9.01	9.17	9.09	18.25	18.46	18.35	1.42	1.47	1.44
(S_{10})) Solid cotton after wheat (2 rows) at 20 May	8.84	9.15	8.99	18.45	20.45	19.45	1.61	1.62	1.61
(S_{11}) Solid cotton after wheat (3 rows) at 20 May	8.50	8.80	8.65	18.05	19.43	18.74	1.38	1.53	1.45
Average of 20th May	8.78	9.04	8.91	18.25	19.44	18.84	1.47	1.54	1.50
Average of cropping systems	13.36	12.34	12.85	33.39	28.48	30.93	2.68	2.38	2.53
L.S.D. 0.05 Cotton cultivars	**			**			**		
L.S.D. 0.05 Cropping systems	2.24			6.12			0.58		
L.S.D. 0.05 Interaction	3.16			8.65			0.82		

Table 6. Fiber length, pressly index and micronaire reading as affected by cotton varieties, cropping systems and their interaction (combined data across 2010 and 2011 seasons).

Characters / Treatments	Fiber length (cm) Giza 86	Giza 90	Mean	Pressly index Giza 86	Giza 90	Mean	Micronaire reading Giza 86	Giza 90	Mean
(S_1) Solid cotton after E.c at 20 March	33.40	32.20	32.80	10.10	9.70	9.90	3.90	3.88	3.89
(S_2)Inter.cotton with faba been (1 side) at 20 March	33.70	31.60	32.65	10.20	9.60	9.90	3.91	3.92	3.91
(S_3) Inter.cotton with faba been (2 sides) at 20 March	33.10	29.70	31.40	10.30	9.40	9.85	3.93	4.00	3.96
(S_4) Inter.cotton with wheat (2 rows) at 20 March	33.00	30.40	31.70	10.20	9.30	9.75	4.00	3.90	3.95
(S_5) Inter.cotton with wheat (3 rows) at 20 March	32.70	29.60	31.15	9.70	9.50	9.60	4.00	4.05	4.02
Average of 20th March	33.18	30.70	31.94	10.10	9.50	9.80	3.94	3.95	3.94
(S_6) Solid cotton after E.c at 20 April	32.90	31.30	32.10	10.00	9.60	9.80	4.00	4.30	4.15
(S_7) Solid cotton after faba been (1 side) at 20 April	33.10	30.00	31.55	9.80	9.10	9.45	4.25	4.11	4.18
(S_8) Solid cotton after faba been (2sides) at 20 April	33.10	30.20	31.65	9.50	9.20	9.35	4.30	4.20	4.25
Average of 20th April	33.03	30.50	31.76	9.76	9.30	9.53	4.18	4.20	4.19
(S_9) Solid cotton after E.c. at 20 May	30.50	32.40	31.45	9.60	9.50	9.55	4.30	4.30	4.30
(S_{10})) Solid cotton after wheat (2 rows) at 20 May	31.00	29.50	30.25	9.60	9.50	9.55	4.11	4.12	4.11
(S_{11}) Solid cotton after wheat (3 rows) at 20 May	31.80	30.00	30.90	9.50	9.30	9.40	4.26	4.01	4.13
Average of 20th May	31.10	30.63	30.86	9.56	9.43	9.50	4.22	4.14	4.12
Average of cropping systems	32.48	30.53	31.50	9.88	9.44	9.66	4.11	4.07	4.09
L.S.D. 0.05 Cotton cultivars	**			*			N.S.		
L.S.D. 0.05 Cropping systems	1.70			0.22			0.23		
L.S.D. 0.05 Interaction	2.40			0.27			0.32		

With respect to fiber technology, the two cotton cultivars were differed significantly for fiber length (uprrer half mean) and pressly index but micronaire reading was not differed significantly. Giza 86 cultivar had higher values of fiber length and pressly index by 6.0 and 4.4 percent, respectively, over than those of Giza 90 cultivar. Cotton fiber quality is mainly influenced by genotype of the cultivars but agronomic practices and environmental conditions were the secondary factors influencing fiber quality (Bednarz *et al*., 2005). Fiber strength was influenced by cotton cultivar (Karademir *et al*., 2010), especially fiber strength is an important trait in determining yarn spinability, because weak fiber (low strength) are difficult to handle during manufacturing process (Saleem *et al*., 2010). These results are in accordance with those obtained by Abou-El Dahab, (1991) and El- Shahawy *et al.* (1994).

Cropping systems

Plant height, numbers of total and open bolls per plant, boll weight, seed cotton yields per plant and per ha and fiber technology traits were affected significantly by cropping systems (Tables 5 and 6). Planting cotton as a solid after E.c or relay intercropping with Faba bean at 20th March (S_1, S_2 and S_3) had the same values of studied cotton traits, but inter-planting cotton with wheat at 20th March (S_4 and S_5) gave the same effects of growing cotton as solid plantings S6, S7 and S8 at 20th April; whereas, cotton was grown after faba bean and after E.c in all characters studied, except boll weight whereas it increased significantly in planting cotton after Faba bean as compared with cotton relay intercropping with wheat 3 rows. Late planting date of cotton (20th May) as followed after E.c or wheat (S_9, S_{10} or S_{11}) caused significant reductions in all studied cotton traits than those planted in the early dates (20th March and 20th April).

With regard to planting date, growing cotton in 20th March or 20th April could be furnished suitable environmental resources for cotton plant which may be reflected on high percentage of seed germination, the timely appearance of seedling and the optimum development of the root system in comparison with the late date. Consequently, significant increments of plant height and yield attributes of cotton plant in 20th March or 20th April could be attributed to longest period of vegetative growth during available normal environmental conditions to produce more dry matter accumulation through photosynthesis process from stem elongation stage to pollination process as compared with the late date. These results reveal that growing cotton either in 20th March or 20th April faced the suitable environmental period between vegetative and reproductive cotton growth which reflected on yield attributes of cotton plant and in turn fiber technology traits. These results are in agreement with El-Moghazy *et al*. (1984), El-Banna *et al.* (1988), Hosny *et al.* (1990), Kamel *et al.* (1991), Seif El Nasr *et al*. (1996) and Sultan *et al*. (2012).

With regard to sequantial cropping systems, growing cotton after E.c at 20/3 and 20/4 or faba bean had high values of plant height, numbers of total and open bolls per plant, boll weight, seed cotton yields per plant and per ha in comparison with those grown after wheat or after E.c 4 cuts. These results could be due to growing E.c (two or three cuts) or faba bean before cotton to suitable environmental conditions (20th April) in comparison with growing cotton after wheat at 20th May. In addition to crop residues of wheat can stunt young cotton seedlings (Hicks *et al*., 1989). The quality of a residue is an important factor to determine the C and N mineralization rate, residue management is a factor affecting this process (Smith and Sharpley, 1990). Obviously, faba bean and E.c (two or three cuts) that has different ability of N fixation played a major role for improving the amount of biological N fixation (BNF) under the experimental soil conditions. Also, increasing plant density of faba bean(S3) or even wheat(S5) had some adverse effects on growth and development of different parts of cotton plant which reflected to yield attributes of cotton plant and fiber technology.

Concerning to relay intercropping faba bean with cotton, it gave higher values of seed cotton yields per plant and per ha than those grown with wheat. These results could be due to faba bean decreased inter and intra-specific competition between the two species for basic growth resources and long period of wheat than Faba bean. After Faba bean is harvested in April, the whole space is available for cotton plants that are still in the seedling stage, and the gaps that appear after the faba bean harvest have to be bridged by the expanding leaf canopy of cotton. It is evident from the data that one row of faba bean per ridge (two plants distanced at 20 cm between hills) may be formed suitable spaces for light transmission during the seedling stage in comparison with the other density (compare S2 and S3). It is known that the light environment surrounding plants affects seedling growth (Schopfer, 1984) and resource use efficiency is not likely to be much affected in intercropping systems with component crops that differ in growing period, since competition between component crops is weak (Fukai and Trenbath, 1993). Also, it seems thats Faba bean fixed most of their N requirements from the atmosphere and not compete with cotton for N resource. Management of a crop residue can contribute to increase nutrient cycling and greater crop yields (Delgado *et al.*, 2007).

With regard to relay intercropping wheat with cotton, growing wheat with cotton increased inter and intra-specific competition between the two species and the same species, respectively, for basic growth resources. From the sowing of cotton in 20th March, until the harvest of wheat, in May, the cotton and wheat are growing simultaneously, competing for light, water and nutrients; especially in the border rows. During this phase, about 8 weeks, the wheat crop shades the cotton plants that are in the growth and development stages. Also, three rows of wheat per ridge could be formed adverse environmental conditions for light transmission inside cotton canopy in comparison with 2 rows. Improved productivity can result from either greater interception of solar radiation, higher light use efficiency, or a combination of the two (Willey, 1990).

On the other hand, the allelopathic effects of wheat stubble indirectly influenced seed cotton yield by affecting population densities (Hicks *et al*., 1989). The high C:N ratios of winter cereal residues causes N immobilitozation (Aulakh *et al*., 1991). In this concern, Stevens *et al.*, (1992) reported that 11% fewer cotton floral buds (squares) on the lower fruiting nodes of cotton seeded directly into wheat stubble than of cotton grown with conventional tillage. Cropping systems which cotton was planted at early dates on March and April gave higher values of fiber length and pressly index than those of late planting date(compare S1,S2,S3,S4 and S5 with S9, S10 and S11). This trend is not true with micronaire reading. Planting cotton on 25th April had significantly increased fiber quality (bundle strength and span length), as compared with late sowing on 15th May (Hayatullah *et al*., 2011). These results are in accordance with those obtained by Elayan *et al.* (2015) who concluded that fiber length was decreased as the planting date was delayed.

Response of cotton cultivars to cropping systems

The interaction between cotton cultivars and cropping systems for each of numbers of total and open bolls per plant, boll weight, seed cotton yields per plant and per ha and fiber technology traits were affected significantly (Tables 5 and 6). Giza 86 cultivar was affected more by delaying sowing date through cropping systems (S_9, S_{10} or S_{11}), than Giza 90 cultivar. The detrimental effects of high diurnal temperature on various physiological processes impacting seed cotton yield are complex. These complicated effects support the need to merge physiological and genetic approaches to address the problem in a systematic manner and to improve the tolerance to heat stress. It is imperative that more heat-tolerant germplasm be identified (Brown and Zeiher, 1998). It may be possible that Giza 90 cultivar was more adapted to high temperature at the late date (20^{th} May) than the other one.

Obviously, plant density of wheat or faba bean is an important agronomic attribute to integrate with planting date since it is believed to have effects on light interception during photosynthesis process of cotton cultivar. It seems to be relay intercropping one row of faba bean or two rows of wheat gave more number of open bolls/plant that reflected on productivity of Giza 86 cotton cultivar without significant differences among all treatments from S1 to S8. Growing Giza 86 cotton cultivar as a followed Egyptian clover or intercropped with faba bean at 20^{th} March (S_1, S_2, S_3, S_4 or S_5) had the same values of cotton traits of those grown as followed faba bean at 20^{th} April (S_6, S_7 or S_8). Accordingly, average values of open bolls and boll weight, seed cotton yield per plant and yield per ha appeared to be affected significantly greater in Giza 90 cultivar by relay intercropping with faba bean or wheat compared to the others. These results may be attributed to differences between the two cotton cultivars played a major role for integration with cropping systems for producing high seed cotton yield per plant. Among various factors affecting seed cotton yield, high temperature act as a key control on the rate of cotton plant growth (Baker, 1965). Accordingly, it may be possible that, the late date had adverse effects on yield/plant of Giza 86 cultivar as it is estimated by about 54.28 and 51.52% of its potential yield/plant when grown at 20^{th} March and 20^{th} April, respectively, meanwhile seed cotton yield/plant of Giza 90 cultivar produced for delaying date of planting by about 39.90 and 37.43% of its potential yield when grown at 20^{th} March and 20^{th} April, respectively. So, Giza 86 was grown in North Delta of Egypt, but Giza 90 cultivar was grown in Middle and South of Egypt. These results reveal that differences in genetic potential between the two cultivares could have considerable

Also, fiber technology (fiber length, pressly index and micronaire reading) was affected significantly by the interaction between cotton cultivars and cropping systems. Intercropping Giza 86 cultivar with faba bean that planting in one side per ridge (S_2) had the highest values of fiber length and micronaire reading than those of Giza 90 cultivar. Fiber length, pressly index and micronaire value (fiber fineness) of Giza 86 were decreased significantly by delaying date of planting to 20^{th} May than other dates of Giza 90.

CONCLUSION

Under the conditions of the present study it be concluded that delaying sowing date of cotton from 20^{th} March to 20^{th} May ;through out sequental a intercropping systems, caused significant reductions in seed cotton yield per plant and per ha. The finding of study may be useful to farmers who planted cotton, faba bean and wheat by using two ways; the first way is planting cotton in relay intercropping with wheat at 20^{th} March when farmer planted wheat, the second way is planting cotton in relay intercropping with faba bean at 20^{th} March or after harvesting faba bean at 20^{th} April as solid culture.

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