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The effect of defoliant application on yield and yield components of some cotton (*Gossypium hirsutum* L.) cultivars at timely and late sowing

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Abstract

This study was aimed to assess the effect of defoliant application on yield and yield components of some cotton cultivars at timely and late sowing under Harran Plain conditions in 2017 and 2018 growing seasons. Field trials were arranged employing randomized blocks split-split plots design with 3 replications. In the study, sowing times (i.e.10[th] of May and 10[th] of June) consisted the main plots, cultivars (i.e. Candia and Lima) placed in the sub-plots and defoliant applications (i.e. Control and Dropp Ultra (600 ml ha^{-1})) were in the sub-subplots. Each plot was sown with a length of 12 m and 6 rows, with a 70 cm inter-row and 15 cm intra-row spacing. In the trials, the defoliant chemical called Dropp Ultra (i.e.120 g Thidiazuron + 60 g Diuron) was used. The application was practiced when the 60 % of boll opened. It was found that Candia and Lima cotton cultivars sown timely gave seed cotton yields of 5296.7 and 5073.3 kg ha^{-1} respectively, whereas at late sowing gave the seed cotton yields of 4672.5 kg ha^{-1} and 4545.8 kg ha^{-1}in 2017 and 2018**;** Candia gave the higher seed cotton yield (i.e. 5179.2 in 2017 and 5013.3 kg ha^{-1} in 2018) than Lima cultivar (i.e. 4790.0 in 2017 and 4605.8 kg ha^{-1} in 2018) in both years. Results indicated that that the defoliant application increased the seed cotton yield comparing control plots. Defoliant application positively influenced the seed cotton yield (kg ha^{-1}), plant height (cm), number of opened bolls (per plant^{-1}), boll weight (g) and boll seed cotton weight (g). However, there were no significant effects on the number of bolls (per plant^{-1}) and 100 seed weight (g). It was concluded that defoliant application and timely sowing can be recommended for farmers in the region.

Keywords: Cotton, Defoliant, Yield, Yield components, Timely and late sowing

Introduction

Since cotton has a perennial and indeterminate growth characteristic, it continues to grow vegetative when the environmental conditions are favorable and therefore its maturation is delayed (Stewart et al., 2000; Bondada and Oosterhuis, 2001). Sowing time is a main factor influencing growth and development of cotton as it influences the time of vegetative and reproductive stage of the crop. Moreover, too early and too late sowings resulted in drastic reduction of seed cotton yield (Bange and Milroy, 2010). Cotton plant is very sensitive to temperature fluctuation and cultivated in a wide range of agro-ecological zones. Sowing date is important to explore the potential of cultivars in a region (Ali et al., 2009). Moreover, optimum-sowing time for a cultivar in a region is crucial to be the most significant controllable factor for cotton plant (Bozbek et al., 2006). Cotton cultivars vary for fiber traits (Mohammad, 2001) and may be affected by the environmental condition (Killi and Bolek, 2005). Cotton cultivars exhibited maximum seed cotton yield in early sowing of 15[th] April as compared to late sowing of 15[th] June (Siddiqui et al., 2004).

In order to obtain a good and high-quality product, it is extremely important to choose reliable cultivar that will be sown in that region. It is desired that the cultivar to be adopted the region, yield and fiber quality properties are superior. However, sowing time is an important factor in the selection of the cultivars to be sown, as the cultivars with a long vegetation periods

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are sown in late (June), their maturation cannot be completed adequately, it may result in major problems at the harvest and the harvest efficiency could be poor. For this reason, the cultivars to be sown in both optimum and late sowing must be different growing habits.

It is extremely important to harvest cotton timely. Generally, it is desirable the harvest of seed cotton to be clean and the harvest efficiency high. Cotton leaves need to be shed both before hand and machine harvesting. Delay harvest of cotton bear the rain risk, and it may result in quality loss. Besides, non-harvested cotton plant may remain in the field due to the lack of worker and the presence of autumn rains (Mert, 2007). Hence, it was necessary to use defoliant to stimulate the boll aperture before harvesting. Therefore it was possible to increase harvest efficiency, reduce the moisture content of seed cotton, fiber contamination, the negative effect of disease and pest attacks (Oglakci, 1992).

When a defoliant or harvesting chemical is applied to the plant, immature bolls may also be present on the plant. As a general rule, the 4th or 5th node downward from the last maturated boll to be collected is used for the time of defoliant application (Larson et al., 2005; Copur et al., 2010). Optimum dosage for desired outcome of any defoliant depends on defoliant application time rather than which of those chemicals used (Edmisten, 1998). For this reason, optimum defoliant application time should be determined by taking into account the genotype characteristic and the regional conditions (Copur et al., 2010). As a result of leaf shedding in early period, the yield decreased and fiber quality was negatively affected (Snipes and Baskin, 1994). Moreover, in case of leaf shedding in later growing periods, adverse weather conditions were encountered (Kerby et al., 1992) and also due to low temperature conditions, sufficient leaf shedding did not occur. Early or late defoliant applications negatively affected fiber quality (Wright et al., 2014). Early defoliant application was critical for maximum yield. Delaying defoliant applications may increase the risk of yield lose due to rain and early frost in the winter season (Bange and Milory, 2000). In addition, as a result of late defoliant application decreases in ginning outturn, fiber yield and fiber quality were experienced. This might affect textile industry negatively.

Many researches were carried out for the defoliant application and boll openers. Sokat (2008) investigated the effects of various defoliant doses on cotton variety of Stoneville 373 as a second crop. As statistically significant effects of the defoliant application were determined on some fiber quality properties (i.e. fiber strength, short fiber content, fiber reflectance and trash count in fiber). This had no significant effects on boll seed cotton weight, ginning outturn, 100 seed weight, fiber length and fiber maturity. Ataş (2008) applied Dropp Ultra defoliant and used cotton cultivar of Delta Opal at the 2 sowing dates in 5 growing periods (i.e. number of nodes on the cracked boll were 2, 4, 6, 8 and 10) under Diyarbakir conditions. It was found that the seed cotton yields were between 3360-4260 kg ha^{-1}, ginning outturn 39.2-41.00%, and fiber strength 29.5-33.2 g tex^{-1}. Copur et al. (2010) found that the application of dropp ultra 60 days after flowering decreased the seed cotton yield, number of bolls, boll weight and fiber index, and delayed defoliant application increased the number of bolls, seed cotton yield and boll weight. All applications had no effect on the ginning outturn and fiber quality.

Awan et al. (2012) reported that defoliant application resulted in cotton the harvest 25 days earlier than the control, the applications gave high seed cotton yield than control plots. As the application affected significantly fiber fineness and uniformity, had no effect on fiber strength. Tülemen (2016) reported that methods and defoliant doses were not statistically significant for the number of total bolls, number of opened bolls, ratio of opened bolls, boll seed cotton weight, ginning outturn and fiber length. Beyyavaş (2019) stated that Drop Ultra (600 cc ha^{-1}) (5422.7 kg ha^{-1}), Appeal 75 ml ha^{-1} + Efhun 3000 ml ha^{-1} (5382.3 kg ha^{-1}) applications gave the highest seed cotton yield in 2012, Sonround (3000 ml ha^{-1}) (4150.7 kg ha^{-1}) in 2013. The highest earliness ratio was obtained from the application of Drop Ultra (300 cc ha^{-1}) + Efhun (3000 m / ha^{-1}) (96.30% and 96.30 %) in both years.

Harran Plain, where the experiment was established is the most important cotton producing area in Turkey. The most cotton fiber need of the textile sector in Turkey is met from the cotton produced in the GAP region. However, cotton harvest is delayed due to the early autumn rainfall in some years. In GAP region, cotton harvesting is mostly done by combine cotton harvesting machine. In order to increase the efficiency of the combine harvesting and achieving clean seed cotton nowadays, it is compulsory practice to shed the leaves on time and open the bolls. This study was carried out to determine the effects of defoliant application on yield and yield components of some cotton cultivars at timely and late sowing.

Materials and Methods

Field trials were conducted according to randomized blocks split-split plots with 3 replications in Sultantepe village in Harran Plain in 2017 and 2018 growing seasons. In the study, sowing times placed in the main plots, cultivars in sub-plots, and defoliant applications placed in sub-subplots.

Candia and Lima cotton cultivars were used as plant material. In the trial, each plot was arranged with 6 rows of 12 m length, 70 cm inter-row and 15 cm intra-row spacing. Sowing was practiced on May, 10th (timely sowing) and June 10 (late sowing) with a pneumatic drill in both years. Some physical and chemical properties of soil samples taken from the trial sites (0-30 cm) were given in Table 1 and some climate data of Sanliurfa province are given in Table 2.

In the field trial, fertilization was performed to be 160 kg ha^{-1} pure N and 70 kg ha^{-1} P. 70 kg ha^{-1} N and 70 kg P_2O_5 (all of the phosphorus) with 20.20.0 composite fertilizer as a basal, and the remaining 90 kg ha^{-1} of nitrogen as a top (urea 46% N) just before the first irrigation were applied with the lister tool. Defoliant (Dropp Ultra 600 cc ha^{-1}) was applied in both years. The defoliant was mixed with water (300 lt ha^{-1}) and applied with a back pump with the pressure set at 4.22 kg/cm^2. Sprayers were calibrated for 4.80 km h^{-1} walking speed before each application. Only water was sprayed to the control plots (Copur et al., 2010). Defoliant were applied in timely sowing

(May, 10th) on September, 10th in 2017, on September, 12th in 2018; in late sowing time (June 10) on September 25 in 2017 and on September 26 in 2018 when 60% of the bolls opened (Edmisten, 2006).

Harvesting was practiced over the remaining area (10 x1.4 = 14 m^2) by discarding 1 meter from the head and the end of the middle two rows of each plot 15 days after the applications. The harvest was performed by hand on October 27 in 2017, on October 29 in 2018 for timely sowing; on November 9 in 2017, on November 10 in 2018 for late sowing. The evaluation of the data obtained from each parameter was examined by JMP 13.2.0 statistical package program according to the randomized blocks split-split plots and the means were grouped according to the $LSD_{(0.05)}$ test.

Table 1. Some physical and chemical properties of soil (Anonymous, 2018a)

Soil Properties	2017	2018
Structure	Clay	Clay
Clay, %	56.50	59.14
Silt - Loam, %	22.70	22.73
Sandy, %	20.80	19.24
Reaction (pH)	7.76	7.68
Lime ($CaCO_3$), %	24.4	24.7
Total Salt, %	0.062	0.068
Organic Matter, %	1.58	1.47

Table 2. Some meteorological data of Sanliurfa province for 2017 and 2018 (Anonymous, 2018a)

	2017			2018			1929-2018
Months	Montly Avg. Temperature (°C)	Rainfall (kg/m^2)	Avg. Relative Humidity (%)	Montly Avg. Temperature (°C)	Rainfall (kg/m^2)	Average Relative Humidity (%)	Long Years Avg. Temperature (°C)
April	16.6	79.2	50.2	19.4	38.2	45.4	16.2
May	22.9	7.2	39.0	23.9	112.8	52.6	22.1
June	29.7	0.0	27.0	28.3	6.8	41.4	28.0
July	34.2	0.0	22.9	31.3	0.0	38.7	31.9
August	32.2	0.0	35.7	31.1	0.0	40.9	31.5
September	29.6	0.0	28.8	27.4	0.0	41.6	27.1
October	20.5	17.1	36.9	20.6	28.8	54.3	20.5
November	13.4	17.4	56.0	14.3	30.5	55.5	13.1

Results and Discussion

Seed Cotton Yield (kg ha^{-1})

Candia and Lima cotton cultivars sown timely (May 10) gave the seed cotton yields of 5296.7 and 5073.3 kg ha^{-1} respectively, same cultivars in late sowing (June 10) gave the seed cotton yields of 4672.5 and 4545.8 kg ha^{-1} in 2017 and 2018. It was observed that more yield was obtained from the timely sowing (Table 3). This was due to the fact that genotypes received more vegetation period in timely sowing (Gormus and Yucel 2002; Huang, 2016). The growing season length was important for cotton yield, and selecting the growing season length by the optimal sowing date was of tremendous importance (Huang, 2016). Gormus and Yucel (2002) found that late sowing resulted in the crop late crop flowering and pushed boll development into the cooler weather, resulting in reduced yield. The results obtained in compliance with Kaynak et al. (2003); Killi and Bolek (2005); Ataş (2008); Beyyavaş (2009); Qamar et al. (2016)'s results that indicate the timely sowing was more yielding than late sowing. It has been determined that defoliant application (5074.2 and 4860.8 kg ha^{-1}) increased seed cotton yield compared to control plots (4895.0 and 4758.3 kg ha^{-1}). Awan et al. (2012); Ming-wei et al. (2013); Mrunalini et al. (2018) stated that defoliant application gived more seed cotton yield than control plots were in accordance with our study; Karademir et al. (2007) opposed that by stating that the control plots gave more seed cotton yield than those of defoliant application. This might be due to the differences of the cultivars and trial locations. When the interactions of sowing time*cultivar*defoliant applications were examined, timely sowing (TS)*Candia*defoliant application (DA) interaction (5750.0 kg ha^{-1}) gave the highest seed cotton yield in 2017, TS*Candia*DA interaction (5350.0 kg ha^{-1}) and TS*Candia*-Control plot interaction (5283.3 kg ha^{-1}) in 2018.

Plant Height (cm)

It is observed that there was no statistically significant difference between Candia and Lima cotton cultivars in timely sowing (May 10) and late sowing (June 10) in 2017. Same cultivars gave the highest plant height in timely sowing (103.31 cm) than late sowing (97.58 cm) in 2018 (Table 3). Killi and Bolek (2005) stated that late sowing decreased the plant height by 15% compared to timely sowing; Qamar et al. (2016) indicated that early sowing increased the plant height confirming with our findings. Porter et al. (1996) report that plant height increased with delaying of sowing; Beyyavaş (2009) stated that plant height decreased in timely sowing those were contradicting with our results. Ataş (2008) reported that sowing times had no effect on plant height. It was observed that the height of Candia cultivar (95.53 and 91.47 cm) was less than Lima cultivar (113.10 and 109.42 cm). This might be due to the difference of the genotypes of the cultivars used in the trial. Defoliant application was found insignificant in the first year of the trial, the plots defoliant applied (102.04 cm) were higher than that of control plots (98.84 cm) in the second year. Sing et al., (2015) indicated that the defoliant application onto plant height was found to be higher than control confirming our second year results. Interaction of sowing time (ST)*Cultivar*-DA were found to be important and formed different groups. TS*Lima*DA interaction formed the highest plant height in both years.

Table 3. Seed cotton yield (kg ha^{-1}), plant height (cm), number of bolls (per plant^{-1}) related to defoliant application in timely and late sowing, and groups formed according to LSD test.

	Seed Cotton Yield (kg ha^{-1})		Plant Height (cm)		Number of Bolls (per plant^{-1})	
Sowing Time	2017	2018	2017	2018	2017	2018
Timely Sowing (TS)	5296.7 a	5073.3 a	107.29 ns	103.31 a	19.93 a	19.35 a
Late Sowing (LS)	4672.5 b	4545.8 b	101.34	97.58 b	13.52 b	13.90 b
LSD %5	127.3	53.1	7.04	3.55	3.93	0.06
Cultivars						
Candia	5179.2 a	5013.3 a	95.53 b	91.47 b	18.16 a	17.46 a
Lima	4790.0 b	4605.8 b	113.10 a	109.42 a	15.29 b	15.78 b
LSD %5	67.5	83.6	2.86	2.01	2.69	0.80
Defoliant Applications						
Dropp Ultra 600 ccha^{-1}	5074.2 a	4860.8 a	104.68 ns	102.04 a	17.15 ns	16.68 ns
Control	4895.0 b	4758.3 b	103.96	98.84 b	16.30	16.58
LSD %5	95.3	62.7	1.15	1.11	2.35	0.61
Interactions						
TS*Candia*DA	5750.0 a	5350.0 a	98.30 d	94.50 d	19.90 a	19.37 a
TS*Candia*Control	5403.3 b	5283.3 a	95.17 e	91.13 e	20.00 a	19.33 a
TS*Lima*DA	5083.3 c	4866.7 b	119.27 a	116.13 a	19.77 a	19.03 a
TS*Lima*Control	4950.0 cd	4793.3 b	116.43 b	111.47 b	20.03 a	19.67 a
LS*Candia*DA	4846.7 de	4770.0 bc	93.27 e	92.03 e	16.50 ab	15.73 b
LS*Candia*Control	4716.7 ef	4650.0 c	95.40 e	88.20 f	16.23 ab	15.47 b
LS*Lima*DA	4616.7 fg	4456.7 d	107.87 c	105.50 c	9.03 c	12.57 c
LS*Lima*Control	4510.0 g	4306.7 e	108.83 c	104.57 c	12.33 bc	11.83 c
LSD (5%)	190.6	125.4	2.30	2.22	4.71	1.22
CV (%)	2.03	1.38	1.17	1.18	14.97	3.89

* Means in each column followed by the same letter are not significantly different ($p<0.05$) ns: Non-significant TS: Timely Sowing LS: Late Sowing DA: Defoliation Applications ST: Sowing Time

Number of Bolls (per plant^{-1})

Candia and Lima cotton cultivars in the timely sowing (May 10) formed bolls as 19.93 and 19.35 per plant^{-1}, respectively, since the same cultivars were sown in late (June 10), 13.52 and 13.90 per plant^{-1}of bolls were obtained in 2017 and 2018 years. It was observed that timely sowing created more bolls (Table 3). Gür et al. (2001) and Beyyavaş (2009) stated that timely sowing created more bolls than that of late sowing time confirming our results. Cotton had an indeterminate growth habit, which provided more bolls per plant if it was remained longer time in the field/sown earlier (Qamar et al., 2016). It was observed from Table 3 that Candia cultivar (18.16 and 17.46 per plant^{-1}) created more bolls than Lima cultivar (15.29 and 15.78 per plant^{-1}). This might be due to the genotypic differences of the cultivars used as material. It was observed that the defoliant applications on the cultivars were formed in the same group with control plots and were statistically insignificant (Table 3). Copur et al. (2010) and Tülemen (2015) stated that defoliant applications did not affect the number of bolls confirming this study. ST*Cultivar*DA interaction was found important in both years of the experiment and formed different groups. However, when evaluated in general, it can be said that the applications in timely sowing consituted more bolls than late sowing time. This situation can be explained by the fact that plants perform more photosynthesis and form more dry matter in timely sowing.

Boll Weight (g)

Statistically significant differences were found between sowing times in terms of the boll weight. Candia and Lima cotton cultivars sown in timely (May 10) formed boll weights of 6.91 g and 6.59 g respectively, same cultivars being sown in the late (June 10) boll weights of 6.34 g and 6.19 g were obtained, so the heavier bolls weight were obtained from the timely sowing in 2017 and 2018 years (Table 4). It can be said that the prolonged vegetation period contributed positively to the boll weight. Boll weight was an important yield attributes which directly affected the seed cotton yield. Qamar et al. (2016) reported that delays of sowing time gave lower boll weight; Cathey et al. (1988) stated that boll weight decreased as a result of delayed sowing; Killi and Bolek (2005) indicated that the seed cotton weight decreased by 14% in late sowing results were coinciding with our study. As Candia cultivar formed heavier bolls (6.83 g) than Lima cultivar (6.43 g) in 2017, there was no difference between cultivars in 2018. Defoliant application had no significant effect in the first year of the trial, and the plots with defoliant formed heavier bolls (6.44 g) than control plots (6.34 g) in the second year. Awan et al. (2012) stated that defoliant and sulfur dose application plots formed the heavier boll weight than control plots; Gormus et al. (2017) found that the defoliant application was heavier than control parcels in the first year, and this was insignificant. Boll weight results in the second year were compatible with the results obtained from this study. ST*Cultivar*DA interactions were found to be important in both years and formed different groups. However, when evaluated two years together, it can be said that TS*Lima*Control plot interaction gave the heaviest boll weight.

Boll Seed Cotton Weight (g)

No significant differences were found between sowing times and cultivars in terms of the boll seed cotton weight in 2017 and 2018 years (Table 4). Süllü (2001) and Beyyavaş (2009) stated that sowing times had no effect on boll seed cotton weight this was coinciding with this study. Defoliant application made a positive contribution to the boll seed cotton weight (5.08 and 4.95 g) compared to control plots (4.95 and 4.73 g). Awan et al. (2012) stated that the defoliant and sulfur doses increased the boll seed weight compared to control plots. Findings supported the result obtained from this study. Tülemen (2015) stated that defoliant applications had no effect on the boll seed cotton weight contradicts with this study. ST*Cultivar*Defoliation interaction was found significant and formed different groups in both years. TS*Candia*DA and LS*Candia*DA interactions were taken part in the first group in both years. It can be said that the application of defoliant to Candia cultivar increaseed the boll seed cotton weight.

Number of Opened Bolls (per plant^{-1})

Candia and Lima cotton cultivars sown in timely (May 10) formed opened bolls as 16.88 and 16.20 per plant^{-1}, respectively in 2017 and 2018 years, since the same cultivars sown in late (June 10) formed 12.97 and 12.41 per plant^{-1}. It can be observed that timely sowing forms more opened bolls than late sowing (Table 4). The Candia cultivar used in the study created more opened bolls (16.20 and 15.79 per plant^{-1}) than Lima cultivar (13.65 and 12.83 per plant^{-1}). Defoliant applications have created more opened bolls (15.96 and 15.13 per plant^{-1}) than control plots (13.89 and 13.48 per plant^{-1}). Ming-wei et al. (2013) stated that all applications contributed to more opened bolls than control plots; Beyyavas (2019) indicated that defoliant applications formed more opened bolls than control plot in the first year of the study this confirmed our results in this study. ST*Cultivar*DA interaction was found significant in both years of experiment and formed different groups. The application of TS*Candia*DA interaction formed the highest opened bolls (18.43 and 18.13 per plant^{-1}) in both years.

Number of Unopened Bolls (perplant^{-1})

Statistically no significant differences were found in terms of the number of un-opened bolls in both timely sowing (10 May) and late sowing (10 June) in 2017 and 2018 (Table 5). Lima cultivar has created more unopened bolls (2.79 and 2.97 per plant^{-1}) than Candia cultivar (1.97 and 2.33 per plant^{-1}) which was not desired. In cultivation, the goal is to achieve the higher number of opened bolls. Defoliant application (1.63 and 2.02 per plant^{-1}) caused more opened bolls than control plots (3.13 and 3.28 perplant^{-1}). These results revealed that defoliant application caused more opened bolls. Ming-wei et al. (2013) stated that defoliant applications contributed to opening more bolls than control plots; Beyyavas (2019) reported that defoliant applications created more opened bolls than control plots in the first year of this study, which were consistent with our results. Tülemen (2015) found that the number of opened bolls between all defoliant applications and control plots were insignificant and was incompatible with this study. ST*Cultivar*DA interaction was found significant in both years of experiment and formed different groups. The least number of unopened bolls were obtained from the TS*Candia*DA interaction. The fact that the same interaction gave the highest number of opened bolls confirms this result.

Ginning Outturn (%)

Sowing times, cultivars used as material and defoliant applications in the first year of the experiment had no effects on the ginning outturn in 2017 and 2018 (Table 5). Süllü (2001), Gormus and Yucel (2002) and Beyyavaş (2009) stated that sowing times had no effect on ginning outturn; Denizdurduran and Efe (2009), Copur et al. (2010), Ming-wei et al. (2013), Tülemen (2015); Gormus et al. (2017) and Beyyavas (2019) stated that the defoliant application had no effect on ginning outturn which were coinciding with results of 2017. ST*Cultivar*DA interactions were found important and formed differ-

Table 4. Boll weight (g), boll seed cotton weight (g), number opened bolls (per plant^{-1}) related to defoliant application in timely and late sowing, and groups formed according to LSD test

	Boll Weight (g)		Boll Seed Cotton Weight (g)		Number of Opened Bolls (per plant^{-1})	
Sowing Time	2017	2018	2017	2018	2017	2018
Timely Sowing (TS)	6.91 a	6.59 a	5.05 ns	4.87 ns	16.88 a	16.20 a
Late Sowing (LS)	6.34 b	6.19 b	4.98	4.80	12.97 b	12.41 b
LSD %5	0.35	0.32	0.51	0.27	1.71	1.18
Cultivars						
Candia	6.83 a	6.48 ns	5.10 ns	4.85 ns	16.20 a	15.79 a
Lima	6.43 b	6.30	4.93	4.83	13.65 b	12.83 b
LSD %5	0.20	0.21	0.19	0.11	0.45	0.81
Defoliant Applications						
Dropp Ultra 600 cc ha^{-1}	6.71 ns	6.44 a	5.08 a	4.95 a	15.96 a	15.13 a
Control	6.54	6.34 b	4.95 b	4.73 b	13.89 b	13.48 b
LSD %5	0.17	0.07	0.09	0.18	0.68	0.89
Interactions						
TS*Candia*DA	7.10 a	6.63 b	5.27 a	4.93 ab	18.43 a	18.13 a
TS*Candia*Control	6.90 a	6.57 bc	4.90 cd	4.77 ab	16.40 bc	15.73 b
TS*Lima*DA	6.83 ab	6.37 de	5.03 bc	5.10 a	17.67 ab	16.23 b
TS*Lima*Control	6.80 ab	6.80 a	5.00 bc	4.70 b	15.03 cd	14.70 bc
LS*Candia*DA	6.80 ab	6.47 cd	5.13 ab	5.07 a	16.07 c	15.67 b
LS*Candia*Control	6.50 b	6.27 e	5.10 ab	4.63 b	13.90 d	13.63 c
LS*Lima*DA	6.10 c	6.30 e	4.90 cd	4.70 b	11.67 e	10.50 d
LS*Lima*Control	5.97 c	5.73 f	4.80 d	4.80 ab	10.23 f	9.87 d
LSD (5%)	0.35	0.15	0.19	0.36	1.37	1.34
CV (%)	2.81	1.24	1.94	3.91	4.87	6.59

*Means in each column followed by the same letter are not significantly different ($p<0.05$) ns: Non-significant TS: Timely Sowing LS: Late Sowing DA: Defoliation Applications ST: Sowing Time

Table 5.Number of unopened bolls (per plant^{-1}), ginning outturn (%)and 100 seed weight (g)related to defoliant application in timely and late sowing, and groups formed according to LSD test.

	Number of Unopened Bolls (per plant^{-1})		Ginning Outturn (%)		100 Seed Weight (g)	
Sowing Time	2017	2018	2017	2018	2017	2018
Timely Sowing (TS)	2.39 ns	2.64 ns	42.85 ns	41.91 ns	10.04 ns	10.63 ns
Late Sowing (LS)	2.37	2.66	43.17	42.29	9.82	10.33
LSD %5	0.87	0.91	1.93	0.90	0.27	0.32
Cultivars						
Candia	1.97 b	2.33 b	42.70 ns	42.03 ns	9.91 ns	10.48 ns
Lima	2.79 a	2.97 a	43.32	42.17	9.95	10.48
LSD %5	0.69	0.33	0.69	1.21	0.10	0.12
Defoliant Applications						
Dropp Ultra 600 cc ha^{-1}	1.63 b	2.02 b	43.09 ns	42.43 a	9.93 ns	10.45 ns
Control	3.13 a	3.28 a	42.93	41.78 b	9.93	10.50
LSD %5	0.53	0.29	0.64	0.50	0.17	0.12
Interactions						
TS*Candia*DA	0.43 c	0.77 e	42.87 b	42.77 ab	10.13 ab	10.43 cde
TS*Candia*Control	3.47 a	3.50 a	42.93 b	41.60 c	9.90 abc	10.63 bc
TS*Lima*DA	2.50 ab	2.90 bc	42.83 b	41.83 bc	9.97 abc	10.93 a
TS*Lima*Control	3.17 ab	3.40 ab	42.77 b	41.43 c	10.17 a	10.50 bcd
LS*Candia*DA	1.20 c	1.63 d	42.33 b	41.77 bc	9.77 c	10.17 f
LS*Candia*Control	2.77 ab	3.43 ab	42.67 b	42.00 bc	9.83 abc	10.70 ab
LS*Lima*DA	2.37 b	2.77 c	44.33 a	43.33 a	9.87 abc	10.27 def
LS*Lima*Control	3.13 ab	2.80 c	43.33 ab	42.07 bc	9.80 bc	10.20 ef
LSD (5%)	1.05	0.57	1.28	1.01	0.34	0.24
CV (%)	23.46	11.60	1.58	1.27	1.82	1.22

*Means in each column followed by the same letter are not significantly different ($p<0.05$) ns: Non-significant TS: Timely Sowing LS: Late Sowing DA: Defoliation Application ST: Sowing Time ent groups in both years. The highest ginning outturn was obtained from the LS*Lima*DA interaction (44.33 and 43.33%).

100 Seed Weight (g)

Statistically no significant differences were found on 100 seed weight in terms of the sowing times, cultivars and defoliant applications in the 2017 and 2018 (Table 5). Seed index (100 seed weight) was a major yield-contributing component that was affected by soil nutrients status, irrigation availability and the rapid environmental changes (Qamar, 2016). Abd-El Gawad et al. (1986) and Beyyavaş (2009) indicated that sowing times had no effect on 100 seed weight; Karademir et al. (2007) and Sokat (2008) stated that defoliant application had no effect on 100 seed weight support the results obtained from this study. Statistically significant differences were found between ST*Cultivar*DA interactions in both years, but this difference varied over the years.

Conclusion

Candia and Lima cotton cultivars sown timely (May 10) gave 5296.7 and 5073.3 kg ha^{-1} of seed cotton yield respectively when 4672.5 kg ha^{-1} and 4545.8 kg ha^{-1} of seed cotton yield were obtained from the same cultivars sown in late (June 10). High yields were obtained from late sowing time in 2017 and 2018.Candia cultivar (5179.2 and 5013.3 kg ha^{-1}) gave the higher seed cotton yield than Lima cultivar (4790.0 and 4605.8 $kgha^{-1}$) in both years. It was thought that this difference between cultivars caused from the genotypic structure of cultivars. While the defoliant application affected positively the properties of examined traits such as seed cotton yield, plant height, number of opened bolls, number of unopened bolls, boll weight and boll seed cotton weight, not effected the number of bolls and 100 seed weight. In addition, it was determined that the seed cotton yield decreased with the delaying of sowing time and negatively affected by early autumn rains. Candia cultivar performed better in defoliant application. According to the results of this study it can be concluded that defoliant application and timely sowing provided higher yield.

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential or perceived the conflict of interests.

Author contribution

The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

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