African Journal of Biotechnology Vol. 9(40), pp. 6654-6659, 4 October, 2010
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB09.1645
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

The effect of different harvesting times on seed-set efficiency in cotton (*Gossypium hirsutum* L.) varieties

Osman Çopur[1]*, Ibrahim Halil Birgul[2], Hasan Haliloglu[3] and Vedat Beyyavas[3]

[1]Harran University, Faculty of Agriculture, Department of Crop Science, 63190 Sanliurfa, Turkey.
[2]Suruc Agricultural Head Office, Adviser of Agriculture, 63800 Sanliurfa, Turkey.
[3]Harran University, Suruç Training School, Department of Industrial Plants Growing and Evaluation, 63800 Suruç-Sanliurfa, Turkey.

Accepted 2 September, 2010

This study was undertaken in the South Eastern Anatolia region of Turkey during the 2006 and 2007 growing seasons to investigate the seed set efficiencies (SSE) of ten cotton cultivars grown in semi-arid climatic conditions. SSE changed by year by approximately 1-2%, averaging 87-88% in both of the study years, respectively. Mean values for varieties ranged from 86.5% (SG-125) to 89.9% (DPL-5111) in 2006 and from 86.2% (SG-125) to 89.5% (Fantom) in 2007. There were significant differences ($p<0.05$) among the cultivars according to harvesting time, except for the first harvest in 2006. Although differences were small, generally, it was observed that SSE diminished in flowers opened at the end of the growing season. The results showed that SSE was significantly affected ($p<0.05$) by cultivars, harvesting times and years. Additionally, SSE was significantly ($p<0.05$) and positively ($r= 0.39^*$ and $r= 0.44^*$) correlated to seed cotton yield and seed yield in 2007. There was a significant difference in the number of seeds within the bolls formed early or late in the season, indicating bolls harvested at different times throughout the growing season could not be used for seed production. However, study results strongly indicated that seeds from the first harvest should be used for cotton seed production.

Key words: Cotton, *Gossypium hirsutum* L., variety, harvesting time, seed-set efficiency.

INTRODUCTION

An increase in the seed cotton yield occurs as a result of the harmony between the varieties and environmental conditions. The leading yield components for cotton varieties are the number of bolls per plant and the average boll weight. In order for a boll to have a desired weight, an optimal amount of fibre and seed should be formed. In other words, each boll should include a low number of motes. The number of seeds in a boll depends on the number of carpels and the number of ovules in each carpel (Stewart, 1986; Kıllı and Tursun, 2007) and it is related to seed set capacity of cultivar. Changes in the number of seeds per boll may be due to fertilization deficit, which is caused by abiotic environmental conditions and a lack of embryo development after fertilization. Both genotype and environmental conditions may affect variations in the number of seeds per boll. Ovules which are not fertilized, or in which embryo development is interrupted shortly after fertilization, are described as mote (Davidonis et al., 2000). An increased number of motes may cause the number of seeds per boll to decrease and therefore, cause a decrease in boll weight and the seed cotton yield in a unit area to also decrease. In addition, motes cause yarn quality to decrease because they contain dead and immature fibres.

Various researchers have previously studied on SSE (Reddy et al., 2000; Sato et al., 2000; Prasad et al., 2003; Bölek and Oğlakçı, 2007). A study by Walhood and McMeans (1964) of eight cultivars stated that SSE is 90%; Turner et al. (1977) showed that SSE decreased late in a season, Waller et al. (1981) showed that pollinator insects and honey bees prefer nectar glands which causes pollens to be carried from one flower to another and; the population of pollinator species in an area, the amount of nectar in a plant and sugar content affect the preference of pollinator species to settle on plants.

*Corresponding author. E-mail: osmancopur@gmail.com. Tel: (90) 4143183690. Fax: (90) 4143183682.

Hughes (1968) stated that SSE is affected by genotype and different climatic conditions during the growing season. In a study of 10 cotton varieties, Bölek and Oğlakçı (2007) found that SSE was between 93 - 95% and SSE varied which depended on cultivars and years area to also decrease. In addition, SSE of the upper and lower parts of a plant is higher than that of the middle part.

The present study investigated the SSE level of bolls harvested on various times from 10 cotton cultivars which are commonly grown in south east Anatolia. In addition, the present study aimed to collect data about the varieties which may be used in improved seed preparation and in providing a source for future studies.

MATERIALS AND METHODS

Experiments were established in 2006 and 2007 growing seasons in Sanliurfa, Turkey. The experimental field is located in Harran Plain (altitude: 465 m; 37°08' North and 38°46' East) near the Turkish-Syrian border. The site is part of the Harran University (Faculty of Agriculture, Department of Crop Science) research station. The local climate varies from arid to semi arid. The average long term temperature was 22°C, annual rainfall is 460 mm, with most of the rainfall occurring from December to April, relative humidity was approximately 49%. The weather is normally hot and dry from May to September and the temperature may reach 46°C. The lowest average temperature recorded during the growing season was 7.7°C in November. The earliest frost in the region is usually at the end of October and the last frost around the third week of April. Most rainfall during the growing season occurred in April and there was almost no rainfall from July to September. The highest humidity (63%) was recorded in April and the lowest (45%) in June and July (Sanliurfa Meteorology Station, 2006 and 2007).

The research field has a clay (60%) type soil with mass based field capacity, permanent wilting point and bulk density values of 32%, 22% and 1.41 g cm^{-3}, respectively; available water was 123.7 mm at 90 cm soil depth and infiltration rate was 13 mm h^{-1}. The soil was low in organic material (1.2%) and soil pH was 7.2. Those values are typical for the study area. The soil was classified as Ikizce soil series (Vertic Calciorthid Aridisol) (Dinç et al., 1988).

The study included 10 upland cotton (*Gossypium hirsutum* L.) varieties that were field tested as a randomized completely block design with three replications in 2006 and 2007. The 10 cultivars were used in the study. Two of them (Erşan-92 and Sayar-314) were developed in Turkey and 8 (Stoneville 453, SG-125, BA-119, Carmen, DPL-388, DPL-5111, GW-Teks and Fantom) were introduced. Varieties were randomized within each of the blocks. Plots were 10 m in length with six rows spaced 0.70 m apart and intra-rows spaces 0.20 m.

Cotton seeds were planted in each plot on 5 May 2006 and 7 May 2007. Plants were thinned to give a stand of approximately 50 to 60 plants per plot (five to six plants per meter) and numbers of plants were counted. All cultural practices were applied according to local standards in each year.

Boll samples were collected three times before harvesting. Harvesting times were September 5th, September 20th and October 5th. 30 bolls were harvested for each randomly selected plant in both years. After counting the number of motes and seeds for each boll, SSE was calculated using the following equation:

[(Number of seeds per boll/number of motes per boll + number of seed per boll) × 100]

Statistical analysis was done by the MSTATC statistical program (Anonymous, 1989). Means were separated using Fisher's protected least significant differences (LSD) test and P= 0.05 denotes the level of significant.

RESULTS

Analysis of variance (ANOVA) showed significant differences in SSE between years (Table 1). Statistically, significant differences were identified between the cultivars and between different harvest times. In addition, it is shown that the interactions of year x cultivar, cultivar x harvest time and year x cultivar x harvest time are also statistically significant except the interaction of year x harvest time.

Means of SSEs (%) and LSD grouping of the cotton (*G. hirsutum* L.) varieties for bolls sampled at the different harvesting time (September 5th, September 20th and October 5th) in 2006 and 2007 are given in Table 2.

While average SSE in 2006 was 88%, the highest was 89.9% (BA-119 and DPL-5111) and the lowest was 85.1% (GW-Teks). In 2007, the average SSE was 86.8%, while the highest was 89.5% (Fantom) and the lowest was 81.7% (GW-Teks). Mean SSE was higher in 2006 (88.0%) than in 2007 (86.8%) (Table 2).

For the bolls sampled at the first harvesting time (September 5th), SSEs in 2006 ranged from 87.1% (Erşan 92) to 90.2% (Carmen), differing by 3.1% and from 86.1% (Erşan 92) to 90.7% (Fantom) in 2007, differing by 4.6% (Table 2). There were no differences among the cultivars for the first harvesting time in 2006, but there were differences in 2007. SSEs of the varieties for the first harvesting time differed between years, except for varieties STV-453, BA-119, Carmen and DPL-5111 (Figure 1).

In 2006, the mean SSEs of the cultivars for the second harvesting time (September 20th) ranged from 86.9% (GW-Teks) to 92.9% (DPL-5111), differing by 6%, and; from 82.1% (GW-Teks) to 90.9% (STV-453) in 2007, differing by 8.8% (Figure 2). The difference between years was 2.6%. SSEs of second harvesting time-set bolls for all cultivars differed between years (Table 2). The difference between years was 2.6%. SSEs of second harvesting time-set bolls for all cultivars differed between years (Table 2).

In 2006, the mean SSEs of the cultivars for the third harvesting time (October 5th) ranged from 78.9% (GW-Teks) to 89.6% (BA-119 and Carmen), differing by 10.7%, and; from 81.7% (GW-Teks) to 89.5% (Fantom) in 2007, differing by 7.8%. SSEs of the varieties for the third harvesting time differed between years, except for variety STV-453 (Figure 3).

In the varieties STV-453, SG-125, DPL-388, GW-Teks, Fantom and Sayar-314, similar trends were seen in terms of SSE during both years; in contrast, in the varieties BA-119, Carmen, DPL-5111 and Erşan-92, SSE values were higher in the second (September 20th) harvesting time in both years.

Table 1. Analysis of variance for SSEs from the three harvesting times in 2006 and 2007.

Sources	Df	MS	F
Replication	2	15.382	4.97
Year (Y)	1	72.860	23.53*
Genotype (G)	9	58.181	15.46**
Harvesting Time (HT)	2	233.085	61.94**
YxG	9	11.954	3.18**
YxHT	2	1.410	0.37
GxHT	18	10.767	2.86**
YxGxHT	18	8.684	2.31**

*, **; Significant at p = 0.05 and p = 0.01, respectively; YxG, year x genotype interaction, YxHT; year x harvesting time interaction; GxHT, genotype x harvesting time interaction; YxGxHT; year x genotype x harvesting time interaction; df; degree of freedom; MS, mean sum;F, frequency.

Table 2. SSE means (%) and LSD groupings of the cotton varieties with boll, sampled from three harvesting times in 2006 and 2007.

Cultivars	2006				2007			
	1st H.*	**2nd** H.	**3rd** H.	**Average**	**1st** H.*	**2nd** H.	**3rd** H.	**Average**
STV–453	89.8	87.9 ^{cd**}	86.0 ^{ab}	87.9 ^{abc}	90.2 ^{abc}	90.9 ^{a}	86.7 ^{b}	89.3 ^{a}
SG–125	88.3	87.9 ^{cd}	83.5 ^{bc}	86.5 ^{cd}	88.9 ^{abc}	86.9 ^{b}	82.8 ^{c}	86.2 ^{bc}
BA–119	88.6	91.4 ^{ab}	89.6 ^{a}	89.9 ^{a}	88.5 ^{bcd}	90.5 ^{a}	86.1 ^{b}	88.4 ^{a}
Carmen	90.2	88.4 ^{bcd}	89.6 ^{a}	89.4 ^{ab}	90.4 ^{ab}	86.8 ^{b}	81.6 ^{b}	86.3 ^{bc}
DPL–388	89.8	89.4 ^{bcd}	85.6 ^{ab}	88.3 ^{abc}	88.2 ^{cd}	87.3 ^{b}	82.0 ^{c}	85.9 ^{cd}
DPL–5111	89.3	92.9 ^{a}	87.5 ^{ab}	89.9 ^{a}	88.9 ^{abc}	89.9 ^{a}	86.5 ^{b}	88.4 ^{a}
GW -Teks	89.5	86.9 ^{d}	78.9 ^{c}	85.1 ^{d}	83.0 ^{f}	82.1 ^{c}	79.8 ^{d}	81.7 ^{e}
Fantom	89.3	88.4 ^{bcd}	87.6 ^{ab}	88.5 ^{abc}	90.7 ^{a}	87.4 ^{b}	90.5 ^{a}	89.5 ^{a}
Sayar–314	89.7	88.8 ^{bcd}	84.8 ^{ab}	87.8 ^{abc}	86.7 ^{de}	87.9 ^{b}	86.3 ^{b}	87.0 ^{b}
Erşan–92	87.1	90.1 ^{abc}	84.3 ^{b}	87.2 ^{bcd}	86.1 ^{e}	86.4 ^{b}	82.7 ^{c}	85.1 ^{d}
Means	89.2	89.2	85.7	88.0	88.2	87.6	84.5	86.8
LSD (0.05)	ns	3.13	5.11	2.66	2.10	1.84	1.70	1.14
CV (%)	2.90	2.04	3.47	1.76	1.39	1.22	1.17	0.77

H, Harvest; **, Mean in each column followed by the same letter are not significantly different (p < 0.05).

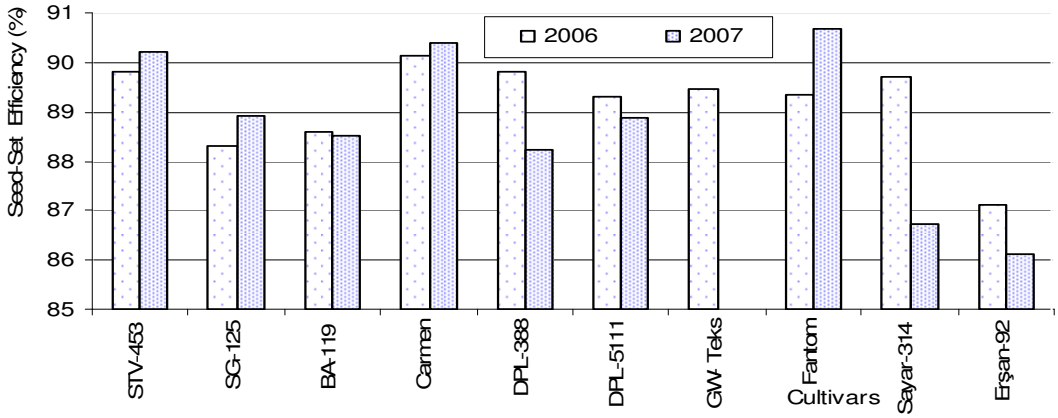

Figure 1. SSE means of cotton varieties in 2006 and 2007 for the first harvesting time.

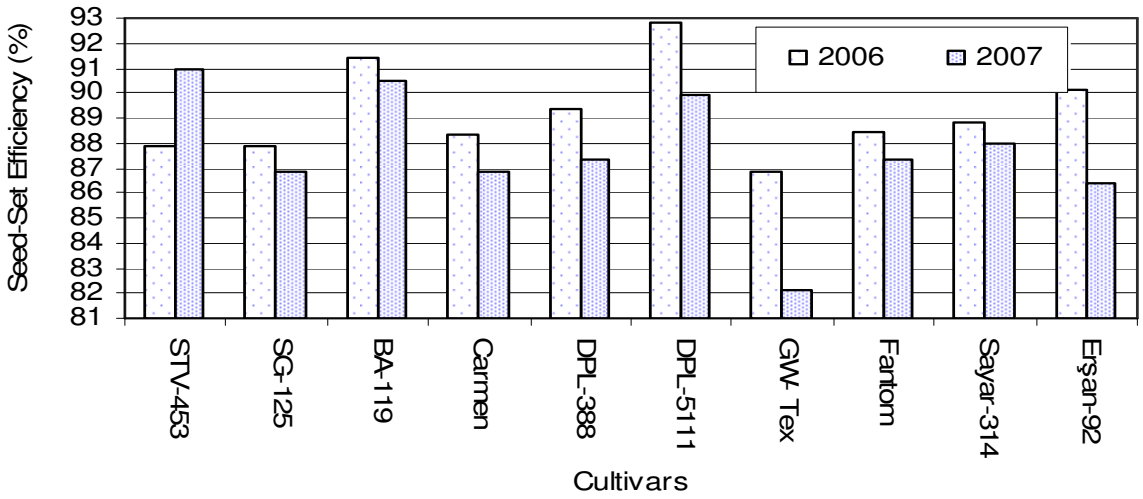

Figure 2. SSE means of cotton varieties in 2006 and 2007 for the second harvesting time.

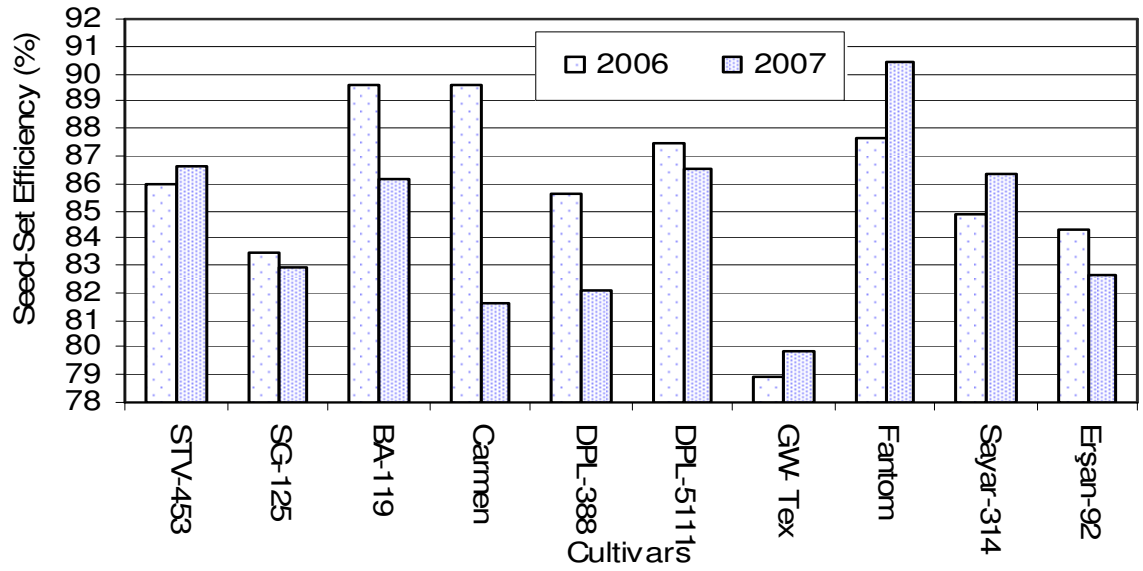

Figure 3. SSE means of cotton varieties in 2006 and 2007 for the third harvesting time.

Correlations between SSE and seed cotton yield and seed yield were significant (r = 0.39 and r = 0.44) in 2007, but they were not significant in 2006 (Table 4). Average seed cotton yield was 4021 kg ha-1 in 2006, while it was 3883 kg ha-1 in 2007 (Table 3).

DISCUSSION

The present study compared the SSE values obtained from bolls harvested from 10 different cotton varieties at different harvesting times. Except for the first harvest of 2006 (September 5th), significant differences were determined between all harvesting times. This results from the fact that bolls developed in different positions on the plants in different periods; therefore, differences arise in temperature, humidity and nutrition (Burke, 2002). In both years, the humidity, the highest and lowest temperature ratings in the initial and terminal blooming periods were between 42 - 45%, 22 - 24 and 32 - 38°C, respectively. The preference of insect populations for cotton flowers can also cause differences in SSE. Similar results were also reported by Gervais et al. (1993) and Bradow et al. (1996).

In the varieties BA-119, Carmen and DPL-5111, the SSE values obtained in the September 20th harvest were found to be higher than those of the September 5th and October 5th harvests. This results from the lateness

Table 3. Mean yield (kg ha^{-1}) and LSD groupings of cotton varieties in 2006 and 2007.

Cultivars	Seed Cotton Yield (kg ha^{-1})		Lint Yield (kg ha^{-1})		Seed Yield (kg ha^{-1})	
	2006	2007	2006	2007	2006	2007
STV-453	4874.1 a*	4541.2 a	1839.0 a	1752.3 ab	3035.1 a	2788.9 a
SG-125	3281.9 f	3183.1 e	1304.4 e	1307.0 f	1977.5 e	1876.1 f
BA-119	4553.3 ab	4321.4 ab	1856.0 a	1824.9 a	2697.3 b	2496.5 bc
Carmen	3862.2 de	3917.3 c	1540.0 cd	1606.7 d	2322.2 cd	2310.6 d
DPL-388	3941.6 cde	3867.4 c	1629.0 bc	1618.8 cd	2312.5 cd	2248.6 d
DPL-5111	3596.4 ef	3451.4 d	1376.8 de	1351.7 f	2219.6 de	2099.7 e
GW-Teks	3385.4 f	3231.5 de	1379.3 de	1322.2 f	2006.2 e	1909.2 f
Fantom	4089.8 bcd	3876.2 c	1565.7 bcd	1494.4 e	2524.1 bc	2381.8 cd
Sayar-314	4233.2 bcd	4209.1 b	1695.1 abc	1720.4 abc	2538.0 bc	2488.7 bc
Erşan-92	4396.9 bc	4235.3 b	1755.1 ab	1687.0 bcd	2641.7 b	2548.2 b
Means	4021.8	3883.4	1594.0	1568.6	2427.4	2314.8
LSD (0.05)	467.2	240.3	199.3	110.9	294.1	138.7
CV (%)	6.78	3.61	7.29	4.12	7.06	3.49

*: Mean in each column followed by the same letter are not significantly different ($p<0.05$).

Table 4. Correlation coefficient values between yield components and SSEs in 2006 and 2007.

Yield (kg ha^{-1})	Sees Set Efficiencies of the Cotton Cultivars	
	2006	2007
Lint Yield (kg)	0.26ns	0.29ns
Seed Yield (kg)	0.23ns	0.44*
Seed Cotton Yield (Total, kg)	0.25ns	0.39*

NS: Not significant. *: Significant at P= 0.05

character of the varieties. In 2006, the values obtained from the September 5th and September 20th harvests were similar and the values obtained from the October 5th harvest were lower than those of the other two harvests, according to the harvesting time and general average values. In 2007, the SSE was found to be affected by the different harvest times and decreased in late harvest times. This is due to the different reactions of the varieties to environmental conditions during the blooming period.

Moreover, the importance of the year and variety interaction supports our findings. The values obtained in the present study are similar to the findings of Turner et al. (1977) but lower than those of Bölek and Oğlakçı (2007). This is probably due to different environmental conditions affecting the experiment. In Fantom cultivar, the SSE values obtained from the October 5th harvest in both years were higher than the values obtained from the September 20th harvest and are similar to the values obtained from the September 5th harvest (Table 2). This is caused by the fact that the Fantom variety developed earlier thus, its SSE value decrease in high temperature periods.

Conclusion

The average seed cotton yield was 4021 kg ha^{-1} in 2006 while it was 3883 kg ha^{-1} in 2007 (Table 4). The yields of the varieties with high SSE values were not high (Table 3) because the number of bolls of the varieties with high SSE values was low. The SSE values of the varieties BA-119, Carmen, DPL-5111 and Fantom were high suggesting that they should be chosen as parents in seed improvement programs.

There were differences of 3-5% between the SSE values obtained from the harvests on September 5th, September 20th and October 5th (Table 2). However, Bölek and Oğlakçı (2007) reported that the SSE values obtained from the bolls which were formed in different parts of the plant are similar to one another and therefore all the seeds in a plant can be used for production. This is caused by different climate conditions. However, in seed improvement programs in semi-arid climate conditions, the seeds obtained from the seed cotton collected in different times should not be mixed and the seeds to be used for cotton production should be harvested in the first week of September.

REFERENCES

Anonymous (1989). User's Guide to MSTATC, An Analysis of Agronomic Research Experiments. Michigan State University, USA.

Bölek Y, Oğlakçı M (2007). Genetic variation among cotton (*Gossypium hirsutum* L.) cultivars for seed-set efficiency. Turk. J. Agric. Forest. 31(4): 229-235.

Bradow JM, Davidonis GH, Hinojosa O, Wartelle LH, Pratt KJ, Pusateri K, Bauer PJ, Fisher B, Sassenrath-Cole GF, Dastoor PH, Johnson A, Landivar JA, Locke D, Moseley D (1996). Environmentally induced variations in cotton fiber maturity and related yarn and dyed knit defects. In: Proc. Beltwide Cotton Conferences (Eds. Dugger CP and Richter DA), National Cotton Council, Memphis, TN. pp. 1279-1284.

Burke JJ (2002). Moisture sensitivity of cotton pollen: An emasculation tool for hybrid. Agron. J. 94: 883-888.

Davidonis GH, Johnson A, Landivar JA (2000). Cotton mote frequency under rainfed and irrigated conditions. 4(1): 1-9.

Dinç U, Şenol S, Sayın M, Kapur S, Güzel N, Derici R, Yesilsoy MS, Yeğingil I, Sarı M, Kaya Z, Aydın M, Kettaş F, Berkman A, Çolak AK, Yılmaz K, Tuncgöğüs B, Özbek H, Gülüt KY, Karaman C, Öztürk N, Kara EE (1988). Harran Plain Soils. University of Çukurova, Faculty of Agriculture, Department of soil science. Project number: TÜBİTAK-TOAG 534, Adana-Turkey (Turkish).

Gervais C, Trahan R, Moreno D, Drolet AM (1993). Phragmites australis in Quebec: geographic distribution, chromosome numbers and reproduction. Can. J. Bot. 71: 1386-1393.

Hughes LC (1968). Motes in varieties of *Gossypium barbadense* L. Cotton Gr. Rev. 45: 266-280.

Kıllı F, Tursun Ö (2007). Lint yield and mote frequnecy of cotton cultivars (G*ossypium hirsutum* L.) grown under irrigated and non-irrigated conditions. The 7th National Field Crops Congress of Turkey, Proceedings of Industry Plant Vol. 2. 25-27 June, 2007, University of Atatürk, Faculty of Agriculture, Department of Field Crops, Erzurum-Turkey (Turkish), pp. 755-758.

Prasad PVV, Boote KJ, Allen Jr. LH, Thomas JMG (2003). Super-optimal temperatures are detrimental to peanut (*Arachis hypogaea* L.) reproductive processes and yield at both ambient and elevated carbon dioxide. Global Change Biol. 9: 1775-1787.

Reddy KR, Hodges HF, Kimball BA (2000). Crop ecosystems and climate change: Cotton. In: Climate Change and Global Crop Productivity (Eds. Reddy KR and Hodges HF). CABI Publishing, Wallingford, Oxon, UK. pp. 161-187.

Sato S, Peet MM, Thomas JF (2000). Physiological factors limit fruit-set of tomato (*Lycopersicon esculentum* Mill) under chronic, mild heat stress. Plant Cell Environ. 23: 719-726.

Stewart JMcD (1986). Integrated events in flower and fruit. In Mauney JR and Stewart JMcD (ed.). Cotton physiology. The Cotton Foundation, Memphis, TN. USA. p. 261-300.

Turner JH, Stewart JMcD, Hoskinson PE, Ramey HH (1977). Seed setting efficiency in eight cultivars of upland cotton. Crop. Sci. 17: 769-772.

Walhood VT, McMeans JL (1964). Seed number as a factor in fruit retention in cotton. Proc. 18th Ann. Beltwide cott. defol. physiol. conf. pp. 30-33.

Waller GD, Wilson FD, Martin JH (1981). Influence of phenotype, season and time of day on nectar production in cotton. Crop Sci. 21: 507-511.