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Cotton Production of Main and Second Crop Established from Seedlings in Aegean Region

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Abstract: Increasing of cotton production and yield is very important for developing countries, because cotton is a raw material for textile industry. For this, it should be used the beneficial effects of suitable irrigation, fertilizing, and crop production techniques. Some of the production techniques increasing cotton yield, lint quality and decreasing production costs are, cotton production from seedlings, twin rows sowing technique, sowing to a stand, sowing under the plastic mulches, and fluid drilling of pre-germinated seeds.
The purpose of this research are, a) the production possibilities of main crop cotton established from seedlings and established from single row and twin rows sowing techniques, and b) the production possibilities of second crop cotton directly from seeds or from seedlings.
The research results about the main crop cotton showed that transplanting of seedlings had the potential to increase the yield and early-maturing though the effects were not significant. However, crops established from seedlings gave 14.37 percent higher earliness than crops established from seeds sown in a single row (conventional sowing). On the contrary, the earliness was equal in transplanted and twin rows drilled plots. The production techniques did not affect the lint quality, significantly.
In the condition of Aegean Region, degree of boll opening of transplanted second crop cotton was 90.9 percent at the end of September. It could be produced the second crop cotton by transplanting at 90.9 percent boll-opening in Aegean region. Second crop yield obtained from drilled plots was found unsatisfactory, because the earliness (boll opening) was 12.84 percent. Yields of main crop cotton established from seedlings was 5,543 kg ha^{-1} averaged over second crop yield (only transplants, 3,966 kg ha^{-1}. Second crop cotton produced directly from seeds decreased dramatically because of the harvest delay.
Transplanting of cotton seedlings provide about 15-30 days advantage. Earlier growth means earlier harvesting. Earlier cotton harvesting provides the opportunity to harvest the quality seed cotton with higher first-hand picking efficiency.
Key words: Transplanting of cotton, twin rows sowing technique, main and second crop cotton production.

INTRODUCTION

Cotton is an important textile material, a source of oil, an important fodder material and an important raw material for many industries. Cotton is produced 2 million tons of seed cotton and 900.000 tons (4 million bales) of cotton lint from an area of 700.000 ha in Turkey. Cotton is produced in Aegean, Mediterranean and Southeast Anatolia Region of Turkey; the share of regions on the production is 30%, 23% and 47%, respectively. The important countries produced cotton is China, USA, India, Pakistan, Brazil and Turkey. The highest lint cotton yields obtained in Australia (1779 kg ha^{-1}), in Israel (1730 kg ha^{-1}) and in Turkey (1428 kg ha^{-1}). China, India, Pakistan, Turkey, USA, Brazil and EU (25) are the important cotton import countries. The cotton consumption trends in Turkey increases higher than cotton production. There are two possibilities to increase the production profitability: increasing incomes (area*yield) and decreasing costs (cotton prices). Cotton is produced in Turkey by modern production technologies. However, there are still the possibilities for improving input efficiency using high production technologies with appropriate mechanization, such as:

- Minimum tillage,
- Main and second crop cotton established from seedlings,
- Twin rows seeding technique,
- Cotton production without thinning,
- Seeding under plastic mulches,
- Second crop cotton production,
- Fluid drilling technique, seeding a pre-germinated seeds,
- Integrated pesticide management (IPM),
- Mechanical cotton harvesting.

World cotton demand is expected to continue to expand in the future. Energy costs are certainly increasing. However, this will have more negative impacts on synthetics production than cotton lint, and will enhance the competitiveness of cotton.

Research on the cotton production from seedlings is new. Önal et al. (2007) had shown that if the cotton seedlings could be established in glass-house and than transplant in the field, both the uniformity of the crop stand and the rapidity of root, leaves and main-stem growth would be improved.

The principles advantages of planting of cotton seedlings are as follows:

- Cotton harvesting could be done earlier, in rainless season. This results in higher quality lint. Drying problems is eliminated. Long-years meteorological data show that first rain occurred in 25th September in Bornova - Izmir (Mutaf, Önal, 1980).
- First-hand cotton harvesting ratio will be high. It is obvious that, first-hand cotton picking is cheaper than second and third-hand picking.
- Mechanical cotton harvesting could be done in one circle because of the uniform crop stand. Excessive rains cause delays in harvesting. In extreme situation stop the harvesting.
- Seedlings transplanting can decrease the irrigation frequency and eliminate the hand thinning and first-hand hoeing work.

Development stages of cotton growing are given in Table 1.

While it is true that in many areas of the cotton belt early planting frequently results in an earlier, higher-yielding crop, growers should temper their enthusiasm with caution. Temperatures below 50 (F) degrees can result in chilling injury or the death of seedlings if they occur while the seed is absorbing water. Planting should be delayed until:

- Soil temperatures at the 3-inch (7.5 cm) depth at 10 a.m. average 65 (F) degrees (18.3 ºC) or higher for three days.
- The five-day forecast calls for dry weather and a minimum of 25 DD-60s.
- Forecast lows will remain above 50 (F) degrees for the two nights following planting.

DD-60 or degree days above 60, is a unit of measurement for the amount of heat received by the plant during the growing season. Degree days are determined by adding the daily high and daily low temperatures, dividing the result by two, and subtracting the temperature threshold of 60. For example, if the daily high is 90 (F) degrees and the daily low is 70, then 90+70= 160; 160.2= 80; 80-60= 20 DD-60s

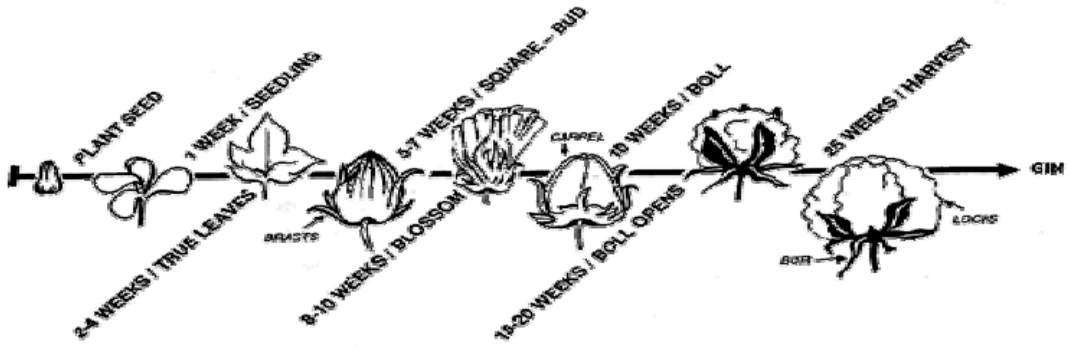
Many experts believe DD-60s provide a more accurate measurement for plant development than the number of calendar days, which can vary with the weather (Anonymous, 1997).

As you seen in Table 1, the first growth period (vegetative growth) extends from seed germination to the appearance of the first square. Under favorable conditions, seedlings emerge five to ten days after planting or after 50 to 60 degree days (DD- 60s). The plant establishes its basic framework –the root, vegetative and fruiting branches and partial leaf canopy- in 45 to 55 days, 450 to 500 DD-60s from planting.

The second growth period (fruit formation) begins with the appearance of the first square and continues until the boll opens. The plant will normally attain its boll-carrying capacity during this period. The plant will set approximately 95 percent of its yield potential during the first four weeks of bloom. The first four weeks of squaring will give rise to the blooms which open during the first four weeks of bloom. The crop begins with the first square, expected about 425 to 475 DD-60s from planting. It can be said that when the first bloom opens, all of the fruiting structures which will be harvested are on the plant.

Table 1. Number of calendar days and the number of degree days (DD-60s) for various stages of growth (Anonymous, 1997).

	Number of days			DD- 60s
	Average	Low	High	
From planting to emergence	-	4	10	50 – 60
From emergence to square	32	27	38	425 – 475
From square to white bloom	23	20	25	300 – 350
From planting to first bloom	-	-	-	775 – 850
From white bloom to open bloom	55	45	66	850
June bloom	-	45	55	To
July bloom	-	55	65	1100 (950 avg.)
Rich soil 4 to 5 days later than thin soils from bloom to full grown boll	21	20	25	From planting to a mature crop 2,150 to 2,300



The third growth period (boll growth and maturation) begins after fertilization of blooms, the boll develops rapidly, reaching full size in about three weeks. Four to five weeks more are required for boll maturation. The boll period-days from bloom to open boll requires an average of 750 DD-60s. Bolls developing from blooms that occurred early in the season usually require about 35 to 40 days from bloom to maturity. Blooms developing in late August and early September require as much as 80 days to accumulate the needed 750 to 1,100 degree days to move from bloom to open boll.

Table 1 indicates that transplanting of cotton seedlings provide about 15 to 30 days advantage. Earlier growth means earlier harvesting. Earlier cotton harvesting provides the opportunity to harvest the quality seed cotton with higher first-hand picking efficiency.

Cotton plants benefits from sunshine, water and soil nutrition uniformly in uniform stand. In the twin rows planting technique, there are two narrow rows instead of single row, and the distance of plants in a row are twice longer than other technique. The fact that in the twin rows planting technique, to plant the seeds in triangle design prove the uniformity of plant growing area and yield. The twin rows sowing technique used for the row crops, such as beans, peas, sunflower, tomatoes, maize, etc., increases the yield and decreases the risk of yield (Stout, 1974; Anonymous, 1979; Anonymous, 1988; Anonymous, 1989; Witzel, 1989). Tozan et al. (1990) modified the mechanical and pneumatic precision seeder to sow the cotton and tomatoes seeds. The most common row spacing for tomatoes is 30 to 35 cm between rows on 150 cm centers. Aykas et al. (2006) showed that the production of cotton as a second crop is possible but in order to this the direct drilling of cotton seeds has to be achieved in dry soil right after the harvest of cereal and then irrigation can be applied right after seeding.

The aims of this study are to find a) the possibilities of main crop cotton production by means of the single row and twin rows sowing, and seedling transplanting techniques; b) the possibilities of second crop cotton production by means of the direct sowing and seedling transplanting techniques.

MATERIALS and METHODS

Climatic Conditions

There is a strong relationship between the techniques of cotton sowing, transplanting of cotton seedlings, cotton harvesting and climatic conditions. Belonging to the Mediterranean belt, the climate of Aegean and Mediterranean Region of Turkey is characterized by more or less heavy winter rainfall with mild temperature during this season and hot and dry summers (Table 2). The cold temperature for cotton seed is 15.5 ºC. For this reason, the minimum soil temperature at 20 cm soil depth must be higher than 15.5 ºc (60 ºF) during the sowing. Figure 1 gives an idea about the daily average soil temperature in April and May at 20 cm soil depth in Bornova- Izmir. From Figure 1, it could be seen that the low soil temperature results a serious problems to cotton sowing in early April. April 23 to May 13 is a suitable period to sow the cotton seeds in Aegean Region.

Table 2. Climatologically data (2005, 2006 and) of Menemen Agricultural Research station of Aegean University, Faculty of Agriculture.

Months		x	xi	xii	i	ii	iii	iv	v	vi	vii	viii	ix	year
Precipitation (mm)	2005	7,4	34	42,6	66,5	128	38,8	13,6	44,2			1	0,5	**376,6**
	2006	5,2	98,2	45,2	45,2	36,8	98,4	14,2	2	0,8			20	**366,0**
	2007	107,7	111,6	118,8	33,1	22,6	29,7	19,3	44,1	0,3				**487,2**
Air temperature (°C)	2005	19,2	13,2	9,9	9	8,1	11	15,1	20	24,4	27,6	27,2	23	**17,3**
	2006	16,6	12,1	10,8	5,5	8,5	11,6	16,1	20,1	25,1	27,3	27,3	22,8	**17,0**
	2007	19,7	13,9	9	10,6	10,6	13,4	16,2	22,4	27,5	30,1	29,2	24,4	**18,9**
Relative humidity (%)	2005	60,2	66	70,5	76,1	71	67,9	59,7	60,9	49,8	43,6	58,1	60,3	**62,0**
	2006	62,1	71,2	71,1	74,1	72,3	70,7	62,7	56,2	50	46,4	54,4	59,5	**62,6**
	2007	64,5	69,3	70	62,2	66,9	59,8	48,8	52,2	44,7	38,7	45,8	48,8	**56,0**
Sunny hours (h)	2005	6,9	5,5	4,3	4,4	4,8	6,3	8,5	9,1	12,2	12,2	11,5	9,8	**8,0**
	2006	4,5	2,7	2,4	3,2	2,6	3,8	4	6,5	7	7,3	6,9	5,3	**4,7**
	2007	7,1	4,5	5,2	6,2	5,1	7,0	9,3	9,2	10,3	12,3	11,3	10,4	**8,2**

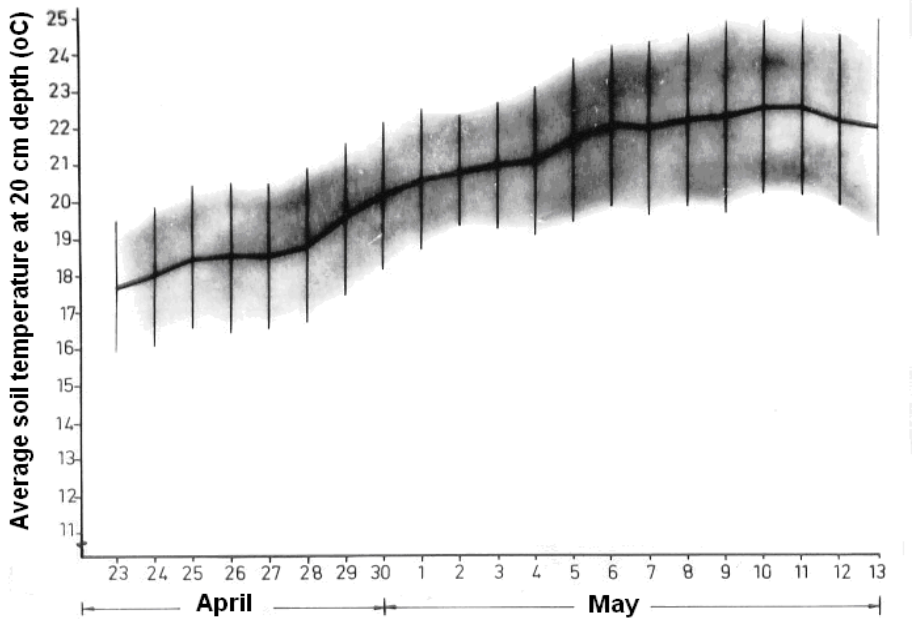


Figure 1. Daily average soil temperature in April and May at 20 cm soil depth in Bornova- Izmir between 1963-1979 (Blackish area indicates the standard deviation) (Mutaf, Önal, 1980)

Timeliness in performing field operations is an important part of successful crop production. Higher precipitation brings serious problems to sow the cotton seeds. From the 17-years climatologically data, the probability of rainfall bigger than 0.25 mm and bigger than 4 mm are illustrated for the period of April 23 to May 13 in Figure 2.

The rainfall probability in Aegean Region decreases after April 28. At a probability level of 0.88, the estimated numbers of suitable days is 10 for the April 23- May 13 planting period. Precipitation and sunny days are the important parameters acting the cotton harvesting. Figure 3 shows the sunny hours in a day in September and October harvesting season.

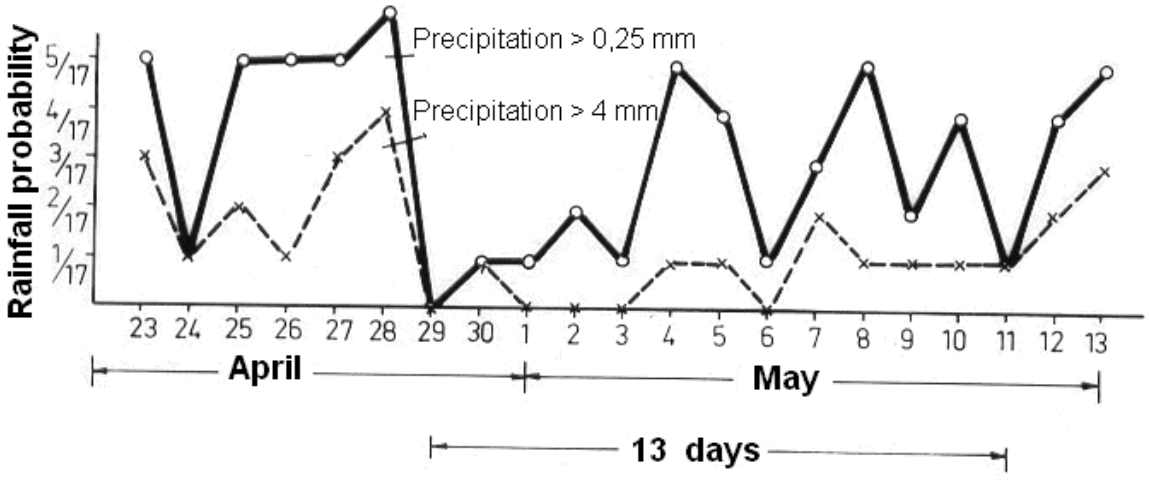


Figure 2. Rainfall probability in Bornova- Izmir bigger than 0.25 mm and 4 mm April 23- May 13 planting period between 1963 and 1979 (Mutaf, Önal, 1980)

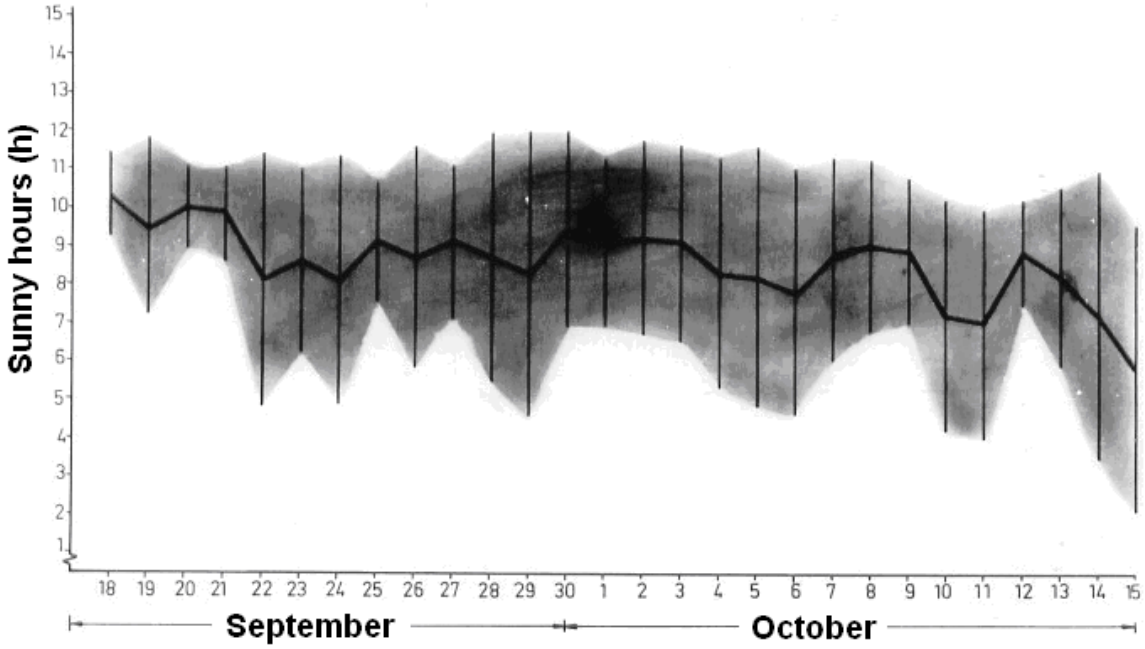


Figure 3. The sunny hours in a day in September and October harvesting season between 1963–1979. (Blackish area indicates the standard deviation) (Mutaf, Önal, 1980).

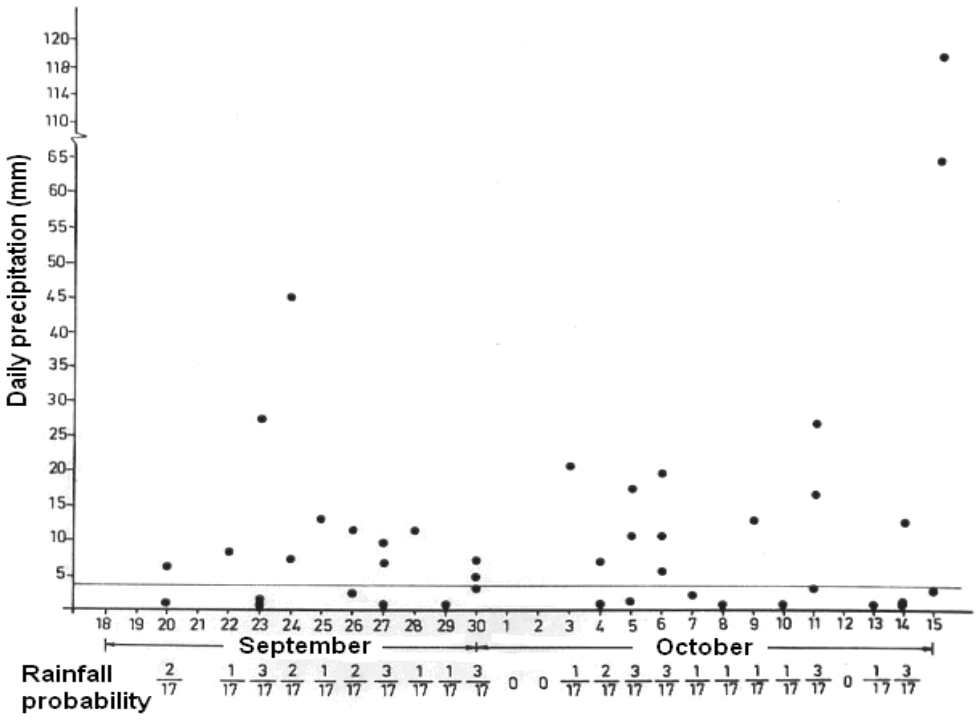


Figure 4. The rainfall probability in Bornova- Izmir during the harvesting period between 1963 and 1979 (Mutaf, Önal, 1980).

The rainfall probability in Bornova- Izmir during the cotton harvesting period (September- October) is shown in Figure 4. Heavy rainfall decreased the cotton lint quality and yield after 20-25 September (especially after October 15) according to the climatologically data of Bornova.

Description of the experimental sites

The field experiments were conducted in Menemen Experiment Station of Aegean University, Faculty of Agriculture, located 35 km west of Bornova. Table 3 gives some details of experimental sites. Menemen Plain has the irrigated alluvial soil.

Table 3. Soil characteristics of the experimental sites. Menemen is located in 38°26˙40˝ north parallel and 26°40˙- 27°07˙ west longitude.

Field	Land class.	Slope %	Altitudes m	Soil structure types			pH	$CaCO_3$
				0-36 cm	36-60 cm	60-80 cm		
Main crop cotton	1.	0-1	10	Loam	Sandy-loam	Loam	7.60	13
Second crop cotton	1.	0-1	10	loam	loam	loam	7.75	4

Methods

Field experiments were carried out in main and second crop plots in a randomized complete block design with three replications. In the main crop plots, cotton seedling transplanting technique was compared with the single row and twin rows sowing techniques.

Previous crop was maize in the main crop plots. The main crop plots were cultivated by heavy disc harrow in autumn, afterwards ploughed with a reversible plough at 25 cm depth. In winter, in March, ploughed field was disc harrowed twice. In spring, seed/ seedling bed preparation were done using 9 legs chisel plough, disc harrow (four fold), rotovator, spike-tooth harrow (twice), and float. Prior the seed bed preparations, 150 kg ha-1 triple super phosphate, 200 kg ha-1 potassium sulfate, 200 kg ha-1 Zinc sulfate, 400 kg ha-1 ammonium sulfate were broadcasted over the field. In the post emergence period, 250 kg ha-1 ammonium nitrate (33%N) was applied in a row at the 2- to 3- true leaf stage during the inter-row cultivation. Block raised plants were transplanted on May 1 (2006) and May 5 (2007) by Ferrari Fmax Model (Italy) transplanting machine. Growing trays had 228 (12*19) pyramidal holes (22.5*22.5*17 mm) 55 mm long. At the same time Stoneville ST 373 delinted cotton seeds were sown by mechanic seeding machine at a seeding rate of 30 kg ha-1 in the main crop plots. The soil moisture content and soil bulk density at 0 to 10 cm, 10 to 20 cm and 20 to 30 cm of soil layers were measured as 17.4%, 22.4%, 25.1% and 1.43 g cm-3, 1.47 g cm-3 and 1.47 g cm-3, respectively. Open field transplant production was done at 17 cm in-row plant spacing and at 76 cm of row spacing (Figure 5a and Figure 5b). Each plot was 50 m long and 4.56 m wide (6 rows). The drilled crops were thinned by hand at the 2-to 3-true leaf stage and the final plant density for single row drilled and transplanted crops were 77,400 plants ha-1. For twin rows, row spacing was taken as 12.5 cm between rows on 76 cm centers. For this reason, twin rows plots had a greater final plant density (105,200 plants ha-1). Fertilizing, plant protection, hoeing and irrigation practices were accomplished according to local recommendations.

Figure 5 a. Ferrari F max model transplanting machine.

Figure 5 b. The main crop plot planted cotton seedlings.

Previous crop was wheat in the second crop plots. Strip tillage machine (inter-row rotary tiller) tilled a soil at a depth of 10-12 cm, and width of 40 cm. Cotton seeds were sown and cotton seedlings were transplanted on the tilled soil band in June 21.2006 and in June 23. 2008. Weeds were controlled by Round-up (pre-emergence) and by Dual (post-emergence) herbicides. The soil moisture content and soil bulk density in second crop plots at 0 to 10 cm, 10 to 20 cm and 20 to 30 cm of soil layers were measured as 7.61%, 7.60, 7.22% and 1.35 g cm-3, 1.38 g cm-3 and 1.44 g cm-3, respectively.

The objectives of field experiments were, to find the plant spacing accuracy of transplanting machine; to find the plant characteristics, seed cotton yield, cotton fiber quality and ginning efficiency in the main and second crop plots.

RESULTS and DISCUSSION

Plant Spacing and Forward Speed of Transplanting Machine

Average plant spacing, standard deviation and coefficient of variation values measured in a field after transplanting after four days are given in Table 4.

A survival rate of seedling of transplanting machine was found 100 percent. The gentleness of the transplanting machine was good. The relationships between the forward speed of the machine and feeding time with a careful and proper placing of seedlings in the turning carousel is given in Figure 6. The proper forward speed (m s-1) could be estimated for 0.75 second feeding time and for Z = 17 cm seedling spacing as a 0.227 m s^{-1}.

Table 4. Plant spacing accuracy of Ferrari (F max model) transplanting machine

Rows	Average plant spacing cm	Standard deviation ± cm	Coefficient of variation %
1.	17.6	3.7	21.0
2.	17.4	4.2	24.1
3.	17.6	3.1	17.6
4.	17.0	3.6	21.2
5.	17.6	4.4	25.0

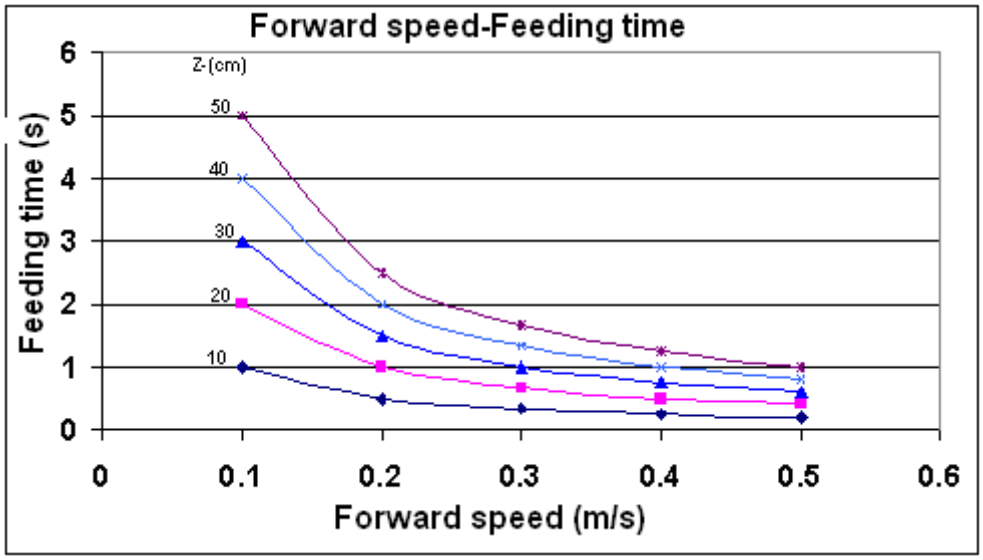


Figure 6. The relationships between the forward speed of machine and feeding time of the turning carousel by hand.

Main crop transplanted and drilled cotton crops

Combined statistical analysis of two years research results (2006-2007) showed that seed cotton yield and ginning efficiency were not significantly different on the main plots (Table 5 and 6). However, transplanted cotton crops gave higher yield than drilled crops in the year of 2007.

Table 5. Seed cotton yield (kg ha^{-1}) in the main crop plots.

Methods	Year 2006		Year 2007		Combined analysis	
	Yield kg ha^{-1}	Statistical groups	Yield kg ha^{-1}	Statistical groups	Yield kg ha^{-1}	Statistical groups
Transplanting	5,709	ns	5,376	a*	5,543	ns
Single row sowing	5,366	ns	4,270	b	4,818	ns
Twin rows sowing	6,253	ns	3,762	b	5,008	ns
*) $p < 0.05$	ns: Not significant			LSR(0.05) = 836.2*		

Table 6. Ginning efficiency (%) in the main crop cotton plots

Methods	Year 2006		Year 2007		Combined analysis	
	Ginning efficiency (%)	Statistical groups	Ginning efficiency (%)	Statistical groups	Ginning efficiency (%)	Statistical groups
Transplanting	44.9	ns	41.5	ns	43.2	ns
Single row sowing	44.2	ns	41.4	ns	42.8	ns
Twin rows sowing	41.8	ns	41.3	ns	41.6	ns

The effects of transplanted and drilled (single, and twin rows) crops upon the plant characteristics, lint quality and degree of boll opening are given in Table 7. From Table 5, 6 and 7, it could be concluded the following results:

- Of the various cultural practices studied, population, transplanting instead of seeding, irrigation and fertilizing have had the most affecting factors on cotton plant characteristics (Önal, 1978). The studies conducted in the past on plant density, population and its effect on plant morphology and lint quality in cotton production revealed important knowledge for those who work in the field of agricultural Mechanization and seeder designers. In twin row plots, consistent raising of the first fruiting nodes occurred with the greater plant population (Table 7). The closely spaced plants developed small laterals with the bolls well distributed along the main stem; the widely spaced ones had heavier branching with more of the crop near the ground.
- The two years experiments on the main crop cotton plots showed that there were no significant differences in seed cotton yield and lint quality between transplanted and drilled crops. However, transplanted cotton crops gave higher seed cotton yield than drilled (single row and twin rows sowing) ones in the year of 2007.
- Transplanting and twin row sowing techniques resulted higher first picking yield. Earliness (open boll, %) had been found 93.60% and 91.56% for transplanted and twins row sown crops, respectively. On the contrary, the earliness was 79.29% for traditional (single row) sowing. Higher first picking efficiency, low pre-harvest loss and higher lint grade are favored by an early harvesting program (McKibben et al, 1965). If the earliness were higher, picking efficiency would be improved and once-over picking method could be realized.
- Root structure of cotton plants in the main crop plots had been listed in Table 7. From Table 7, it could be concluded that the roots of transplanted cotton plants elongated laterally rather than axially. However, the lateral roots elongated sometimes axially and compensate the overall root growth. Roots of transplanted cotton were found not to penetrate so deeply like drilled crop, but the total number of roots and the proportion of root hairs were both found to be higher. Although the information is not definitive, the larger number of roots and particularly the larger total root surface in a soil indicate that a better root-soil contact is obtained than drilled cotton crop. Avcıoğlu and Gürel (2000) indicated that aged root cells have not capable to take the plant nutrition. For this reason, root density is a reliable measure than total root weight.

Second crop transplanted and drilled cotton crops

The effect of transplanting and drilling of cotton seeds on seed cotton yield and lint quality are given in Table 8 and 9.

Combined statistical analysis of two years (2006-2008) indicated that second crop transplanted cotton gave higher seed cotton yield than drilled cotton, significantly. Transplanting and drilling method did not give significant difference on lint quality (Table 9).

The second crop cotton results shown in Table 10 indicate that earliness (open boll, %) from transplanted crops was, on average, 78.06% higher than conventionally drilled crops. Cotton crops established from seedlings started to ripen earlier than those established from delinted seeds. Seed cotton yield from crops established from seedlings was 3,966 kg ha-1, 96.82 percent higher than crops directly established from delinted seeds.

The root structure of second crop transplanted and drilled crops showed the same tendency (Table 10).

Table 7. Effects of transplanted and drilled crops in the main crop plots upon the plant characteristics, lint quality, and boll opening (2006-2007).

Plant characteristics and lint quality		Transplanting	Single row sowing	Twin rows sowing
Plant population (plant ha^{-1})	**Years**	77400	77400	105200
Average plant height (cm)	2006	123.27 ± 4.25	134.40 ± 3.57	109.88 ± 4.04
	2007	114.00 ± 12.91	123.30 ± 6.61	114.60 ± 1.99
Avera. main root length (cm)	2006	30.75 ± 2.81	34.20 ± 2.49	30.75 ± 3.69
	2007	34.50 ± 6.43	35.10 ± 7.23	30.20 ± 5.89
>1 mm Ø root length (cm)/ plant	2006	14.58 ± 1.21	15.86 ± 2.05	14.16 ± 1.93
	2007	12.99 ± 3.33	15.64 ± 5.28	14.87 ± 5.08
>1 mm Φ av.Nr. of root / plant	2006	7.08 ± 1.57	4.70 ± 1.24	5.13 ± 1.41
	2007	6.00 ± 2.36	3.20 ± 0.93	2.80 ± 1.11
<1 mm Φ av.Nr. of root/ plant	2006	9.08 ± 3.41	9.20 ± 1.72	9.50 ± 2.54
	2007	9.80 ±4.93	16.80 ± 5.84	8.00 ± 4.64
Average stem diameter (mm)	2006	16.63 ± 2.10	12.76 ± 1.08	10.31 ± 0.41
	2007	10.60 ± 1.24	10.64 ± 1.86	8.64 ± 0.67
Average number of branch/ plant	2006	16.50 ± 0.88	16.3 ± 1.06	14.50 ± 1.18
	2007	14.80 ± 1.99	15.80 ± 2.41	13.00 ± 1.92
Average number of boll/ plant	2006	18.17 ± 2.87	10.5 ± 2.03	8.0 ± 1.45
	2007	22.20 ± 5.40	20.2 ± 4.80	12.60 ± 2.43
Earliness (open boll, %)	2006	93.66	79.29	91.56
	2007	89.19	59.41	66.67
Height of first fruiting node(cm)	2006	14.25 ± 5.22^{+}	34,2 ± 5,39	28.9 ± 4.97
	2007	18.80 ± 10.72	20.70 ± 16.38	27.00 ± 3.94
+) Standard errors				
Seed cotton yield (kg ha^{-1})	2006	5,709	5,366	6,253
Ginning efficiency (%)		45.26	44.21	41.79
Fiber fineness (micronaire index)		3.81	4.03	3.84
Maturity		0.88	0.885	0.89
Fiber length (mm)		30.32	30.90	30.84
Fiber strength		32.9	31.9	32.25
Brightness		82.15	83.10	80.95

Table 8. Seed cotton yield (kg ha^{-1}) in the second crop plots.

Methods	Year 2006		Year 2008		Combined analysis	
	Yield kg da^{-1}	Statistical groups	Yield kg da^{-1}	Statistical groups	Yield kg ha^{-1}	Statistical groups
Transplanting	4,788	ns	3,145	a*	3,966	a*
Single row sowing	2,509	ns	1,522	b	2,015	b
ns:Not significant			LSR(0.05)= 396		LSR(0.05) = 1,548	

Table 9. Ginning efficiency (%) in the second crop cotton plots

Methods	Year 2006		Year 2008		Combined analysis	
	Ginning efficiency (%)	Statistical groups	Ginning efficiency (%)	Statistical groups	Ginning efficiency (%)	Statistical groups
Transplanting	44.9	ns	42.7	ns	43.8	ns
Single row sowing	40.8	ns	44.9	ns	42.9	ns

CONCLUSIONS

The followings were concluded from the study:

- The results obtained from the experiments showed that block raised seedlings could be transplanted 100 percent survival rate of seedlings. The gentleness of the transplanting machine in handling the seedlings was good. Plant distribution accuracy in a row, as an average of coefficient of variation, was 21.8 %
- The results of the two years of main crop cotton experiments indicated that there were no significant seed cotton yield and lint quality difference between transplanted and drilled plots. However, crops established from seedlings gave 14.37 percent higher earliness than crops established from seeds sown in a single row (conventional sowing). On the contrary, the earliness was equal in transplanted and twin rows drilled plots. Twin rows sowing technique gave higher plant distribution uniformity over an area. Crops profit from sunshine, water and soil nutrition uniformly on the plots drilled by twin rows technique. Transplanting of cotton seedlings give us the earlier cotton harvesting opportunity. Low-moisture cotton favors the harvesting. On the contrary, lint color is adversely affected by high seed cotton moisture. Optimum lint moisture is approximately 11 percent (Mc Kibben et al, 1965).
- The roots of transplanted main crop cotton plant in a field elongated laterally rather than axially. However, some of the lateral roots elongated axially and compensate the overall root growth. Roots of transplanted cotton were found not to penetrate so deeply like drilled crop, but the total number of roots and a proportion of root hairs were both found to be higher. Avcıoğlu and Gürel (2000) indicated that aged root cells have not capable to take plant nutrition. For this reason, root density is a reliable measure to gain nutrition from soil than total root weight.

Table 10. Effects of transplanted and drilled crops in the main crop plots upon the plant characteristics, lint quality and boll opening (2006 and 2008).

			
Plant characteristics and lint quality		**Strip tillage Transplanting**	**Strip tillage Direct seeding**
Plant population (plant ha^{-1})	**Years**	77400	77400
Average plant height (cm)	2006	57.95 ± 3.86	55.86 ± 2.98
	2008	74.67 ± 4.87	72.56 ± 5.67
Average. main root length (cm)	2006	24.50 ± 3.19	27.86± 1.50
	2008	23.33 ± 4.31	18.50 ± 2.11
>1 mm Ǿ average root length (cm)/ plant	2006	15.39± 0.96	17.77± 4.51
	2008	16.47 ± 1.75	12.72 ± 2.04
>1 mm Φ average number. of root / plant	2006	8.42± 1.43	2.06± 0.71
	2008	5.67 ± 0.52	3.56 ± 0.53
<1 mm Φ average .number. of root/ plant	2006	6.42± 1.38	5.11± 0.84
	2008	5.67 ± 2.76	4.89 ± 0.99
Average stem diameter (mm)	2006	9.6± 1.97	9.68± 0.52
	2008	10.89 ± 1.66	7.94 ± 1.01
Average number of branch/ plant	2006	10.33± 0.70	8.83± 1.14
	2008	10.17 ± 1.11	8.56 ± 0.74
Average number of boll/ plant	2006	13.5± 2.19	9.22± 1.26
	2008	16.5 ± 4.72	8.11 ± 0.99
Earliness (open boll, %)	2006	90.92	12.84
	2008	84.85	32.92
Height of first fruiting node(cm)	2006	13.58±1.05^{+}	23.75± 1.60
	2008	14.17 ± 0.72	22.11 ± 3.53
+) Standard errors			
Seed cotton yield (kg ha^{-1})	2006	4,788	2,509
Ginning efficiency (%)		42.2	39.7
Fiber fineness (micronaire index)		4.59	4.4
Maturity		0.91	0.93
Fiber length (mm)		31.35	32.8
Fiber strength		31.4	32.7
Brightness		78.2	77.7

- Main and second crop experiment results indicated that root structure of transplanted and drilled crops showed the same growth tendency.
- Combined statistical analysis showed that second crop transplanted cotton gave 90.80 percent higher seed cotton yield than drilled cotton ($p < 0.05$). Transplanting and drilling did not give significant difference on lint quality; because both plots had been picked in dry season. It is clear that first hand picking rate (earliness, boll opening) in the second crop plots was 12.84 percent. This means that it could be produce the second crop cotton by transplanting 90.9 percent boll-opening in Aegean region. Second crop yield obtained from drilled plots was found unsatisfactory, because the earliness (boll opening) was 12.84 percent. Truly, Aykas et al (2006) found that second crop drilled cotton could be produce in Aegean Region after harvesting main crop wheat, but time delay should not be made and planting should be performed right after wheat harvest, and irrigation should be made immediately so that harvest time of cotton will not come to the late autumn (First picking 28-30 October, second picking 5-22 November).

Results of field studies in 2006, 2007 and 2008 indicated that transplanting of cotton seedlings has a great potential to increase the yield and lint quality, as well as the economical advantages, and to plan the early harvesting program. Transplanting of cotton seedlings provide about 15 to 30 days advantage. Earlier growth means earlier harvesting. Earlier cotton harvesting provides the opportunity to harvest the quality seed cotton with higher first-hand picking efficiency.

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