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PERFORMANCE EVALUATION OF A TRACTOR MOUNTED MECHANICAL COTTON PICKER

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Abstract

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Mechanical cotton harvesting showed significant progress in Turkey for last decade. The most common cotton harvesters are self-propelled, high capacity, horizontal spindle type pickers. These types of pickers need to be run in more than 150-200 ha per season to reach an economical picking in Turkish conditions. However, agricultural lands are in Turkey are mostly small (avg. 6 ha) and fragmented. This structure has led the small-scale farmers to seek alternative ways. One of them was tractor-mounted pickers that suitable for small-scale farms. The objective of this study was to determine the qualitative and quantitative performance of two narrow row (0.76 m) tractor mounted with vertical spindle prototype cotton picker manufactured in Turkey. Field trials were held at four locations with three different varieties (Stoneville 393; Stoneville 457 and Carmen - Fibermax) at 0.76 m inter-row spacing. Results revealed that plant and field conditions and defoliation were effective on the quantitative performances results. In general, the prototype picker showed a successful performance and can pick with average 3% ground loss if suitable conditions are provided. No significant effect was observed between the treatments (hand and mechanical picking) and fiber quality values. The prototype picker used in the study was found suitable for small-scale farms.

Key words: cotton, harvest, mechanical picking, picker

Abbreviations: W- White; SP- Spotted; LSP- Light Spotted; M- Middling; SLM- Strict Low Middling; LM- Low Middling; SGO- Strict Good Ordinary

Introduction

Cotton as a raw material for many industrial sectors is one of the most important crops for Turkey and its economy. It is also such a crop that many people are employed in different sectors. Turkey with a yearly cotton lint production of approximately 1 million metric tons produces %3 of cotton in the world (FAOSTAT, 2012) and it is mainly grown in the Aegean (western), Mediterranean (southern) and South Eastern Anatolia.

Cotton production that gained a special important in a commercial sense since 1950s exhibited a labor-intensive structure due to hand harvest. The labor requirement especially in the harvest seasons was met by local workers. However, an increased trend of industrialization in the Aegean and Mediterranean regions caused a significant reduction in the number of workers who worked in cotton harvest since they started to work in different areas of the industry. The necessary labor force for cotton picking were met by the seasonal workers who migrated from the Southern Anatolia where arid climate and inadequate irrigation facilities and high level of unemployment due to undeveloped industry limited the farming practices to reach the desired level until 1990s. This situation continued until the mid 90s and then changed with an increased level of irrigation facilities and developments that took place in social life and in the area of agriculture within the scope of a project namely Southern Anatolian Project (SAP). The SAP is an integrated and large project and aims to improve the living standards, income and job opportunities of nearly four million people in the Eastern and Southeastern Anatolian regions. The project that includes nine provinces in the region on the other hand will help irrigating an additional land of 1.7 million hectares. This land is almost 20% of the total irrigable areas in Turkey (Anonymous, 2012). With

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partially implemented project in 1996, almost 17% of the irrigation projects were completed (Anonymous, 2012) and it is expected that cotton can be grown in a land of approximately 1.2 million hectares out of 1.7 million hectares. With partially implemented irrigation opportunities, the increase in cotton production in the region was more than expected. The region in 1996 produced 25% of the total cotton production where it reached almost 56% at present (TurkStat, 2012a).

Increased production in the region especially in the province of Sanliurfa where the highest production was obtained caused a significant reduction in the number of workers who seasonally migrate to other regions (Kalaycioglu, 2001; Akis and Akkus, 2003). The reduced number of workers resulted in an increased wages and harvest costs. As a result, the harvest cost had a share of 25% in the total cost and cotton production in other regions became uneconomic due to increases in other inputs such as fuel, irrigating, fertilizer and chemicals (Yilmaz et al., 2005; Budak and Budak, 2006; Gul et al., 2009; Isin et al., 2009).

These problems changed the vision of the farmers who were not willing to harvest their crops by hand due to vast number of workers and low wages. Starting 1998s, some producers exported some narrow row (0.76 m) cotton pickers from the United States and started to use them for harvesting operations.

Transition to mechanical cotton picking by pickers slowed down in 2000 due to economic crisis but than speeded up in the following years. Because of recovering economy, the number of cotton pickers jumped from 13 in 1998 to 730 at present where 2/3 of these pickers are located in the Aegean and Mediterranean regions (TurkStat, 2012b).

The cotton pickers in Turkey are generally 4 or 5 narrow-rows (0.7, 0.76, 0.81 m), horizontal spindle type self propelled pickers. For an economical production, large production areas are needed when these types of pickers are used since they have high fieldwork rate up to 10-12 metric tons (Evcim, 2000a; Oz and Evcim, 2002). Studies conducted in cotton harvesting by pickers indicates that an economical production can be achieved if these pickers are used for cotton harvesting in a land between 150-200 hectares a year (Evcim, 2000a). However, the land ownership shows a fragmented structure in Turkey. The average land size is approximately 6 hectares and consists of 2-5 pieces of land (Table 1).

Cotton producers overcome the difficulties that they have faced due to larger capacity of the pickers by different scenarios for an economical production. Machinery rings among farmers who have a land more than 30 hectares, cooperatives and contracting applications can be listed as examples of these scenarios. However, none of these applications could become a solution for the small-scale farmers in the region. Some of the reasons for this could be stated as the high initial price of these pickers, fragmented structure, and topographic structure of the land where the pickers cannot be operated.

Some tractor mounted and pto driven 4 row cotton pickers (0.76 m) with vertical spindles were exported from Uzbekistan as a results of the efforts of small-scale farmers for an economical production. The difficulties in order to attach the tractor, inappropriate structure of the picking units and low efficiency in high yield lands limited the use of these pickers in Turkey even though they were suitable for small lands. Considering these difficulties, a company mainly manufacturing tractors designed a prototype tractor mounted cotton picker with vertical spindles in 2006.

There are many studies conducted on high capacity cotton pickers under the conditions of Turkey but the studies on tractor mounted type pickers are limited and they are mainly on Uzbekistan type pickers (Oz, 2005; Demirtas and Dogan, 2006).

Hence, the objective of this study was to determine the qualitative and quantitative performance of prototype two narrow row tractor mounted cotton picker manufactured in Turkey.

Materials and Method

Field trials were held at four locations in the Aegean (west) and the Southeast Anatolia region of Turkey. Three different varieties; Stoneville 393 (St393)[1], Stoneville 457 (St457) and Carmen (Fibermax) were planted at 0.76 m inter-row spacing. Cultural operations such as thinning, hoeing, fertilizing and

Table 1
Structure of agricultural lands in Turkey (TurkStat. 2011c)

Land size, ha	Number of farms	%	Average size, ha	Number of fragments, %			
				1	2 – 5	6 – 9	> 9
0 – 4.9	1958269	64.8	2	24.8	60.3	11.7	3.2
5 – 19.9	887332	29.4	9.2	10.1	53.2	24.0	12.8
20 – 49.9	153688	5.1	26.8	7.6	47.2	24.5	20.7
> 50	21905	0.7	95.5	11.4	38.3	23.6	26.8

[1] Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the author.

spraying were performed by farmers according to common methods. All locations were furrow irrigated. Defoliant applications were performed with mechanical sprayers.

The prototype picker consisted of four main parts as tractor, picking units, fan and basket (Figure 1).

Tractor is the main power source of the picker and it was equipped with a backward driving system for moving in a backward direction when picking.

The picking units are attached to the tractor from the three-point hitch and driven by a hydraulic motor attached to the tractor's power takeoff. Motion taken from the hydro motor transmitted to the four picking drum which located in line as group of two by means of a sprocket system. Each drum has 13 bars that vertical located and rotatable freely around its axis. These bars surrounded with sharp ended - spirally rounded metal sheets for removing seed cotton from the bolls. Removal of seed cotton from these bars after picking was performed by four rotating brushes, which are located as a group of two on both sides of the drums (Figure 2). Seed cotton is conveyed by air to the basket located right above the tractor's engine block with four conveying pipes. Vertical movements of the picking units are provided by three-point hitch. Picking units also equipped with automatic leveling system for moving automatically according to the field roughness.

Some specifications of the picker used during the tests are given in Table 2.

Performance of the picker was determined both, quantitatively and qualitatively. Quantitative performance values included ground and stalk losses and picking efficiency, which represent the success of the harvest while qualitative performance values consisted of fiber quality.

Fig. 2. Metal sheets and brushes on drum

For evaluating of the quantitative performance, the field and plant conditions were initially determined. In this context, six nonadjacent plots containing two rows, each 3 m

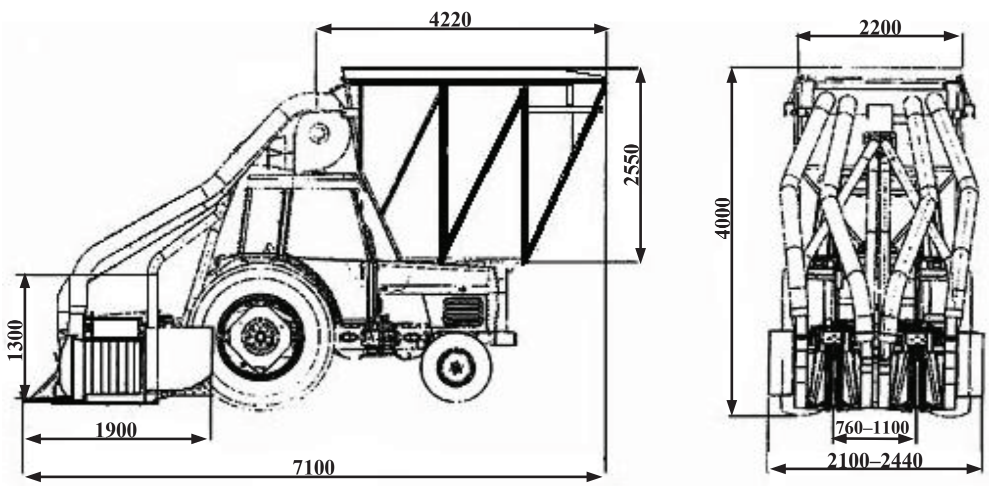

Fig. 1. Schematic view of prototype picker (Anonymous, 2006b)

Table 2
Specifications of prototype picker (Anonymous, 2006a)

Energy source	Tractor - 4WD (min. 55 kW)
Ground speeds:	0-3.1 km/h – 1st picking 0-4.7 km/h – 2nd picking
Picking Units	
Number of rows:	2
Row spacing:	0.76 m – 1.1 m (optional)
Picking style:	Vertical
Drum orientation:	In line
Number of drums:	4 (per unit)
Number of bars:	13 (per drum)
Drum drive system:	Gear
Drum height control:	Hydraulic
Doffer type:	Brush (polyethylene)
Conveying	
Fan type and speed:	Induced air @ 3800 rpm
Basket	
Capacity:	9 m^3
Unloading type:	Vertical. backward unloading
Compactor:	Roof-mounted. rail type
Dimensions	
Overall length:	7.1 m
Width:	2.1 m
Height:	4.0 m
Wheelbase:	1.6 m

long, were selected randomly and diagonally in six different areas representing major crop conditions. In the first three plots measurements were carried out to determine field–plant conditions while the other plots were used to determine quantitative performance values.

Measurements were conducted based on cottonseed counting method that has been adopted by leading cotton picker manufacturers (Evcim, 2000b). In this context, ten typical bolls from each row were randomly selected which reflect the overall structure of the field. In these plants, fully opened bolls were counted and harvestable boll ratio (%) was determined. Then these bolls were collected and weighed to determine average field yield (%). Finally, bolls fallen to the ground by natural causes (wind, rain, sagging, etc.) were collected and weighed for calculating pre-harvest losses (%).

In the plots allocated to determine qualitative performances, ten typical bolls from each row were randomly selected and counting the cottonseed average number of cottonseed per boll was determined. Then, bolls ready to pick were counted and multiplying this by the average number of cottonseeds per boll, the number of harvestable cottonseeds were determined.

After the harvest is completed, all cottonseeds fallen onto the ground in these plots were collected and the number of cottonseeds was counted and divided by the number of harvestable cottonseed to find the ground losses (%). The similar method was also applied to the remaining cottonseeds on the plant and stalk losses (%) determination. By subtracting total loss (ground+stalk loss) from 100, the total picking efficiency (%) was calculated.

To determine the qualitative performances, machine picked seed cotton samples were taken from the basket, 5 times per each unloading operation. Entire samples both carefully handpicked for determining yield (will be referred as ***Ref.***) and taken from the basket (will be referred as ***Bsk.***) were ginned to determine gin turnout ratios by laboratory type roller gin which has not a pre cleaning unit. Measurements for the lint quality factors were performed on the lint samples according to international classification (USDA, 2005) at the HVI (Ulster HVI Spectrum) laboratory located at Commerce Exchange in Manisa. All tests were replicated five times.

Results and Discussion

Table 3 shows the plant and field conditions of the trial fields before harvest. As seen from the table, Soke was found the ideal location from the point of plant and field conditions. It was thought that the suitability of the variety to mechanical harvesting (such as medium height, fewer vegetative branches, etc.) and experience of the farmer about mechanical harvesting due to having a self propelled picker were significantly effective in this location. In Menemen, where the same variety planted unfavorable conditions were observed mainly caused from inadequate weed management, unfinished defoliation, excessive growth pattern and too many logged plants. The field conditions were found much better in Mardin comparing with the other locations (Adiyaman) located in southeast. Adiyaman was determined as the poorest pre-harvest conditions among the entire locations. It was seen that the vegetative development of the plants not completed before harvest in this location is due to considerably late planting (end of May). This has caused to high number of green leaves and lower defoliation (27%). It was measured lower field yield values although high harvestable boll ratio comparing with other locations.

It was observed that differences between plant and field conditions highly affect the quantitative performance values. Thus, higher losses were measured in Menemen and Adiyaman where pre-harvest conditions were comparatively poor (Table 4).

Ground loss, defined as seed cotton fallen to the ground by the picker is accepted as the most important parameter among the quantitative values. Because there is no chance to re-pick the bolls that fallen to the ground during harvest operation, ground losses are non-recoverable losses. Thus, ground loss is a real loss and can be accepted as an indicator of how successfully a picker performs the harvest.

National test standards in Turkey (Anonymous, 2006b), dictates that the ground loss should not exceed 5% of average field yield provided the field, plant and harvesting conditions are convenient and the pre-harvest losses are less than 2%. In the light of observing lower pre-harvest loss in the locations although higher values obtained in Adiyaman, it can be expressed that the ground loss values were within the proposed limits indicated by national standards.

Ground loss is affected by different factors such as field and plant conditions, appropriate variety, picker adjustments and experienced operators. Results are evaluated in this respect, it is understandable to reach higher losses in Menemen and Adıyaman where plant and field conditions were insufficient. It was thought that, insufficient defoliation and unsuitable plant conditions for mechanical harvesting such as excessive vegetative growth, logged plants, immature bolls, etc., were effective on the losses. No significant relationship was observed between field yield and harvestable boll ratio. In Menemen, the downward trend was observed in ground loss val-

Table 3
Pre-harvest conditions of the trial fields

Locations	Variety	Defoliant	Field conditions	Plant conditions	Plant height*, m	Pre harvest loss, %	Harvestable boll ratio [HBR], %	Field yield, kg/ha
Soke (west)	Carmen	Dropp Ultra	Good	Good	0.90 - 1.00	0.3	92	5039
Menemen (west)	Carmen	Appeal %EC	Average	Average	1.00 - 1.20	0.3	90	4666
Mardin (southeast)	St 393	Finish	Good	Good	0.90 - 1.00	0.2	90	3544
Adiyaman (southeast)	St 457	Dropp Ultra&Finish	Average	Bad	0.70 - 0.80	2.6	96	2791

* at harvest

Table 4
Variation of the quantitative performance values (as averages of the repetitions)

Locations	Variety	Defoliant	Plots	Field yield, kgha	HBR, %	Ground losses (GL), %	Stalk losses (SL), %	Total losses (TL=GL+SL), %	Picking efficiency (100 - TL), %
Soke (west)	Carmen	Dropp Ultra	1	4634	93	2.9	1.2	4.1	95.9
			2	4994	89	1.4	1.4	2.8	97.2
			3	5489	89	2.4	2.7	5.1	94.9
			Mean	**5039**	**92**	**2.2**	**1.8**	**4.0**	**96.0**
Menemen (west)	Carmen	Appeal %EC	1	4610	94	1.4	3.6	5.0	95.0
			2	4402	88	3.7	10.7	14.4	85.6
			3	4987	88	5.0	9.1	14.1	85.9
			Mean	**4666**	**90**	**4.0**	**7.8**	**11.2**	**88.8**
Mardin (southeast)	St 393	Finish	1	3320	88	3.6	3.8	7.4	92.6
			2	3768	92	2.6	2.3	4.9	95.1
			3*	--	--	--	--	--	--
			Mean	3544	90	3.1	3.1	6.2	93.8
Adiyaman (southeast)	St 457	Dropp Ultra&Finish	1	3434	96	5.6	0.6	6.2	93.8
			2	2469	97	5.7	6.9	12.6	87.4
			3	2469	94	3.8	7.8	11.6	88.4
			Mean	**2791**	**96**	**5.0**	**5.1**	**10.1**	**89.9**

* Measurement could not be completed due to unexpected heavy rain.

ues increasing with field yield and harvestable boll ratio, but this tendency was not found meaningful in other locations.

Studies carried out with high capacity, self propelled, spindle pickers showed that the ground losses can vary between 2% – 4% depending of the success of field preparation and plant conditions (Evcim and Oz, 1997; Saglam and Akyol, 2002; Simsek and Ozkan, 2005a, 2005b) while 3% - 6% in Uzbek originated, tractor mounted, vertical spindle pickers (Oz, 2005 and Demirtas and Dogan, 2006). From this point of view, it is possible to say that the prototype picker showed a successful performance and can pick with average 3% ground loss if suitable conditions are provided.

Stalk loss (also expressed as picking efficiency) was found to vary over a wide range compared to the ground loss. Stalk loss is related to variety characteristics; especially the suitability of the bolls for picking, as well as plant and field conditions. It is also affected by the picker's adjustments. Although stalk loss may not be accepted as a real loss because of a chance for a second picking, it is another indicator of successful harvesting.

According to national standards, stalk loss should not exceed 5% of the total field yield for appropriate field and plant conditions and if the boll-opening ratio is more than 95%. In this respect, it is possible to say the result obtained from the locations were within the proposed limits except Menemen. The results indicated that field and physical plant conditions were dominant for the picking performance values rather than variety characteristics. The variety, Carmen, had different results depending on its growing location rather than its varietals characteristics. Insufficient weed management and too many lodged plants caused more stalk loss for the Menemen than Soke where planted Carmen variety. In Adiyaman location where St 457 variety was planted uncompleted growing pattern probably due to very late planting (end of May) has restricted the suitability of the bolls for picking. High preharvest losses and very low defoliant rates (about 27%) were measured in this location. Harvesting was performed with higher loss values as compared to the other region since the farmer did not want to wait until the maturity period for fall due to possible rains. As in ground loss, no significant effect was determined between stalk loss and field yield and harvestable boll ratio.

Previous studies with self propelled, high capacity, spindle pickers showed that stalk loss can vary between 3% and 5% if all of the conditions are suitable (Oz and Evcim, 2002; Simsek and Ozkan, 2005a, 2005b) while average 1.7% in Uzbek originated, tractor mounted, vertical spindle pickers (Oz, 2005; Demirtas and Dogan, 2006). It was also determined that the stalk loss can go up to 9% due to some constructive problems with these types of pickers (Oz, 2005).

Field capacity of the picker being tested was calculated to be between 0.35 – 0.40 $ha.h^{-1}$. This capacity is quite low as compared to the self-propelled spindle pickers on the market and is due to the test picker's small basket size and low ground speed. No significant relationship was found to exist between the picker field capacity and the field yield or boll opening ratio.

The field capacity values are instantaneous and they were calculated by ignoring the time spent for unloading, turning and etc. In agricultural management standards (ASABE, 2006) the field efficiency for cotton pickers accepts as between 60% - 75% and averages 70%. In this case, the field capacity of the experimental picker with an average field efficiency of 70% would be 0.26 $ha.h^{-1}$. The daily capacity, assuming 10 working hours a day, was estimated to be between 9.2 and 13.1 metric tons excluding the results obtained from the province of Adiyaman. This mechanical picking capacity is equal to the hand harvest capacity of 113 to 227 workers a day by considering that a seasonal worker can hand pick 60 to 80 kg of seed $cotton.day^{-1}$.

Table 5 shows the commercially important qualitative performance values of the picker. Gin turnout values that measured in basket samples were found 2%–7% lower than reference samples. National standards indicate that the difference between gin turnout values for basket samples and the reference samples should not be more than 1%. In this respect, results obtained in entire locations were higher than desired limits. It was thought that the field and plant conditions have significant effect on the results. Thus, lower differences were measured between samples (reference and basket) in Soke and Mardin where have better conditions comparing with the other locations. Actually, differences between samples can be considered as normal. Since the hand picker picks cotton by pulling and the machine by spinning, the machine picker causes more bracts and other thrash to break off and come with the seed cotton. The machine picking increases the amount of bracts and other trash in the seed cotton and, as a result, the gin turnout ratio goes down for machine picker harvest.

It is thought that the reason for obtaining low gin turnout for the samples taken from the basket could be constructional structure of the picking units of the picker. The vertical bar type pickers' face with more plants as compared to spindle type pickers and as a result of this situation, picking units may sometimes cause to break off the branches carrying cottonseed, bracts and leaves that have a tendency to fall down. During the ginning process, these materials weigh heavier and this may result in reduced gin turnout.

In general, the decrease in gin turn out caused by mechanical picking was not large. In fact, the important parameter to consider in cotton harvest is the amount and quality of lint

Table 5
Variation of commercially important qualitative performance values (as averages of the repetitions)

Locations	Variety/ defoliant	Plots	Gin turnout, %		Trash content, %		No of particles		Rd		+b		Color grade		Diff.···
			Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	
Soke (west)	Carmen/ Dropp Ultra	1	42.1	41	1.02	2.77	63	178	74.1	64.5	7.7	10.0	W–SLM	SP–SGO	–1
		2	41.4	40.4	0.60	2.76	39	139	76.9	67.1	8.0	9.1	W–M	LSP–SGO	–2
		3	41.9	40.1	0.78	2.90	45	164	76.6	63.4	8.3	8.9	W–M	LSP–SGO	–2
		Mean	**41.8**	**40.8**	**0.80**	**2.81**	49	160	75.9	65	8.0	9.3	W–M	LSP–SGO	–2
Menemen (west)	Carmen/ Appeal %EC	1	43.2	39.8	0.64	2.59	49	148	77.9	66.7	7.9	9.4	W–SLM	LSP–SGO	–1
		2	41.2	39.8	0.62	2.17	48	137	78.5	65.1	7.9	9.7	W–M	LSP–SGO	–2
		3	42.2	39.4	1.00	2.06	61	137	76.9	63.3	7.8	9.4	W–M	LSP–SGO	–2
		Mean	**42.2**	**39.7**	**0.75**	2.27	53	141	77.8	65	7.9	9.5	W–M	LSP–SGO	–2
Mardin (southeast)	St 393/ Finish	1	42.4	40.9	0.33	1.85	34	118	76.1	69.9	8.7	7.9	W–M	W–LM	–2
		2	41.4	41.6	0.20	1.90	18	118	77.2	69.9	8.4	8.0	W–SLM	W–LM	–1
		3*	--	--	--	--	--	--	--	--	--	--	--	--	--
		Mean	**41.9**	**41.3**	0.27	1.88	26	118	76.7	69.9	8.6	8.0	W–M	W–LM	–1
Adiyaman (southeast)	St 457/Dropp Ultra& Finish	1	44.6	44.3	0.47	2.67	41	185	76.9	66.2	9.0	8.9	W–SLM	LSP–SGO	–1
		2	43.1	39.7	0.24	2.38	23	183	75.7	65.7	8.8	9.6	W-M	LSP–SGO	–2
		3	43	37.7	0.42	2.04	34	154	76.5	66.7	9.1	9.5	W-M	LSP–SGO	–2
		Mean	**43.6**	**40.6**	**0.38**	2.36	33	174	76.4	66.2	9.0	9.3	W-M	LSP–SGO	–2

··· Color grade differences between ***Ref***. and ***Bsk***. samples
* Measurement could not be completed due to unexpected heavy rain

cotton harvested by hectare that is actually baled and not the percentage of trash that might come in with the harvested seed cotton. However, the trading is based on seed cotton in Turkey in contrast to the other countries. Therefore, gin turnout has a great importance from the point of commercial profit for the Turkish farmer.

Depending on gin turnout, high trash content values were obtained in basket samples. Trash content, which express foreign materials (such as the leaves, bracts, etc.) involved into the fiber, can be defined as an indicator of how careful the pre-harvest preparation was. Like gin turnout, it can be considered as an important parameter that affect fiber quality as well as commercial profit.

As seen from the table, trash content values are higher in basket samples than references in all locations. In practice, it is possible to expect such a difference because all of the samples were ginned with a roller-gin without using a pre-cleaning unit. Therefore, dried but not dropped yet leaves crumbled and mixed into the ginned fiber. Furthermore, the fact that there has not been a significant decrease in the gin turnouts despite the high trash content and particle amount support the idea that the foreign matters in seed cotton are composed of leaf crumbles, also known as pepper trash.

On the other hand, as mentioned before trash content is an indicator of successful defoliation application. Lower defoliation rates in Adiyaman influenced the results naturally. There was no significant relationship between variety and seed cotton trash content after harvest. The effect of defoliants was found to be not significant, although slightly lower trash values were observed with Finish in the province of Mardin.

High trash contents caused color grades to decrease in basket samples as compared to references. Depending on the trash content, there is a decrease in the reflectance (Rd) values of the basket samples in comparison to the reference samples and an increase in yellowness (+b) values. Therefore, one or two-full lower Color Grades were obtained on the average for the basket samples. This was mainly the result of ginning all of the samples by a roller-gin without using a pre-cleaning unit. The color grade decreased since fine trash was not removed from the lint prior to ginning. Although the trash content was higher and the color grade was lower for the basket samples, the results are acceptable because the lower color grade and higher trash content can be eliminated by proper pre-cleaning and ginning.

Other fiber quality values are given in Table 6. Micronaire is one of the most important factors among fiber quality parameters due to effect on textile processes (Hake et al., 1990; Jordan, 2001; ITC, 2011). Micronaire values are divided into three groups (Premium Range: between 3.7 and 4.2 – Base Range: between 3.5 and 3.6 or 4.3 and 4.9 – Discount Range:

Table 6
Variation of the other fiber quality factors (as averages of the repetitions)

Locations	Variety/ defoliant	Plots	Maturity, %		Micronaire		Fiber length, mm		Length uniformity, %		SFI, %		Fiber strength, g/tex	
			Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.	Ref.	Bsk.
Soke (west)	Carmen/ Dropp Ultra	1	91.5	90.5	4.71	4.66	28.57	29.48	84.30	83.90	7.4	7.1	32.90	30.60
		2	92.5	90.5	4.67	4.59	28.56	29.66	84.45	84.10	7.1	6.9	33.15	29.60
		3	90.5	90.5	4.42	4.63	29.54	29.11	83.95	83.60	7.5	7.8	31.85	30.95
		Mean	91.5	90.5	4.6	4.63	28.89	29.42	84.23	83.87	7.3	7.3	32.63	30.38
Menemen (west)	Carmen/ Appeal %EC	1	90.5	92.5	4.48	4.86	29.4	29.35	85.40	84.05	7.3	7.3	34.45	30.35
		2	90.0	92.5	4.33	5.03	29.06	29.31	85.20	83.65	7.4	7.3	34.35	30.15
		3	89.5	91.0	4.29	4.89	28.87	29.70	84.90	84.35	7.8	6.8	34.55	31.50
		Mean	**90.0**	92.0	4.37	4.93	29.11	29.45	85.17	84.02	7.5	7.1	34.45	30.67
Mardin (southeast)	St 393/Finish	1	86.0	88.0	3.78	4.01	27.66	28.26	81.70	83.30	9.0	8.2	25.50	26.70
		2	90.0	89.0	3.83	3.90	27.55	28.03	84.10	81.60	8.1	9.1	28.50	27.80
		3*	--	--	--	--	--	--	--	--	--	--	--	--
		Mean	**88.0**	**88.5**	**3.81**	**3.96**	27.61	28.15	82.90	82.45	8.6	8.7	27.00	27.25
Adiyaman (southeast)	St 457/ Dropp Ultra&Finish	1	91.5	97.5	5.06	5.65	28.16	27.26	83.90	85.05	7.5	8.1	30.30	30.04
		2	89.0	93.0	4.84	5.09	26.84	27.00	81.60	84.35	8.2	8.4	30.80	29.70
		3	92.0	92.0	5.12	5.31	26.03	27.09	81.60	82.90	9.1	8.4	28.50	30.01
		Mean	90.8	94.2	**5.01**	**5.35**	**27.01**	**27.12**	**82.37**	**84.10**	**8.3**	**8.3**	**29.87**	**29.92**

* Measurement could not be completed due to unexpected heavy rain.

below 3.4 or above 5.0) in terms of market value (USDA, 1995). According to this values obtained in Menemen and Soke were in "Base Range" while "Premium Range" in Mardin. In Adiyaman values were measured above the acceptable limits.

Many studies revealed that the micronaire is basically genetic, and variety selection, environmental conditions (light, temperature, etc.), cultural processes carried out throughout the production may affect this value (Bradow and Davidonis, 2000; Lewis, 2002; Silvertooth et al., 2003; Montalvo, 2005). In this respect, it can be said that the pickers will have not negative effect on this value. It may expressed that factors that abovementioned had an effect on results. The differences between samples (reference and basket) can be explained by the difference of trash contents. Researches indicated that if the fiber has high trash content, then it would look riper than it is, the micronaire values will be higher (Valco, 2007). Other reasons for high micronaire are listed as poor boll allocation, small boll production due to water stress (Hake et al., 1990; Jordan, 2001; Powell, 2010), and unbalance between vegetative growth and boll retention (Bange et al., 2009). Therefore, it was thought that the plant conditions have strong effect on micronaire in Adiyaman. It can be said that uncompleted vegetative growth lead to worse results in this location comparing with the other locations.

When the results evaluated in terms of fiber length, no significant differences were observed although slightly higher values were obtained in the basket samples. Fiber length and length uniformity ratio are as important factors as micronaire among the fiber quality parameters. Studies show that the fiber length is genetic to a significant extent (Bradow and Davidonis, 2000; Jordan, 2001 and Krieg, 2002), it can be affected by environmental conditions, and it may vary even within the same plant (Silvertooth et al., 2003; Valco, 2007). Another factors affecting to fiber length are stated that harvesting methods and ginning (Jordan, 2001 and Braden, 2005). In some studies, differences were determined between strippers and pickers in terms of fiber length (Behery, 1993; ICAC, 2001), but no negative effect was observed in mechanical picking as compared to hand picking (Baker et al., 2003; Baker and Hughes, 2008; Evcim and Oz, 1997; Faulkner et al., 2006, 2007). In textile processes, long fibers (≥28 mm) and high length uniformity (≥83%) are desired for spinning of yarn fast and easily (Bange et al., 2009).

When the results from the trial are evaluated in the light of the above information, it is possible to say that the variety characteristics had come forward and picker did not have negative effect on fiber length and therefore length uniformity.

Short fiber index (SFI) or short fiber content (SFC) is defined as the ratio of fibers less than 12.7 mm long in all fiber bundles (Bange et al., 2009). Short fibers are not desirable in textile processes since they cause a lot of waste and to reduce the production efficiency. SFI is closely related with fiber length and length uniformity. Therefore, the factors that affect the fiber length are the ones such as genetic, environmental conditions, ginning, etc. It was also stated that early defoliation might cause to increasing in SFI (Hill, 2010). Under the ideal conditions, SFI desired to be lower than 8% (Bane et al., 2009). When the results examined, it was observed that values took place within the ideal limits in Soke and Menemen. Slightly higher values were measured in Mardin and Adiyaman. These differences can be explained with the variety characteristics. It was thought that late planting and insufficient defoliation influenced the results. The differences between samples (reference and basket) are negligible. Therefore, it can be expressed that the picker has not negative effect on SFI.

Another parameter that is directly and indirectly related to the fiber length and short fiber index is fiber strength. Fiber strength is affected by variety and environmental conditions as in micronaire and fiber length. It is also directly related to short fiber content, high strength fibers will be subjected to less tear up during the ginning process, and therefore, short fibers will remain in a lower level (Braden, 2005).

Fiber strength should be lower than 27 $g.tex^{-1}$ (Bange et al., 2009). In this respect, it was observed that the values measured in all locations were placed within desirable limits. It is possible to say to variety characteristics were dominant on the results. Lower values measured in basket samples in the west locations while opposite situation were observed in southeast. However, values measured in the basket samples are in acceptable limits in entire locations. Therefore, it can be said that the picker did not have a negative effect on this parameter.

Conclusion

The success of the cotton pickers depend on many factors related with field and plant conditions. These factors affected to the performance of the prototype picker in quantitative and qualitative aspects.

Using the ground loss as the main indicator of successful harvesting, it was found to be in the range as suggested by Turkish national standards under the appropriate field and plant conditions. Although comparing self-propelled and tractor mounted pickers may not to be true due to technological differences, however, the results revealed that the differences of picking systems are not influental on the quantitative performance. The results also indicated that the field losses were mostly related to the physical field and plant conditions rather than the design of the picker itself.

The field capacity was found to be lower than self-propelled spindle pickers due to lower ground speed and small size of basket. It is possible to state that the prototype picker is suitable for small farms of between 100 to 150 ha and can be increased with better harvesting organization.

Expected results were obtained from the point of qualitative performance. The differences between hand and machine picking were not significant although there was a small decrease in some factors due to the machine picking. The picker does not adversely affect on the fiber properties such as micronaire, fiber length, length uniformity, SFI and fiber strength. It was found that the fiber property changes depended upon the cotton variety and not on harvesting or defoliant application.

The prototype picker used in the study is the one that was designed to be suitable for small scale farms. Its overall performance was found to be quite satisfactory.

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