Cotton Sown in Different Row Distances after Wheat Harvest: Seed Cotton Yield and Yield Components

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Abstract— *This study was conducted to determine seed cotton yield and yield components of some cotton varieties sown in different row distances after wheat harvest in Kahramanmaras conditions. Eleven cotton varieties (Albania-6172, Aktas-3, Beli Izvor-432, Azerbaycan-3038, Delta Opal, ST-468, DP-388, DP-5111, Golden West, ST-453 and Maras-92) and two different row distances (conventional row: 70x20 cm, narrow row: 35x20 cm) were used in the study. The experiment was designed as a split-plot with three replication in which sowing densities were the main plots and cotton cultivars were sub plots. In the study first harvest seed cotton ratio (FHSR), plant height (PH), number of fruit branches per plant (NFBP), number of bolls per plant (NBP), seed cotton weight per boll (SWB), ginning turn out (GTO) and seed cotton yield (SCY) were investigated. As a result of variance analyses, FHSR, PH, NFBP and SCY were affected by row distances. All the investigated characteristics except SWB were significantly affected by cultivar and interaction effects for FHSR, PH, NFBP and SCY were observed. In addition, the highest SCY was obtained from cultivar of Aktas-3 (2200 kg ha^{-1}) in narrow row distance and it was followed by cotton cultivars of ST-468 and DP-388.*

Keywords— ***Cotton, Row distance, Narrow row, Cultivar, Seed cotton yield, Yield components.***

I. INTRODUCTION

Cotton is an industrial cash crop which has an important role in world agriculture and trade. In Turkey, the area of cotton during 2015 was 434 000 hectares with lint production of 738 000 tones and average lint yield of 1700 kg ha^{-1}. Recently, cotton consumption has increased tremendously owing to the expanding textile industry in Turkey. Currently, over 50% of lint cotton consumed is imported. Increased demand has created a need to revitalize the cotton industry. The Mediterranean region of Turkey, with a warm and long growing season, allows a small grain crop to be followed by other field crops in the same season, thereby increasing the productivity of the land (Killi and Bolek, 2006). Therefore, planting cotton after a winter cereal in regions having a long growing season, such as the Mediterranean region, may be one of the means of meeting the increasing demand. In Kahramanmaras city, located in the eastern part of the Mediterranean region, the textile industry is expanding very fast, but the land used for cotton planting is not.

Historically cotton has been grown in 28 to 32 inch rows due to equipment considerations in Turkey. A proper space between plants and row spacing is a key agronomic factor to optimize the crop profit (Zaxosa *et al.* 2012). Plant density directly influences the radiation interception, moisture availability, wind movement and humidity (Heitholt *et al.* 1992) that in turn affects the canopy height, branching pattern, fruiting behavior, crop maturity and yield. Plant populations in narrow row cotton production systems are higher, but more plants/acre could increase cotton yields, especially on poorer soils (Balkcom *et al.* 2010). Jost and Cothren (2000) reported a yield increase for cotton grown in narrow rows during a dry growing season, while Boquet (2005) reported no yield advantage for narrow row cotton production. In a study of eight transgenic cultivars, yields for cotton planted in ultra-narrow rows were higher than conventional row spacings (Witten and Cothren, 2000). In a 2-yr study in South Carolina, seed cotton yield, lint yield, and gin turnout were different among row spacings and cultivars (Jones, 2001). Significant row spacing by cultivar interaction was reported for seed cotton yield. Nichols *et al.* (2004) reported that plant height, number of fruit per plant, number of total nod per plant and number of boll per plant were decreased in narrow row planting. Jahedi *et al.* (2013) reported that plant height, sympodia and total bolls per plant were reduced in cotton grown in narrow row spacing. In most cases, cotton grown in narrow rows had lint yields equal to or higher than those attained in the 70 cm spacing. A study in Texas, narrow row planting (40 cm) was compared with 60 cm spacing for yield and yield components of eight cotton varieties. It was determined that higher seed cotton yield was obtained from 40 cm row spacing, and the value of yield and yield components had changed according to cultivars (Smit, 1989). Past research has also indicated that in higher plant populations (> 15.3 plants m²) cotton plants typically produce fewer apical main-stem nodes and monopodial branches plant (Siebert, 2006; Bednarz, 2000; Jones and Wells, 1998; Siebert and Stewart, 2006). In dense plant populations (> 10.0 plants m²), shading caused by excessive vegetative growth may result in a greater potential for boll rot, fruit abscission, increased plant height, and delayed maturity, leading to reduced yield and fiber quality (Bednarz, 2000; Bednarz *et al.* 2005, York, 1983; Siebert and Stewart, 2006). Recent research has reported optimal yields in plant populations ranging from 9.0-21.5 plants m² in Georgia [Bednarz *et al.* 2005], 3.4-15.3 plants m² in Louisiana [Siebert, 2006], 9.0-13.0 plants m² in Mississippi (Pettigrew and Johnson, 2005), and 2.0-12.0 plants m² in North Carolina (Jones and Wells, 1998). Yield reduction can occur at plant populations of 3.4-7.0 plants m² (Siebert, 2006, Bednarz *et al.* 2005, Siebert and Stewart, 2006, Pettigrew and Johnson, 2005), and may be magnified by early season stress caused by seedling diseases, sand blasting, hail, and soil crusting prior to emergence (Gannaway *et al.* 1995). Low plant populations may also result in delayed maturity (Siebert, 2006, Jones and Wells, 1998, Siebert and Stewart, 2006) and reduced harvest efficiency due to increased branching (Gannaway *et al.* 1995). Due to its perennial and indeterminate growth habit, cotton is extremely sensitive to environmental conditions and management practices (Oosterhuis, 1994). The growing of early maturing cotton cultivars has an advantage of proper time for rotation of other crops allowing timely sowing of wheat in cotton-wheat-cotton cropping system in Pakistan and other countries (Ali *et al.* 2003). Narrow row production systems with high plant populations planting cotton as a second crop after cereals have not been examined in East Mediterranean cotton production areas.

The aim of this study was to determine the seed cotton yield by increasing the number of plants in second crop planting after wheat harvest. Therefore, yield and yield components in sown cotton after wheat harvest at 70 cm (traditional row) and 35 cm (narrow row) spacing were compared using different cotton cultivars.

II. MATERIALS AND METHODS

Field experiments were conducted to evaluate eleven cultivars of cotton grown after wheat harvest under two row spacings. Albania-6172, Aktas-3, Beli Izvor-432, Azerbaycan-3038, Delta Opal, ST-468, DP-388, DP-5111, Golden West, ST-453 and Maras-92 were evaluated in row spacings of 35 and 70 cm. Seeds of all these varieties were kindly provided by the Cotton Research Institute (Nazilli – Turkey), the East Mediterranean Transitional Zone Agricultural Research Institute (Kahramanmaras – Turkey) and the Ozbugday Seed Company (Hatay – Turkey). Some characteristics of tested cotton cultivar are given in Table 1.

TABLE 1
SOME CHARACTERISTICS OF ELEVEN COTTON CULTIVARS

Cultivars	Origin	Days to 1st flower	Days to boll opening	First harvest seed cotton ratio (%)
Albania - 6172	Albania	50	111	95
Aktas - 3	Azerbaijan	50	109	92
Beli Izvor - 432	Bulgaria	51	95	95
Azerbaycan - 3038	Azerbaijan	53	118	96
Delta Opal	USA	50	105	80
ST - 468	USA	52	110	70
DP - 388	USA	50	102	75
DP - 5111	USA	51	105	75
Golden West	USA	50	110	50
ST - 453	USA	52	115	50
Maras - 92	Turkey	53	129	54

These eleven cotton varieties were evaluated for first harvest seed cotton ratio, plant height, number of fruit branches per plant, number of bolls per plant, seed cotton weight per boll, ginning turn out and seed cotton yield at two different row spacings (conventional row: 70x20 cm, narrow row: 35x20 cm) during 2006 at the Agricultural Research Institute of Kahramanmaras, Turkey. Kahramanmaras province is located in the East-Mediterranean region of Turkey between 37º 36' north parallel and 46º 56' east meridians. The soil is an alluvial clay loam with the following mean properties; pH 7.5, organic matter 1.7%, N 0.05%, $CaCO_3$ 19.8%, available P 5.15 kg ha^{-1} and available K 7.3 kg ha^{-1}. In the study, nitrogen and phosphorus were applied pre-sowing at a rate of 80 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5. Additional nitrogen (80 kg N ha^{-1}) was top-dressed 30 days after planting (prior to first irrigation). Overall 6 irrigations were applied and weeds were controlled by hoeing. Control of insects was performed during the growing season according to local recommendations.

After the wheat harvest, plant residues in the study field are mixed with the soil plow at 14 June. Then land was plowed twice with harrows and irrigated with furrow irrigation. When soil moisture is appropriate for tillage, approximately 6 day after, surface tillage has been made with harrow and compacted with roller for planting. Treatments were arranged as split plots in a randomized complete block design with main plots consisting of row spacings (35 and 70 cm) and subplots consisting of cultivars. Main plots were approximately 12 m long and 30.8 m wide. Subplots were 12 m long and 2.8 m wide, so that the number of rows varied depending on row spacing treatment. Plant populations were approximately 71,000 plants ha^{-1} in the conventional row plots and approximately 142,000 plants ha^{-1} in the narrow row plots. Each treatment was replicated three times. The seeds were sown using a cotton drill on June 20, 2006. Seed rate was approximately 50 kg per hectare. After emergence, plants were thinned to 20 cm in rows (about five plants per m) when the seedling had three true leaves. After all harvestable bolls matured, all seed cotton at 10-m lengths of the centre two rows was hand-harvested at physiological maturity for yield analysis. Yield was determined after hand harvesting the centre two rows from each plot twice and weighing the seed cotton. The first harvest commenced when the cotton was approximately 70% open; the second harvest was three weeks later. Harvested seed cotton was ginned with the machine of roller gin and separated as seed and lint. Ginning turn out (%) was calculated as: [lint (g) / lint (g) + seed (g) x 100]. It was determined as the average number of studying on seed cotton samples of the harvested 20 boll in each plot. Data on all indices were subjected to analyses of variance by the MSTAT-C statistical program and where F- test indicated significant effects (p/0.05), means were separated using LSD tests.

Weather data were collected at the nearest weather station located about 5 km from the experimental site. Monthly minimum, maximum and mean temperatures, total rainfall, and humidity are given in Table 2. Average air temperature during the growing season changed from 10.3°C (November) to 30.2°C (August). The temperature at the experimental site during the growing season was favorable for cotton growth and development. The maximum temperatures reached 38.6°C for August. There was considerable variability in amount and distribution of rainfall from month to month. The rainfall was highest in October and November, but there was an extended dry and hot period during June, July, August and September. Humidity during the growing season changed from 58.4% (June) to 66.8% (July).

TABLE 2
MONTLY MINIMUM, MAXIMUM AND MEAN TEMPERATURES, PRECIPITATION AND HUMUDITY AT KAHRAMANMARAS, TURKEY, IN 2006*

Months	Mean (°C)	Maximum (°C)	Minimum (°C)	Precipitation (mm)	Humidity (%)
June	27.4	35.3	20.5	-	58.4
July	28.6	35.9	22.9	0.1	66.8
August	30.2	38.6	23.7	-	63.3
September	26.2	33.6	19.3	5.3	52.6
October	19.3	25.8	13.7	87.6	63.9
November	10.3	16.7	5.0	77.0	60.6

*Weather data were taken from Meteorology Station of Kahramanmaras, located about 5 km from the experimental site.

III. RESULTS AND DISCUSSION

Results of variance analyses revealed that the effects of row distances on FHSR, PH, NFBF and SCY except NBP, SWP and GTO were significant. Cultivar effects for all investigated characteristics except SWP were also significant. In addition, significant row distance - cultivar interaction for FHSR, PH, NFBP and SCY were noted (Table 3).

TABLE 3
THE RESULTS OF ANALYSES OF VARIANCE, SHOWING ROW DISTANCE, CULTIVAR AND INTERACTION EFFECTS ON INVESTIGATED PROPERTIES

Source	Df	FHSR	PH	NFBP	NBP	SWB	GTO	SCY
Row distance (R)	1	75.9*	51.2*	22.7*	3.7	0.1	0.3	66.1*
Cultivar (C)	10	18.6**	1421.8**	32.8**	4.3**	0.5	6.1**	412.0**
R x C	10	5.6**	2.6*	3.2**	0.7	0.4	0.5	330.1**

*: P <0.05; **: P<0.01; FHSR: First harvest seed cotton ratio; PH: Plant height; NFBP: Number of fruit branches per plant; NBP: Number of bolls per plant; SWB: Seed cotton weight per boll; GTO: Ginning turn out; SCY: Seed cotton yield

3.1 First harvest seed cotton ratio (FHSR)

The effects of row distance and cultivar on FHSR were significant (Table 4). FHSR between the two row distances ranged from 78.5% (narrow row) to 82.9% (conventional row). Cotton planted in wide rows had a higher percentage (4.4%) of FHSR than cotton grown in narrow row. The FHSR is an important characteristic affecting to earliness. Cotton earliness is a quantitative trait which is mainly affected by environment and crop genotype (Kassianenko *et al.* 2003). The effect of plant density on earliness may be greater and of more economic importance than yield (Zaxosa *et al.* 2012). The interaction between row spacing and cultivar was significant for FHSR (Fig.1). Response of cultivar to row spaces was different. In 35 cm row planting, Azerbaycan-3038 and DP-388 had higher FHSR values than the other varieties. Albania-6172, Aktas-3, Beli Izvor-432 and Azerbaycan-3038 gave the highest FHSR values in conventional and narrow row space. It was determined that these varieties are the earliness varieties in Kahramanmaras conditions. However Deltaopal, ST-468, DP-5111, Golden West, ST-453 and Maras-92 gave the highest value in narrow row planting. Cultivars as well as row spacing significantly affected almost all the characters related to earliness (Saleem *et al.* 2009). Rossi *et al.* (2004) reported that earliness has been attributed to narrow row spacing while Brodrick *et al.* (2010) found no differences in crop maturity between the row spacings. Earliness index (percent first-pick) is most frequently used to estimate earliness in cotton (Bourland *et al.* 2001). In our study, FHSR was significantly affected by row spacing. Although lower boll retention was measured in narrow rows but these bolls did not mature earlier than wider rows (Brodrick *et al.* 2010).

3.2 Plant height (PH)

The values of PH between the two rows ranged from 63.8 cm (conventional row) to 67.4 cm (narrow row). Cotton planted in narrow rows had a higher length (3.6 cm) of PH than cotton grown in conventional rows. Differences in PH among cultivars are presented in Table 4. PH values of cultivars were ranged from 52.3 cm (ST-453) to 100.1 cm (Delta Opal). Varieties showed different responses to the row spaces. So the row spacing by cultivar interaction was significant (Fig.2). Siddiqui *et al.* (2007) reported that plant height, branches, open and un-open bolls per plant were significantly affected by plant spacing and varieties. While Delta Opal gave the highest PH in narrow row (35 cm) planting, ST-453 gave the lowest PH in conventional row (70 cm) planting distance.

TABLE 4
MEAN VALUES OF INVESTIGATED PROPERTIES FOR ROW DISTANCES AND CULTIVARS

	FHSR (%)	PH (cm)	NFBP	NBP	SWB (g)	GTO (%)	SCY (kg ha^{-1})
Row Distances							
Conventional Row (70x20 cm)	82.9 a	63.8 b	5.95 a	3.8 a	5.15 a	39.9 a	1779.1 a
Narrow Row (35x20 cm)	78.5 b	67.4 a	5.52 b	3.7 a	5.09 a	40.2 a	1753.0 b
Cultivars							
Albania-6172	88.2 ab	89.8 a	7.06 a	3.9 a	5.10 a	40.0 bc	1670.0 e
Aktaş-3	87.1 ab	60.8 c	7.56 a	4.2 a	5.34 a	39.6 cd	2093.3 a
Beli İzvor-432	90.0 a	82.0 b	5.10 c	3.8 ab	5.10 a	38.1 de	1873.3 b
Azerbaycan-3038	92.6 a	55.3 e	3.80 d	3.8 ab	5.01 a	37.0 e	1835.0 c
Delta Opal	73.8 d	100.1 a	7.55 a	3.3 c	5.02 a	39.2 cd	1840.0 c
ST-468	70.3 d	54.9 e	6.15 b	4.2 a	5.13 a	40.6 abc	1808.3 d
DP-388	69.2 d	52.9 f	4.90 c	3.9 a	5.06 a	41.5 ab	1833.3 c
DP-5111	81.2 c	61.0 c	5.33 c	4.2 a	5.05 a	40.6 abc	1673.3 e
Golden West	81.8 c	56.8 d	5.33 c	3.4 bc	5.36 a	40.8 abc	1525.5 g
ST-453	82.3 bc	52.3 f	5.31 c	3.2 c	5.17 a	42.3 a	1610.0 f
Maraş-92	71.3 d	55.2 e	5.01 c	3.2 c	4.98 a	40.6 abc	1665.0 e
Mean values in the same column without a common letter are significantly different (*P* < 0.05) according to the Least Significant Difference (LSD) multiple range test.							

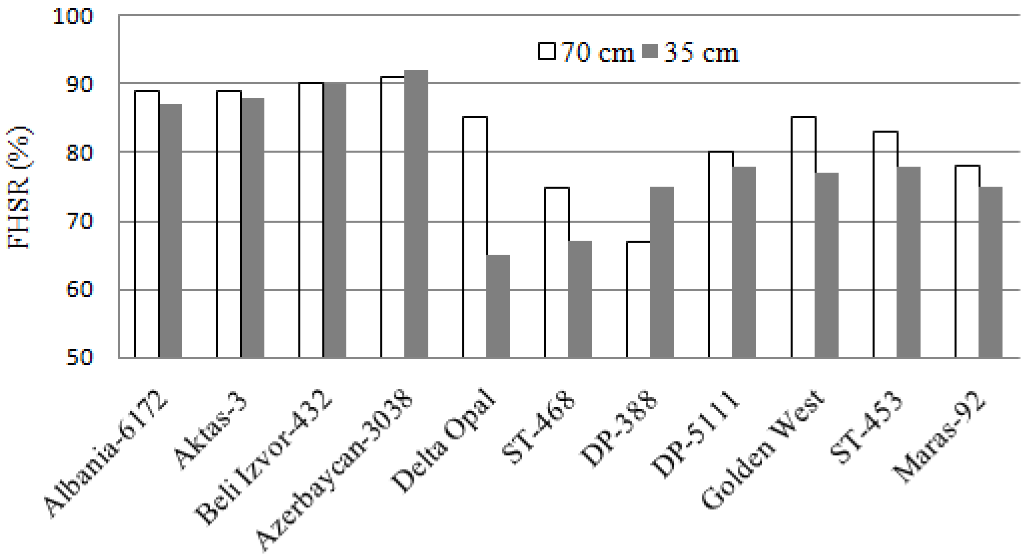

FIGURE 1. ROW SPACE CULTIVAR INTERACTION EFFECTS FOR FHSR.

All the varieties produced higher PH in narrow row planting than the PH values in conventional planting. The plant height values of Albania-6172, Beli Izvor-432 and Delta Opal varieties was high while the plant height values of other varieties was low at both row spacing. These results are in agreement with the results reported by Wali and Koraddi (1989), Kumar (1989) and Sharma (1998) they reported that closer plant spacing increased the height of the plants.

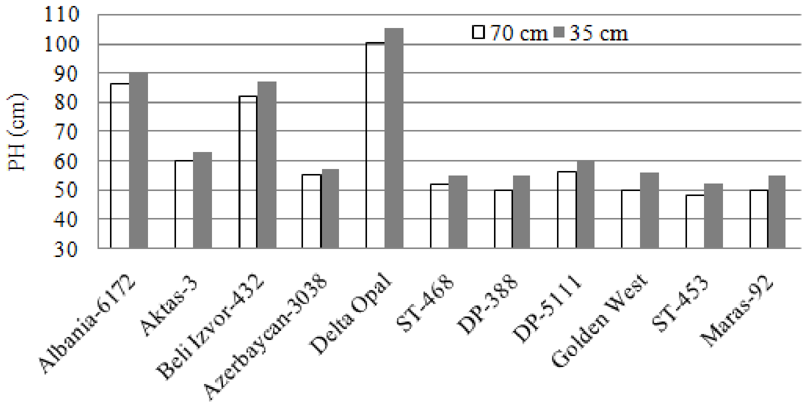

FIGURE 2 ROW SPACE CULTIVAR INTERACTION EFFECTS FOR PH.

3.3 Number of fruit branches per plant (NFBP)

Row spacing (35 and 70 cm) effect on NFBP was significant. The values of NFBF between the two rows ranged from 5.52 (narrow row) to 5.95 (conventional row). Cotton planted in conventional rows had a higher value (0.42) of NFBP than cotton grown in narrow rows. It was observed that number of fruit branches per plant in cotton planted at wider intra row spacing gave more branches. These results are in agreement with the results reported by Sharma (1994), Singh and Singh (1998), Sharma (1998) and Mukharjee (1999) all were in the view that wider plant spacing enables plant to attain maximum branches due to efficiency in the rate of photosynthesis. Differences in NFBP among cultivars are presented in Table 4. NFBP values of cultivars were ranged from 3.80 (Azerbaycan-3038) to 7.56 (Aktas-3). Varieties showed different responses to the row spaces. So the row spacing by cultivar interaction was significant (Fig.3). It was noted that plant height, branches, open bolls per plant, un-open bolls per plant were significantly affected by plant spacing and varieties (Siddiqui *et al.* 2007). In 35 cm row planting, Aktas-3, Azerbaycan-3038, ST-468 and DP-388 had higher NFBP values than the other varieties. The highest NFBP value was obtained from Delta Opal in conventional row planting and this variety was followed by Albania-6172. The lowest NFBP value was obtained from Azerbaycan-3038 in two row distances. These results are in accordance with the results reported by Wali and Koraddi (1989), Siddiqui *et al.* (2007) and Iqbal and Khan (2011).

3.4 Number of bolls per plant (NBP)

Row distances had essentially no effect upon NBP. The NBP values of two row distances are similar. These results are in contrast with the results reported by Yadav (1997) and Siddiqui *et al.* (2007) that cotton sown in wider intra row space increased in the number of boll per plant, while closer plant spacing did lowest number of bolls per plant. The difference in our results may be due to different environmental factors and varieties.

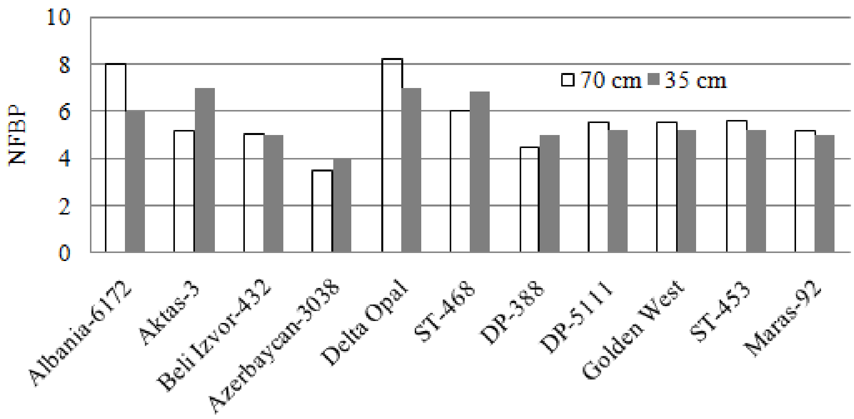

FIGURE 3. ROW SPACE CULTIVAR INTERACTION EFFECTS FOR NFBP.

Cultivar effects for NBP were significant, but not significant row distance - cultivar interaction was noted. Cultivars Albania-6172, Aktas-3, ST-468, DP-388 and DP-5111 had higher NBP, while Delta Opal, ST-453 and Maras-92 had the lower NBP. In the present study, NBP ranged from 3.2-4.2. NBP is an important characteristic and it can be affected by factors such as cultivar, growing conditions, plant nutrition and environmental conditions (Oosterhuis, 1994). There is a strong positive correlation between NBP and NFBP (Killi, 1995). The highest NBP (36.12%) and NFBP (35.31%) were obtained from

Albania-6172 and Akatas-3 cultivars. Besides ST-453 and Maras-92 cultivars with low NFBP had the low NBP. These results are in accordance with those of Hussain *et al.* (2000) who reported significant increase in number of bolls per plant using different varieties. Such increase in number of bolls per plant was direct consequence of more number of monopodial and sympodial branches per plant. However, the interaction between the varieties and plant spacing was found to be non significant.

3.5 Seed cotton weight per boll (SWB)

Different row distances and cultivars had essentially no effect upon SWB (Table 4). The SWB values of two row distances are similar. The SWB values of cultivars were ranged from 4.98 g (Maras-92) to 5.32 g (Golden West), and all cotton varieties were in the same group. Boll weight is an important yield contributing parameter (Ali *et al.* 2009). They reported that statistically same average boll weight (3.78 g) was obtained in 30 cm and 22.50 cm plant spacing. In our study, average boll weight for row distance and cultivar was 5.12 g and 5.63 g, respectively. However, the interaction between the varieties and plant spacing was found to be non significant.

3.6 Ginning turn out (GTO)

Data regarding GTO are shown in Table 4. A perusal of the data indicated that plant spacing did not influence GTO. However, GTO ranged between 39.9% to 40.2% in 70 cm (conventional) and 35 cm (narrow) row spacing respectively. These results are similar with those reported by Hussain *et al.* (2000), Ahmad *et al.* (2009) and Ali *et al.* (2009) who reported that plant spacing did not affect the GTO. Ginning turn out is very important character and it determines the percentage of lint in seed cotton. Cultivar effects for GTO were significant, but not significant row distance - cultivar interaction was noted. The comparison of the GTO values of eleven cotton varieties shows that ST-468, DP-388, DP-5111, Golden West, ST-453 and Maras-92 present the higher GTO values while Azerbaycan-3038 presents the lower value. Cotton GTO values of the eleven varieties ranged from 42.3% (ST-453) to 37.0% (Azerbaycan-3038). Cotton varieties with over 40% GTO are important varieties for the textile industry due to high fiber yield. Cultivars Aktas-3, Beli İzvor-432, Azerbaycan-3038 and Delta Opal had the lower GTO less than 40% value.

3.7 Seed Cotton Yield (SCY)

Row distances and cultivars had essentially effect upon SCY. It was noted that lint and seed cotton yield were significantly affected by plant spacing and varieties (Siddiqui *et al.* 2007). The values of SCY between the two rows ranged from 1753.0 (35 cm) to 1779.1 (70 cm) kg ha^{-1}. Jost and Cothren (2000) reported a yield increase for cotton grown in narrow rows during a dry growing season, while Boquet (2005) reported no yield advantage for narrow row cotton production. Jahedi *et al.* (2013) reported that cotton grown in narrow rows had lint yields equal to those attained in the 70 cm spacing. Differences in SCY among cultivars are presented in Table 4. SCY values of cultivars were ranged from 1525.5 (Golden West) to 2093.3 (Aktas-3) kg ha^{-1}. Varieties showed different responses to the row spaces. So the row spacing by cultivar interaction was significant (Fig.4). While Aktas-3 gave the highest SCY in narrow row planting, Golden West gave the lowest in that planting distance. Albania-6172, Azerbaycan-3038, DP-5111, Golden West and Maras-92 produced higher SCY than the other cultivars in conventional planting (70 cm), while Aktas-3, Beli Izvor-432, ST-468, DP-388 and ST-453 had higher SCY than the other cultivars in narrow row planting (35 cm). In a 2-yr study in South Carolina, seed cotton yield, lint yield, and gin turnout were different among row spacings and cultivars (Jones, 2001). In a study of eight transgenic cultivars, yields for cotton planted in ultra-narrow rows were higher than conventional row spacings (Witten and Cothren, 2000). Iqbal and Khan (2011) reported that seed cotton yield differed significantly among different plant spacing and genotypes.

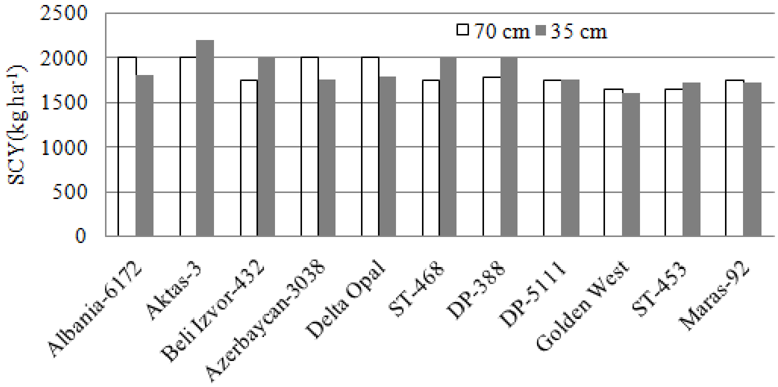

FIGURE 4. ROW SPACE CULTIVAR INTERACTION EFFECTS FOR SCY

IV. CONCLUSION

In the present study, first harvest seed cotton ratio, PH, numbers of fruit branches per plant and seed cotton yield were affected by row distance. It has been observed that cotton planted in narrow or conventional rows after cereals, there is no negative effects for yield and yield components. Narrow row cotton appears to be a viable agronomic cotton production practice for the East Mediterranean conditions as a second crop after cereals. All the investigated characteristics except seed cotton weight per boll were significantly affected by cultivar and interaction effects for first harvest seed cotton ratio, PH, numbers of fruit branches per plant and seed cotton yield were observed. For this reason, narrow row planting after wheat harvest for East Mediterranean can be recommended in order to obtain high seed cotton yield. In addition, the highest seed cotton yield was obtained from cultivar of Aktas-3 (2200 kg ha^{-1}) in 35 cm row distance and it was followed by cotton cultivars of ST-468 and DP-388. Delta Opal had the highest numbers of fruit branches per plant (7 no. $plant^{-1}$) in conventional row.

REFERENCES

[1] Balkcom, K.S., Price, A.J., Santen, E.V., Delaney, D.P., Boykin, D.L., Arriaga, F.J., Bergtold, J.S., Kornecki, T.S. and Raper, R.L. 2010. Row spacing, tillage system, and herbicide technology affects cotton plant growth and yield. *Field Crops Res.*117:219-225.

[2] Boquet, D.J. 2005. Cotton in ultra-narrow row spacing: Plant density and nitrogen fertilizer rates. *Agron. J.* 97:279–287.

[3] Heitholt, J. J., Pettigrew, W. T. and Meredith, W. R. 1992. Light interception and lint yield of narrow row cotton. *Crop Sci.* 32: 728-733.

[4] Jahedi, M.B., Vazin, F., Ramezani, M.R. 2013. Effect of row spacing on the yield of cotton cultivars. *Cercetari Agronomice in Moldova,* 4 (156): 31-38

[5] Jones, M.A. 2001. Evaluation of ultra-narrow row cotton in South Carolina. p. 522-524. *In Proc. Beltwide Cotton Conf.,* Anaheim, CA. 9-13 Jan. 2001. Natl. Cotton Counc. Am., Memphis, TN.

[6] Bourland, F.M., N.R. Benson, E.D. Vories, N.P. Tugwell and D.M. Danforth (2001). Measuring maturity of cotton using nodes above white flower. J. Cotton Sci.5:1-8.

[7] Pettigrew, W.T., and J.T. Johnson. 2005. Effects of different seeding rates and plant growth regulators on early-planted cotton. J. Cotton Sci. 9:189-198.

[8] Siebert, J. D., and Stewart, A. M. 2006. Influence of plant density on cotton response to mepiquat chloride application. Agron. J. 98:1634-1639.

[9] Gannaway, J. R., Hake, K. and Harrington, R. K. 1995. Influence of plant population upon yield and fiber quality. p. 551-556. In Proc. Beltwide Cotton Prod. Res. Conf. San Antonio, TX. 4-7 Jan. 1995. Natl. Cotton Counc. Am., Memphis, TN.

[10] Jost, P.H. and Cothren, J.T. 2000. Growth and yield comparisons of cotton planted in conventional and ultra narrow row spacing. *Crop Science,* 40: 430-435.

[11] Killi, F. and Bolek, Y. 2006. Timing of planting is crucial for cotton yield. *Acta Agriculturae Scandinavica Section B-Soil and Plant Science,* 56: 155-160

[12] Jones, M.A. and Wells, R. 1998. Fiber yield and quality of cotton grown at two divergent population densities. Crop Sci. 38:1190-1195.

[13] Nichols, S. P., Snipes, C. E. and Jones, M. A. 2004. Cotton growth, lint yield, and fiber quality as affected by row spacing and cultivar. *J. Cotton Sci.* 8:1-12.

[14] Bednarz, C.W., Shurley, W.D., Anthony, W.S. and Nichols, R.L. (2005). Yield, quality, and profitability of cotton produced at varying plant densities. *Agron J* 97: 235-240.

[15] York, A.C. 1983. Response of cotton to mepiquat chloride, varying N rates and plant populations. Agronomy Journal 75: 66-70.

[16] Witten T.K., Cothren J.T. 2000. Varietal comparisons in ultra narrow row cotton (UNRC). p. 608. *In: Proc. Beltwide Cotton Conf.,* San Antonio, TX. 4-8 Jan. 2000. Natl. Cotton Counc. Am., Memphis, TN.

[17] Zaxosa, D., Kostoulaa, S., Khaha, E.M., Mavromatisa, A., Chachalisb, D. and Sakellarioua, M. 2012. Evaluation of seed cotton (*Gossypium hirsutum* L.) production and quality in relation to the different irrigation levels and two row spacings. *Int. J. Plant Prod.* 6 (1): 129-148.

[18] Ali, A., Tahir, M., Ayub, M., Ali, M., Wasaya, A., Khalid, F., 2009. Studies on the Effect of Plant Spacing on the Yield of Recently Approved Varieties of Cotton. Pak. j. life soc. sci., 7(1):25-30

[19] Smit, C. W., Chandler, J. M., Morrison, J. E. 1989. Genotypic Response to Narrow Rows at Temple, Texas. Reprinted from Proceedings: 1989 Belt Wide Cotton Research Conferences pp. 120 – 122.

[20] Siebert, J. D., A. M. Stewart, and B. R. Leonard (2006). Comparative growth and yield of cotton planted at various densities and configurations. Agron. J. 98:562-568.

[21] Bednarz, C. W., Bridges, D. C., Brown, S.M. 2000. Analysis of cotton yield stability across population densities. Agron. J. 92:128-135

[22] Ahmad, A. U. H., Ali, R., Zamir, S. I., Mahmood, N., 2009. Growth, yield and quality performance of cotton cultivar BH-160 (*Gossypium hirsutum* L.) as influenced by different plant spacing. The Journal of Animal & Plant Sciences 19(4): 189-192.

[23] Rossi, J., Novick, G., Murray, J., Landivar, J., Zhang, S., Baxevanos, D., Mateos, A., Kerby, T., Hake, K. and Krieg, D. 2004. Ultra Narrow Row Cotton: Global Perspective and Reduce Pesticide use Proceedings of the Technical Seminar of the 3rd Plenary Meeting of the ICAC: How to improve yields. Mumbai, India. Nov. 2004, p. 7-11.

[24] Brodrick, R., Bange, M. P., Milroy, S. P. and Hammer, G. L. 2010.Yield and maturity of ultra-narrow row cotton in high input production systems. Agron. J. 102(3): 843-848.

[25] Siddiqui, M. H., Oad, F. C. and Buriro, U. A. 2007. Plant spacing effects on growth, yield and lint of cotton. Asian Journal of Plant Sci., 6: 415-418.

[26] Oosterhuis, D. M. 1994. Arkansas Experiment Station Special Report 166. University of Arkansas, Department of Agronomy. Proceeding of the 1994 Cotton Research Meeting, pp. 31-40.

[27] Saleem, M.F., Anjum, S.A., Shakeel, A., Ashraf, M.Y., Khan, H., 2009. Effect of row spacing on earliness and yield in cotton. *Pak. J. Botany*, 41(5): 2179-2188.

[28] Sharma, V.P., 1998. Influence of intra row spacing on the performance of cotton varieties. Ind. J. Agric. Sci., 22: 310-316.

[29] Kumar, R.K., 1989. Effect of plant spacing on the growth and yield of cotton. Maharashtra J. Agric. Res., 12: 410-415.

[30] Wali, B.M., Koraddi, V.R., 1989. Biometrical studies in rain fed cotton. Mysore Journal of Science, 23: 441-446.

[31] Yadav, V.S., 1997. Influence of various plant spacing on the growth and yield of cotton. Ind. J. Agric. Sci., 21: 998-1023.

[32] Kassianenko, V. A., Dragavtsev, V. A., Razorenov, G. I., Razorenov, T. S., 2003. Variability of cotton (*G. hirsutum* L.) with regard to earliness. Genet. Resour. Crop Evol. 50: 157-163.

[33] Ali, C. R., Arshad, M., Khan, M. I., Afzal, M., 2003. Study of earliness in commercial cotton (*G. hirsutum* L.) genotypes. J. Res. Sci. 14(2): 153-157

[34] Killi, F., 1995. Correlation and path analysis for seed cotton yield and some yield components of cotton (*Gossypium hirsutum* L) in East Mediterranean and Southern Anatolia conditions. *Tr. J. of Agriculture and Forestry* 19 (5): 379-382.

[35] Hussain, S., Farid, Z.S., Anwar, M., Gill, M.I., Dilbaugh, M., 2000. Effect of plant density and nitrogen on yield of seed cotton of CIM-473. Sarhad J. Agric., 16: 2000.

[36] Iqbal, M., Khan, M. A., 2011. Response of cotton genotypes to planting date and plant spacing. Frontiers of Agriculture in China, 5(3): 262.

[37] Mukharjee, B., 1999. Influence of different plant spacing on the growth and yield of cotton cultivars. Ind. J. Agric. Res., 10: 280-286.

[38] Sharma, B.D., 1994. Performance of various cotton cultivars under different row and plant spacing. Maysoor J. Agric. Res., 12: 211-217.

[39] Singh, V.P. and R.K. Singh, 1998. Effect of different row and plant spacing on the growth and yield of cotton varieties. Indian J. Agron., 13: 150-155.