Agrotechniques in Industrial Crops

Journal Homepage: https://atic.razi.ac.ir

Value of Cultivation and Use (VCU) Evaluation of Some New Promising Genotypes of Upland Cotton (*Gossypium hisutum* L.) in Razavi Khorasan Province

Aidin Hamidi*[1], Mohammad Reza Ramezani Moghaddam[2], Hassan Najjar[3], Morteza Arab Salmani[4], Akram Mohajer Abbasi[4]

[1]*Agriculture Research, Education and Extension Organization (AREEO), Seed and Plant Certification and Registration Institute (SPCRI), Karaj, Iran*

[2]*Crop and Horticultural Science Research Department, Khorasan Razavi Agricultural and Natural Resources Research and Education Center, AREEO, Mashhad, Iran*

[3]*Agriculture Research, Education and Extension Organization (AREEO), Khorasan Razavi province Agriculture and Natural Resources Research and Education center, Kashmar Agricultural Research Station, Kashmar, Iran*

[4]*Agriculture Research, Education and Extension Organization (AREEO), Tehran province Agriculture and Natural Resources Research and Education center, Varamin, Iran*

ARTICLE INFO

Original paper

Article history:
Received: 11 Sep 2022
Revised: 8 Nov 2022
Accepted: 21 Dec 2022

Keywords:
Canopy structure
Earliness index
Fiber quality
Seed cotton yield

ABSTRACT

In order to evaluate the value of cultivation and use (VCU) of three new upland cotton genotypes, KC8801, KC8802 (introduced as Kashmar and Khorshid new commercial cultivars respectively), and genotype R7 in comparisons to three commercial common cultivars Golestan, Khordad and Varamin (as control cultivars) in Khorasan Razavi province, a two-year field experiment conducted based on randomized complete blocks design with four replications. Seed cotton yield and its components, earliness index and some related morphological and fiber quality traits were measured during the 2012-2013 year. The results showed that the weight of the bolls was higher in the second year, and the seed cotton yield was higher in the second year and the earliness index was higher in the first year. Also, genotype R7 and the new KC8802 genotype had the highest and the lowest fruiting branches number respectively. Both the Khordad control cultivar and KC8802 new genotype had the highest number of bolls (17 bolls), and the KC8801 new genotype had the highest crown diameter and plant height (120 cm) during two cropping seasons. Also, in both years, Khordad and Golestan control cultivars had the highest, and KC8802 and KC8801 new genotypes had the lowest number of vegetative branches (1.325 and 1.250 in the first year and 1.355 and 1.255 in the second year respectively). The KC8801 new genotype had higher gin turn-out and fiber strength. Therefore, based on the results, higher plant height and less vegetative branches number and a closed canopy structure, KC8802 and KC8801 new genotypes which lead to means that they can be cultivated with a higher plant density cultivation capability in ultra-narrow row cultivation, their higher field performance expected and are suitable for cultivation in Razavi Khorasan province and similar areas.

DOI: 10.22126/ATIC.2023.8346.1069

1. Introduction

Cotton is one of the most important industrial crops (Ahmad and Hasanuzzaman, 2020) and in the 2020-2021 crop year, the harvest area, and the amount of seed cotton production in Iran were 79,673 hectares and 202,882 tons respectively, and the seed cotton yield per hectare was 2,849 and 1434 kilograms per hectare, in irrigated and dryland cultivation respectively (Ministry of Jihad-e-Agriculture, 2022). Plant breeding is the process of selecting and creating new genetic changes in plant species, which leads to the release of superior cultivars with high performance and resistance to stresses. Therefore, plant cultivars are considered the most important achievements of cross-breeding research (Thaker *et al.*, 1989). New plant varieties must be evaluated before being introduced and released for

* Corresponding author.
E-mail addresses: a.hamidi@areeo.ac..ir

commercial use by farmers, and this evaluation is called the value of cultivation and use trial (VCU). The purpose of the trial is to compare the cultivation value of new cultivars of a crop from different aspects with common commercial cultivars and to identify the cultivars that are superior in a particular ecological region (Mozafari *et al*., 2010). European Community and India, have an advanced VCU evaluation system, and newly introduced cultivars are registered based on VCU trial results. Compared to common cultivars, new cultivars are released and introduced by performing a trial to determine the cultivation value and use (Sudhir, 2010). The cotton new varieties introduction aims are mainly to increase yield, earliness, and resistance to biotic and abiotic stresses (Soliz *et al*., 2008; Oosterhus and Cothren, 2012). VCU trial results in 13 places in Brazil revealed the superiority of the new cultivar BRS293 for earliness, seed cotton yield and fiber gin turn out and length compared to common cotton varieties and then the cultivar introduced (Morello *et al*., 2010). Also, by conducting the VCU trials in 9 regions of Brazil for 2 years and assessment of 16 traits related to yield, gin turn out and fiber length of transgenic cotton progenies, 2 new superior cultivars were selected and introduced as high-yielding cultivars (Suassuna *et al*., 2018). Also, by conducting the VCU trials for 2 years in 17 regions of Brazil and comparing the yield, gin turn-out and fiber length, a promising genotype superior to the common cultivars among 50 transgenic cotton progenies was selected and introduced as a medium maturity cultivar for the northern and northeastern regions of Brazil (Vianna Barroso *et al*., 2017). Assessment of 13 varieties of upland cotton in Varamin region conditions revealed that there was a significant correlation between cultivars, morphological traits related to yield, and also between different traits with yield (Vafayi Tabar and Tajick Khaveh, 2012). The study of the performance of the newly introduced cotton cultivars in Pakistan showed that the tested cultivars were different in terms of plant height, number of bolls per plant, boll weight, seed cotton yield and fiber quality characteristics (Ehsan *et al*., 2008). The comparison of 5 cotton cultivars showed that the first three fruiting places on the fruiting branches are more important than the rest of the fruiting places in terms of yield formation, and the first fruiting place has the greatest role in yield formation (Anjum *et al*., 2001). A comparison of the productivity of 12 new and old cotton cultivars from seven decades of breeding efforts showed that the fiber yield of the old cultivars was 24% lower than that of 20 advanced genotypes (Meredith *et al*., 1986). Also, advanced cultivars produced a large number of smaller bolls with a higher gin turnout (Seddighi *et al*., 2013). In most advanced cultivars, the first fruit-producing branch is formed on the fifth to eighth nodes of the main stem (Boman, 2013). In general, the conducted research shows that most of the yield is obtained from the first and second positions on the 9th to 14th nodes of the main stem and more than 80% of the yield is obtained from these positions. (Oosterhus and Cothren, 2012). Despite the new cotton cultivars that have been modified and introduced, the majority of the Iran cotton cultivation area, especially in Razavi Khorasan province, is still devoted to the Varamin cultivar, which has been introduced and cultivated for 60 years (Hamidi *et al*., 2012). Our research aim was to new cotton genotypes seed cotton yield and its components and some agronomic and fiber quality traits performance assess in comparison to common cultivars by VCU trial for commercializing new genotypes commercialize of the best genotype(s) as new commercial cotton cultivar(s) for cotton mechanical harvest development in the conditions in Razavi Khorasan province.

2. Materials and methods

This trial was carried out in Razavi Khorasan Province in the Agricultural and Natural Resources Research Station Kashmar farm as a completely randomized block design with 4 replications during the 2012-2013 cropping year. The station is located 2 km from Neqab Road and in 58 degrees 23 minutes 50 seconds to 58 degrees 26 minutes 58 seconds longitude and 35 degrees 12 minutes 10 seconds to 35 degrees 13 minutes 4 seconds latitude and 1060 meters above mean sea level altitude (Table 1).

The trial was conducted in a field where the land was left fallow in the previous year and primary tillage operations included deep plowing in the fall season and secondary tillage operations included medium depth plowing and disking and the operation of preparing the seed bed by harrowing, leveling and furrowing with a distance of 70 cm in early spring. Each plot consists of 4 planting rows with a length of 6 meters and the planting was carried out by respecting the planting distance of 20 cm on the row and the uniform planting depth of the seeds and fertilization, irrigation and plant protection operations carried out ordinarily in the field during the growth and development period and the date of the first irrigation as the date planting was considered (Hamidi, 2016). The new genotypes and commercial control cultivars were: 1- Varamin (control), 2- Khordad (control), 3- Golestan (control), 4- R7 (new genotype), 5- KC8801 new genotype (recently introduced as Kashmar new commercial cultivar) and 6 – KC8802 new genotype (recently introduced as Khorshid new commercial cultivar).

The seed cotton yield was measured as the total harvested seed cotton weight in two middle rows of each plot, and the earliness index was calculated as equation 1 (Seed and Plant Certification and Registration Institute, 2009):

Earliness index (%) = (First harvest time seed cotton yield (kg)/ Total harvested seed cotton yield (kg)) × 100 (1)

Table 1. Average temperature, precipitation and relative humidity data of Kashmar meteorology station during trial conduction months in 2012-2013 years (Khorasan Razavi Province Meteorology Office, 2012; Khorasan Razavi Province Meteorology Office, 2013)

Year	Month	Average emperature (°C)	Average recipitation (mm)	Average Relative umidity (%)
2012	21 April-21 May	18.90	1.330	78
	22 May-21 June	25.70	5.420	63
	22 June-22 July	28.90	2.051	62
	23 July-22 August	30.30	3.043	62
	23 August-22 September	25.20	3.049	69
	23 September-22 October	21.10	7.331	70
Mean		25.02	3.704	67.33
2013	21 April-21 May	21.90	6.023	65
	22 May-21 June	26.60	4.014	58
	22 June-22 July	27.30	9.136	69
	23 July-22 August	32.10	3.600	65
	23 August-22 September	26.40	3.050	70
	23 September-22 October	20.80	8.001	72
Mean		25.85	5.639	66.50

To calculate the boll weight, 20 bolls were randomly picked and weighed in each plot from the middle part of the plant, and the average weight was recorded as the average boll weight for each plot. Also, six plants were randomly selected from each plot and the characteristics of the number of bolls per plant, height of the plant in centimeters (measured with a ruler), crown diameter in centimeters (with a caliper), the number of vegetative branches and the number of fruiting branches were measured and recorded. In order to measure the quantitative and qualitative attributes of the fibers, a quantity (about 200 grams) of cotton lint was prepared for each plot as the homogenous sample from two harvests and after ginning the seed cotton by 8 saws laboratory gin machine in the Cotton Fiber Technology Laboratory of the Agricultural and Natural Resources Research and Education Center of Tehran province at Varamin (Hamidi, 2016), fiber gin turnout was calculated in terms of percentage according to equation 2 (Seed and Plant Certification and Registration Institute, 2009):

Fiber gin turnout (%) = (Fiber weight/Fiber weight + Cotton seed weight) ×100 (2)

Then the fiber samples some technological attributes including fiber length (mm), fiber fineness (in micronare), fiber strength (in g/tex), fiber uniformity (in percentage) and fiber elasticity (in percentage) were determined by HVI (High Volume Instrument) equipment (Hamidi, 2016). The trial data statistical analysis including homogeneity of variances test (Bartlett's test), time-combined analysis of variance and means comparisons by Duncan's Multiple Range Test (DMRT) was conducted by SAS software version 9.1.

3. Results

In order to check the assumption of homogeneity of variances, it is necessary to perform the homogeneity of variances test (Bartlett's test) (Yazdi Samadi *et al*., 2013). The results of Bartlett's test on the seed cotton yield and its components and some related morphological and fiber quality traits showed, the variance of data errors in the years of trial for the boll weight, boll number, seed cotton yield, earliness index, crown diameter attributes were not significant (Table 2) and therefore an error of variance was homogeneous, so data time combined analysis was performed for these traits (Table 3). But the data errors in the years of the experiment for gin turn out, fiber length, uniformity, fineness, strength and elasticity traits were significant (Table 2) and therefore time combined analysis was not performed for those traits and each year's data of those traits were separately analyzed (Tables 5 and 6).

The results of the time combined analysis of variance showed there was no significant difference in the gin turnout, fiber uniformity, fineness and elasticity of the studied new genotypes and control cultivars and those traits had no significant difference in trial years. Also, during trial years, new genotypes and control cultivars were significantly different in boll weight and the number of fruiting branches, and the interaction effect of year × genotypes and cultivars was significant for boll number, crown diameter, plant height, and the number of vegetative branches, fiber length and strength (Table 3).

Table 2. Error variance of VCU trial data for time-combined analysis during trial conduction years.

	Error Variance													
	Boll weight	Boll Number	Seed Cotton Yield	Earliness index	Crown Diameter	Plant height	Vegetative branches number	Fruiting branches number	Fiber gin turnout	Fiber Length	Fiber Uniformity	Fiber Fitness	Fiber Strength	Fiber Elasticity
χ^2	0.000094^{ns}	3.5462^{ns}	0.1529^{ns}	0.5061^{ns}	3.0607^{ns}	3.5466^{ns}	1.2209^{ns}	1.3542^{ns}	12.330**	7.300*	9.146*	4.903*	12.330**	9.146*
χ^2Probablity level	0.9923	0.0597	0.6958	0.4769	0.0802	0.0597	0.2692	0.2445	0.025	0.069	0.025	0.027	0.004	0.003

ns non-significant, * significant at 5 percent probability level and ** significant at 1 percent probability level.

Table 3. Mean squares of time-combined analysis of variance studied traits in VCU trial.

Source of variation	df	Boll weight	Boll Number	Seed Cotton Yield	Earliness index	Crown Diameter	Plant height	Sympodial branches number	Fruiting branches number
Year	1	4.48658**	590.8033**	40245628.12**	1695.9938**	0.22687**	589.4008**	5.20083**	0.0483^{ns}
Block(Year)	6	0.28476^{ns}	11.8256*	133156.105^{ns}	59.5215^{ns}	0.01098^{ns}	20.1875^{ns}	0.17861^{ns}	0.016528^{ns}
Genotypes	5	0.51516*	7.16200^{ns}	4045306.25^{ns}	163.9376^{ns}	0.01638^{ns}	627.6028**	5.38683**	7.55150**
Year× Genotypes	5	0.15391^{ns}	12.98733*	2061001.94^{ns}	112.6876^{ns}	0.04959**	580.8588**	0.72683**	0.25682^{ns}
Error	30	0.16114	3.89689	977098.2306	103.2885	0.009.8	58.3055	0.11728	1.06461
CV (%)		7.21	11.95	17.76	13.70	6.26	7.31	15.76	7.44

ns non-significant, * significant at 5 percent probability level and ** significant at 1 percent probability level.

In the first year of the trial, the highest boll weight belonged to the Varamin control cultivar (Fig. 1) and other studied new genotypes and control cultivars were placed in the same statistical group in this sense (Fig. 2).

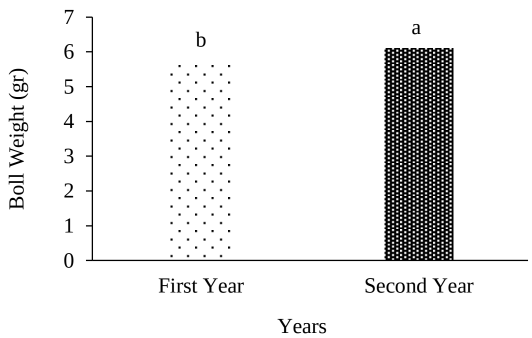

Figure 1. Mean comparisons of boll weight during trial years.

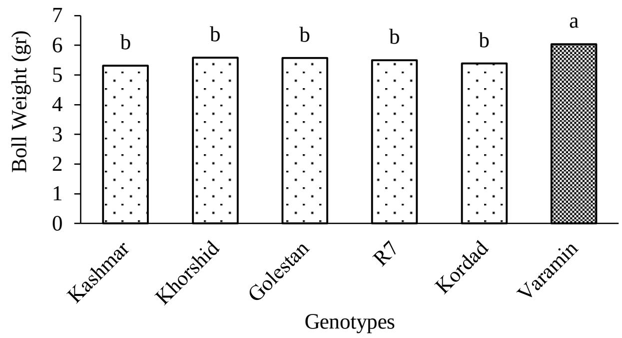

Figure 2. Studied cotton new genotype and control cultivars boll weight mean comparisons

The Khordad control cultivar had the highest number of bolls in the first and second years of the trial and was placed in the same statistical group as the KC8802 new genotype (Table 4). Due to the fact that the KC8802 new genotype is a non-branching type, and apart from the Khordad control cultivar had a higher number of bolls than other branching cultivars and genotypes, so the production capacity of the KC8802 new genotype is high.

The comparison of the means of seed cotton yield in the years of the trial showed that the seed cotton yield was 2069.13 kg, equal to 30.79% higher in the second year of the trial than the first year seed cotton yield (Fig. 3).

The earliness index was 12.62% higher in the second year of the trial than the first year (Fig. 4). Considering the higher average air temperature in the second year of the experiment (Table 1), this was anticipated.

The comparison of the means showed that during two years of trial, the crown diameter of the KC8801 new genotype was greater than the other genotypes and cultivars investigated and had a significant difference with the KC8802 new genotype (Table 4). The crown diameter has been known as a selection index for improving the yield capacity and tolerance to water stress by examining the indices of resistance to water stress (Zangi, 2002).

The plant height of the KC8801 new genotype was higher than the other investigated new genotypes and control cultivars in both years of trial, and the plant height of the R7 new genotype was ranked second (Table 4).

Also, the R7 genotype had the highest number of fruiting branches (15.13 fruiting branches per plant), and the KC8801 new genotype was in second place in this respect, and the Varamin control cultivar was also in the same statistical group (Fig. 5).

Table 4. Mean comparisons of year× genotypes interaction for boll number, crown diameter and vegetative branches number.

Year	Genotype	Boll Number	Crown Diameter (cm)	Plant height (cm)	Vegetative branches number
1	KC8801	16.33^{ab*}	1.59^{a}	120.13^{a}	1.325^{bc}
1	KC8802	17.33^{a}	1.47^{b}	100.25^{c}	1.250^{c}
1	R7	16.20^{ab}	1.55^{ab}	109.55^{b}	1.575^{b}
1	Golestan	16.68^{ab}	1.48^{ab}	95.93^{c}	1.950^{a}
1	Khordad(Control)	17.65^{a}	1.53^{ab}	100.50^{c}	2.000^{a}
1	Varamin(Control)	14.98^{b}	1.52^{ab}	95.93^{c}	1.875^{ab}
2	KC8801	16.65^{ab}	1.65^{a}	120.50^{a}	1.355^{bc}
2	KC8802	17.70^{a}	1.50^{b}	100.75^{c}	1.255^{c}
2	R7	16.35^{ab}	1.65^{ab}	110.00^{b}	1.596^{b}
2	Golestan(Control)	16.70^{ab}	1.50 ^{b}	96.23^{c}	1.970^{a}
2	Khordad(Control)	17.95^{a}	1.55^{ab}	100.55^{c}	2.100^{a}
2	Varamin(Control)	15.27^{b}	1.55^{ab}	96.00^{c}	1.895^{ab}

*Means, in each column and for each factor, followed by at least one letter in common are not significantly different at the 5% of probability level- using Duncan s Multiple Range Test.

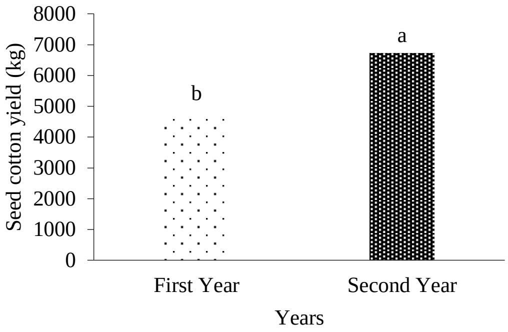

Figure 3. Mean comparisons of seed cotton yield during trial years.

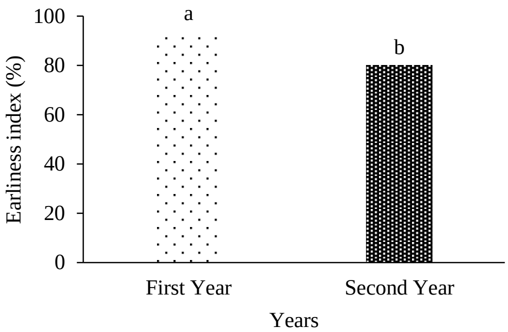

Figure 4. Mean comparisons of earliness index during trial conduction years.

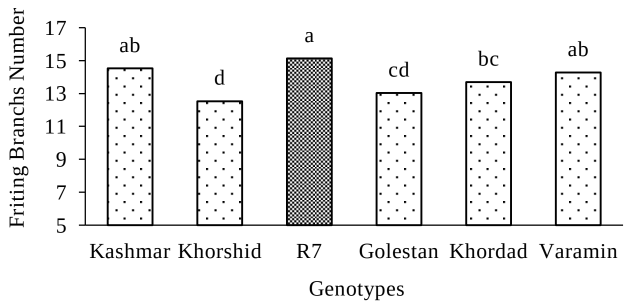

Figure 5. Mean comparisons of studied cotton genotypes and cultivars fruiting branches number.

According to the results of Bartlett's test (Table 2) and the significance of the variance of the errors of the data of the fiber quality traits, separate analysis of the variance of these data was done in the years of the trial conduction and the results showed that in the first year of the trial, the difference of fiber gin turns out, length and strength of studied genotypes and cultivars and difference of the length and strength of fibers in the second year of the trial were significant (Tables 5 and 6). Means comparison revealed that the KC8801 new genotype had the highest gin turnout in the first year and fiber strength in the second year. Also, the Varamin control cultivar had the highest fiber length in the first and second years and the highest fiber strength in the first year (Table 7). The higher means of fiber length and strength of the fibers can be attributed to the higher average temperature of the test site in the second year (Table 1). Therefore, the KC8801 new genotype gin turnout was superior to other new genotypes and control varieties.

Table 5. Analysis of variance (mean squares) of some fiber quality traits in the first year.

Source of variation	df	Fiber gin turnout	Fiber Length	Fiber Uniformity	Fiber Fitness	Fiber Strength	Fiber Elasticity
Block	3	3.61483^{ns}	105.4787^{ns}	0.8044^{ns}	0.12931^{ns}	0.8549^{ns}	0.03486^{ns}
Genotypes	5	15.21635**	4.2560**	1.6990 ^{ns}	0.03342^{ns}	5.4567**	0.04475^{ns}
Error	15	998091.5004	1.30711	1.8527	0.06164	1.85278	0.029194
CV (%)		3.54	3.71	1.62	5.71	3.48	2.34

ns non-significant, * significant at 5 percent probability level and ** significant at 1 percent probability level.

Table 6. Analysis of variance (mean squares) of some fiber quality traits in the second year.

Source of variation	df	Fiber gin turnout	Fiber Length	Fiber Uniformity	Fiber Fitness	Fiber Strength	Fiber Elasticity
Block	3	8.0925^{ns}	0.7782^{ns}	3.5256^{ns}	0.14111^{ns}	0.4294^{ns}	0.05222^{ns}
Genotypes	5	6.3718^{ns}	7.0884**	1.2170^{ns}	0.08967^{ns}	4.5577*	0.03767^{ns}
Error	15	9.4609	1.0088	1.4212	0.09211	1.3908	0.02722
CV (%)		8.68	3.29	1.42	6.77	4.07	2.27

ns non-significant, * significant at 5 percent probability level and ** significant at 1 percent probability level.

Table 7. Mean comparisons of fiber quality traits during trial conduction years in the value of cultivation and use (VCU) trial on cotton new genotype and cultivars in Khorasan Razavi province Kashmar agricultural research station.

Genotypes And Cultivars	Fiber gin turnout- First Year	Fiber Length (mm)- First Year	Fiber Length (mm)- Second Year	Fiber Strength (g/tex)- First Year	Fiber Strength (g/tex)- Second Year
KC8801	39.96^{a*}	29.88^{bc}	31.35^{ab}	27.20^{c}	30.48^{a}
KC8802	37.43^{b}	29.48^{c}	30.03^{bc}	28.08^{bc}	28.50^{b}
R7	33.96^{c}	31.03^{abc}	29.83^{bc}	29.40^{ab}	27.78^{abc}
Golestan(Control)	37.88^{ab}	31.88^{abc}	28.73^{c}	29.78^{a}	27.46^{c}
Khordad(Control)	38.06^{ab}	30.88^{abc}	30.48^{bc}	29.08^{ab}	28.80^{abc}
Varamin(Control)	37.57^{b}	32.33^{a}	32.58^{a}	30.40^{a}	29.93^{ab}

*Means, in each column, followed by at least one letter in common are not significantly different at the 5% of probability level- using Duncan s Multiple Range Test.

4. Discussion

The number of bolls in the plant, the number and weight of seeds, the weight of bolls and the percentage of fiber (gin turnout) determines the cotton yield (Ahmad and Hasanuzzaman, 2020). By comparing different agronomic traits of new genotypes and commercial cotton cultivars in order to determine the value of cultivation and use trial, the superiority of the Varamin control cultivar in terms of boll weight was observed (Naderi Arefi and Hamidi, 2014). Boll weight is one of the most important components of seed cotton yield, and there is a positive correlation between seed cotton yield and boll weight and an increase of one unit in boll weight increases the boll seed cotton yield by 48-53 grams (Salahuddin *et al*., 2010a).

The number of bolls per plant is one of the factors that determine the yield of cotton. The components of cotton yield include the number of bolls, boll weight, number of seeds per boll and fiber and cotton seed weight, and these components are under the influence of the physiological activity of the plant and its interaction with the environment, and the number of bolls per unit area is the critical variable trait for seed cotton determination (Boquet *et al*., 2004; Wu *et al*., 2005). Despite this, Vafayi Tabar and Tajick Khaveh (2012) reported that there is a great variation between cultivars in terms of yield correlation with various traits, including the number of bolls per plant. A positive and significant correlation of yield with the number of bolls per plant was observed and the increase in yield in cotton genotypes is directly influenced by this trait (Baloch *et al*., 2016). A significant difference in the number of bolls per plant of different genotypes and cultivars of cotton has been reported (Naderi Arefi and Hamidi, 2014).

This yield rise may be due to the higher average air temperature in the second year of the trial (Table 1). Cotton yield is affected by genotype (G), environment

(E) and their mutual effects (G × E) (Raper *et al.*, 2019). Almost, genetic variance plays a greater role than the environmental variance for cotton seed yield determination, and traits such as the number and weight of bolls, as well as seed and fiber index have a positive correlation with seed cotton yield (Khan *et al*., 2008; Batool *et al*., 2010; Khan *et al*., 2010). In general, a temperature lower than 15 C° is not suitable for the continuation of growth and formation of cotton yield, and a temperature higher than 35 Celsius degrees is also unsuitable due to the decrease in the speed of carbon exchange, the decrease in the viability of pollen grains, and the increase in night respiration. The importance of keeping the leaf temperature in the desired range has been determined by numerous studies conducted on leaf stomatal conductance of different cotton cultivars, especially long staple cotton varieties (Lokhande and Reddy, 2014). Day and night 30 and 25°C temperatures respectively are known as optimal temperatures for cotton growth and development during the reproductive stage (Reddy *et al*., 2017). The night temperature of 21 25°C has been reported as the optimal night temperature for cotton photosynthesis, and genetic variation in the response of different cotton genotypes to this temperature has also been observed (Kloth and Turley, 2010). It has also been determined that low night temperatures reduced the elongation and the rate of increase of dry matter of the fibers grown on cotton ovules (Rehman and Farooq, 2020). Also, the cotton yield has high heritability (Jarwar *et al*., 2018).

Earliness is important in achievement to more yield in the first harvest, because the earliness index is calculated from the ratio of first harvest seed cotton yield to the total harvested seed cotton yield, and if the main part of the seed cotton yield is achieved earlier, avoidance of follow crop cultivation to early Autumn temperature decrease, leads to cotton taking the place in rotation with Autumn crops. Unlike some plants of unlimited growth, such as soybean, cotton is not sensitive to photoperiod, and the beginning of its flowering is not affected by seasonal changes in day length (Gwathmey *et al*., 2016). Earliness in cotton is considered a polygenic trait that is influenced by genetic and environmental factors affecting the morphological, phenological and physiological characteristics of the plant (Conaty *et al*., 2015).

Plant height is one of the important vegetative characteristics of cotton, which is usually influenced by the amount of inputs used and the genetic structure of the cultivated cultivar, and this trait directly plays a role in yield (Zabihi *et al*., 2013). It has been reported that plant height changes in different cultivars and genotypes and in different environmental conditions (Ehsan *et al*., 2008). Also, a significant difference in plant height of different cotton genotypes and cultivars has been observed (Naderi Arefi and Hamidi, 2014; Hamidi *et al*., 2018). In both years of the trial, the highest number of vegetative branches belonged to the Khordad control cultivar, and the number of vegetative branches of the Golestan control cultivar was also in the same statistical group, and the number of vegetative branches of the Varamin control cultivar was the next after those two control cultivars (Table 4). The slightly higher means of vegetative branches number in the second year of the trial compared to the means of this trait in the first year of the trial can be related to the higher air temperature in the second year (Table 1). KC8801 and KC8802 new genotypes vegetative branches lower number which makes closed canopy-type of genotypes (zero type genotypes) capable of cultivation in the higher plant densities which leads to higher seed cotton yield. While R7 genotype and control cultivars have an open canopy and plant density increase lead to competition between plants and probably consequently their seed cotton yield drop. Therefore, KC8801 and KC8802 new genotypes cultivation in more than the usual planting pattern (20 × 70 cm) and higher plant densities, even cultivation in ultra-narrow rows recommendable. Seed cotton yield has a negative and significant correlation with the height and number of fruiting branches (Alaeddin *et al*., 2017). Also, the bolls and fruiting branches number per plant, and fiber gin turn out to have high heritability (Paterson, 2009).

In terms of the length of the fruiting branches, cotton has three plant forms, long branches, short branches and zero types. For the mechanized harvesting of early-maturing varieties with an average height of 90 to 100 cm, short branches, short internodes and smaller stems are suitable (Singh, 2011). There is a positive and strong correlation between the number of fruiting branches and the yield of the plant, and the yield of the plant is directly and indirectly affected by this trait (Satange *et al*., 2000; Soomro, 2000). The number of fruiting branches has the greatest effect on the yield of cotton bolls, and there is the most positive and significant correlation between the number of fruiting branches and the seed cotton yield, and the increase of one fruiting branch in a plant causes an increase of 7.5 grams in seed cotton weight (Salahuddin *et al*., 2010b). There is a positive and significant correlation between the length and the number of fruiting branches (Kazerani, 2012). Reduction of internode length has the most negative direct effect on seed cotton yield (Rauf *et al*., 2005). Also, the number of nodes in the first fruiting branch has a very high correlation with earliness (Babar *et al*., 2002).

Gin turnout determines the performance of fibers and the amount of fiber that can be achieved, as well as fiber strength, which is considered one of the important technical characteristics of cotton fibers. A significant diversity of gin turnouts of cotton cultivars has also been observed (Khan *et al*., 2010; Ashokkumar, 2011). The performance of cotton fibers is determined by their components, including the number and weight of bolls and the percentage of fibers (Wu *et al*., 2004). The quality of cotton fiber attributes including fiber length, strength, elasticity, maturity and elasticity are important factors for modern textile industries (Jaime *et al*., 2013). The elongation of cotton fiber cells is under the control of genetic and environmental factors and their mutual effects (Amjad Ali *et al*., 2008). The evolution of fiber length is strongly influenced by the maximum and minimum temperature, latitude, temperature fluctuations and altitude above sea level, and temperature is the main factor of genotype and environment interaction for fiber length, and the first and mid-season bolls have longer fiber length than bolls produced at the end of the season (Percy *et al*., 2006; Rahman *et al*., 2007).

5. Conclusion

The weight of the bolls and seed cotton yield was higher in the trial second year and the earliness index was higher in the first year of the trial. Also, the new genotype R7 and the KC8802 new genotype had the highest and lowest number of fruiting branches, respectively. Both the Khordad control cultivar and the KC8802 new genotype had the highest number of bolls in both years of trial, and the KC8801 new genotype had the highest crown diameter and plant height in both trial years. Also, in both years, the Khordad control cultivar had the highest vegetative branches and KC8802 and KC8801 new genotypes had the lowest number of vegetative branches. The lower number of vegetative branches means the possibility of planting with high plant density. The KC8801 new genotype also had a higher fiber gin turnout and fiber strength in the first year and second years of trial respectively. Therefore, based on the results of the research and considering that the KC8802 and KC8801 new genotypes have a larger crown diameter, which indicates greater tolerance to drought, and a higher plant height, which indicates greater competition strength with weeds, and a lower number of branches, which is indicative of the form of a closed plant canopy (in the form of a cluster plant) or zero-type cotton cultivars (without vegetative branches which bolls grow directly on the main stem in two and three boll clusters) and can be cultivated with a higher and suitable density being for cultivation in the system of ultra-narrow rows of cultivation and mechanized harvest with a picker machine. So, it is expected that their yield will be higher in such a system, so the KC8802 (Khorshid) and KC8801 (Kashmar) new genotypes are suitable and recommendable for cultivation in Razavi Khorasan province and similar areas.

Conflict of Interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

Informed Consent

The authors declare not to use any patients in this research.

Funding/Support

This study was supported by the Agriculture Research, Education and Extension Organization, Iran.

Acknowledgement

This article was achieved based on the material and equipment of Agriculture Research, Education and Extension Organization, that the authors thanks it.

References

Ahmad S., Hasanuzzaman M. 2020. Cotton Production and Uses, Agronomy, Crop Protection, and Postharvest Technologies. Springer Nature Singapore Pte Ltd. https://doi.org/10.1007/978-981-15-1472-2

Alaeddin H., Zangi M.R., Nezamzadeh R. 2017. Evaluation of genotypic and phenotypic correlation with yield and earliness in tetraploid species cotton. Iranian Journal of Cotton Research 5(1): 77-90.

Amjad Ali, M., Khan I.A., Awan S.I., Niaz S. 2008. Genetics of fiber quality traits in cotton (*Gossypium hirsutum* L.). Australian Journal of Crop Science 2(1): 10-17.

Anjum R., Soomro A.R., Chang M.A., Memon A.M. 2001. Effect of fruiting position on yield in American cotton. Pakistan Journal of Biological Science 4(8): 960-962. https://doi.org/10.3923/pjbs.2001.960.962

Ashokkumar K., Ravikesavan R. 2011. Morphological Diversity and *per se* Performance in Upland Cotton (*Gossypium hirsutum* L.). Journal of Agricultural Science 3(2): 107-113. https://doi.org/10.5539/jas.v3n2p107

Baloch M., Baloch A.W., Ansari U.A., Baloch G.M., Abro S., Gandahi N., Baloch G.H., Baloch A.M., Ali M., Baloch I.A. 2016. Interrelationship analysis of yield and fiber traits in promising genotypes of upland cotton. Pure and Applied Biology 5(2): 263-269. https://doi.org/10.19045/bspab.2016.50034

Babar B., Soomro A., Anjum R., Memon R., Soomro A.W. 2002. Two preliminary reliable indicator of earliness in cotton. Asian Journal of Plant Science 1: 121-122. https://doi.org/10.3923/ajps.2002.121.122

Batool S., Khan N.U., Makhdoom K., Bibi Z., Hassan G., Marwat K.B., Farhatullah F., Mohammad R., Khan I.A. 2010. Heritability and genetic potential of upland cotton genotypes for morpho-yield traits. Pakistan Journal of Botany 42(2): 1057-1064.

Boman R. 2013. Monitoring pre-bloom cotton fruiting in Oklahoma. Available at http://cotton.okstate.edu/plant-growth-and-development/montring-cttn-prebl-fruiting-ok.pdf

Boquet D.J., Hutchinson R.L., Breitenbeck G.A. 2004. Long-term tillage, cover crop, and nitrogen rate effects on cotton: Plant growth and yield components. Agronomy Journal 96: 1443-1452. https://doi.org/10.2134/agronj2004.1436

Conaty W., Brodrick R., Mahan J., Payton P. 2015. Climate and its interaction with cotton morphology. Cotton 57: 401-417. https://doi.org/10.2134/agronmonogr57.2013.0021

Ehsan F., Asghar A., Muhammad A.N., Muhammat T., Atif M. 2008. Comparative Yield Performance of New Cultivars of Cotton (*Gossypium hirsutum* L.). Pakistan Journal of Life and Social Science 6(1): 1-3.

Gwathmey C.O., Bange M.P., Brodrick R. 2016. Cotton crop maturity: A compendium of measures and predictors. Field Crops Research 191: 41–53. https://doi.org/10.1016/j.fcr.2016.01.002

Hamidi A., Naderi arefi A., Forghani S. R., Vafayi tabar M., Arab Salmani M. Hakimi M. 2012. Cottonseed production and technology. Seed and plant certification and registration institute. 648 pp.

Hamidi A. 2016. Evaluation and determination of some new cotton (*Gossypium hirsutum* L.) cultivars Value for Cultivation and Use (VCU). Research Project Report, Seed and Plant Certification and Registration Institute (SPCRI), 74 pp. (In Farsi).

Hamidi A., Ghasemi Bezdi K., Jafari Y. 2018. Evaluation of Morphological Characteristics of Cotton (*Gossypium hirsutum* L.) New Genotypes in Golestan Province. Journal of Crop Breeding 10(9): 66-74. (In Farsi).

Jarwar A.H., Wang X., Wang L., Jarwar Z.H., Ma Q. Fan S. 2018. Genetic Advancement, Variability and Heritability in Upland Cotton (*Gossypium hirsutum* L.). Journal of Environmental and Agricultural Sciences 16: 24-31.

Jaime R., McKamey J., Cotty P.J. 2013. Module Storage Time, Leaf Grade and Seed Moisture Influence Fiber Quality and Aflatoxin Contamination of Cotton in South Texas, Journal of Cotton Science 17: 60–68.

Kazerani B. 2012. Determination of the best cotton cultivars and selection criteria to improve yield in Gorgan climatic region. African Journal of Agricultural Research 7(13): 2004-2011. https://doi.org/10.5897/AJAR11.1602

Khan N.G., Naveed M., Khan N.I. 2008. Assessment of some novel upland cotton genotypes for yield constancy and malleability. International Journal of Agriculture and Biology 10(1): 109-111.

Khan N.U., Marwat K.B., Hassan G., Farhatullah S., Batool K., Makhdoom W., Ahmad Khan H.U. 2010. Genetic variation and heritability for cottonseed, fiber and oil traits in *G. hirsutum* L. Pakistan Journal of Botany 42(1): 615-625.

Khorasan Razavi Province Meteorology Office 2012. Agricultural Meteorology News Bulletein. Khorasan Razavi Province Meteorology Office Province Meteorology Office Scientific Publication.

Khorasan Razavi Province Meteorology Office 2013. Agricultural Meteorology News Bulletein. Khorasan Razavi Province Meteorology Office Province Meteorology Office Scientific Publication.

Kloth R.H., Turley R.B. 2010. Physiology of Seed and Fiber Development. In: Physiology of Cotton, pp111-122, By: McD. Stewart, J., Oosterhuis, D.M., J.J. Heitholt, Mauney, J.R. (eds.), Springer Science+Business Media B.V. https://doi.org/10.1007/978-90-481-3195-2_11

Lokhande S., Reddy K.R. 2014. Quantifying Temperature Effects on Cotton Reproductive Efficiency and Fiber Quality. Agronomy Journal 106(4): 1275–1282. https://doi.org/10.2134/agronj13.0531

Meredith J.r., William R., Wells R. 1989. Potential for increasing cotton yields through enhanced partitioning to reproductive structures. Crop Science 29(3): 636-639. https://doi.org/10.2135/cropsci1989.0011183X002900030017x

Ministry of Jihad-e-Agriculture, 2022. Crops area, production and yield in 2020-2021 crop year report. Information and Communication

Technology Center of Ministry of Jihad-e-Agriculture. 98p. (In Farsi).

Morello C.L, Suassuna N.D., Correia Farias F.J., Lamas F.M., Pedrosa M.B., Ribeiro J.L. Campos Godinho V.P. Freire E.C. 2010. BRS 293: A midseason high-yielding upland cotton cultivar for Brazilian savanna. Crop Breeding and Applied Biotechnology 10: 180-182. https://doi.org/10.12702/1984-7033.v10n02a13

Mozafari J., Sadeghian S.Y., Mobasser S., Khademi H. Mohammadi S.A. 2010. Principles of plant Cultivar protection. Ministry of Jihad-e-Agriculture Agricultural Research Education and Extensions Organization (AREEO), Seed and Plant Certification and Registration Institute (SPCRI), (In Farsi).

Naderi Arefi A., Hamidi A. 2014. Seed Cotton Yield and some Related Traits in Different Cultivars of Cotton (*Gossypium hirsutum* L.) in Garmsar Conditions. Seed and Plant Production 30(4): 401-420. (In Farsi). https://doi.org/10.22092/sppj.2017.110558

Oosterhus D.M., Cothren J.T. 2012. Flowering and fruiting in cotton. Cotton foundation Reference book series, The Cotton Foundation Cordova, Tennessee, U.S.A.

Paterson A.H. 2009. Genetics and Genomics of Cotton. Springer Science Business Media, LLC. https://doi.org/10.1007/978-0-387-70810-2

Percy R.G., Cantrell R.G., Zhang J. 2006. Genetic variation for agronomic and fiber properties in an introgressed recombinant inbred population of cotton. Crop Science 46: 1311-1317. https://doi.org/10.2135/cropsci2005.08-0284

Rahman H., Murtaza N., Shah M.K.N. 2007. Study of cotton fibre traits inheritance under different temperature regimes. Journal of Agronomy and Crop Science 193: 45-54. https://doi.org/10.1111/j.1439-037X.2006.00239.x

Raper T.B., Snider J.L, Dodds D.M., Jones A., Robertson B., Fromme D., Sandlin T., Cutts T., Blair R. 2019. Genetic and Environmental Contributions to Cotton Yield and Fiber Quality in the Mid-South. Crop Science 59: 307–317. https://doi.org/10.2135/cropsci2018.04.0222

Rauf S., Mansoor Khan, T., Nazir S. 2005. Combining ability and heterosis in *Gossypium hirsutum* L. International Journal of Agriculture and Biology 1: 109-113.

Reddy K.R., Brand D., Wijewardana C., Gao W. 2017. Temperature effects on cotton seedling emergence, growth, and development. Agronomy Journal 109(4): 1379-1387. https://doi.org/10.2134/agronj2016.07.0439

Rehman A., Farooq M. 2020. Morphology, Physiology and Ecology of Cotton, In: Cotton Production, First Edition. Edited by Khawar Jabran and Bhagirath Singh Chauhan. John Wiley & Sons Ltd. Published 2020 by John Wiley & Sons Ltd. https://doi.org/10.1002/9781119385523.ch2

Salahuddin S., Abro S., Kandhro M.M., Salahuddin L., Laghari S. 2010a. Correlation and path coefficient analysis of yield components of upland cotton (*Gossypium hirsutum* L.) sympodial. World Applied Sciences Journal 8: 71-75.

Salahuddin S., Abro S., Rehman A., Iqbal K.H. 2010b. Correlation analysis of seed cotton yield with some quantitative traits in upland cotton (*Gossypium hirsutum* L.). Pakistan Journal of Botany 42(6): 3799-3805.

Satange T.V., Khorgade P.W., Wandhre M.R. 2000. Studies on genetic variability and correlation coefficient in American cotton. Journal of Soil and Crops 10(1): 94-97.

Seddighi E., Ramezani Moghaddam M.R., Sirousmehr A.R. Asgharipour M.R. 2013. Investigation on the effect of cotton cultivars and different planting dates on barley-cotton double cropping system in Gonabad climatic conditions. Journal of Agroecology 5: 58-66.

Seed and Plant Certification and Registration Institute 2009. National Guideline for Testing Value for Cultivation and Use of Cotton. Seed and Plant Certification and Registration Institute (SPCRI), Karaj, Iran. (In Farsi).

Singh J. 2011. Final report of Impact Assessment IPM Cotton project for boosting diversification process in Punjab. 68 pp.

Soliz L.M.A., Oosterhuis D.M., Coker D.L., Brown R.S. 2008. Physiological response of cotton to high night temperature. American Journal of Plant Science and Biotechnology 2: 63-68.

Soomro Z.A. 2000. Genetic architecture of quantitative and qualitative traits in *Gossypium hirsutum* L. M. Phil. Thesis, Dept. Plant Breeding and Genetics, Sindh Agriculture University Tandojam, Sindh, Pakistan.

Sudhir K. 2010. How effective is *Sui Generis* Plant Cultivar Protection in India: Some Initial Feedback. Journal of Intellectual Property Rights 15: 273-284.

Suassuna N.D., Morello C.L., Pedrosa M.B., Vianna Barroso P.A., da Silva Filho J.L., Falleiro Suassuna T.M., Perina F.J., Sofiatti V., da Cunha Magalhães F.O., Correia Farias F.J. 2018. BRS 430 B2RF and BRS 432 B2RF: Insect-resistant and glyphosate-tolerant high-yielding cotton cultivars. Crop Breeding Applied Biotechnology 18: 221-225. https://doi.org/10.1590/1984-70332018v18n2c31

Thaker V.S., Saroop S., Vaishnav P.P., Singh Y.D. 1989. Genotypic variations and influence of diurnal temperature on cotton fiber development. Field Crops 22: 1-13. https://doi.org/10.1016/0378-4290(89)90063-4

Vafayi Tabar M., Tajick Khaveh Z. 2012. Variation in yield and earliness correlation with other quantitative traits of early upland cotton cultivars. Electronic Journal of Cotton Fiber Crop 1: 97-114

Vianna Barroso M.B., Suassuna N.D., Pedrosa M.B., Morello C.L., da Silva Filho J.L., Lamas F.M., Bogiani J.C. 2017. BRS 368RF: A glyphosate tolerant, midseason upland cotton cultivar for Northeast and North Brazilian cerrado. Crop Breeding and Applied Biotechnology 17: 399-402. https://doi.org/10.1590/1984-70332017v17n4c59

Wu J, Jenkins J.N., McCarty J.C., Watson C.E. 2005. Comparisons of two statistical models for evaluating boll retention in cotton. Agronomy Journal 97: 1291-1294. https://doi.org/10.2134/agronj2004.0216

Wu J., Jenkins J.N., McCarty J.C., Zhu J. 2004. Genetic association of yield with its component traits in a recombinant inbred line population of cotton. Euphytica 140: 171-179.

Yazdi Samadi B., Rezaei A., Valyzadeh M. 2013. Statistical Designs in Agricultural research. Tehran University Publication. 764 pp.

Zabihi H.R., Ramazani moghadam M.R., Noorihosseini S.M. 2013. Effect of nitrogen and irrigation water on cotton yield and yield components. Iranian Journal of Cotton Research 1(2): 43-55. (In Farsi). https://doi.org/10.22092/ijcr.2013.100779

Zangi M.R. 2002. Genetic diversity of cotton tetraploid genotypes to drought stress. Iran Cotton research institute, Final Report of Research Project, No. 100-24-15-79-04-79-152. (In Farsi).

HOW TO CITE THIS ARTICLE

Hamidi A., Ramezani Moghaddam M.R., Najjar H., Arab Salmani M., Mohajer Abbasi A. 2022. Value of Cultivation and Use (VCU) Evaluation of Some New Promising Genotypes of Upland Cotton (*Gossypium hisutum* L.) in Razavi Khorasan Province. *Agrotechniques in Industrial Crops* 2(4): 166-176. 10.22126/ATIC.2023.8346.1069