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Research Paper

Investigation of the Genetic Diversity of Cultivars and Lines of Tetraploid Cottons by the use of Quantitative Morphologic Properties of Fibers

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Abstract

The aim of conducting this research is surveying the genetic diversity of cultivars and lines of tetraploid cotton by the use of quantitative morphologic properties of fibers. To this aim, 8 lines along with 2 observed cultivars (Sahel and Varamin) were evaluated during agricultural year 2012 in the form of randomized complete block design (RCBD) with three repetitions in Hashemabad research station of Gorgan. The variance analysis of different properties showed that plant height, earliness, overall yield and quality index were significant which indicated the genetic diversity among cultivars and lines. According to the path analysis the highest correlation on total yield was related to earliness (P= 0.399) and it is possible to choose this trait as the criterion. Surveying the correlation coefficients of studied properties showed that overall yield had the highest positive and significant correlation with earliness at probability level 1%; also the highest and lowest phenotypic coefficients belonged to properties of earliness with 23.87% and fibers weight with 3.42%.

Keywords: Tetraploid Cotton, Genetic Diversity, General Heritability.

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1. Introduction

Cotton is not only important as a fibrous and oil plant, but also as a source of bioenergy production. Cotton is the most important fibrous plants being cultivated in different regions of the world since a long time ago. Due to some unique features such as strength, resistance to moisture and heat, durability, tonality, heat absorption, moisture transfer, quality and softness of produced fabrics, cotton fibers are very important and valuable among different societies. It has been proved that cotton fabrics have the ability to absorb more heat, they less become wrinkled, and they do not lose their color, quality or softness because of being washed [1]. Generally, cotton includes cotton and boll or protective capsule and the combination of seed, fibers and linter is called cotton. Each of these derivatives turn into a new product after passing some processes; for example, its fibers are used for producing yarn and fabrics, its seed

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including cottonseed kernel and cottonseed hull; the first one used for making soap, glycerin, oil, animal feed, and the second one is used for making furfuryl alcohol and ethanol. Linter is used for making flooring, plastics, paint etc. Boll skin is used for making three-layer wood, alcohol, paperboard and paper. Practically, in each ton of fibers around 1750 kg seed is produced and around 50% is used for cultivating in the next year. Cottonseed includes 50% extractable oil and 22% protein [2]. 55 to 65% of cotton weight is the seed and averagely, from producing 100 kg fibers, 170 kg cottonseed is achieved. Cottonseed consists of the following components: linter (around 6.1%), coat (27.1%), crude oil (15.6%), biomass (45.2%) and other materials (6%). Nowadays cotton is both important in terms of textile industry and food industry and it is among the 5 important oil plants in the world and around 8% of globally consumed oil is provided by the cotton. It has been more than one century that mankind uses cottonseed oil as an edible substance. Cottonseed oil is used in different products such as edible oils, margarine, soap, and different types of plastics. In addition to hull, flour, and grout, cottonseed is also used for human feed and animal feed but due to the existence of some natural toxins such as gossypol and cyclopropenoid fatty acids in the cottonseed its usage is limited [1]. Around 5% of produced cottonseed is used for cultivation and the rest is used in the oil factories. 50% of value of cottonseed is related to its oil and 30 to 35% of it is related to its biomass. Crude oil existing in the cottonseed is brown and similar to olive oil it includes 45 to 50% oleic acid, 25 to 30% linoleic acid, 20 to 25% palmitic acid and stearic acid used in margarine factories and soap factories. Cottonseed flour includes a considerable amount of protein and it could be used for bakery. Cottonseed biomass is also one of the best nutrients for feeding dairy cows. In addition to economic importance, cotton also has an effective role in progress of new sciences and technologies as the model plant for biological studies (evaluating the genome size evolution, polyploidization in plants and interpreting cellular processes; and this plant is still at the center of attention of scholars [3]. Cotton is a dicot, phanerogam, from the family Malvaceae and genus gossypium. Genus Gossypium was firstly detected and named by Linneaus in the middle of 18^{th} century. First botanist researchers have provided many different ideas about the cotton family and in further researches they put it in family Malvaceae or Bombacaceae, tribe Gossypieae or Hibisceae and gender Gossypium. Cotton is a shrub, naturally a perennial, self-pollinated plant with unlimited growth. Its wild species are perennial and its crop species are annual and usually neutral to photoperiod. This plant is cultivated in tropical and subtropical regions and in more than 70 countries in the latitudes of 36 degrees South latitude to 47 degrees north latitude. Cotton is very sensitive to water-deficit stress; in a way that its flowers and young bolls fall under water-deficit stress and some environmental tensions. With the beginning of sympodial phase of cotton the monopodial growth decreases. Also, it is possible that during the growth and development of boll, the speed of monopodial growth and flowering decreases and the fall increases; thus the aim of conducting this research is surveying the genetic diversity of cultivars and lines of tetraploid cotton by the use of quantitative morphologic features of fibers.

2. Methodology

In this test, 8 lines of cotton along with two observed cultivars (Varamin and Sahel) were cultivated in the form of RCBD with 4 repetitions in Hashemabad research station of Gorgan. At the research implementation stage, the land plowed during the first days of January 2012 and by the use of disk operation during the first days of April 2012, the land was ready for cultivation. Based on soil test, the required amount of nitrogen, phosphate and potassium fertilizers were added to the land. For removing the weeds, Trifluralin herbicides of 2.5 liters per hectare was added before planting the seeds and it was mixed with the soil by the use of disk. The cropping pattern included each area including six 6-meter rows, with 80 centimeters distance between rows and 20 centimeters distance between cotton plants. During the growth season irrigation, fertilization, removing weeds and controlling pests were conducted on the area according to the standards of Cotton Research Institute of Iran; and properties of overall yield, earliness (from the ratio of first harvesting yield to the overall yield the total sum of first and second harvest is achieved), height and boll weight were written down. For measuring the amount of boll in plants, before the first harvest, 5 plants were randomly chosen from each area and the number of bolls was counted and they were reported based on the number of bolls in each plant. Also, the average plant height (centimeters) was calculated for these 5 plants. For measuring the boll weight, before 1^{st} harvest, 30 bolls were randomly chosen from each line and the total cotton weight based on gram was written down. After separating the seed from cotton, the lint percentage of fibers (ratio of fibers weight to cottonseed weight) was determined. Table 1 shows quantitative properties of fibers.

Table 1. Quantitative properties of Sahel cotton cultivar.

Yield (Cotton)	4500kg/hectare
Boll weight	6-7 grams
Fibers length	30-31 millimeters
Weight of 100 seeds	10-10.5 grams
Fibers length	30-31 millimeters

The mean square of observations in each area in each repetition was used for the statistical analyses; then the variance analysis of properties was conducted; and Pearson correlation was used for surveying the data correlation. In all analyses the significance level was $p<0.05$.

3. Results

Results achieved from the variance analysis of studied properties are shown in table 1 and 2. Variance analysis table showed that there was a significant difference between cultivars and lines for most studies properties such as (cotton weight, fibers weight, seed weight, earliness, boll weight, plant height, 1st harvest, 2nd harvest and overall yield) at probability level 1%. In terms of number of bolls there was no significant difference between cultivars and lines. Regarding the significant difference between most surveyed properties at statistical level 1% it could be said that the surveyed cultivars and lines have a good genetic diversity. Breeders' success in breeding appropriate cultivars depends on the diversity of crops and their wild relatives. According to calculation of percentage of coefficient of variation, the highest coefficient of variation belonged to properties of 2nd harvest (25.72%) and number of bolls (19.85%); high coefficient of variation indicates the existence of environmental effects along with genetic factors of plant and high diversity in the properties. Lowest coefficient of variation belonged to cotton weight (4.82%). Existence of coefficient of variation (C.V) for the breeders means error based on the mean percentage of test which indicates that the less the test coefficient of variation, the more accurate the test; because, it has less test error and vice versa, the more the coefficient of variation the less accurate the test and the bigger the test error.

Results of correlation analysis between variables are shown in table 3. The highest simple positive and significant correlation of boll weight at statistical probability level 1% belonged to overall yield ($r= 0.427^{**}$) and at probability level 5% the highest positive and significant correlation was observed between boll weight and other properties of seed weight ($r= 0.857^{*}$), and quality index ($r= 0.330^{*}$). Overall yield had the highest positive and significant correlation with boll weight ($r= 0.427^{**}$) at probability level 1% and also had a negative and significant correlation with seed weight ($r= -0.428^{**}$) at probability level 1%. The highest positive and significant correlation at probability level 1% was observed in plant height.

Table 2. Variance analysis of surveyed quantitative properties for tetraploid cotton cultivars.

Source of variation	Degrees of freedom	Mean Squares (MS)						
		Cotton weight (gr)	Fibers weight (gr)	Seed weight (gr)	Earliness	Boll weight (gr)	1st harvest (kg/hectare)	2nd harvest (kg/hectare)
Block	3	36.37$^{n.s}$	2.49$^{n.s}$	25.83$^{n.s}$	523.37**	0.03$^{n.s}$	1532334.04**	475890.79*
Treatment	9	805.80**	249.76**	318.05**	985.25**	0.85**	2038101.32**	1078758.31**
Test error	27	74.68	19.20	44.86	85.37	0.09	171350.25	124639.19
%CV		4.82	6.76	5.86	14.71	4.90	17.15	25.72

*, **, and $^{ns.}$ Are significant at probability level 5%, 1% and non-significant, respectively.

Table 3. The rest of table of variance analysis of surveyed quantitative properties of tetraploid cotton cultivars.

Source of variation	Degrees of freedom (df)	Mean squares (MS)			
		Overall yield (kg/hectare)	Plant height (centimeter)	No. of bolls (gr)	Quality index (%)
Block	3	702944.16*	265.89*	55.07$^{n.s}$	31764788*
Treatment	9	455852.48**	662.48**	9.27$^{n.s}$	44868518.10**
Test error	27	100485.76	90.40	16.13	9321057.60
%CV		8.37	7.73	19.85	14.13

*, **, and $^{ns.}$ Are significant at probability level 5%, 1% and non-significant, respectively.

Table 4. Simple correlation between quantitative properties of cultivars and lines of tetraploid cotton.

	Lint percentage	Boll weight	Overall yield	Plant height	No. of bolls	Quality index	Earliness
Lint percentage	1.000						
Boll weight	0.197	1.000					
Overall yield	0.031	0.427**	1.000				
Plant height	-0.392*	-0.059	0.136	1.000			
No of bolls	0.063	-0.133	0.108	-0.191	1.000		
Quality index	-0.193	0.330*	-0.047	0.189	-0.210	1.000	
Earliness	0.014	-0.308	0.399*	0.281	0.396*	0.021	1.000

The highest simple positive and significant correlation at probability level 1% was observed between quality index and seed weight (r= 0.427**) and also there was a positive and significant correlation at probability level 5% between quality index and boll weight (r= 0.330*) and cotton weight (r= 0.342*). Based on the conducted survey, the highest positive and significant correlation at probability level 1% was between earliness and overall yield (0.399*) (Table 4).

4. Discussion and Conclusion

The aim of conducting this research was surveying the genetic diversity of cultivars and lines of tetraploid cotton by the use of quantitative morphologic properties of fibers. Results showed that there was a positive and significant relationship between boll weight and overall yield. Also, there was a significant relationship between boll weight and other properties such as seed weight and quality index. These findings are consistent with findings of Vafaei Tabar (2012). They showed that there was a positive and significant correlation between boll weight, and yield components in different cotton cultivars; and this is consistent with the current test results. In the survey of simple correlation results, Ramezani Moghaddam et al. (2002) reported that two yield components of number of seeds in boll and boll weight had the highest positive and significant correlation with yield [5]. Also research results of Songwan and Yadava (1987) showed a positive and significant correlation between two properties of number of seeds in boll, boll weight and one-plant yield and this is consistent with the current test results [6]. Also the overall yield had a positive and significant correlation with boll weight and a negative and significant correlation with seed weight. These findings are consistent with research results of Kohel (1974) and Donald (1994). They indicated the negative and significant correlation between yield and seed weight that is consistent with the results achieved from the current test. Yield is a complicated trait that includes many quantitative components and it has polygenic inheritance [9]. Kaushik et al (2003) indicated that one-plant yield had a positive and significant correlation with boll weight and the stated that increasing the boll weight also increases the yield and this is consistent with the current test results [10]. Dadashi et al (2010) reported that there was a negative and significant correlation between yield and boll weight and this is inconsistent with the current test results [11]. Based on the conducted survey, the highest positive and significant correlation was between earliness and overall yield. In a study, Vafaei Tabar (2013) surveyed the diversity of correlation between different properties of 13 upland cotton cultivars and reported that there was high diversity in terms of correlation between yield and earliness and other properties of cultivars and this is consistent with current test results [4]. Interpretation of variance analysis results of different properties showed that most studied properties had a significant difference and it could be concluded that the surveyed cultivars and lines have desirable genetic diversity. Also existence of diversity in different properties means that they could be used in breeding.

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