11TH MEETING OF INTER-REGIONAL COOPERATIVE RESEARCH NETWORK ON COTTON FOR THE MEDITERRANEAN AND MIDDLE EAST REGIONS

PROCEEDINGS

A Joint Workshop and Meeting
of the All Working Groups

November 05-07, 2012, ANTALYA Turkey

11th Meeting of the Inter-Regional Cooperative Research Network on Cotton for the Mediterranean and Middle East Regions

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November 05-07, 2012
Antalya, Turkey

This Meeting Coordinated By

Prof. Dr. Oktay GENÇER

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Welcome

Oktay GENCER
General Coordinator of the Network

Dear Distinguished Delegates, Ladies and Gentlemen,

On behalf of the organising committee, it is my great pleasure to extend you a cordial welcome to the 11th Meeting of the Inter-Regional Cooperative Research Network on Cotton for the Mediterranean and Middle East Regions.

It is an honor for us to host this meeting and have such an outstanding attendance.

There is no need to tell you, about the significance of cotton growing and it's ecomomy in the world. For this reason we still need to expolore how all cotton producing, trading and consuming countries can work individually and collectively to promote cotton.

In this meeting there are 49 distinguished specialists from 11 countries. And 36 papers will be presented and discussed in working groups (Breeding, Biotechnology, Agronomy, Economy, Fiber and Yarn Technology) besides the evaluation of past and future activities of groups. I strongly believe that the participants will be able to search for new and innovative solutions to our mutual problems and also will be able to initiate new cooperative research projects among themselves and the member countries.

It is my hope that the information presented here during the meeting and discussions among the representatives, our cotton world will be better equipped to meet the challenges we face.

I wish to thank again all distinguished representatives of participant countries (Bulgaria, Egypt, France, Greece, India, Mozambique, Pakistan, Spain, Sudan, Turkey and USA).

Besides exchanging information and knowledge on subjects related to cotton within and among the working groups, I hope all of you will enjoy your stay here and experience the well known Turkish hospitality.

I want to express our appreciations and sincere thanks to Dr. Rafiq CHAUDHARY, head of technical section of International Cotton Advisory Committee, for his support to this meeting.

And I want to express special thanks to all who supported this meeting; specifically to International Cotton Advisory Committee, to the Cukurova University, to the Mustafa Kemal University, to the Ege University, Research and Application Center of Science and Technology, to the Ege University, Department of Bioengineering, to the Dicle University, to the Gul Cotton Company, to the Republic of Turkey Ministry of Food, Agriculture and Livestock, General Directorate of Agricultural Research and Policy, to the Republic of Turkey Ministry of Food, Agriculture and Livestock, International Agricultural Training Center, to the Agricultural Research for Development (CIRAD), to the Camlaralti College.

I also want to express my sincere thanks to all members of the organizing committee for their outstanding work.

And, I want to express my special thanks to Dr. Yasar AKISCAN, secretary of the network meeting, for his devotion and hard work.

Wishing that the Workshop and Joint Meeting could fulfill its aims successfully, I again welcome all of you. Have a good time, while exchanging your ideas and puting your new knowledge to work.

Best regards

Keynote Addresses

Cost of Production Structure is Changing in Cotton

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Abstract

The International Cotton Advisory Committee (ICAC) undertakes a survey of cotton of production of cotton every tree years. Thirty-four countries that planed about 90% of the world cotton area in 2009/10 participated in the last survey. The data is for the year 2009/10. Average cost of production of seedcotton per kilogram increased from 30 US cents in 1994/95 to 43 US cents/kg seedcotton in 2009/10. The cost of production of lint in 1994 was US$0.93/kg lint, which increased to US$1.22/kg lint in 2009/10. In 2009/10, the world average data showed that 28 US cents were spent on every kilogram of lint produced in the world, more than any other input/operation including harvesting and ginning. Cost of production in terms of fertilizer has almost doubled from 1994/95 to 2009/10 i.e. 15 cents and 28 cents respectively. Cost of weeding even more than doubled in 2009/10 over 1994/95. Insecticides cost formed almost 23% of total cost in 1994/95 that declined to only 11% in 2009/10. Many factors are responsible for decline in insecticide use including lesser use of insecticides, awareness about severe consequences resulting in cautious use, lower cost of insecticides and better chemistries. Insect resistant biotech cotton also helped to lower insecticides use. Recent stagnation in yields will have a negative impact on cost of production of cotton. Newer technologies are needed to increase yields for lowering cost of production.

Keywords: *Cotton, Cost, Survey.*

Progress in GM Cotton Development in Public Sector

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Abstract

Nearly two third of cotton produced globally is GM in nature. All top six producing countries (Australia, Brazil, China, India, Pakistan and USA) have officially adopted GM cotton which is being grown safely and successfully for the last 10 – 15 years.

Almost all the biotech cotton being grown commercially has been developed by private sector. The public sector have strong R&D programmes on developing GM cotton for various traits like resistant to pathogens and various abiotic stresses, enhancement of quality (oil) and fiber improvement. Though none of these endeavors yet reached to commercialization. However, these efforts will be further strengthen now by availability of complete genome of diploid cotton (Gossypium rhamondii)) having DD genome. It is expected that sequence of tetraploid cotton (AADD) and other diploid cotton (AA) will soon be available in public data base. Majority of ESTs of cotton are already in use by the biotech researchers. All these activities will be reviewed with special reference to cotton biotech programme of Pakistan which is being carried out in public sector.

The issues of patent and bio-safety aspects which are tightly related to GM crop are two major impediments to the commercialization of Biotech cotton. Therefore, out of nearly 80 cotton growing countries there are still only 11 countries where system is in place to grow GM crops. These issues will also be highlighted.

Keywords: *GM Cotton, Pakistan.*

Country Reports

ORAL PRESENTATION

Cotton Situation in Greece

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Abstract

The cultivated area in Greece fluctuates last years among 250000 – 300000 ha and the average seedcotton yield is 2500kg/ha. 10.0% of Greece's total agricultural production is cotton and around 76% of the EU's total output is grown in Greece.

Cotton sector is characterized by small size farms (4.5ha) where cotton cultivation is fully mechanized. All the governmental measures in compliance with EU rules, are focused on Integrated Crop Management from sowing to collecting and ginning including pest and weed control.

At the processing level, a total of 70 private and co-operatives ginneries convert the raw cotton to fiber. The Cotton Standardization Centre of Karditsa which belongs to the Cotton and Industrial Plants Institute is established the last two years in order to classify the producing Greek cotton bales with accredited HVI equipment. The current regulatory framework from the Common Agricultural Policy, with the direct and attached support for cotton and other crops, was due to expire at the end of 2012, but extended for one more year until the end of 2013, because there is a significant delay in the negotiations at European level. Nevertheless the subsidies, cotton research in Greece, is targeted to improve cotton competitiveness either by increasing yields and reducing cost or by improving the product's performance to increase market share.

Keywords: *Cotton, Greece.*

Introduction

Cotton is Greek national product because 10.0% of Greece's total agricultural production was cotton and around 76% of the EU's total output (about 1.45 million tonnes of raw cotton) is grown in Greece.
It is the 5th national product in exports (total 391 million euros) and occupied, in this difficult period, 70.000 families in agriculture and 150.000,00 employees in other sectors (manufacturing, marketing - distribution - third party services, etc.).

Table 1. Cotton cultivation and production in Greece.

Year	Cultivated area (ha)	Production (tones)	Average yield (kg/ha)
2000	405000.0	1.235.000	3050
2001	378737.8	1.246.839	3290
2002	360500.0	1.131.500	3140
2003	367100.0	972.000	2650
2004	383791.0	1.254.780	3270
2005	363000.0	946.000	2610
2006	380380.0	765.400	2010
2007	338724.0	668.181	1970
2008	284157.0	670.000	2360
2009	233000.0	600.000	2580
2010	260374.8	565.000	2140
2011	301405.5	795.710	2640
2012 *	283964.6		

* estimation, Source: ***Ministry of Rural Development and Food (2000-2009) and OPEKEPE (2010-2012)***

Varieties

In order to cultivate a cotton variety in Greece it has to be registered to National or European Catalogue. There are a total of 107 varieties registered in National Catalogue for 2012 but from them cultivated in extended area only 20-30.

The registration of varieties to the National Catalogue, the control of maintainers as long as the trials for assurance of varieties, are the main tasks of Variety Research Institute of Cultivated Plants (V.R.I.C.P.) which also belongs to the Ministry of Rural Development and Food.

Cultivation

Cotton sector in Greece is characterized by small (4.5ha) highly specialized cotton farms while there is a trend toward single cropping in some areas (Thessaly), where cotton accounts for 60% of the arable land (Figure 1).

Cotton cultivation is fully mechanized and the governmental measures in compliance with EU rules are focused on Integrated Crop Management from sowing to collecting and ginning including pest and weed control.

Water management is of outmost importance and special attention is given due to the declining of water resources. Cotton cultivation is almost 100% irrigated and drip irrigation is recommended where the cost can be afforted.

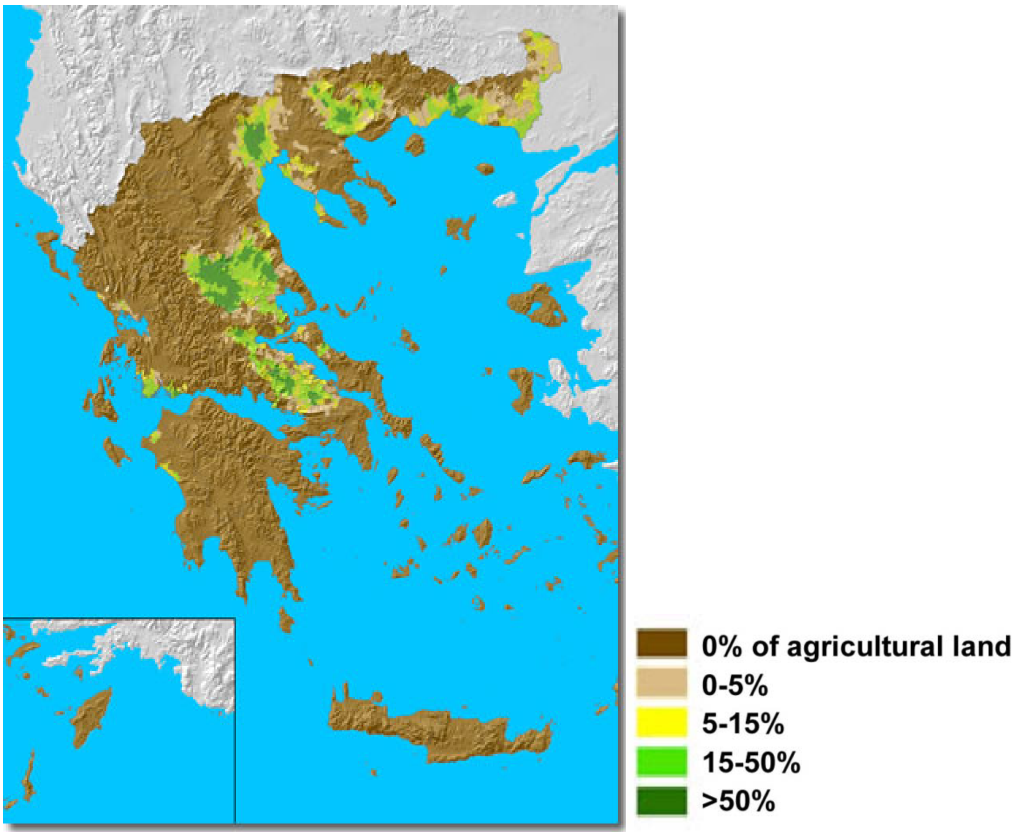

Figure 1. Areas of cotton cultivation in Greece.

The main cotton enemies are the pink and green bollworms but usually we have few generations and infestations are limited, compared to other countries.

Bollworm infestations are no occurring every year and in the years of high infestation two or three sprays maximum are efficiently controlling the pest population.

Aphids and thrips are sometimes affecting crop but to a limited extent, therefore no sticky cotton occurs in Greece.

The main cotton disease is cotton wilt caused by the fungi Verticillium Wilt. The only way to face the problem and control the disease is the use of resistant or tolerant varieties and the application of an integrated control program. In the recent years damages due to this disease have been restricted to a great extent, mainly because of the cultivation of resistant varieties.

Processing

At the processing level, a total of 70 private enterprises and co-operatives convert the raw cotton to its usable state through the ginning process. The produced bales are the first material of the local textile industry or exported, mainly to Turkey and China.

The instrument testing offered by Cotton Standardization Centre of Karditsa which belongs to the Cotton and Industrial Plants Institute, gives the opportunity to measure the most important characteristics of each single cotton bale produced in Greece, rapidly with standard methods and verificated instruments. The accurate and repeatable results on instrument testing can evaluate the correct performance of cotton and assist the complete cycle of the cotton textile process (ginner, seller, spinner and finally the consumer).

EU policy

OPEKEPE is the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes and is also supervised by the Ministry of Rural Development and Food. OPEKEPE's main task is the control and payment of beneficiaries, according to European and national Laws.

From 2006 the new CAP were introduced the direct (single, decoupled aid) and the special area payment (attached support, coupled aid).

The amount of the direct payment scheme is in principle, equal to the average of the grants received by each farmer the three years 2000-2002 (historical period). The single payment withheld each year at the request of producer, regardless of type and current production.

The special area payment is for farmers who cultivate and produce cotton. In 2006 there was a ceiling of 370000,0 ha eligible for Greece to grant the total of this special area aid but for 2011/12 this support was 805,6 € / ha if the total cotton cultivated land was 250000,0ha.

Figure 2. Cotton Standarization Centre of Karditsa, Greece

According to Ministry of Rural Development and Food, the current regulatory framework for the CAP, especially for direct payments was due to expire at the end of 2012, but extended for one more year until the end of 2013, because there is a significant delay in the negotiations at European level about the new regulations for the programming period 2013-2020.

Research

The Ministry of Rural Development and Food is the major coordinator of cotton research, in Greece. Cotton and Industrial Plants Institute which belongs now to Hellenic Agricultural Organisation - DEMETER (former National Agricultural Research Foundation NAGREF) along with the Agricultural Departments in the Universities deal with cotton research. The National and European Union programmes are sources of research funding and in few cases cooperatives and Regional Operational Programmes.

Research, is targeted to improve cotton competitiveness either by increasing yields and reducing cost or by improving the product’s performance to increase market share.

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Hellenic Agricu ltural Organisatio n – DEMETER (for mer National Agricultural Research Foundation NAGREF) http://www.elgo.gr or http://www.nagref.gr

Study on the cotton sector in the European Union final report European Commission Directorate General for Agricultu re and Rural Developm ent, 2007. http://ec.europa.eu/agriculture/analysis/external/cotton/fulltext.pdf

Regulation (EC) No 1782/2003 establishi ng common rules for direct support schemes under the common agricultura l policy and establishing certain support schem es for far mers, as regards the support schem e for cotton{SEC(2007) 1481}{SEC(2007) 1482}

ORAL PRESENTATION

Summary of current status of Cotton Research Program in the Sudan

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Abstract

Cotton in Sudan is indigenous. Commercial growing of the crop, however, started in 1867. In Sudan cotton is produced both under rain and under irrigation. This large production has, since the beginning, been backed by a strong research program. The Agricultural Research Corporation (ARC) has an intensive program to develop new varieties, increase yield and improve quality in both hirsutum and barbadence. The frame work of the cotton research is pillared mainly upon variety improvement, Agronomy, Stickiness and testing technology. Cotton improvement addresses higher yields, earliness, disease and insect resistance breeding new variants having different balances of fiber characteristics. As results, more than 50 varieties released but Only 7 varieties are currently grown. Genetically engineered Bt-cotton (open pollinated) is recently adopted, resulting in average increase of 54% and 87% in seed cotton yield over local checks. Technical packages that fit both ecological different zones and variability in crop duration were also generated as well as fiber testing, monitoring the quality performance of the prospective genotypes and existing cultivars. Research on stickiness problem continued, where better practical knowledge on avoiding stickiness in-field practices were shared in Sudan. According to International Textiles Manufacturers Federation Survey a better position for stickiness in Sudan was reported. Work on soil moisture, methods likely to improve the spinning process and future mapping of zones varying in stickiness incidence is ongoing.

Keywords: *Cotton, Sudan.*

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ORAL PRESENTATION

Turkey Cotton Report

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Abstract

World cotton area, production and consumption is estimated 35.9 million hectares and 27.3 million tons, and 22.7 million tons respectively in 2011/12. Domestic cotton production and area was 480.000 hectares and 817 000 in 2010/11, respectively. Turkish cotton area and production are projected to decrease about 17% and 27% in 2011/12 due to the fall in the price of cotton in relation to previous years as well as the decreasing competitiveness of cotton in relation to wheat, corn and soybeans. In 2011/12, Turkey represent 2.7% of total cotton production, 5.4% of total cotton consumption, and 5.4% of total cotton imports in the world. Turkey is the eight largest producer in the world. However, it was estimated that Turkey imports a total of 480 000 tons of cotton in 2011, of which 363 772 ton or 82 % was US cotton. The cotton is produced in three major areas, in descending order the Southeastern Anatolia (GAP), Aegean, Cukurova. With the expansion of irrigation area to 1.04 million hectares by 2014, cotton planting and production area would be increase in the GAP region, accounted for 300 000 hectares planting area and over 500 000 tons cotton production. During last decade private sector had significant role for cotton seed supply and improvement of new cotton varieties. The ratio of cotton seed production by private sector jumped from %19 to %100 between 2001 and 2011. The textile industry is one of the most important and dynamic sectors in the Turkish economy accounting for 8 percent of its GDP. In 2011, Turkey's textile exports were valued at 7.709 billion US$, and Turkey's clothing and apparel exports were valued at 15.666 billion US$, for a total value of 23.373 billion US$. These sectors had a 17,3% share in total export volume in 2011.

Keywords: *Cotton, Turkey.*

Introduction

A warm climate crop, cotton is cultivated between 37° N and 32° S, and about 90% of cotton is grown in the Northern Hemisphere. Cotton is grown in more than 60 countries and planted on about 2.5% of the world's arable land making it one the most important industrial crops in the world. It also provides employment to millions of person during cotton production, transportation, ginning, baling and storage, and in allied industries such as agriculture inputs, machinery and equipment, cotton seed crushing and textile manufacturing. The most important, cotton provides food and fiber which are the most basic requirements of human being. Among edible oil consumed in the world cotton oil is the fifth rank.

Cotton planting area, yield, production, and trade in selected countries in 2011/12 and 2012/13 were given in Table 1. The ICAC Secretariat reported that 2011/12 world cotton area and production is estimated at 35.977 million hectares and 27.3 million tons. In 2011/12, world cotton consumption is expected to be 22.7 million tons 7.3% lower than last season, 24.5 million tons in 2010/11. Global cotton production was 25.1 million tons in 2010/11 and cotton production reached 27.3 million tons in 2011/12 (8.7 % increase in cotton production). World cotton production is forecast 25.5 million tons in 2012/13 down by 6.6 % from this season. The decline in prices during 2011/12 (2010/11: 164.26, 2011/12: 1.00 U.S. $ per pound) has driven cotton planting down this year in many countries.

Although cotton is produced in 61 countries in the world during 2011/12, only eight of them, China (Mainland), India, USA, Pakistan, Brazil, Australia, Uzbekistan and Turkey share 86.8% of production, 78.3% of area and 80.6% of consumption. The average world cotton planting area is between 30 and 36 million hectares for long term. Last decade cotton yield increased average 10 Kg ha^{-1} per year. According to the latest the ICAC estimates, the world average yield is expected at 748 kilograms per hectare in 2011/12. Average yield in cotton was varied from 164 Kg ha^{-1}(Kenya) to 1900 Kg ha^{-1} (Australia) regard less of planting area in 2011/12. The five highest yielding countries in 2011/12 in descending order were Israel, Australia, Mexico, Brazil and Turkey (ICAC, 2012).

After a 25% jump to 9.6 million tons in 2011/12, the volume of cotton traded internationally is expected to drop by 21% to 7.6 million tons in 2012/13. The leap in global cotton trade in 2011/12 does not reflect improved demand for cotton. In fact, global cotton mill use is estimated down by 7% to 22.7 million tons, the smallest in eight years. A small rebound in global cotton mill use is projected in 2012/13, on the basis of lower prices and a more robust global economy. This improved demand will boost cotton imports, but not enough to offset the expected drop in demand by China, which now holds large stocks. Imports by China are projected to fall by almost half to 2.7 million tons in 2012/13, whereas imports by the rest of the world could rebound by 18% to 4.9 million tons. Global 2012/13 cotton production is forecast at 25.5 million tons, down by 6.6 % from this season: the decline in prices during 2011/12 has driven cotton plantings down this year in many countries. Global stocks are expected to expand by 14.1% in 2012/13 to 15.72 million tons. By the end of July 2013, global cotton stocks could represent 66.8% of global consumption, the highest stocks-to-use ratio since the mid-1980s. The projected accumulation of cotton stocks will weigh on international cotton prices in 2012/13 (ICAC, 2012).

Table 1. Cotton Planting Area, Yield, Production, and Trade in Selected Countries in 2011/12 and 2012/13

Countries Area			**Yield**		**Production**		**Consumption**		**Import**		**Export**	
		(1000 ha)	**(Kg ha^{-1})**		**(1000 MT)**		**(1000 MT)**		**(1000 MT)**		**(1000 MT)**	
A		B	A	B	A	B	A	B	A	B	A	B
China	5.528	4.975 1.	339	1.379	7.400	6.860 8.	635	8.635	5.342	2.535	5	5
India 12.	178	11.540	493	472	6.001	5.447	4.421	4.775	120	120	2.295	618
USA	3.829	4.226 886		878	3.391	3.725 718		351	4	1	2.526	2.504
Pakistan 2.	800	2.900	819	740	2.294	2.146	2.163	2.336	195	381	250	120
Brazil 1.	393	1.045	1.352	1.426	1.884	1.490	888	897	6	17	1.043	666
Australia 600		515	1.800	1.924	1.080	991	8	8	0	0	1035	818
Uzbekistan 1.	316	1.285	669	700	880	900	273	281	1	1	532	568
Turkey	542	407 1.	384	1.550	750	630 1.	250	1.325	519	765	7	7
Sub-Total	28.186	26.893			23.680	22.189	18.356	18.608	6.187	3.820	7.693	5.306
Other	7.791	7.349			3.602	3.295	4.423	4.940	3.416	3.764	2.023	2.278
World Total	35.977	34.242	758	744	27.282	25.484	22.779	23.548	9.603	7.584	9.716	7.584

A: 2011/12, B: 2012/13.

Source: ICAC, Cotton This Month, October 1st, 2012

In China, cotton prices in 2012/13 will be supported by the minimum support price policy, under which the government organizes daily purchases of new crop cotton between September 2012 and March 2013. In the rest of the world, the pressure of accumulating stocks, combined with weak demand, could drive cotton prices down. Due to the Chinese government's commitment to support domestic prices and the rebuilding of its national reserve (4,6 million tons at the end of August 2012), Therefore, cotton imports by China will likely drop sharply in 2012/13. The Secretariat expects China to import 2.5 million tons this season, less than half the record quantity purchased last season. With the projected sharp decline in Chinese imports, the 2012/13 outlook in the rest of the world is conducive to lower international prices. Cotton production outside China is forecast down by 6% to 18.6 million tons in 2012/13, as a result of the significant drop in prices last season. Cotton production in the southern hemisphere is projected down by 17% to 3 million tons in 2012/13 as a result of the fall in cotton prices since last year. The decline in production will be more pronounced in Brazil (-21% to 1.5 million tons) and Argentina (-22% to 164,000 tons, respectively) than in Australia (down by 8% to 991,000 tons) (ICAC, 2012). The separation between cotton prices and the prices for other agricultural crops, like corn and soybeans, promises to lead to a significant decline in cotton acreage for the 2013/14 season (Cottoninc, 2012). At its present level of 16.7 million tones, the projection for 2012/13 global ending stocks is the highest ever. The stocks-to-use ratio climbed to 67.1% also a record (Table 2).

Cotton Production in Turkey

Turkey is one of the important countries in terms of the magnitude of total cotton production, consumption and total imports in the world. Turkey has produced over 500 000 tons of cotton lint per year since 1980. Domestic cotton production and area was 480.000 hectares and 817 000 in 2010 /11, respectively. Turkish cotton area and production are projected to decrease about 17% to 400.000 hectares and 27% to 600.000 MT in 2011/12 (USDA b, GAIN Report, 2012). The decrease is expected to occur due to many issues including the fall in the price of cotton in relation to previous years as well as the decreasing competitiveness of cotton in relation to wheat, corn and soybeans. Cotton compete with wheat and corn production for land use, depending on which is more profitable for producers. In 2011/12, Turkey represent 2.7% of total cotton production, 5.4% of total cotton consumption, and

5.4% of total cotton imports in the world. Turkey is the eight largest producer in the world (Table 1).

Table 2. World Cotton Balance Sheet

	2008/09	2009/10	2010/11	2011/12 (Estimate)	2012/13 (Proj.)
			Millions of Metric Tons		
Beginning Stocks	12.257	11.397	8.638	9.380	13.780
Production	23.455	22.168	25.210	27.282	25.480
Supply	35.712	33.565	33.848	36.662	39.260
Export	6.609	7.805	7.625	9.716	7.580
Import	6.647	7.928	7.725	9.603	7.580
Consumption	23.817	25.470	24.517	22.779	23.550
Ending Stocks	11.939	8.638	9.380	13.782	15.720
Stocks/Use Ratio	50.1	33.9	38.3	60.5	66.8
Cotlook A Index*	61.20	77.54	164.26	100	84**

* U.S. cents per pound, ** Average for the first two months of 2012/13 (August to September 2012).
Source: ICAC, Cotton This Month, October 1st, 2012.

The cotton planted area, production, and yield trend in Turkey is given Table 3. The area under cotton increased considerably between 1945 and 1955, and cotton production thus kept on increasing in that of years. Since 1955, cotton planting area has fluctuated between 650 000 and 750 000 hectares. The lowest (400 000 ha) and highest (760 000 ha) planting area were recorded in 2011/12 and 1998/99 respectively. An all time record cotton production of 910 000 tons achieved in 2001/2002. Until a few years ago, with a lint cotton production of about 900 thousand tons, Turkey used to be ranked as the sixth largest cotton producing country in the world, after China, the USA, India, Pakistan and Uzbekistan. However, a significant reduction in cultivation area and production has been witnessed during the recent years. With its new production regions and increased annual production levels, Brazil has significantly surpassed Turkey in production capacity. Severe drought, low cotton prices, coupled with the farmers' switch to alternative crops, have resulted in a dramatic drop in cotton production in the recent years, from around 900 thousand tons level a few years ago, to as low as 400 thousand tons level last season (ICAC, 2010).

Last three decades yield increased from average 700 Kg ha-1 to 1600 Kg ha^{-1}. The increase in cotton production has also been instrumented in expanding the textile industry. The variety potential and the agro -climatic conditions are the determining factors in terms of high yield. Also, increase in yield may be attributed to the improvement in plant protection and agronomical applications, and fertilizers. Better protection against pests has impact yields in China and the USA. On the other hand, average yield increase in Brazil is due to a shift in cotton area to high yielding area (Chaudhry, 2004). In Turkey, all cotton planted areas are irrigated. With better growing conditions, increased use of certificated seeds and availability water during the growing season has increased yields in most areas especially at the Southeast Anatolian (GAP) region. The average yield in 2011/12 is expected to be 1500 Kg ha^{-1}. Overall yields improved in recent years due to the investment of modern equipment, planting at larger fields, increased utilization of certified seeds and mechanical harvesting. Field yields are improving because the farmers that continue to plant cotton are the most efficient and experienced, well equipped and have larger fields. Turkish Government is also increasing its efforts to unite small and divided farms. Therefore, better planting techniques and economies of scale are helping to achieve higher yields. Increases in the use of certified seeds over the years had also helped increasing yields. The increase in certified seed use is driven by a ten percent higher production bonus for certified seed users. The rate of certified seeds utilization has rapidly increased in all cotton productions areas and reached to 100%. Farmers have been using seeds which are delinted, high quality, and high germination rate and to which insecticides were applied in recent years (Sarsu and Yucer, 2011; USDA a, GAIN Report, 2012).

The cotton is grown in three main areas; the Southeastern Anatolia (GAP), Aegean, Cukurova, and small amounts of cotton also are produced around Antalya. The highest cotton planting and production regions in 2011/12 in descending order were the Southeastern Anatolia (GAP), Aegean, Cukurova and Antalya (Table 4). Among the cotton production areas Sanliurfa, Aydin, Adana, Hatay and Izmir have the highest cotton planting area and production. These provinces produced 638 MT or 78% of total Turkey cotton production in 2010/11. Cotton planting area is continuing to gradually increase in the Southeastern Anatolia (GAP) region from 8%

(1980/81) to 60% (2010/11) due to an increasing in irrigation system created by the GAP. The Southeastern Anatolia Project (GAP) is a massive $32 billion public project to harness the power and potential of the upper reaches of the Tigris and Euphrates rivers and to irrigate the fertile plains that lie between them. GAP is estimated to double Turkey's irrigable farm land. It is planning to irrigate a total of 1.7 million hectares of land by the end of this project. Average annual expansion of the irrigation network during the last five years is about 10 000 hectares. Crop yields of cotton, wheat, barley, lentils and other grains have tripled in the Harran plain as a result of irrigation from the Ataturk Dam. Cotton planting area in the GAP has climbed from 50 000 ha to 300 000 ha last three decades. At the same period cotton yield rose from 500 Kg ha^{-1} to 1500 Kg ha^{-1}, that is three times more. Cotton production increased from 26,000 tons (1980/81) to 450,000 tons (2010/11), making the GAP region the top cotton producer area. This region produces over 50% of Turkey's total cotton production. With the expansion of irrigation, The GAP region will account for over 300 000 hectares planting area and over 500 000 tons cotton production. Harran is the heart of the cotton growing area in the GAP region, where 140,000 hectares are under irrigation. An estimated 15,000 hectares of land have been affected by salt accumulation caused by poor irrigation practices. However, drainage channels have been built to prevent harm to the cotton fields from rising underground water levels due to excessive irrigation. The Turkish Government also provides technical and financial assistant to farmers to build modern drip irrigation systems to prevent ecological problems and wasting water resources (USDA b, GAIN Report, 2012).

The Turkish government has spent more than US$ 22.5 billion over the past three decades on a gigantic irrigation and agricultural extension project in Southeast Anatolia, known as the GAP project. When finished, some 1.5 million hectares of land will be irrigated and a total of 22 dams will be completed. So far about seventy-four percent of the hydroelectric projects are completed but only fifteen percent of the irrigation projects. In 2008 the government promised to allocate US$ 12 billion in five years for dams, irrigation and infrastructure in the region. During the last three years, the Turkish government allocated funds for some of the irrigation projects. If actually realized, a total of 1.04 million hectares of land will be irrigated by 2014 which could eventually increase cotton planting and production in the region. In the first Master Plan of GAP, 25% of irrigated land thought to be as a cotton growing area and then it was switched to 45%. In GAP region, the ratio of cotton planting area in the new open irrigated land would be up to 90% depends on cotton price. Even half of the irrigated land will be advocated to cotton, this means that cotton planting area in the GAP would be over 500 000 ha in the future.

Table 3. Cotton Area, Production, and Yield in Turkey

Years	**Area (1000 h)**	**Production (1000 MT)**	**Yield (Kg h^{-1})**
1945/46	231	54	235
1955/56	625	157	251
1965/66	685	325	474
1975/76	670	480	716
1985/86	659	518	832
1995/96	757	851	1127
2001/02	697	920	1214
2002/03	694	983	1035
2003/04	637	918	1396
2004/05	640	936	1462
2005/06	547	864	1582
2006/07	591	977	1653
2007/08	530	868	1636
2008/09	495	673	1360
2009/10	420	638	1520
2010/11*	481	817	1700

*Republic of Turkey Ministry of Food. Agriculture and Livestock, Turkish Statistical Institute.

In Cukurova region, cotton production area is gradually decreased from 350 000 to 103 000 ha last three decades. The increased cost of production and high insecticide usage against to whitefly (*Bemisia tabaci* Genn.) and competition from other crops forced the cotton growers to switch to citrus orchards, soybean, wheat/corn double crop rotations. In Antalya, cotton areas are under residential and tourism development, horticulture and citrus orchards pressures. Depends on competition with other crops in terms of returns, cotton planting area has fluctuated between 80 000 and 250 000 hectares in Aegean for last three decades. Except for GAP region, in all regions cotton production will fluctuate in accordance with the return of alternative crops and the cost of production. Expansion in the GAP region will be able to compensate for the decreasing in traditional growing areas.

In Cukurova region, farmers had a difficult time deciding between corn and cotton production. Corn is profitable in terms of high yields, low cost, ready buyers and relatively high prices. There is one big irrigation project in the region called Yedigoze dam which will irrigate 75.000 ha of land in the Imamoglu Valley. Farmers in the region will switch from wheat to first season corn and cotton. The project will be finished in 2014. The government sets targets for every sector up to 2023. In terms of agriculture, Adana agriculture will be much different in 2023 than today. Corn and Cotton will be the dominant crops for the first season crop. Sunflower and Canola area will increase (USDA a, GAIN Report, 2012).

The Hatay region was flooded in January and February by extensive rain and opening of a dam door. Almost 15,000 ha of wheat area were badly affected by these floods. Wheat most probably will be replaced by cotton and corn in April 2012 (USDA a, GAIN Report, 2012). Even though farmers are not happy with the returns on cotton, recent floods in the Hatay region destroyed wheat fields, which will leave farmers with no other choice than to plant cotton (USDA b, GAIN Report, 2012).

Corn is one of the main crops compete with cotton in terms of planting area. A major increase in corn planting area was observed in several areas. In Cukurova it was due to farmers' heavy investments loss on cotton planting in MY 2011, In the Aegean region, it was due to a dramatic increase in the number of livestock farms. In the Marmara region, it was due to increased demand from the broiler industry (USDA a, GAIN Report, 2012).

In South East Anatolia region heavy rainfall in autumn prevented farmers from harvested second season corn in some regions and some farmers allocated land to cotton planting (USDA a, GAIN Report, 2012). Excessive rains in the GAP region also prevented wheat planting last fall. This left cotton as the only option for some farmers. Similarly in the Hatay region, floods destroyed wheat fields, which are expected to be replaced by cotton. Hot summers in the GAP region adversely affect corn production, which creates risks and also makes cotton more attractive than corn (USDA a, GAIN Report, 2012).

Table 4. Cotton Planting Area, Production and Yield at Southeastern Anatolia (GAP), Aegean, Cukurova, and Antalya Regions.

	Southeastern Anatolia (GAP)			Aegean		
Years	**Area (1000 h)**	**Production (1000 MT)**	**Yield (kg h^{-1})**	**Area (1000 h)**	**Production (1000 MT)**	**Yield (kg h^{-1})**
1980/81	51 (8%)	26 (5%)	504	218 (32%)	185 (37 %)	852
1990/91	141 (22%)	142 (22%)	1014	258 (40%)	285 (44%)	1102
2000/01	317 (48%)	427 (49%)	1346	208 (32%)	286 (33%)	1375
2001/02	298 (43%)	422 (46%)	1212	236 (34%)	269 (29%)	1146
2002/03	320 (46%)	454 (46%)	1422	224 (32%)	305 (31%)	1359
2003/04	300 (47%)	444 (48%)	1478	203 (32%)	266 (29%)	1311
2004/05	325 (51%)	476 (51%)	1463	176 (28%)	254 (27%)	1445
2005/06	295 (54%)	448 (52%)	1517	144 (26%)	219 (25%)	1524
2006/07	310 (52%)	503 (51%)	1436	151 (26%)	225 (23%)	1058
2007/08	292 (55%)	472 (54%)	1480	119 (22%)	166 (19%)	951
2008/09	313 (63%)	423 (63%)	1169	83 (17%)	95 (14%)	830
2009/10	236 (56%)	349 (55%)	1273	81 (19%)	114 (18%)	982
2010/11	288 (60%)	464 (57%)	1614	84 (17%)	114 (18%)	1206
	Cukurova			**Antalya**		
Years	**Area (1000 h)**	**Production (1000 MT)**	**Yield (kg h^{-1})**	**Area (1000 h)**	**Production (1000 MT)**	**Yield (kg h^{-1})**
1980/81	369 (55%)	253 (51%)	687	35 (5%)	36 (7%)	1039
1990/91	211 (33%)	190 (29%)	900	32 (5%)	38 (6%)	1192
2000/01	116 (18%)	153 (17%)	1315	13 (2%)	14 (2%)	1108
2001/02	152 (22%)	218 (24%)	1427	11 (2%)	11 (1%)	1072
2002/03	141 (20%)	212 (22%)	1482	9 (1%)	12 (1%)	1360
2003/04	126 (20%)	196 (21%)	1276	8 (1%)	12 (1%)	1520
2004/05	130 (20%)	192 (20%)	1474	9 (1%)	14 (2%)	1600
2005/06	103 (19%)	187 (22%)	1823	5 (1%)	10 (1%)	1902
2006/07	126 (21%)	241 (25%)	1626	4 (1%)	8 (1%)	1810
2007/08	115 (22%)	223 (26%)	1750	4 (1%)	6 (1%)	1590
2008/09	95 (19%)	150 (22%)	1372	4 (1%)	5 (1%)	1330
2009/10	100 (24%)	170 (27%)	1470	3 (1%)	5 (1%)	1530
2010/11	105 (22%)	201 (25%)	1884	4 (1%)	7 (1%)	1770

Source: Republic of Turkey Ministry of Food. Agriculture and Livestock, Turkish Statistical Institute.

In MY 2011, cotton area increased at the expense of the wheat area but due to subsequent price shocks in the cotton sector, many farmers decided to grow either wheat or corn in MY 2012. In MY 2011, cotton farmers couldn't find enough seeds to plant and even went to cotton ginning premises to collect seeds. Similarly, in MY 2012 farmers demand for corn seed was higher than expected, and global and local seed companies are almost out of corn seed stocks. High cotton premiums in MY 2012 will not be enough to attract farmers to grow more of these crops. In MY 2011, cotton farmers couldn't find enough seed to plant and even went to cotton ginning premises to try to collect some seed. In MY 2012, farmers demand for corn seed was higher than expected and global and local seed companies are almost out of corn seed stocks. Since, corn is profitable in terms of high yields, low cost, ready buyers and relatively high prices. (GAIN Report, 2012).

Table 5. Average Fiber Quality Parameters of Cotton Growing Regions

Cotton Growing Regions	Fiber Length (mm)	Fiber Strength (g/tex)	Mic.	UI (%)	Short Fiber Index	Reflectance (% Rd)	Yellowness (b)	Trash Count (g/number)
Aegean	29.8	31.5	4.59	84.7	8.9	70.8	7.9	35.3
Cukurova	28.8	29.8	4.79	83.1	9.5	68.5	8.2	49.4
Southeastern Anatolia (GAP)	29.2	30.4	4.44	84.4	8.8	69.3	7.8	72.8

Cotton is profitable due to record high prices and a government subsidy (420 TL/MT). In MY 2011, there was a rush to purchase cotton seed due to incredibly high cotton prices. In MY 2012, a similar rush occurred for purchasing corn seed. The government was late announcing 2012 commodity premium. Farmers have already decided on either planting corn, cotton, oilseed plants or forage crops. The government premium has been a very important factor in farmers' planting decisions. In the past two years, the government made a point of announcing premiums in time to influence planting decisions but in MY 2012, farmers had to decide on crops according to market conditions or anticipated premiums because premiums were announced later. The Government's main target is to encourage production of more oilseed crops and cotton by increasing the sunflower seed premium from 230 to 240 TL/MT, and the cotton premium from 420 to 460 TL/MT in 2012, whereas the corn premium was kept the same as the previous year (USDA a , b,GAIN Report, 2012). On the other hand Farmer leaders argue that this year the bonus should be 600 TL/MT per kilogram due to increased production costs (USDA b, GAIN Report, 2012). All the cotton growing regions have received adequate rains and irrigation water is reported to be sufficient in all regions. But in spite of availability of irrigation water, higher input prices such as seed, fertilized, fuel and electricity continue to be concerns for cotton farmers (USDA a, GAIN Report, 2012).

Average fiber quality parameters of three regions were given Table 5. Aegean cotton generally is considered to be the best quality and is preferred by the local textile industry.

During MY 2011, local cotton prices moved along with world prices. A sudden drop in world cotton prices following record high prices and continuing low domestic prices disappointed farmers and persuade some of them plant other crop such as wheat, corn and soybean in the cotton growing regions. Prices declined forty-six percent last spring from the previous year's highs (GAIN Report b, 2012).

Last three years cotton prices fluctuated in Turkey from US$ 1.79 in 01.2010 to US$ 4.66 in 03.2011. The decline in prices during 2011/12 has driven cotton planting down this year in many countries including Turkey. Local Standard 1 Aegean cotton was US$ 2.26 per kilogram in October 2011 and went down to US$ 1.95 per kilogram in January 2012. A cotton export ban in India raised hopes of local producers for a recovery of domestic prices, but the ban was removed quickly. Local cotton is presently (09.2012) quoted for US $ 1.91 per kilogram, compared to US$ 2.49 per kilogram a year ago.

Classification, Harvesting and Ginning

The ginning rate averages about 41 percent in the Aegean region, about 39 percent in the GAP and 38 percent in Cukurova. Ginners generally purchase seed cotton directly from growers. Lint generally is graded and certified by the government–regulated inspectors at the gins, using a green card system. The government started a project about three years ago to introduce a mechanized HVI testing system and has sent technicians to the United States for training at USDA's Memphis facilities. Accordingly, there was going to be HVI measurement centers in Izmir, Adana and Urfa and Turkey will eventually move to the HVI testing system in the next five years (USDA, GAIN Report b, 2012).

Table 6. World Cotton Prices (US $/Kg) during 2009, 2010, 2011 and 2012.

Years Month	Cotlook A Endeks	USA Memphis	ICE Std. Guarantee
2009 1	1,27	1,32	1,14
2009 2	1,22	1,25	1,20
2009 3	1,13	1,14	1,17
2009 4	1,25	1,29	1,30
2009 5	1,37	1,45	1,50
2009 6	1,36	1,38	1,55
2009 7	1,42	1,45	-
2009 8	1,42	1,52	-
2009 9	1,41	1,53	1,57
2009 10	1,47	1,61	1,54
2009 11	1,56	1,72	1,63
2009 12	1,69	1,79	1,73
2010 1	1,72	1,79	1,77
2010 2	1,77	1,82	1,79
2010 3	1,90	1,97	2,04
2010 4	1,95	1,98	2,22
2010 5	1,99	2,00	2,22
2010 6	2,05	2,02	2,29
2010 7	1,89	1,89	-
2010 8	1,71	1,75	2,35
2010 9	2,30	2,34	2,55
2010 10	2,77	2,80	3,04
2010 11	3,39	3,37	3,71
2010 12	3,71	3,70	3,74
2011 1	3,94	3,86	3,94
2011 2	4,70	4,65	4,43
2011 3	5,06	5,02	4,66
2011 4	4,71	4,73	4,42
2011 5	3,66	3,92	3,63
2011 6	3,66	4,01	3,43
2011 7	-	-	2,54
2011 8	2,52	2,65	2,57
2011 9	2,58	2,73	2,49
2011 10	2,44	2,55	2,26
2011 11	2,31	2,40	2,07
2011 12	2,09	2,26	1,94
2012 1	2,23	2,42	1,95
2012 2	2,22	2,32	2,15
2012 3	2,19	2,24	2,10
2012 4	2,21	2,27	2,07
2012 5	1,98	2,04	1,96
2012 6	1,81	1,87	1,90
2012 7	1,85	1,90	1,92
2012 8	1,86	1,88	1,91
2012 9	1,86	1,89	1,91

Source: Izmir Commodity Exchange

The Ministry of Foreign Trade undertook a program to establish HVI machine classification of Turkish cotton. They planned to create facilities furnished with HVI machines in Izmir, Urfa and Adana. The initial plan was to start the project in 2011 but due to budget problems the new system is expected to be functional in five years. When active, the system will collect data for each bail in a national database. The new system was intended to facilitate making production support payments according to quality, and also allowing cotton trade in a futures market (USDA, GAIN Report b, 2012).

Because of cheap labor cost, mechanical harvest equipment was not extensively used by the farmers. Mechanical harvesting became popular after 2000 because of the significantly increased labor costs. Currently, about one-fourth of the Turkey's cotton is hand-picked. The primary development in the next five years will likely be the adoption of present harvesting technology. Mechanical harvesting has reduced the cost of picking by %25 (Sarsu and Yucer, 2011). The total number of harvesters in Turkey increased with great speed reaching approximately 1,000. The great majority, about 680 of them, are new modern harvesters. About 220 are secondhand and about 100 are old tractor-pulled harvesters. The demand for harvesters has increased particularly during the last season when a delay in planting caused cotton fields to mature at the same time and a lack of harvesters and labor caused delays and losses (USDA, GAIN Report b, 2012).

In Turkey the number of gins is estimated to be around 500 and all of them are privately owned. The majority of the gins in the Aegean region are roller gins, more suitable for longer staple cotton, while about half of the gins in Cukurova and the Southeast are roller gins and half are saw gins. However the recent increase in machine harvesting has triggered construction of new saw gins. The agricultural cooperatives Taris and Cukobirlik have invested in new saw gins to meet the needs of their members. There are saw gin projects in the GAP region as well by private groups (USDA, GAIN Report b, 2012).

Organization of the cotton trade

Commodity Exchanges are established for bringing purchasers and suppliers together, registering and announcing the prices and ensuring the well functioning of the market mechanism. The reference prices in the cotton markets constitutes in the commodity exchanges. Cotton is purchased by the cooperatives and ASCUs, ginning plants and traders. These institutions have important roles in the domestic trade of cotton. Almost all of the cotton producers have been organized within the framework of the 89 agriculture sales cooperatives and 4 Unions. Total number of members of Taris, Antbirlik and Cukobirlik is around 123.693. The Agriculture Sales Cooperatives and ASCUs operating under the Law No.457211 have purchased, processed, stored and sold the products of their members and if necessary products of the other producers. These Cooperatives and ASCUs have important ginning-pressing, fibre, storehouse and oil factories enterprises. Cooperatives and ASCUs supply the substantial amount of the production inputs of the producers and distribute it. Generally, they give the inputs, which they supplied, to the producers as in rem credit. In order to be eligible to use their voting rights, members of the cooperatives have to submit minimum 50% of their products, which they commit to the cooperatives. The remaining part is sold to other purchasers. Cooperatives and ASCUs can also give cash credit to their partners according to their financial situation. Another important aspect worth mentioning is the significantly weakened positions of the Agricultural Sales Cooperatives and their Unions, such as Taris, Cukobirlik and Antbirlik, can also be regarded as a major factor for the limited interest to cotton growing because these ASCUs used to be very powerful in the past, also in charge of implementing government support policies. They even continued giving such supports from their own resources at times when “the premium levels” had fallen short of their members’ expectations. These cooperative unions had long been regarded as “good shelters” for most of the small to medium sized growers. However, their recently weakened financial positions greatly deprived them being of significant use (ICAC, 2010). Cotton purchase ratio of The Agriculture Sales Cooperatives were given in Table 7. Agriculture Sales Cooperatives and the Agricultural Sales Cooperatives Unions (ASCUs) (namely Taris Pamuk Birligi, Cukobirlik, Antbirlik and GAP Birlik) purchased approximately 20% of the total cotton production between 1998-2002 in Turkey. Then the ratio declined to 4% in 2010 due to the their recently weakened financial positions. It is worth to remember that price supports on behalf of the government through the Agricultural Sales Cooperatives Unions have ceased to be practiced and seed cotton purchases of these unions have been solely on their own accounts, especially since the 2000/01 season. The amount of cotton the ASCUs get from their members depends largely on the procurement prices they announce, payment conditions and the prices offered by the ginners, traders, and other intermediaries in relation to market realities (ICAC, 2010). Those ASCUs, especially Taris, which had overlooked the market realities during the recent years and offered their members prices much higher than the prevalent market prices, have put them selves under big losses as well as under severe shortages of finance for their upcoming cotton procurements. Cukobirlik, the second largest ASCU, which operates in the Mediterranean and the South Eastern regions, has been more cautious when announcing their procurement prices of seed cotton. Since the ASCU's have not sufficient finance, their role in price setting will not be significant under the present market circumstances.

Cotton is freely traded in the market and prices are determined by domestic supply and demand conditions, as well as by the international market prices. Seed cotton trading market is consisted mainly of the Agri cultural Sales Cooperatives Unions (ASCUs), the individual cotton producers, traders and cotton ginners, while the main players in the lint cotton market are again the ginners, spinning mills, directly or through their commission agents, and finally the domestic and foreign trading cotton companies. Private sector involvement in the seed cotton market is mainly through the ginners or traders/ginners. Local intermediaries buy seed cotton and sell to ginners charging them a small profit margin. Imported cotton prices also affect the formation of prices in the domestic market (ICAC, 2010).

Organic Cotton Production

The first serious attempt for organic cotton production started in 1980 in Turkey to include cotton as a rotation crop and also to prove that organic farming should not be limited to only food production. Organic cotton production in Turkey was several hundred tons during early 1990's and reached several thousand tons by early 2000's. Turkey was the world leader for organic cotton production but domestic production has declined 18.000 ton in 2010. Organic cotton is still in a stage at growth, being cultivated in 24 countries worldwide with the top three producers India, China and Turkey (Sarsu and Yucer, 2011; Ozudogru, 2011)

Improvement New Cotton Varieties

The Seed Registration and Certification Center was established within the Ministry of Agriculture in 1959 and has been officially functioning within the Ministry of Food, Agriculture and Livestock since then. Almost all of the cotton seeds are renewed every year in Turkey. The rate of certified seeds utilization has rapidly increased in all cotton productions areas and reached to 100% (Sarsu and Yucer, 2011). Variety registration studies started in 1964, however it accelerated after 1990. Four varieties were developed in 1970s, 5 varieties were developed in 1980s, 23 varieties were developed in 1990s, 66 varieties were developed in 2000s. The increase in developed varieties is expected to continue in 2010s.

Table 7. Cotton Purchase Ratio of Agricultural Sales Cooperatives Unions

Years	Taris (%)	Cukobirlik (%)	Antbirlik (%)	Total (%)
1997	8.1	3.1	2.0	13.2
1998	11.8	9.0	2.4	23.2
1999	12.2	6.9	2.6	21.7
2000	8.6	5.5	1.6	15.7
2001	10.9	6.5	1.2	18.6
2002	12.1	4.8	1.2	18.1
2003	10.6	2.8	1.2	14.6
2004	11.1	4.8	0.6	16.5
2005	7.2	3.3	0.4	10.9
2006	6.5	3.4	0.5	10.4
2007	5.2	3.6	0.4	9.2
2008	5.1	3.6	0.5	9.2
2009	1.7	0.5	0.6	2.8
2010	2.4	0.6	1.0	4

Public sector started cotton breeding in 1959 and private sector started cotton breeding in 1995 (Sarsu and Yucer, 2011). Between 2002 and 2007 total 34 new cotton variety was registered and the ratio of private sectors in registered cotton variety (16 new cotton variety) was 47% during this period. Last five years total 37 new cotton varieties improved and 26 of that was registered by private sectors. Between 2008 and 2012, the ratio of private sectors in registered new cotton varieties were increased to 70%. The major innovation in variety development was carried out by private sectors. However majority of registered cotton varieties were introduced from other countries as a breeding line or new cotton variety. A few of private sectors have own breeding or research and development program. The amount of cotton seed supply by public and private sectors were given Table 8. The amount of cotton seed supply by public and private sectors were varied from 7.662 (2003) to 26.809 (1995) tons. Until 2000, the majority of cotton seed (75%) was provided by public sectors, however the ratio of private sectors in cotton seed production gradually increased and reached 100 % in 2010.

Table 8. Cotton seed supply by public and private sectors

	Public Sector		**Private Sector**		**Total**
	MT	**%**	**MT**	**%**	
1995	26.457	99	352	1	26.809
1999	14.343	85	2.514	15	16.857
2000	11.936	77	3.666	23	15.602
2001	15.204	81	3.572	19	18.776
2002	19.286	77	5.846	23	25.132
2003	1.512	20	6.150	80	7.662
2004	910	8	9.858	92	10.768
2005	4.144	21	15.432	79	19.576
2006	2.542	13	16.314	87	18.856
2007	1.750	12	12.572	88	14.322
2008	79	1	10.907	99	10.986
2009	0	0	10.811	100	10.811
2010	104	1	15.574	99	15.679
2011	20	0	16.890	100	16.910

Cotton Supply and Distribution in Turkey

Cotton supply and distribution of Turkey is given Table 9. Domestic cotton consumption is expected to be 1.250 and 1.325 MMT in 2011/12 and 2012/13. Turkey is the fourth largest consumer of cotton in the world behind China, India, and Pakistan. MY 2012 cotton consumption is now projected to 1.325 MMT 6% higher than 2012 (USDA, GAIN Report a, b, 2012).

Table 9. Supply and Distribution of Cotton in Turkey

2009/	10	2010/11	2011/12* (ICAC Est.)	2012/13* (ICAC Proj.)
Area Planted (1000 ha)	420	481	542	407
Yield (Kg ha^{-1}) 1.52	0	1.700	1.384	1550
Production (1000 MT)	638	817	750	630
Beginning Stocks (1000 MT)	331	290	275	267
Imports (1000 MT)	957	729	519	765
Total Supply (1000 MT)	1.926	1.836	1.544	1.662
Domestic Cons. (1000 MT)	1.603	1.508	1.250	1.325
Export 33		32	7	7
Total Domestic Consumption (1000 MT)	1.636	1540	1.257	1.332
Ending Stocks (1000 MT)	290	296	287	350
Stock to Use (%)	18	20	23	26

* ICAC, Cotton This Month, October 1st, 2012

Turkey's cotton imports fluctuated between 493 000 (2002/03) and 960 900 tons (2009/10) during last decade (Table 10). Turkey continued to be a major market for cotton of foreign origin because the domestic production was not sufficient to meet the demand of its textile industry. Turkey continued to import about a third of its cotton supply in 2011/12. Turkey is the third largest cotton importer country after China and Bangladesh. Turkey imported 729.4 MT cotton in 2010/11 and the U.S., Greece, Turkmenistan, Brazil, and Tajikistan was the first five supplier countries in descending order. The United States was the leading supplier with 476 000 tons (66%). During the first eleven months of MY 2011 Turkey imported 465.292MT, which is a thirty-four percent decline compared to the same period last marketing year and is due to high local production. Although the US was the leading supplier with 195,889 MT, its market share declined from the usual sixty percent to forty-two percent. Rapid fluctuations in the global cotton price during the last two seasons have caused millers to prefer small orders from domestic sources, or from sources near-by, such as Greece. Marketing year-end imports are expected to remain at about 520,000 MT compared to 730,000 MT last year. Cotton imports are expected to increase in MY 2012 to about 620,000 MT due to a projected decrease in domestic production.

During MY 2011 USA and Greece countries were the traditional suppliers, but Brazil, Arg entina and Australia are em erging as new cotton suppliers for Turkey (Table 11) (USDA, GAIN Report a, b, 2012).

Table 10. Turkey Cotton Import During Last Decade

Years	Imports (1000 MT)	US $ (Milyon $)
2001/02 648.5		592.3
2002/03 493.8		549.1
2003/04 516.9		761.5
2004/05 748.4		882.8
2005/06 762.3		960.8
2006/07 877.3		1,137.9
2007/08 711.4		1,099.8
2008/09 630.2		866.4
2009/10 960.9		1,570.2
2010/11 729.4		2,044.1

Source: Turkish Statistical Institute.

Table 11. Turkey Cotton Import in 2010/11 and 2011/12

2010/	**11**		**2011/12**	
Countries	**Imports (1000 MT)**	**%**	**Imports (1000 MT)**	**%**
U.S. 476,	9	65,4	195,9	42,1
Greece 87,3		12,0	80,7	17,3
Turkmenistan 51,2		7,0	23,2	5,0
Brazil 27,8		3,8	72,9	15,7
Tajikistan 21,1		2,9	11,4	2,5
Uzbekistan 16,7		2,3	6,9	1,5
India 11,1		1,5	6,0	1,3
Australia 0		0	8,4	1,8
Argentina 6,2		0,8	10,6	2,3
Egypt 5,2		0,7	4,5	1,0
Burkina Fasoo	3,6	0,5	0	0,0
Others 22,1		3,0	38,9	8,4
TOTAL 729,	4	100,0	465,2	100,0

Source: USDA, GAIN Report b, 2012).

Cotton Industry in the Future

Cotton production: Cotton planting area gradually drop in all production regions at varying degrees in Turkey. It is expected that increase in cotton growing area in the Southeastern Anatolia, may no longer be seen in the near future. High production costs, unattractive prices and better returns from alternative crops such as corn and wheat, have generally discouraged the cotton growers from growing cotton even in this region. In the Cukurova region, there will not be significant increases in area since farmers in this region have switched to alternative crops, mainly to maize, soybeans or cereals. Cotton planted area in Antalya region is also experiencing a gradual decrease. The Aegean region, where the best quality "upland" cotton is being grown, cotton growers has also been experiencing significant diversion to other crops, mainly to maize, simply because of higher cost of cotton production (ICAC, 2011). Machine picking has become common all cotton growing regions owing to high cost and severe shortages of labour in hand picking. This development also contributed to the significant reduction in contamination. The ginning industry, which is largely composed of roller-ginning plants, has also adopted itself in dealing with machine-picked cotton by incorporating pre and post ginning cleaners as well as using higher capacity roller ginning equipment (ICAC, 2011).

Cotton consumption prospects: In a quota-free world, the domestic textile industry will be affected by low priced imported textile products, and also the demand for domestic yarn, raw and finished fabric would be reduced. Therefore it will not be difficult to foresee a drop in cotton consumption, which will affect not only the domestic cotton production but also the consumption of imported cotton. A similar outcome is also foreseen following the recent move by many textile companies (spinners, weavers, knitters, etc.) to relocate themselves in the neighbouring countries, where most of the production factors (labour, energy, finance, etc) are comparatively cheaper than they are in Turkey (ICAC, 2011).

5.3 Cotton export/import prospects: Turkey was a net cotton exporting country until 1992. From 1993 onwards Turkey has become a net cotton importing country, with steady increases in cotton imports being realized during the last decade. This situation made Turkey the third largest cotton importing country in the world (ICAC, 2011).

Textile Industry in Turkey

With the gradual development of the textile and clothing sectors during the last three decades, cotton has become important to the industrial sector as well as to the internal and external trade of Turkey. However, significant drops in the domestic production have continued to necessitate imports of cotton of considerable magnitude, making the country the third largest importer of cotton after China and Bangladesh (ICAC, 2010).

Textiles and clothing are among the most important sectors of the Turkish economy and foreign trade. Accounting for about 6-7% of the (gross domestic product) GDP together, these two sectors are the core of Turkish economy in terms of GDP contribution, share in manufacturing, employment, investments and macroeconomic indicators.

In 2011, Turkey's textile exports were valued at 7.709 billion US$, and Turkey's clothing and apparel exports were valued at 15.666 billion US$, for a total value of 23.373 billion US$. These sectors had a 17,3% share in total export volume in 2011 (Table 12).

Higher prices and labor force problems in some of the major manufacturing countries such as China have played a part in Turkey' s receipt of increased orders from the United States and the EU. In 2011, textile exports to Ukraine, USA, UK, Italy, Iran, Poland, France and Russia saw the highest percentage increase over 2010 exports; and clothing and apparel exports to Ukraine, UAE, Poland, Iraq, Netherland and Spain saw the highest percentage increase over 2010 exports. Turkey's top ten textile export destinations included Russian Fed., Italy, Germany, Iran, United Kingdom, Poland, Romania, United States, Bulgaria, and Egypt. Turkey's top ten clothing and apparel export destinations included Germany, United Kingdom, Spain, France, Netherland, Italy, Denmark, United States, Belgium, and Russian Fed. (Table 13).

There are more than 40,000 textile and clothing companies in Turkey with an estimated workforce of 750,000 employees. Turkey is one of the main actors in the world clothing industry. Turkey ranks 8th in world cotton production and 4th in world cotton consumption. The Turkish clothing industry is the 7th largest supplier in the world, and the 2nd largest supplier to the EU behind China. It has a share of 4% in knitted clothing exports and it ranks 5th among the exporting countries. With a share of 2,6%, Turkey ranks 10th among the woven clothing exporters in the world.

The Turkish textile industry, which is listed in the world's top ten exporters, is also the second largest supplier to the EU. The Turkish textile and clothing industry has a significant role in world trade with the capability to meet high standards, and can compete in international markets in terms of high quality and a wide range of products (Ministry of Economy, 2012). Since Istanbul is becoming a fashion and shopping center, most of the companies have shifted their production facilities to the inner provinces. Izmir, Bursa, Ankara, Denizli, Gaziantep, Kayseri, Tekirdag, Adiyaman, Kahramanmaras and Adana are now major cities for textile and clothing production (Ministry of Economy, 2012).

EU is the most important market for Turkey's clothing exports. In 2011 Turkey exported clothing of US$ 11 billion to the EU, which was equivalent to 81,6% of Turkey's total clothing exports. Main markets among the members of EU were Germany and the UK. Clothing exports to these countries were US$ 5.2 billion, which was nearly half of Turkey's clothing exports to the EU With its fashion-oriented and quality products, Turkey has been increasing her share in the main markets, especially in the European market which has high standards and sophisticated customer needs. In 2011, Turkish companies exported to more than 170 countries in the world (Ministry of Economy, 2012).

Table 12. Turkey's Textiles, Clothing and Apparel Exports Compared to Total Exports (billion US$)

	2007	%	2008	%	2009	%	2010	%	2011	%
Textile (Cotton Products) *	3.010	2.8	2.514	1.9	2.090	2.0	2.866	2.5	3.693	2.7
Textile * (cotton, synthetic, Wool, silk and other fibers)	6.363	5.9	6.640	5.0	5.374	5.3	6.352	5.6	7.709	5.7
Clothing and Apparel **	15.563	14.5	15.234	11.5	12.854	12.6	14.205	12.5	15.664	11.6
Sub-Total	21.926	20.4	21.874	16.6	18.228	17.8	20.557	18.1	23.373	17.3
Total Export **	107.271		132.027		102.164		113.883		134.954	

* Mediterranean Exporter Associations www.akib.org.tr
** Istanbul Textile and Apparel Exporters' Associations www.itkib.org.tr/itkib/istatistik

Despite all the bleak economic developments around the world, Turkish textile and garment exporters managed to increase exports in both categories during MY 2011 Higher cotton prices and production costs in China helped Turkish textile exporters to compete against Chinese products in the international markets and prevented declines in textile exports. Experts indicate that economic problems in the main Turkish textile export market, the EU, and political problems in neighboring countries will eventually have an adverse effects on exports and the domestic economy.

Table 13. Leading Countries for Textile and, Clothing and Apparel Export of Turkey in 2011

Countries	Textile Export (million US$)	Ratio %	Countries	Clothing and Apparel Export (million US$)	Ratio %
Russian Fed.	1.004	13.0	Germany	3.884	24.8
Italy 778		10.1	UK	2.036	13.0
Germany 458		5.9	Spain	1.347	8.6
Iran 294		3.8	France	1.254	8.0
UK 288		3.7	Netherland	856	5.5
Poland 288		3.7	Italy	817	5.2
Romania 283		3.7	Denmark	460	2.9
USA 273		3.5	USA	429	2.7
Bulgaria 237		3.1	Belgium	414	2.6
Egypt 207		2.7	Russian Fed.	295	1.9
Spain 201		2.6	Sweden	286	1.8
France 176		2.3	Iraq	269	1.7
Morocco 168		2.2	Poland	165	1.1
Tunisia 168		2.2	UAE	160	1.0
Ukraine 167		2.2	Romania	152	1.0
Netherland 151		2.0	Israel	150	1.0
Greece 145		1.9	Austria	144	0.9
China 142		1.9	Switzerland	139	0.9
Belgium 127		1.7	Czech Rep	133	0.9
MFZ 118		1.5	Ukraine	117	0.8
Sub-Total 5.68	1	73.7	Sub-Total	13.518	86.3
Total 7.709			Total	15.664	

Source: Istanbul Textile and Apparel Exporters' Associations (ITKIB), 2012.

Machinery Investments, According to the Switzerland-based International Textile Manufacturers Federation (ITMF), during the period of 1990-2009, Turkey ranked second globally in investments in large circular knitting machinery as well as open-end rotors; third in long-staple spindles; fourth in short-staple spindles; and fifth in shuttleless looms. ITMF's 2009 and 2010 International Textile Machinery Shipment Statistics reports indicate that Turkey invested in a significantly greater amount of textile machinery in 2010 over 2009, particularly in spinning machinery: Imports of false-twist spindles increased by 633 percent; long-staple spindles, 607 percent; open-end rotors, 587 percent; and short-staple spindles, 234 percent. In addition, Turkey's imports of large-diameter circular knitting machinery increased by 348 percent; flat-knitting machinery, 192 percent; and shuttleless looms, 284 percent (www.fibre2fibrefashion.com/industry-article).

Firms invested profits heavily into machine capacity. For example, by 2008, Turkey has advanced to own 7.3% of OE rotor, 5% of long staple spinning, and 5.1% of wool weaving looms capacity of the world. In 2011, Turkey was the 4th rank and imported 628 000 short-stable spindles. The single biggest investor in long stable spindles was Turkey (32.500) followed by China, Iran, UA Emirates and Italy. In terms of investments in open-end rotors and in the segment of double heather draw-texturing spindles Turkey was the 3th country (35.250 for open-end rotors, 20.000 for double heather draw-texturing spindles) after China and India. Turkey was the 4th investor country in the segment of circular (900 machines) and electronic flat knitting machines (2.150 machines) (www.fibre2fibrefashion.com/industry-article).

Geographic Concentration of Turkish Textile Sector

According to employment numbers, number of companies and the export figures, textiles and apparel production is mainly concentrated in three geographic regions in Turkey: Marmara Region, Aegean Region and Cukurova region (Porter, et al., 2012)..

Marmara Region

The textile activity within the Marmara region is concentrated in the Tekirdag, Istanbul and Bursa provinces. Marmara Region constitutes the largest textile cluster within Turkey's economy, responsible for 56% of the total textile employment in the country. The region accommodates around 67 % of the total textile related companies (Ministry of Labor and Social Security Statistics), and performs 71% of the total textile exports within the Turkish economy (Turkstat). The major production activities are garment manufacturing, yarn production, knitting and textile finishing (Porter, et al., 2012)

Aegean Region

Aegean region has concentrated on home textiles, mainly towels and bathrobes. It has a share of 12% of the textile employment within Turkey, is responsible from 10% of the total of the total textile exports and accommodates 11% of the total textile companies (Porter, et al., 2012).

Cukurova Region

Last but not the least, Cukurova is an up and coming region for textiles production in Turkey. This region observes higher growth in terms of the textile exports, textile employment and textile related companies than any other. The major products for the region are machine carpets, rugs, yarn production and weaving and finishing of cotton.

The export performances of these regions differed significantly during the last decade. Although all increased total exports numbers between 2002 and 2011, only Cukurova was able to increase its share in total textile exports (Table 14) (Porter, et al., 2012).

Table 14. Relative Export Performance of the Regions.

	% of total textile exports of Turkey	
Regions	2002	2011
Marmara	78	71
Aegean	12	11
Cukurova	5.4	11.7

Since (Agreement on Textiles and Clothing) ATC became effective in 2005, overall Turkish textile sector has been in stagnation or decline. Despite this trend, Cukurova region managed to grow its textile employment(Porter, et al., 2012). Due to international market pressures, as textiles lost its competitiveness in Marmara and Ege regions, labor and capital moved to relatively more profitable sectors, such as automotive. However, Cukurova offers many benefits to textile producers that make the region promising and uniquely positioned to compete internationally and reach significantly higher GDP and export figures (Porter, et al., 2012).

Although the region has a diversified economy, textile is among main sources of employment. Local cotton production and closeness of provinces to ports has made a significant contribution to the development of textile sector within the region. During the last decade, more than 500 companies entered in textile industry in Cukurova. Not only the number of firms has increased, but also the firms have started to grow in their exports and sizes. For example, in year 2010, 12 of the textile companies that are operating in the Cukurova region have ranked in the top 500 firms in Turkey (Porter, et al., 2012).

Some Advantages of Cukurova Region

1. Cukurova is very well connected to Mersin and Iskenderun ports and the rest of the country,
2. Cukurova's proximity to the Mediterranean and Middle Eastern markets provides an important advantage.
3. The second largest airport of Turkey is under construction in closely Mersin, to be finished by 2014.
4. Geographical proximity to main cotton production area (GAP)
5. Labor in Cukurova, relative to western part of Turkey, is cheaper, and this gives the region a competitive advantage in textiles over Marmara and Aegean
6. Adana is the 4th biggest city in Turkey with a population of 1.8 million people and Cukurova region is densely populated overall.

Industry Future

The industry, today, has become one of the most important components of the Turkish economy with its total export value of 23.4 billion US dollars (Textile: 5.7, clothing and apparel: 15.6 billion US$). Turkish clothing manufacturers must create and market their own brands, produce higher value-added apparel abroad to compete with the China and India. Competitiveness of the sector needs to be significantly enhanced and strategically planned, since being a low cost producer is not enough anymore to reach sizable export figures. Turkey has the production capacity to meet almost all the raw material needs of clothing industry. Turkey has also gained valuable experience in fabric design and it is started to present its special design with fashion shows in prominent markets. Turkish textile industrialist, most of whom has created their own trademark together with the patent rights, provide the most important foreign home textile and clothing companies with their fabric (ITKIB, 2011).

Many pattern design competitions that make important contributions to development of fabric design in Turkey are organized by different institutions leading to emergence of young designers and creations of product diversity. Turkey either takes part in many famous international textile fairs or organize international textile fairs. Turkey's potential shown successfully all over the world (ITKIB, 2011). The main goals of the sector under the current world conjuncture are to produce high value added, original and high quality products and to sell them at a reasonable price level. On the other hand, as parallel to the current trend in the world, Turkey has shown great success in the technical textile products in cooperation with the university-industry and government institutions and by giving importance to R&D.

Main advantages of Turkish Textile Industry:

1. Use modern technology,
2. Existence of a well-developed textile finishing industry,
3. Talented designers and creations of product diversity,
4. Marketing of highly value added, fashionable and quality products
5. Richness in basic raw material
6. Geographical proximity to main markets, especially European markets
7. Short logistics period due to the geographical proximity,
8. Qualified and well-educated labor force,
9. Liberal trade policies,
10. Giving importance to quality, environment and human health, sensitivity on working conditions of workers,
11. Custom Union agreement with European Union and free trade agreements with many other countries (ITKIB, 2011).

Turkey is aiming to achieve $500 billion in total exports and rank among the top 10 economies in the world by 2023, the 100th anniversary of the founding of the Republic. The textile and apparel industry certainly will play a role in helping Turkey attain this goal, as it is a leading force in the economy. The industry has invested more than US$100 billion in integrated and advanced technology; accounts for 25 percent of its export revenue and 11 percent of the national gross income; and provides direct employment for more than two million people. Turkey's textile and apparel industry aims to achieve US$80 billion in exports by 2023 - with apparel accounting for US$60 billion; and textiles, US$20 billion (textileworldasia, 2012).

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ORAL PRESENTATION

Status of Organic Cotton Production in Turkey

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Abstract

Cotton production has been improved in respect to amount and quality with contributions of scientific and technological innovations. Increased sensitivity to health and environmental issues has caused development of new subjects such as organic agriculture. Organic production systems are based on specific standards that combine tradition, innovation and science. It sustains human and animal health and maintains ecosystem and soil quality. Organic agriculture stops the use of pesticides and nutrient pollution.

Turkey has a good knowledge on organic farming and is one of the leading countries in this regard. Organic cotton is grown in 23 countries around the World. India, Syria and Turkey in can be seen in the rank of the countries related with organic cotton production in 2011. Textile Exchange Organic Cotton Farm and Fiber Report in 2011 announced that organic cotton production increased 15 percent from 209.950 metric tons (MT) in 2008 - 09 to 241.276 MT (1.1 million bales) grown on 461.000 hectares (1.14 million acres) in 2009 - 2010 in the world. Organic cotton now represents approximately 1.1 percent of global cotton production. In the future, it is anticipated that demand for organic cotton fiber will be greater than supply. Organic cotton is considered as a niche product or niche-market product up to now, but textile sector relevant to organic cotton with the effects of consumer awareness is start to move from a niche market to mainstream with contributions of many clothing companies.

In Turkey, organic cotton production faced with fluctuations from year to year due to several difficulties such as pest and disease intensity, marketing and contracting problems, demand and supply balance, etc. Taking into consideration

demands of producers and consumers of cotton and also textile manufacturers, several product types including organic and also natural colored cottons have to be created in order to provide progress in this field.

Keywords: *Organic Cotton, Turkey.*

Introduction

Cotton production has been improved in amount and quality by contributions of scientific and technological innovations. Increased sensitivity to health and environmental issues has caused development of new subjects such as organic agriculture (14).

Organic production can be defined in many ways. IFOAM, the International Federation of Organic Agriculture Movements, defines organic agriculture as follows: "Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" (12).

When cotton sold as organic, it requires a third party certification by an independent, accredited certification agency. Further in the processing chain, care must be taken not only to separate organic cotton from conventional cotton, but also to ensure environment-friendly processing. However, organic cotton can also be processed conventionally and the textile end-product can be sold as made from organic cotton (4, 5).

Importance of Organic Cotton

Increasing consciousness about conservation of environment as well as of health hazards caused by agrochemicals has brought a major shift in consumer preference towards organic production particularly in the developed countries. Global consumers are increasingly looking forward to organic production that is considered safe and hazard-free (12).

Cotton is considered the world's 'dirtiest' crop due to heavy use of insecticides and hazardous pesticides to human and animal health. Cotton covers 2.5% of the world's cultivated land. Cotton is being sprayed with 16% of the world's insecticides (11).

Organic cotton has been considered as a niche product or niche-market product up to now, but textile sector relevant to organic cotton with the effects of consumer awareness is being started to move from a niche market to mainstream with contributions of many clothing companies (2).

Conventional cotton is produced in over 60 countries, but organic cotton was grown in 23 countries by the 2010/11 growing season. Those countries were Bangladesh, Benin, Brazil, Burkina Faso, China, Egypt, Greece, India, Israel, Kyrgyzstan, Mali, Nicaragua, Pakistan, Paraguay, Peru, Senegal, South Africa, Syria, Tanzania, Turkey, Tajikistan, Uganda, and the USA. Most production was taking place in India, Syria, China, Turkey, the United States, Tanzania and Uganda (1, 9).

According to the 2011 Textile Exchange Organic Cotton Farm and Fiber Report, organic cotton production grew 15 percent from 209,950 MT in 2008-09 to 241,276 MT grown on 461,000 hectares in 2009-2010. Organic cotton production was declined 35 percent from 241,697 MT in 2010/11 to 151,079 MT this year (8). Organic cotton now represents 1.1 percent of global cotton production (Figure 1) (7, 8, 10).

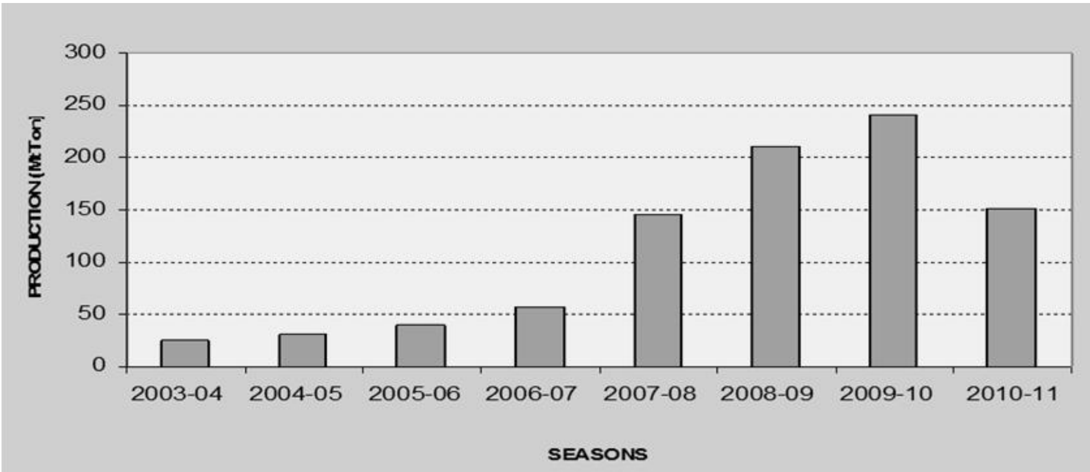

Figure 1. Global Organic Cotton Production in the World

Table 1. Organic Seed Cotton Production in Turkey

	Organic Seed Cotton Production (Ton)							
Province 2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Izmir -	1.706	1.716	253	2.315	1.731	1.088	2.068	2.326
Aydin 9.841	6.181	5.099	6.742	12.507	6.356	647	2.598	50
Denizli						233	265	1206
Canakkale 10	-	-	-	-	-	-	-	-
G.Antep 75	135	60.00	-	-	-	-	-	-
Hatay 572	1.060	-	-	26	70	3.026	2.497	2.217
Manisa 228	319	154	170,00	175	69	-	567	491
Sanliurfa 21.928	19.647	25.321	52.780	39.582	57.822	6.108	22.506	8.472
Mardin -	1.220	855	-	84	596	637	1.322	954
Diyarbakir -	-	-	464	366	-	-	-	-
Mugla -	-	-	13	-	-	-	-	-
Adiyaman -	-	-	-	480	1.480	-	-	142
K.Maras -	-	-	-	-	187	-	252	-
TOTAL 32.654	**30.269**	**33.206**	**60.422**	**55.535**	**68.311**	**11.738**	**32.076**	**15.857**

Until present, organic cotton was produced in 13 provinces in Turkey. The following table gives the production values of the provinces where organic cotton is grown in Turkey. The highest production is in Sanliurfa, followed by Izmir province in 2011. (Table 1) (13, 15). Last year lint cotton production was 6.342 tons (Figure 2) (13, 15). The amount of organic cotton production varies significantly over the years. These production figures vary significantly due to the reasons such as climatic factors, the decrease and increase in diseases and pests over the years, the marketing problem, absence of verification of number and the inadequate production amounts reported by private companies.

General Problems on Organic Cotton Production in Turkey

Turkey has a good knowledge on organic farming and is one of the leading countries in this regard. Although Turkey has a great potential for organic cotton production, very different problems are experienced during the production phase. Taking a glance at these problems, the biggest problem in our country in organic cotton production is that the middle-scale farmers, who choose organic production, have difficulties in abandoning their habits to use chemicals since use of chemical pesticides is very wide-spread in cotton production (12). For large-scale farmers, organic cotton production is not attractive since they prefer to earn higher from their lands within a short time. Since our farmers do not have sufficient know-how in organic cotton production, they have difficulties in accessing the biological preparations licensed for organic agriculture, and they also complain about high prices of such preparations.

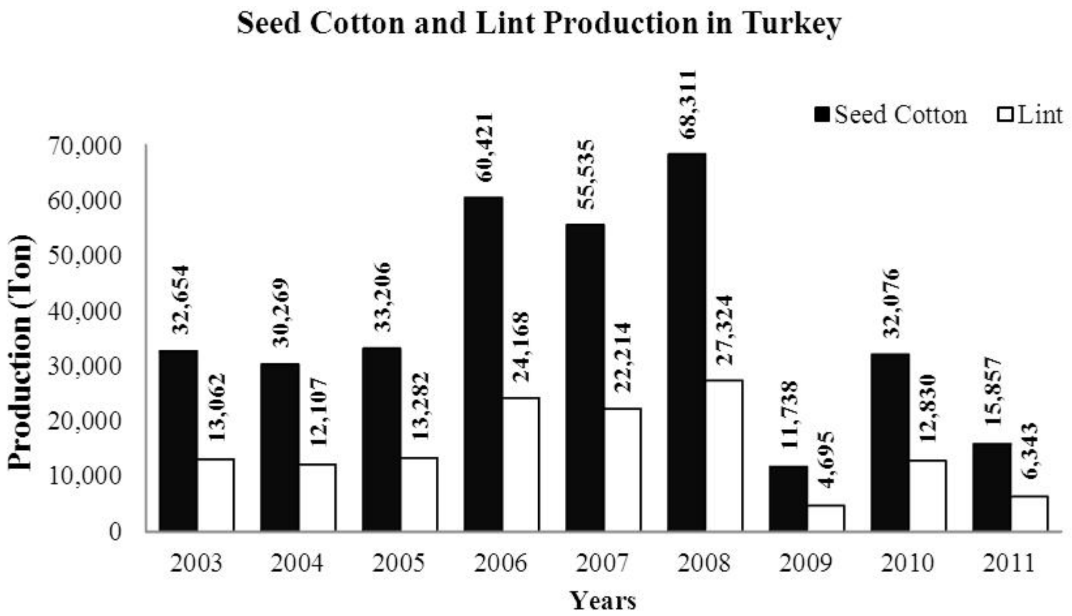

Figure 2. Organic Seed Cotton and Lint Production in Turkey

Besides, the oppression of large chemical pesticide trusts on the market is also a matter of concern. Such companies are concerned about declines in their market shares, as chemical preparations used in conventional agriculture are replaced by biological preparations as organic production increases, and they convey their negative ideas about organic agricultural production to the producers.

During organic cotton production, it is necessary for the producers to give more importance especially to plant nutrition, appropriate rotation and green fertilization. In addition, extending the production and use of biological preparations and compost is another significant matter in organic agriculture (4, 5).

The market for organic cotton is held by a small and specific buyer segment, and this situation leads to marketing problems. The companies that entered the market first in organic cotton production do not want the organic cotton go out of their control therefore the increase in production is limited (6).

One other thing that Turkey has to do in relation with organic cotton is the establishment of an organic cotton stock exchange. Although we have been producing organic cotton for a long time, and even though we were placed near the top of the list in some years, an organic cotton stock exchange could not have been established in our country yet. This is a significant requisite for our country, which will lead to improvements in organic cotton production.

In Turkey, sometimes there are problems in supplying organic cotton seeds. The producers face difficulties in years when organic seed production is not sufficient. The organic cotton seeds should not contain GMOs, and they should not be delinted with chemicals. The cotton seeds in Turkey are GMO-free (2). The ban on the import of seeds with GMOs into the country is a great advantage for Turkey nowadays. With respect to the future of organic cotton, this is an important point for our country.

In addition, the cottonseed, used as an organic animal feed, is an important source of nutrition for organic livestock farming with its significant protein content. The extent of organic cotton in our country brings forward the utilization of cottonseed oil, which is a product with different areas of use. Despite the favorable nutritional values of conventional cottonseed oil, it may be inconvenient to use it in food industry due to high levels of chemical residues. Therefore, it is thought that organic cottonseed oil may gain importance as a food product since it is cheap and reliable.

Also the other important subject in organic production is the careful selection of varieties adapted to local conditions in terms of climate, soil and resistance to pests and diseases.

In Turkey, there are a high number of cotton varieties available on the seed market provided by research stations and seed companies. Unfortunately, these varieties have not been breeding for organic farming. There is still lack of organic cotton breeding activities for organic farming.

Taking into consideration the demands of producers and consumers of cotton and also textile manufacturers, several product types including organic and natural colored cottons have to be bred in order to make progress in this field.

Natural colored cotton's future depends on continuous improvement of fiber quality and appropriate manufacturing process. Breeders have still improved the properties of naturally colored cotton. Because of low yields, inability of the fiber to machine spinning, naturally colored cottons have not been utilized for commercial textile production. This has been declined due to limited market demand (3).

Conclusion

Turkey has many advantages such as suitable ecological and climatic conditions, enough knowledge, high experience and developed textile sector to carry out organic agriculture. Breeding programs have to be start in Turkey with the aim of developing convenient varieties for local conditions. Turkey has a potential to increase product range using organic and also natural colored cotton.

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Breeding and Biotechnology

ORAL PRESENTATION

Recent Developments in Cotton Breeding and Biotechnology Fields in Turkey

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Abstract

Cotton is a culture plant that has an important place in agriculture, industry and trade both in Turkey and the World. Turkey, one of the leading countries in the world both in terms of textile industry and cotton processing capacity, provides various textile products to world markets.

The traditional cotton breeding studies in Turkey first started with the introduction materials obtained from USA in 1927 and then the selection studies were continued by using these plant materials. Cotton breeding studies gained acceleration in 1960s. There are 123 cotton varieties in Turkey registered primarily by research institutes, private companies and universities using introduction, selection and crossing breeding methods.

Cotton biotechnology studies including tissue culture and molecular genetics have been conducted for nearly the past 15 years in Turkey. Plant tissue culture researches were started in 1960s in our country and private companies that had permission of tissue culture production have preferred to work on crops other than cotton. Universities have taken the lead in tissue culture studies in cotton and also leaded the establishment of infrastructures of research institutes and centers. Researches still continue to provide regenerations through embryogenesis and organogenesis for obtaining the complete plants using cell, tissue and organ cultures in cotton, to select somaclonal variants resistant to different types of abiotic stresses (mainly salinity, drought, etc.) and biotic stress factors such as *Verticillium dahliae* Kleb., and to produce haploid and doubled haploid plants.

Especially in the last 10 years, the number of researches has been quite increased on characterization of cotton species using DNA markers by molecular methods and mapping the genes that are effective on fiber quality and controlling the resistance to Verticillium wilt in cotton genome. The universities also have leaded the molecular genetic researches on cotton and therefore with their contributions, necessary infrastructures have been started to establish in public research institutions, centers as well as private companies.

Although the size of cultivation areas of transgenic cotton varieties, which are biotechnology products, has increased throughout the world, they are not allowed to be grown in Turkey due to the current biosafety law. However, some transgenic varieties were tested in field experiments under controlled conditions in research institutes. Cotton researchers which have high knowledge continue to conduct successful researches for developing cotton genotypes with better yield and fiber quality and, also resistant to biotic and abiotic stress factors in order to meet the demands of producers, textile suppliers and consumers by integrating conventional and modern biotechnology techniques.
Keywords: *Cotton, breeding, Turkey*

Introduction

Cotton is a strategic plant that makes important contributions to national economies with its added value and employment opportunities. Cotton fiber is the main raw material of textile industry, and furthermore, cotton seed oil has been started to be used increasingly as raw material in biodiesel production. For this reason, cotton has become a part of energy agriculture.

Turkey is one of the leading countries in the world on account of both its cotton processing capacity and strong textile industry and introducing textile products to global markets.

Cotton production decreased throughout the world due to the negative effects of global economic crisis in 2008 and 2009.

Alternative products have been started to be preferred in cotton production fields and in Turkey due to high production cost of cotton, lower subsidy rates compared to other cotton producing countries, and high number of the other crops in

Ege and Cukurova Regions which are important cotton production locations and cotton production has decreased to a critical threshold.

Cotton cultivar development studies have gained momentum with the use of conventional plant breeding methods to solve different problems seen in cotton production in Turkey and also with the use of biotechnological methods in the recent years.

Conventional Cotton Breeding In Turkey

The most important issues of breeding programs include increasing income levels of producers by improving yield potential with higher quality and meeting the requirements of consumers. Cotton breeders in Turkey carry out studies on developing high yielding varieties, increasing fiber quality, earliness, resistance to disease, pests and stress factors of various abiotic origins like aridity and saltiness, extending gene pool with the use of wild species(Barut, 2003; Basal, 2007; Sezener, 2012).

The early developments in Turkish cotton production started with the establishment of Cotton Research Institutes in Adana in 1924 and in Nazilli in 1934.The researchers initiated the first breeding studies with the selections of introduction materials obtained from foreign countries and hybridization studies gained acceleration in 1960s. A total of 123 cotton varieties have been registered by public institutes, universities and private institutes by using various breeding methods between 1950 and 2012 in Turkey. The half of the bred cotton varieties were obtained as introduction material, while 34% were obtained with hybridization method and 16% were obtained by recurrent selection breeding method. Approximately 15-20 varieties are commercially produced at present. Mutation breeding is not widely used and a commercial achievement has not been obtained yet. There is no transgenic cotton variety in official records.

The leading Agricultural Research Institutes dependent on Ministry of Food, Agriculture and Livestock of Turkey Republic related with cotton breeding researches are Nazilli Cotton Research Station (Nazilli-Aydin), East Mediterranean Agricultural Research Institute (Adana), GAP International Agricultural Research and Training Center (Diyarbakir) East Mediterranean Gateway Zone Agricultural

Research Station (Kahramanmaras), GAP Agricultural Research Institute (Urfa) and West Mediterranean Agricultural Research Institute (Antalya).

35 Cotton varieties are developed by Nazilli Cotton Research Station. The tasks of this institute which incorporates molecular genetics, tissue culture, phytopathology and fiber technology laboratories are divided into national and international categories.

In addition, this institute is one of 6 Excellence Centers of Islam Development Organization and is assigned to ensure coordination among affiliated countries on cotton studies, as well as prepare, coordinate and carry out projects and also to organize training programs. In this context, this institute continue to collaborate on cotton breeding issues with some countries such as Azerbaijan, Turkmenistan and Uzbekistan other than the members of The Organization of Islamic Cooperation.

Introduction Breeding

Introduction plant materials provided by transferring seed, plant and vegetative plant parts from one ecological region to another contribute to genetic diversity for breeding studies. Several cotton varieties brought to Turkey from USA as introduction materials in different years have made important contributions to cotton production: Acala-8(1927), Deltapine-15 (1948), Coker (1958), Carolina Queen 201 (1963), Sealand-542 (1965), Delcerro (1977) etc. Introduction breeding is continued through commercial companies at present.

Selection Breeding

The selection breeding was the most preferred method in breeding studies due to inadequate number of genetic materials in the initial years of cotton production in Turkey. With selection breeding studies, important cotton varieties including Acala-1086, Coker 100 A/2, Nazilli 66-100, Adana 967/10, Cukurova 1518, Adana 98, Nazilli 84-S, Nazilli 143 and Nazilli 954 were registered.

Hybridization Breeding

Hybridization or combination breeding constituting the basis of global cotton breeding at present is carried out to combine positive sides of two or numerous genotypes in one genotype. Approximately, 40 cotton varieties registered in Turkey were obtained by this method.

Biotechnological Researches on Cotton In Turkey

Molecular technologies are used as routine in plant breeding studies in many countries. Turkey has only recently started to use these technologies in plant breeding and genetic studies and many laboratories have been established on this subject.

Especially in the last 10 years, the number of researches in Turkey has been quite increased on characterization of cotton varieties using DNA markers by molecular genetics methods and mapping the genes which are effective on fiber quality, fiber color and also the genes controlling resistance to Verticillium wilt in cotton genome (Bolek et al., 2005; Altan et al., 2010).

Association and genome mapping are made mostly by using SSR, AFLP and SNP marker technics on hybrid populations in our country. The universities also have leaded the molecular genetics researches on cotton and therefore with their contributions, necessary infrastructures have been started to establish in public research institutions, centers as well as private companies.

Some of the private seed growing companies established in Turkey have started to use molecular technologies as routine in their breeding studies. Conventional breeding methods will continue to play active role in meeting the demands of producers and textile industry; however, biotechnological methods will also be used by cotton breeders to develop new cotton varieties.

Plant Tissue Culture Researches on Cotton In Turkey

These techniques are used in creating somaclonal variability and developing new varieties, and also they give important opportunities in genetic engineering field for performing studies on resistance to pests and diseases. *Invitro selection* techniques focused on in the recent timeshave great potentials in order to solve several abiotic stress problems in cotton.

Studies on plant tissue cultures were started in 1960s in Turkey, and private institutions allowed for tissue culture production generally focused on products other than cotton, and universities took the lead in studies on cotton and infrastructures could be established in research institutes and centers in cooperation with universities. Various studies are carried out in Turkey on whole cotton plant through cell, tissue and organ cultures, obtaining regeneration through somatic embryogenesis and organogenesis, obtaining and selecting somaclonal genotypes resistant to abiotic stress factors like salinity, drought and biotic stress factors like Verticillium spp., and producing haploid and doubled haploid plants. Detailed studies on obtaining haploid cotton plant by fertilization with pollens subject to gamma ray (Cobalt-60) were conducted in Turkey (Gurel et al., 2003; Aydin et al., 2004; Turkoglu, 2007; Hayta et al., 2010).

It is known that researchers more carefully and prudently deal with developing of transgenic varieties that pose no harm to environment and human health. Besides cotton resistance to herbicides and pests, there are also successful researches conducted to increase the fiber yield and quality and improve the fatty acid composition of cotton seeds. It is evident that this kind of studies will diversify and continue to increase.

Cultivation area of biotechnology product transgenic cotton varieties rapidly increases throughout the world (Zhu et al., 2011; James, 2012); however, it is not possible to produce transgenic cotton due to the current biosafety legislation in Turkey. On the other hand, some transgenic varieties are investigated in test fields under controlled conditions in research institutes.

Breeding Programs of Public, University and Private Organizations in Turkey

The main topics of cotton breeding studies of public institutions in Turkey generally include increasing yield and fiber quality characters, tolerance to drought and high temperatures, resistance to disease and pests, earliness, developing new varieties, tissue culture and biotechnology. Of these studies, 34% are about adaptation and variety development, while 21% are about fiber quality, 13% earliness and second product in cotton breeding, 8% resistance to drought and high temperature, 8% mutation, 8% storage, 4% resistance to diseases and pests, and 4% tissue culture and biotechnology.

Considering the cotton breeding studies of private organizations, Turkey is the production center of especially non-transgenic seeds of many products including cotton thanks to the peculiar ecology and soil condition in Turkey, and therefore, many international and foreign origin firms produce commercial cotton seeds in Turkey.

The most important institution that supports the finance of agricultural researches in Turkey is Turkey Scientific and Technical Researches Institution (TUBITAK). TUBITAK supports the projects of public institutions, university and private sectors to develop science and technology policies, contribute toe establishment of necessary infrastructures and tools to realize these aims, support and carry out research and development activities and lead the creation of science and technology culture considering the national priorities in cooperation with all parts of society and relevant institutions in order to increase and perpetuate the competitive capacity and welfare of Turkey. Agricultural research and development activities are also supported and coordinated by General Directorate of Agricultural Research and Policies of Ministry of Food, Agriculture and Livestock. In addition, there is another financial supporting program named as "Industrial Thesis Program" on new technology adaptation, process development, quality improvement and environmental modification projects belonging to Ministry of Science, Industry and Technology.

Conclusion

Seeds, the main input of plant production, are preliminary condition for a fertile and good quality plant production. Seed trade was limitedly made in the world in past, while international seed sector has demonstrated a rapid growth in the last 20 years.

The increasing international seed trade poses an important threat to countries with inadequate seed production capacities. Foreign varieties are commonly used for nearly all important arable crops including the ones with adequate seed production or high native production.

The prerequisite to put an end to foreign-source dependency is the development of native varieties by establishing various breeding programs. Therefore, national cotton breeding programs should be strengthened by using biotechnological techniques in order to develop native varieties.

Biotechnological techniques should be integrated into conventional breeding programs in order to shorten variety breeding time, increase the efficiency of selection studies and compete with other companies in the world.

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ORAL PRESENTATION

Identification of QTLs for Cotton Fiber Quality in a M5 Mutant Segregating Population

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Abstract

A segregating mutant population has been developed from the standard Bulgarian variety "Chirpan 603" for identification of QTLs related to fiber quality characteristics. SSR markers developed in interspecific crosses and further confirmed in intraspecific crosses, together with in-house developed ISSR markers were used for association mapping of fiber strength, length, uniformity, micronaire and elongation. QTLs were identified with major effect on all traits with the ones related to fiber strength, uniformity and micronaire co-localizing on the same region of one linkage group.
Keywords: *Cotton, Gossypium hirsutum, mutation, QTL, mapping.*

Introduction

Upland cotton (*Gossypium hirsutum* L., 2n = 52) is the most extensively used of the four cultivated *Gossypium* species. However the narrow genetic background of the germplasm used for developing modern cotton varieties is slowing the speed of increases in productivity worldwide. Stagnant yield, declining fiber quality, and damages from biotic and abiotic stresses affect proftability of cotton production. The high value per hectare of cotton and global textile market demand for increased fiber uniformity, strength and extensibility clearly justify the importance of new and innovative approaches toward evaluating and understanding genetic mechanisms underlying fiber qualities. Thus the species has been the target of numerous genetic studies and breeding efforts.

The level of genetic diversity is low in *G. hirsutum*, especially among agriculturally elite types, as revealed by different means of assessment (Gutierrez et al. 2002; Ulloa et al., 2002; Wendel et al. 1989). Increasing diversity is therefore essential to genetic improvement efforts. Each of the three major approaches to increasing genetic diversity – germplasm introgression, mutagenesis, and transformation – has its advantages and disadvantages.

G. barbadense (L.) is the only cultivated relative of Upland cotton (*G. hirsutum*) with the same chromosome number (2n = 4x = 52). It is valued for its fiber quality, whereas Upland cotton is higher valued for its yield potential. While these species are easily hybridized, even the very early studies (Stephens, 1949) on conventional backcrossing and/or inbreeding were quick to find that it leads to extensive loss of introduced variability. One of the challenges in interspecific introgression is to use valuable alien traits of *G. barbadense* germplasm, such as fiber length, fineness, and strength to improve Upland cotton (Lacape et al. 2005). Traditional plant breeding approaches for improving fiber quality through interspecific introgression have been hindered by complex antagonistic genetic relationships (Culp et al., 1979). Recent molecular mapping studies associated *G. barbadense* chromosomes with many favorable QTLs affecting fiber and agronomic traits (Rong et al. 2004; Lacape et al. 2005).

Attempts to incorporate genes into Upland cotton through classical breeding methods have generally not achieved stable introgression of the *G. barbadense* fiber properties (Stephens, 1949; McKenzie, 1970). Associated with these attempts at introgression have been poor agronomic qualities of the progeny, distorted segregation, sterility, mote formation, and limited recombination due to incompatibility between the genomes (Reinisch et al., 1994).

Genetic transformation on the other hand has been most successful in modifying main agronomic traits, such as herbicide and insect tolerance, while the attempts to improve fiber quality are still in their infancy. This is mostly due to the paucity of information about the genes that specifically control quality traits and their regulation in particular.

One of the main avenues for identifying and studying quality-related genes has been induced mutagenesis. This approach proved effective in many crops, including cotton (Ahloowalia and Maluszynski, 2004). In the present study we chose to apply a combination of mutagenic treatment with the application of molecular markers for identifying quantitative trait loci (QTLs) in a segregating mutant population developed from commercially used Bulgarian variety. Within this study the main objectives set forth were to identify molecular markers related to fiber quality characteristics and to identify QTLs with practical applicability for Bulgarian cotton breeding programs.

Material and Methods

Plant material

The Bulgarian variety Chirpan 603 was selected for the present study as it was commercially grown over more than 80% of the cultivation area in 2005.

Phenotypic observations

Fiber quality characteristics measured were: length (mm), fineness (Micronaire), strength (g/tex), elongation (%), uniformity (%), and maturity.

Gamma irradiation treatment and greenhouse cultivation conditions

Five hundred grams of seeds were gamma-radiation treated. Based on previous experience with breeding materials from *G. hirsutum* species the applied treatment was with 150 Gy, which appeared to be the most effective in inducing useful mutations.

After producing the M1 generation in a greenhouse seeds from all the following generations were planted and seed cotton collected in the field. The plants were phenotyped during the growing season and the fiber quality of the ones that produced enough seedcotton determined.

SSR analysis

Selection of the SSR primers for use in the present study was performed as described elsewhere (Ivanova and Bojinov, 2009). Sequences of SSR primers were downloaded from the CMD database (http ://ukcrop.net/perl/ace/search/CottonDB), and oligonucleotides synthesized by Microsynth AG (Balgach, Switzerland).

ISSR analysis

Inter simple sequence repeat (ISSR) marker system was developed by Zietkiewicz et al. (1994) to circumvent the requirement of SSRs for flanking sequence information. It has thus found wide applicability in a variety of plants where the most signifcant uses remain in genetic mapping, diagnostic fngerprinting and in the study of genetic structure within and between populations of individual species. ISSR polymorphisms can provide useful discriminatory information for phylogenetic and systematic studies of closely related species and subspecific lineages (Bussell et al., 2005). The application of these markers to cotton was rarely attempted and did not expand beyond verifying the capacity of the system to reveal both intraspecific variations (Liu and Wendel, 2001) and an accidental use as a sub-sampling technique for producing SSR markers (Zhang et al., 2009).

Results and Discussion

After 5 generations of selfing and reproducing the lines were considered sufficiently stable and homogenous for determining the fiber quality properties for identification of QTLs.

The freely available mapping software MapDisto (Lorieux, 2012) was used for QTL identification and mapping. The procedure for computing QTLs in Recombinant Inbred Lines (RILs) was used as best corresponding to characterizing a population of mutation-derived sister lines.

For molecular marker analysis a total of 3 pairs of SSR and 13 ISSR primers were screened for their capacity to reveal polymorphisms.

ISSR primers were able to produce high number of markers. The screening of the population with the 13 primers resulted in great differences in producing polymorphic bands where 3 of them resulted in no polymorphisms revealed, while the 10 remaining produced between 2 and 8 polymorphic bands. Altogether ISSR primers produced 41 polymorphic bands throughout a population of 126 individuals. Of these only 35 could be mapped as some had just a single appearance in the studied population (Table 1).

Table 1. Linkage groups of ISSR markers.

	Linkage groups from all loci*	
Group	**Number of loci**	**ISSR marker №**
Unlinked:	*11*	2 6 7 9 22 24 25 26 31 33 34
group 1:	*12*	1 4 5 10 14 16 17 20 21 27 30 32
group 2:	*10*	3 8 13 15 18 19 23 28 29 35
group 3:	*2*	11 12

* LOD min: 3,00; r max: 0,10; cM max: 10,1

Phenotyping for the fiber properties revealed significant differences in fiber quality within the population (Table 2).

Table 2. Range of quality characteristics observed in tagged M5 plants.

Mic		**Str**	**Len**	**Unf**	**Elg**	**Mat**
Minimum	3 23,8		23,3	79,3	5,9	0.38*
Maximum	6,2 34,9		30,1	88,5	15,2	0.99
Mean	4,3 28,8		26,8	83,9	8,9	0.92
Chirpan 603 untreated	4.9 27.6		26.6	83.5	9.6	0.90

*- single outlier that was discarded for calculating the mean.

The results showed that the variations generated by mutagenic treatment were sufficient for identification of loci, linked to fiber quality characteristics. The lowest observed value for micronaire for example was 3.0. Nonetheless several progenies had high micronaire readings with one progeny having 6.2. At the other extreme of this trait there was one progeny with micronaire reading of 3.0 and three more progenies with micronaire of 3.3-3.4. The progeny with the lowest micronaire has apparently not reached maturity as both its strength (at 23.8) and length (at 25.6) were significantly lower than that of the parent variety. The other three genotypes with low micronaire had the trait actually affected by the mutagenic treatment as their strength (varying between 28.1 and 28.4 g/tex), length (26.8-27.9 mm) and elongation (8.5-8.9) indicate that their fiber has completed its development.

The progeny with the lowest fiber strength had the lowest micronaire as well, thus the trait variation in this case could be attributed to the incomplete fiber development. At the other extreme there were four progenies with fiber strength varying only slightly (34.2-34.9 g/tex). Micronaire of these progenies varied little, too (4.5-4.8), while fiber length was more variable (24.8-27.3 mm). Interestingly the elongation of the progenies with the longest fiber (27.2-27.3) within this group was close to the one of the parental genotype and varied very little (7.7-8.1) thus indicating that within these progenies the only affected trait was fiber strength.

In line with the preliminary expectations fiber length was affected both positively and negatively with extremes evenly spaced from the mean. Three of the four progenies with shortest fiber had high to very high micronaire (4.7-6.2) and equal or higher fiber strength to the parent genotype (27.2-29.2g/tex), which indicates that these progenies have reached full maturity and their fiber length is actually negatively affected by the mutagenic treatment.

The analysis of the progenies with longest fiber did not result in similarly clear-cut conclusions. The progeny with the longest fiber (30.99 mm) had its strength (26.6 g/tex) and elongation (8.2) essentially equal to that of the parent, while its uniformity was significantly increased (88.5%). The next three progenies with longest fiber (29.6-29.8 mm) had their strength significantly increased (28.6n-31.0 g/tex), while micronaire was moderately to significantly decreased (3.5-4.5).

The complex nature of the inheritance and the requirement to combine several different (and often negatively correlated) traits makes breeding for the varieties with good agronomic performance, and carrying at the same time multiple improved fiber characteristics a daunting task that every cotton breeder strives to resolve. Marker assisted selection (MAS) has risen as a tool of choice in the recent years as it significantly facilitates the selection of genotypes for intercrossing in each generation. As more and more alleles having positive effect on the traits of interest are identified and molecularly tagged, this tool becomes more and more accessible for the actual breeding programs. Up to the present study no MAS tools with practical applicability were available for Bulgarian breeding programs as the ones developed outside the country were based on germplasm of little interest when peculiarities of local cotton cultivation are taken into account. A further hindrance is that the studies aiming at making such tools readily available within the country are suffering from insufficient funding and lack of accumulated expertise. By using one of the most commercially important varieties in the country this study attempts to provide knowledge and tools needed to keep Bulgarian breeding programs competitive.

One of the main steps in identifying appropriate molecular markers for use in MAS is the association of these markers with the traits of interest. In the present study several such markers were identified. Furthermore, mapping those to a genetic map provided further insight of what could have actually resulted in modification of the traits of interest.

Of the 41 ISSR polymorphic bands identified within the present study only 35 could be mapped (Table 1 and 3). Of these markers ISSR12 had significant effects simultaneously on fiber length and uniformity (Table 3) explaining 4.6 and 8.7%

respectively of the variability of these traits. Marker ISSR30 was the only other marker with effect on fiber length, explaining 6.14% of the variation of that trait.

Table 3. Distances (in cM) and significance of the effects of ISSR markers on fiber quality in M5 population.

ISSR marker N°	cM	len	Unf	Str	Elg	Mat
1	0,0	1,94	0,12	0,89	2,21	2,68
2	23,2	0,21	0,01	2,08	1,79	0,58
3	36,1	2,04	0,04	3,65	0,37	0,06
4	0,0	0,80	0,00	0,01	0,02	0,02
5	4,2	1,99	0,01	0,01	1,29	0,01
6	0,0	0,74	0,15	3,14	0,03	1,47
7	0,0	0,00	0,02	0,45	0,10	0,06
8	16,8	1,17	0,76	1,06	0,12	0,15
9	42,5	1,67	0,80	1,17	0,00	0,96
10	0,0	0,31	0,11	0,19	0,03	3,95 *
11	18,3	3,32	0,76	0,52	0,03	0,58
12	25,1	4,58 *	8,68 **	0,32	0,16	0,50
13	0,0	0,83	0,34	0,02	0,53	0,05
14	0,0	0,07	0,01	0,19	1,21	0,03
15	0,0	0,02	0,29	0,09	0,22	0,00
16	0,0	0,30	0,00	0,17	1,92	0,01
17	1,9	0,58	0,01	0,26	3,21	0,00
18	0,0	1,20	0,70	0,75	0,45	0,01
19	2,7	1,12	1,58	0,92	0,21	0,04
20	0,0	1,00	0,10	2,09	3,15	0,10
21	10,0	1,23	0,52	0,02	0,63	0,55
22	30,0	0,17	0,00	1,93	0,24	1,05
23	0,0	0,96	1,06	0,20	0,03	0,01
24	18,3	0,32	0,23	0,14	0,55	0,95
25	41,5	0,09	2,79	1,41	5,11 *	0,01
26	60,6	0,15	2,31	0,14	1,71	0,09
27	0,0	0,34	0,05	0,36	1,36	0,16
28	0,0	1,52	1,16	3,95 *	2,51	17,54 ****
29	6,1	0,63	0,06	0,00	7,94 **	0,00
30	0,0	6,14 *	3,87	3,77	3,58	0,05
31	0,0	1,42	1,49	2,35	0,33	0,22
32	0,0	0,15	0,01	0,00	1,16	3,29
33	0,0	0,09	0,24	0,07	1,91	0,29
34	0,0	0,00	0,25	0,83	0,94	0,87
35	0,0	0,02	0,26	0,80	0,12	0,04

Marker ISSR28 was another marker with significant effects on more than one trait. It explained about 4% of the variation in fiber strength together with more than 17% of the variability of maturity. Marker ISSR10 was the other one having significant effect on maturity explaining about 4% of the variability of the trait.

Differences in fiber elongation were attributed to the presence of two ISSR markers, namely ISSR25 and ISSR29. The observed polymorphisms of the former could be attributed to explaining about 5% of the total variation of the trait, while about 8% were attributed to the polymorphisms of the latter.

Of the SSR polymorphic bands identified within the present study only one had a significant effect on the fiber length. This locus was associated with the LG1 (Fig. 1) and had statistically significant effect, explaining 6.6% of the total trait variation. Fiber strength was significantly affected by two different loci – one on LG3, explaining 4.7% of trait variability and the other on LG4, explaining 7.7%. Uniformity on the other hand was affected by two different regions – one included markers CM1-290 and CM3-100 (encompassing 7.2 cM on LG1 and explaining 18% of the total variation), while the other was tagged by single marker (CM7-100), responsible for 9.8% of the variation and placed on the LG3. Elongation was affected by a single region on the LG3 explaining 14.3% of trait variation.

Micronaire appeared as the trait that had highest percentage of the variation explained by loci with statistically significant effect. The trait was affected by loci on two different linkage groups. The region on the first group (LG1) is relatively wide - encompasses 24.7cM and is responsible for 20% of the trait variation within the population. The other linkage group with major effect on micronaire was LG3.

In our study the upper region of the LG3 contained a region encompassing 5 cM that had statistically significant effect on fiber strength, micronaire and elongation. This finding is in line with the observations that micronaire as a measurement affected by both fiber fineness and maturity is affected by the buildup of cellulosic fibrils (which improves strength, but reduces elasticity). Therefore, the mutagenic treatment applied at the beginning of present study may have affected some basic processes of cellulose synthesis and/or deposition that are defined by the locus/loci tagged with the abovementioned markers. Further studies would be needed to identify which of the many possible mechanisms are affected, but the simultaneous effect on the modification of all three traits by the genetic constitution of a single locus strongly supports such theory. The possibilities for using SSR markers, identified in inter- and intraspecific crosses as linked to fiber quality characteristics in cotton, for identification of loci affected by a mutagenic treatment of seeds from the standard Bulgarian variety (Chirpan 603) were demonstrated in the present study. Furthermore, the applicability of ISSR markers in MAS mutation breeding was demonstrated as well. Genetic linkage map has been constructed which consisted of 5 linkage groups. Markers linked to all studied fiber characteristics were found with loci having statistically significant effect on corresponding traits explaining between 4 and 17% of the total trait variation. Combining maps for individual traits allowed for identification of a region, affecting several quality traits at once (namely fiber strength, micronaire and elongation). The markers tagging this region may prove of particular interest for future breeding efforts that would aim at applying marker assisted selection (MAS) for pyramiding multiple positive alleles.

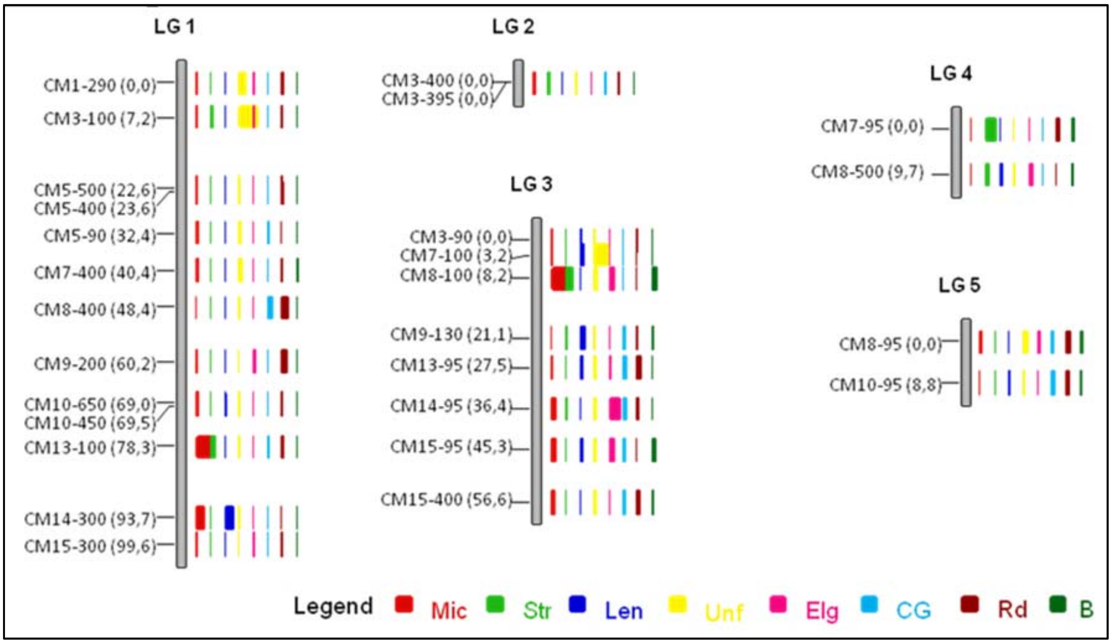

Figure 1. Combined genetic map for studied traits. The width of colored bars represents the percentage of trait variability explained by marker presence at each locus.

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ORAL PRESENTATION

Phule Anmol : *G. arboreum* Cotton Genotype released for Quality Fibre Introgressed from *G. anomalum*

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Abstract

The wild species *Gossypium anomalum* L. is having high fibre length, fineness, strength and maturity alongwith resistance to jassids, mites, bollworms, rust, bacterial blight and CLCV. To introgress these characters into cultivated *G. arboreum*, efforts were made by crossing and as a result of this, the strain RAC-024 was developed under TMC project and tested in TMC trials at different locations as well as MLT in AICCIP trials. The overall mean performance indicated that this genotype recorded 21.16 per cent higher seed cotton yield (1305 kg ha^{-1}) than the check JLA-794 (1077 kg ha^{-1}). The Phule Anmol was adjudged as the best entry in the trials conducted at 10 locations in respect of fibre length and strength. This genotype was found promising for fibre length (27.7 mm), strength (23.2 g tex^{-1}) and micronnaire value (4.5). These fibre properties are comparable with the existing *G. hirsutum* genotypes. Therefore, this variety is recommended under the name "Phule Anmol" for commercial cultivation in *Khandesh* region of Maharashtra.

Keywords: *Cotton, fibre quality, G. arboreum.*

Introduction

Cotton is one of the most important cash crop in Maharashtra and occupies 39.42 lakh ha area (2010-11). After introduction of Bt hybrids the area under diploid cotton is consistently decreased. However, under rainfed condition and in marginal soils, the performance of Bt hybrids is not consistent. Suitability for rainfed conditions, low cost of cultivation and resistant to biotic and abiotic stresses are the advantages of the diploid cotton varieties (Anonymous, 2011a). Looking to these advantages, the area under diploid cotton is again increasing. In *Khandesh*, *desi* cotton is very well adopted to the fluctuating rainfall and poor growth conditions and hence suit well to scanty resources of the poor farmer. *Desi* cotton is also resistant to many biotic and abiotic stresses. There is a large coverage under *G. arboreum* cultivar Y-1, JLA-794 and some of the private sector varieties/hybrids. These *arboreum* cultivars have comparatively low fibre properties as compare to American and Egyptian cotton. Looking to the present trend of growing cotton organically *desi* cotton can be a suitable alternative. As the fibre qualities of these varieties was found to be low as compared to *hirsutum*, work of developing *G. arboreum* variety with superior fibre properties at Cotton Improvement Project, MPKV, Rahuri was initiated.

Materials and Methods

G. arboreum basically possess a coarse, rough and medium fibre used to be commercially rated lower than *hirsutum* cotton. The wild species *G. anomalum* is having high fibre length, fineness, strength and maturity. This species is also resistance to jassids, mites, bollworms, rust and bacterial blight and CLCV. To introgress these characters in to cultivated *G. arboreum*, efforts were made by crossing. The cross was made between *G. arboreum* MPKV GMS x *G. anomalum,* Wew. & Peyr at Cotton Improvement Project, MPKV, Rahuri during the year 2001-02 and the strain RAC-024 was developed by Pedigree selection method. The genotype was tested consecutively for five years under TMC projects at different locations as well as MLT and AICCIP trials. The university multilocation trials were conducted at Rahuri, Jalgaon and Dhule during 2006-07 and 2007-08, whereas, the Co-ordinated trials were conducted at 16 locations (Sriganganagar, Faridkot, Ludhiana, Hisar, Kanpur, Khandwa, Amreli, Akola, Parbhani, Jalgaon, Bharuch, Dharwad, Raichur, Nandyal, Mudhol and Kovilpatti). The fibre properties *viz*., 2.5 % span length, uniformity, micronaire, strength, elongation and SFC were tested at CIRCOT, Mumbai. The genotype was tested for wider spacing as well as higher doses of fertilizers. It was also tested for major pests and diseases at MPKV, Rahuri as well as in Co-ordinated trials. The variety was released under the name "Phule Anmol" for commercial cultivation in *Khandesh* region of Maharashtra in the year

2011. The statistical analysis was carried out according to Panse and Sukhatme (1985).

Results and Discussion

Performance of RAC-024 in different Trials

The performance of RAC-024 in different trials *viz*., Station, Multilocation and Co-ordinated trials is presented in Table 1. During 2003-04, the strain recorded the highest seed cotton yield at Surat (2290 kg ha^{-1}) as compared with check G.Cot.16 (991kg ha^{-1}). At Nanded, during 2004-05 the culture RAC-024 recorded the highest seed cotton yield (2528 kg ha^{-1}) as compared with check PA-183 (1139 kg ha^{-1}) and in 2005-06 it recorded significantly higher seed cotton yield (2015 kg ha^{-1}) over both the Checks PHH-316 (1041 Kg ha^{-1}) and NH-545 (984 kg ha^{-1}) in TMC MM 1.3 trial. During 2006-07, at Rahuri centre, in TMC MM1.1 project, the culture RAC-024 recorded significantly highest seed cotton yield (1452 kg ha^{-1}) over local check JLA-794 (1235 kg ha^{-1}) while in TMC MM1.3 project, the culture recorded significantly highest seed cotton yield (1058 kg ha^{-1}) over local check JLA-794 (780 kg ha^{-1}). In university station trial during 2009-10, the genotype recorded significantly highest seed cotton yield (2083 kg ha^{-1}) over local check JLA-794 (1732 kg ha^{-1}) (Anonymous, 2011b).

The university multilocation trials were conducted at Rahuri, Jalgaon and Dhule during 2006-07and 2007-08. The entry recorded lower yield than the check JLA-794, however, the fibre properties were superior over the checks. The Co-ordinated trial conducted at 16 locations indicated that the genotype RAC-024 recorded 1144 kg ha^{-1} seed cotton yield which is 25.2% higher than the local check JLA-794 (914 kg ha^{-1}) (Anonymous, 2011b).

The genotype was also tested in Drought Screening Trial in TMC MM 1.3 trial at Nanded during 2005-06 (Table 2). Amongst the genotypes tested, RAC-24 was found promising as drought tolerant due to less reduction in chlorophyll content (21.87 %) and high relative water content (88.63%) during stress period of the season. The entry recorded higher seed cotton yield (1708 kg/ha) than the check NH-545 (736 kg/ha), however, it was at par with the other check PA-402 (1858 kg/ha).

Table 1. Performance of RAC-024 in different Station/ MLT/ Co-ordinated/ trials.

Sr. No.	Trial Location		RAC-024	JLA-794 (C)	Other Checks
Station trials					
1	TMC MM 1.3 trial Surat (2003-04)	1	2290	-	981 G.Cot.16 (C)
2	TMC MM 1.3 trial Nanded (2004-05)	1	2528	-	1139 PA-183(C)
3	TMC MM 1.3 trial Nanded (2005-06)	1	2015	-	1041 PHH-316 (C)
4	TMC MM 1.1 trial Rahuri (2006-07)	1	1452	1235	1165 PA-255 (C)
5	TMC MM 1.3 trial Rahuri (2006-07)	1	1058	780	667 PA-255 (C)
6	Station trial (2009-10)	1	2083	1732	-
	Drought Screening Trial				
1	TMC MM 1.3 Nanded (2005-06)	1	1708	-	1958 PA-402 (C)
	Mean		**1876**	**1249**	**1159**
Multilocation trials					
1	MLT 2006-07	3	994	1314	-
2	MLT 2007-08	3	1138	1540	-
	Mean		**1066**	**1427**	**-**
Co-ordinated trials					
1	Mean of 16 locations (2010-11)	16	1144	914	-
	Mean		**1144**	**914**	
	Overall Mean		1305	1077	
	% increase over JLA-794			21.16	

Pest and diseases:

The screening of RAC- 024 in TMC MM 1.3 trial at Nanded (2005-06) and Rahuri (2006-07) for sucking pest complex and locule damage revealed that infestation due to sucking pests was below economic threshold level at both the locations except for thrips damage at Nanded (Table 4). The culture has shown resistant reaction to BLB, and disease free reaction to dahiya and ALB (Table 5).

Table 2. Perfor mance of RAC-024 for drought tolerance tested at CRS, Nanded in TMC MM 1.3 trial during the year 2005-06.

Sr. No.	Genotype	Seed Cotton Yield (kg ha^{-1})	% reduction in Chlorophyll	RWC (%)
1	RA C-024	1708	21.87	88.63
2	N H-545 (C)	736	31.77	84.78
3	PA -402 (C)	1858	28.91	85.20
	General Mean	**1032.33**	**38.43**	**80.04**
SE	±	145.97		
C	D at 5%	403.96		

Table 4. Screening of RAC-024 against sucking pest complex and bollworm in TMC MM 1.3 Trial at Nanded (2005-06) and Rahuri (2006-07).

Sr. No	Name of variety	Aphids	Jassids	Thrips	White flies	Visual grade	Locule Damage
2005-06 Nanded							
1	RAC-024	9.83 (3.21)	1.33 (1.35)	11.26 (3.42)	4.51 (2.44)	I	4.99 (2.86)
2	PA-402 (C)	8.11 (2.93)	1.65 (1.46)	10.46 (3.31)	4.87 (2.31)	I	2.34 (1.34)
3	NH-545 (C)	12.66 (3.62)	2.90 (1.82)	13.92 (3.79)	4.62 (2.25)	I	17.75 (10.22)
SE ±		**0.19**	**0.12**	**0.17**	**0.15**	**-**	**0.29**
CD at 5%		**0.51**	**0.33**	**0.48**	**0.41**	**-**	**0.79**
2006-07 Rahuri							
1	RAC-024	7.00	1.00	0.83	3.50	I	29.0
2	JLA-794 (C)	4.66	0.03	0.02	1.73	I	25.0
3	PA-255 (C)	3.00	0.83	0.03	2.20	I	31.0
SE ±		**0.75**	**0.13**	**0.08**	**0.27**	**-**	**2.32**
CD at 5%		**2.40**	**0.41**	**0.27**	**0.85**	**-**	**5.54**
Economic threshold level		10/leaf	2/leaf 10/le	af 5/le	af	-	Below 10%

* The figures in parenthesis indicates arc sign values

Quality characters:

RAC 024 was adjudged as the best entry in the trial conducted at 10 locations in respect of fibre length and strength. Th is genotype recorded average fibre length (27.7 mm) and strength (23.2 g tex^{-1}), along with Micronnaire (4.5) in different trials conducted during 2004-05 and 2010-11 (Anonymous, 2011c).

Table 5. Screening of RAC-024 against major diseases in TMC MM 1.3 Trial at Nanded (2005-06) and Rahuri (2006-07, 2010-11).

Sr. No	Name of variety	Disease grade		
		ALB	BLB	GM
2005-06 Nanded				
1	RAC-024	1(R)	1(R)	0 (DF)
2	PA-402 (C)	2 (MR)	2 (MR)	0 (DF)
3	NH-545 (C)	1(R)	2 (MR)	2 (MR)
2006-07 Rahuri				
1	RAC-024	0 (DF)	1(R)	0 (DF)
2	JLA-794 (C)	0 (DF)	2 (MR)	1(R)
3	PA-255 (C)	0 (DF)	0 (DF)	1(R)
2010-11 Rahuri				
1	RAC-024	1 (R)	0 (DF)	1 (R)
2	Y-1(C)	2 (MR)	0 (DF)	3 (MS)
3	JLA-794 (C)	2 (MR)	1 (R)	3 (MS)

Table 6. Fibre quality parameters of RAC-024 in comparison with JLA-794 and Phule-688.

Sr. No.	Genotypes 2.	5 % SL	UNIF (%)	MIC value	STRE. g tex^{-1}	ELON. (%)	SFC (%)	SL ratio
1	RAC-024 *G. arboreum*	27.7 49		4.5	23.2	5.4	12.9	0.85
2	JLA-794 (C) *G. arboreum*	25.6 49		4.9	20.0	-	-	0.78
3	Phule-688 (C) *G. hirsutum*	27.0 50		4.0	22.1	8.0	-	0.82
Fibre Norms		26-28	48-50	3.5-4.5	21-22	-	-	Above 0.80

In view of superior fibre properties and yield potential over the *G. arboreum* check varieties Y-1 and JLA-794, the strain RAC-024 was released under the name "Phule Anmol" and recommended for commercial cultivation in *Khandesh* region of Maharashtra (Jalgaon, Dhule and Nandurbar districts) in the year 2011.

Acknowledgement

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ORAL PRESENTATION

Estimation of Combining Ability Effects for Resistance to *Verticillium* Wilt (*Verticillium dahliae* Kleb.), Earliness and Seed Cotton Yield in Upland Cotton

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Abstract

This study was carried out to investigate the genetic behaviors for resistance to *Verticillium* wilt (*Verticillium dahliae* Kleb.), earliness and seed cotton yield at the six parent lines of cotton (*Gossypium hirsutum* L.), VD-4, PAUM-15, Cukurova 1518, VD-18, Stoneville 468, Nazilli 84S, were crossed in all possible combinations according to the half-diallel mating design, in the years of 2008-2009. Combining ability analysis of the data revealed that general combining ability effects were highly significant ($P \leq 0.01$) for resistance to *Verticillium* wilt, earliness and seed cotton yield. The general combining ability (GCA) variances were greater than specific combining ability (SCA) variances for resistance to *Verticillium* wilt and earliness, which showed the predominance of additive gene effects. SCA variance was greater than GCA variance for seed cotton yield and this showed the predominance of non-additive gene effects. Among the six parents, Stoneville 468 for resistance to *Verticillium* wilt, Cukurova 1518 for yield and PAUM-15 and Nazilli 84S for earliness appeared to be the best general combiners. Among the fifteen cross combinations, 12 for resistance to *Verticillium* wilt, 2 for earliness and 7 for seed cotton yield was found best specific combiner.

Keywords: *Half diallel, general combining ability, specific combining ability.*

This study was carried out as a part of PhD thesis..

Introduction

Improvement of seed cotton yield, earliness and resistance to *Verticillium* wilt (*Verticillium dahlia* Kleb.) are important aims for cotton breeders in Turkey. *Verticillium* wilt is one of the most important diseases in the cotton production areas of Turkey (Celik et. al., 2010). This disease reduces cotton yield and quality. The fungus of *Verticillium* causes a wilt that cannot be effectively controlled by chemical or cultural methods. The best means of control is an intrinsic genetic resistance (Fiola and Swartz, 1994).

Diallel analysis has been widely used by plant breeders in the selection of parents and crosses in the early generations (Marani, 1967; Green and Culp, 1990; Islam et al., 2001; Braden et al., 2003; Kiani et al., 2007). Combining ability describes the breeding value of parental lines to produce hybrids. General combining ability (GCA) effects are the average performance of a parent in combination with all other parents so parents with the highest GCA effects should have greater impact on trait improvement. Specific combining ability (SCA) identifies the best hybrid combinations for trait performance (Kearsey and Pooni, 1996; Rauf et. al., 2006). Information related to the different types of gene action could prove an essential strategy to the cotton breeders in the screening of better parental combinations (Karademir and Gencer, 2010).

The main objectives of this study were evaluate the general combining ability of parents and specific combining ability of their crosses for selecting the superior crosses for inspected traits.

Material and Methods

Six cotton genotypes, VD-4, PAUM-15, Cukurova 1518, VD-18, Stoneville 468 and Nazilli 84S, were selected as parents based on their yield performance, earliness and resistance to *Verticillium* wilt. Parents were crossed using a half diallel mating design in 2008.

Six parents and their fifteen F_1 crosses were planted in a randomized complete block design with three replications at the experimental field of Cukurova University, Cotton Research and Application Center (Adana) in 2009. Rows were 12 m length and distance between and within the row spacing were 70 cm and 20 cm, respectively. Plants were inoculated with the defoliating pathotype of *Verticillium* Wilt, called Mn/8 by Gore, 2007. Stem-puncture technique was used to introduce the conidia (containing 0.2 ml and 10^6 conidia ml^{-1} concentration) directly into the xylem tissues.

All plots were harvested twice by hand on September 10, and September 26, 2009. Earliness was calculated as the percentage of first harvest. After the harvest, the main stem of each plant was cut near the ground. And disease index were rated on plants as a scale of 0 to 4 according to intensity of vascular discoloration. A disease index range from 0 to 2 indicates resistance, and index value above the 2 indicates susceptible (Wilhelm et al. 1974).

A SAS program for the diallel analysis system was used for analysis of variance and estimates of GCA and SCA effects for inspected traits (Zhang ve Kang, 2003, Akiscan, 2011). Estimates of GCA and SCA effects were based on the Griffing's (1956) method II, model I.

Results and Discussion

Analysis of variance (Table 1.) indicated that highly significant differences ($P<0.01$) among the genotypes for inspected traits were found. The mean squares obtained from combining ability analysis (Table 1.) revealed that GCA and SCA variances were significant ($P < 0.01$) for all the traits. SCA variance was greater than GCA variance for seed cotton yield and this showed the predominance of non-additive type of gene actions (dominance or epistatic effects) in the inheritance of this trait. Al-Enani ve Atta (1986), Gulyasar (1987), Kanoktip (1987), Alam et. al. (1991), Kapoor (2000), Karademir (2005), Ilyas et. al. (2007), Karademir et al. (2009) and Karademir and Gencer (2010) also reported the predominance of non-additive type of gene actions regarding this trait. However, GCA variances were greater than SCA variances for resistance to *Verticillium* wilt and earliness, which showed the predominance of additive gene effects.

Table 1. Analysis of variance for genotypes and combining ability in half diallel cross of cotton.

Source of Variation	D.F.	Seed cotton yield (kg da^{-1})	Earliness (%)	Disease index
Replications	2	393.37	362.14	0.17
Genotypes	20	12624.15 **	237.37 **	1.42 **
Error	40	2170.57	30.60	0.10
GCA	5	10070.33 **	481.22 **	3.20 **
SCA	15	13475.42 **	156.09 **	0.83 **
Error	40	2170.57	30.60	0.10
GCA/SCA		0.75	3.08	3.86

** Significant at the *P<0.01 levels of probability*.

The general combining ability effects of parents (Table 2) indicated that genotype Cukurova 1518 was best general combiner for seed cotton yield, while PAUM-15 was found best combiner for earliness followed by Nazilli-84. Higher disease index indicated susceptible genotypes therefore, negative GCA values were considered better for this trait. Then Stoneville 468 was best general combiner for disease index and followed by VD-18 genotype.

Table 2. General combining ability effects of parents for investigated traits.

Genotypes	Seed cotton yield (kg da^{-1})	Earliness (%)	Disease index
VD-4	-1.557	-1.974	**0.631** **
PAUM-15	14.664	**5.326** **	-0.055
Cukurova 1518	**19.414** *	-1.928	-0.009
VD-18	9.231	-6.724 **	**-0.197** **
Stoneville 468	-37.411 **	1.064	**-0.467** **
Nazilli 84S	-4.340	**4.235** **	0.097

**, ** Significant at the P<0.05 and P<0.01 levels of probability, respectively.*

The SCA effects of the crosses for inspected traits are presented in (Table 3). Significant and positive SCA effects for seed cotton yield were observed in seven crosses of the fifteen cross combinations. Cross combination of Cukurova 1518 x Stoneville 468 was best specific combiner for seed cotton yield followed by VD-4 x PAUM-15, Stoneville 468 x Nazilli 84S, PAUM-15 x Cukurova 1518, VD-4 x Cukurova 1518, PAUM -15 x Nazilli 84S and VD-4 x Stoneville 468, respectively. However, significant and positive SCA effects for earliness were observed only in the two combinations. PAUM-15 x Nazilli 84S was best specific combiner for earliness followed by Stoneville 468 x Nazilli 84S.

Table 3. Specific combining ability effects of crosses for investigated traits.

Genotypes	Seed cotton yield (kg da^{-1})	Earliness (%)	Disease index
VD-4 x PAUM-15	**73.176** **	2.649	0.714 **
VD-4 x Cukurova 1518	**57.159** *	4.736	-0.199
VD-4 x VD-18	-6.091	0.065	**-0.478** **
VD-4 x Stoneville 468	**49.384** *	-0.522	**-0.407** *
VD-4 x Nazilli 84S	-52.020 *	5.240	**-0.355** *
PAUM-15 x Cukurova 1518	**60.005** *	3.536	-0.046
PAUM-15 x VD-18	34.288	-5.168	0.008
PAUM-15 x Stoneville 468	-93.304 **	-8.955 **	-0.255
PAUM-15 x Nazilli 84S	**56.259** *	**11.707** **	**-0.419** *
Cukurova 1518 x VD-18	-41.829	3.686	**-0.371** *
Cukurova 1518 x Stoneville 468	**82.113** **	4.865	**-0.467** **
Cukurova 1518 x Nazilli 84S	-90.691 **	-13.805 **	**-0.599** **
VD-18 x Stoneville 468	38.030	1.128	-0.113
VD-18 x Nazilli 84S	10.826	2.390	0.389 *
Stoneville 468 x Nazilli 84S	**65.167** **	**10.536** **	-0.274

**, ** Significant at the P<0.05 and P<0.01 levels of probability, respectively.*

Furthermore, significant negative specific combining ability was observed in seven crosses for disease index. Cukurova 1518 x Nazilli 84S cross combination was best combiner for disease index followed by VD-4 x VD-18, Cukurova 1518 x Stoneville 468, PAUM-15 x Nazilli 84S, VD-4 x Stoneville 468, Cukurova 1518 x VD-18 and VD-4 x Nazilli 84S, respectively.

Conclusions

Significant additive genetic effects were observed for earliness and disease index. Therefore, selection in the early generations (F_2-F_3) may be more suitable for these traits. On the other hand, non-additive genetic effects were observed for seed cotton yield. Hence, selection in the advanced generations (F_4-F_5) may be more suitable for this trait. Among the 15 cross combinations, 7 for seed cotton yield, 2 for earliness and 7 for resistant to *Verticilium* wilt were selected as the promising crosses for the future studies.

Acknowledgment

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ORAL PRESENTATION

Characterization of *PROFILIN* Genes From Allotetraploid (*Gossypium hirsutum*) Cotton and Its Diploid Progenitors and Expression Analysis in Cotton Genotypes Differing in Fiber Characteristics

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Abstract

The actin-binding protein profilin (PRF) plays an important role in cell growth and expansion by regulating the organization of the actin filaments. Recent studies have reported association between fiber elongation in cultivated cotton (*Gossypium hirsutum*) and PRF expression. In the present study, we cloned four genomic clones from allotetraploid cotton (*G. hirsutum*) and its putative diploid progenitors (*G. arboreum* and *G. raimondii*) designated *GhPRF1_A*, *GhPRF1_D*, *GaPRF1*, and *GrPRF1* encoding cotton PRF and characterized their genomic structure, phylogenetic relationships and promoter structure. Sequence analysis of the coding regions of all clones resulted in a single protein product which revealed more than 80% similarity to most plant PRFs and a typical organization with an actin-binding and a polybasic phospholipid binding motif at the carboxy terminus. DNA blot hybridization suggested that *PRF* gene is present with more than one copy in the allotetraploid species *G. hirsutum*. Expression analysis performed in various organs of cultivated cotton revealed that the *PRF* gene was preferentially expressed in cotton fibers. Very low levels of expression were observed in whole flowers, while PRF transcripts were not detected in other organs examined. Furthermore, higher levels of expression were observed at the early stages of cotton fiber development (at

10 days post anthesis), indicative that this gene may play a major role in the early stages of cotton fiber development. Quantitation of the expression by real-time PCR revealed higher expression levels in a *G. hirsutum* variety with higher fiber percentage compared to a variety with lower percentage. In addition, higher levels of expression were found in cultivated allotetraploid *G. barbadense* cotton species with higher fiber length in comparison to cultivated allotetraploid *G. hirsutum*.
Keywords: *PROFILI, Cotton*

ORAL PRESENTATION

Determination of Heterotic Effects of Seed Cotton Weight Per Boll in F_1 Hybrids of Double Cross in Cotton

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Abstract

Double-crosses, compared to the single- mulattos, a larger wealth of genetic terms (diversity) have, where they are ecologically wider spans, more adaptable to environmental conditions, in other words the general adaptation to the environment (adaptation) are the ability to cause a high particularly in the textile industry overcome many problems that may occur with a mixture of varieties increases the likelihood of success.

This study was carried out in order to determine the heterotik effects of investigated properties in the population which created from 45 double cross F_1 generation, using the double cross breeding method, in Diyarbakir ecological conditions in 2010. The trials are conducted as complete block design (RCBD) with three replications. In the study seed cotton weight per boll was studied.

Twenty hybrid cotton combination had positive and high values heterobeltiosis in terms of cotton weight per boll were determined as promising and future studies that need to be taken into consideration in this hybrid combinations.

Keywords: *Cotton, Double Cross, Heterosis, Heterobeltiosis*.

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Agronomy

ORAL PRESENTATION

The Antioxidant Potential: Factor of Abiotic Stress Tolerance in Cotton

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Abstract

Two cotton – abiotic stress factors systems have been investigated: cotton – K/Na imbalance (caused by deficiency of K in the soil and over accumulation of Na in the leaves), phenotypically expressed as leaf reddening, and cotton – water shortage causing drought.

Both stress factors are inducers of a state of oxidative stress. To counteract it cotton plants deploy the antioxidant potential by triggering various mechanisms.

Regarding the first system, in stress-free conditions plants synthesize the anthocyanidin malvidin (with mono hydroxy- substituted B-ring), whereas in stress conditions (reddening) the synthesis of anthocyanidins is intensified and shifted to

another molecule, cyanidin (having o-dihydroxy-substituted B-ring). This structural difference namely determines the higher antioxidant activity of cyanidin as compared to malvidin, finally contributing to the better antioxidant performance of the red leaves.

In overcoming drought stress cotton plants utilize other components of the antioxidant pool. Upon water shortage drought tolerant cotton genotypes maintain higher levels of carotenoids, proline and polyphenols, including flavonoids, as compared to sensitive genotypes. Moreover, they possess a higher ratio of quercetin to kaempferol aglycons, the quercetin being distinguished by a stronger antioxidant activity due to the specific hydroxylation pattern of the B-ring.

Thus the conclusion can be drawn that cotton plants employ an effective versatile network of antioxidant compounds for defense against various abiotic stress constraints. The data obtained contribute to the understanding of the biochemical bases of abiotic stress tolerance in plants, and can serve as a rationale in modeling and engineering abiotic stress tolerant cotton crops.

Keywords: *Cotton, stress, antioxidant potential*

Introduction

It is commonly recognized that the primary event induced by stress factors is the burst of reactive oxygen species (ROS) leading to a state of oxidative stress having a deleterious effect on cell function and structure. Plants have elaborated a diversified defense network of antioxidants (ROS scavengers) to regulate the oxidative stress this allowing the maintenance of normal functioning and survival (Blohina et. al. 2003).

In our research on cotton stress physiology we studied two systems differing in the nature of abiotic constraints: K/Na imbalance (Na accumulation), phenotypically expressed as leaf reddening, and water deficit. Both factors induce a state of oxidative stress (Alia et. Al., 1993; Yildiz-Aktas et. al. 2009).

The purpose of the present paper is to investigate the involvement of antioxidant compounds in the responses of cotton plants to the above stressors.

Material and Method

Experiments on reddening cotton plants were carried out by using Nazilli 84-S cv. grown in three locations of Ege region – Soke, Tire and Bergama. Drought-tolerant Sahin 2000 cv. and drought-sensitive Nazilli 84-S cv. grown in Soke region were used in water shortage experiments being subjected to limited water supply (1/3 field capacity). In leaf samples a range of enzymatic (peroxidase) and non-enzymatic (proline, carotenoids, polyphenols, anthocyanins) antioxidants was determined, and the HPLC (High Performance Liquid Chromatography) profiles of polyphenols and anthocyanins were assayed. Transmission electron microscopy, photosynthetic performance and malonyldialdehyde test were used to assess leaf functional and structural integrity. The methods applied were described elsewhere (Stoyanova-Koleva et. al. 2005; Edreva et. al. 2006; Yildiz-Aktas et. al. 2009).

Results and discussion

In the red cotton leaves a strong accumulation of proline (225 %), total polyphenols (430 %) and anthocyanins (662 %) (percent of controls, green leaves) was recorded. Peroxidase activity was also increased (387 %). All these molecules are endowed with antioxidant properties (Blohina et. al. 2003), and their overproduction contributes to the normalization of ROS level, increased as a result of K/Na imbalance and Na accumulation in the leaves of reddening plants.

HPLC profiles revealed that the predominant anthocyanidin in stress-free conditions (green leaves) is malvidin having mono-hydroxy substituted B-ring whereas in stress conditions (red leaves) the synthesis of anthocyanidins is shifted to cyanidin possessing o-dihydroxy substituted B-ring. This specific molecular feature – the presence of o-dihydroxy grouping – determines the higher antioxidant activity of cyanidin as compared to malvidin which contributes to the better antioxidant protection in red leaves. It is evidenced by the lower fragmentation of membrane lipids as shown by the malonyldialdehyde test (57 % of controls) and the preserved membrane integrity according to data of transmission electron microscopy (Yildiz-Aktas et. al. 2009).

In the leaves of the drought-tolerant genotype Sahin 2000 higher contents of proline, carotenoids, total polyphenols, cinnamic acid derivatives and flavonoids as compared to the sensitive genotype Nazilli 84-S were observed. This impressive difference was expressed in both stress-free conditions (normal water supply) and upon water limitation. Moreover HPLC profiles of polyphenols point to the higher ratio of quercetin to kaempferol flavonoid aglycons in the tolerant than in the sensitive genotype, quercetin being distinguished by a stronger antioxidant activity due to the presence of o-dihydroxy grouping in the B-ring. Thus it can be surmised that the high antioxidant potential is a protective tool against drought which is proved by the better photosynthetic performance and lower membrane damage observed in the drought-tolerant than in the sensitive genotype.

Conclusion

The data revealing the protective role of antioxidants against abiotic stress factors can be used in modeling stress-tolerant cotton crops.

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ORAL PRESENTATION

Performance of New Bulgarian and Foreign Cotton Varieties

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Abstract

This study was conducted to determine yielding performance and some fiber quality characteristics of new Bulgarian and foreign cotton varieties under the conditions of Bulgaria. Eleven Bulgarian varieties - Chirpan-539, Beli Iskar, Veno, Trakia, Helius, Avangard-264, Perla, Vega, Natalia, Darmi and Colorit, four Turkish – Nazilli-84/5, Nazilli-663, Nazilli-954 and Barut-2005, and one Macedonian – 5140 were included in a trial carried out in 2008-2010, in 4 replications and harvested plot of 20 m^2 with sowing design 60×10×1. It was found that most characters were influenced strongly by the year conditions. Under the Bulgarian conditions, Darmi, Helius and Natalia varieties appeared to be the best. The Turkish varieties were not suitable for direct use in Bulgarian production because of maturity latency and insecure yields. However, they had longer fiber, higher lint percentage and bigger bolls, and set up higher their fruit-branches, which makes them very valuable for the cotton breeding programs. The different behavior of Bulgarian and foreign varieties in 2010 compared to the previous two years reflected on their clustering.

Key words: *Cotton, Varieties, G. hirsutum L.,Economic characters*

Introduction

The cotton breeding in Bulgaria achieved undeniable results during the past years. Ten new cotton varieties were created and approved by the Executive Agency for Variety Trials, Approbation and Seed Control in 2007-2010. These varieties have been realized in the frame of two differently purposeful breeding programs by applying of different breeding methods (Stoilova, Valkova, 2008; 2010; Stoilova *et al.*, 2010; Valkova, Stoilova, 2010; Stoilova, 2011).

Foreign cotton varieties have been tested in our country based on the decision of the Inter-Regional Cooperative Research Network on Cotton (Bozhinov *et al.*, 1998a; 1998b; Stoilova, Bozhinov, 2004; Stoilova, Valkova, 2005). Studies on their genetic remoteness showed that some of them could be used in one breeding program with the Bulgarian ones to get a new source material and to create new cotton varieties (Stoilova *et al.*, 2005; Stoilova, Bozhinov, 2006).

Uninterrupted progress in the cotton breeding in the world, including the Mediterranean and Middle East countries, and created variability of new varieties, necessitate genotypes to be examined under various conditions which will permit a better understanding of their genotypic and ecological performance, and to achieve an efficient management in their introduction.

The aim of this research was to examine yielding performance and some fiber quality characteristics of new Bulgarian and foreign cotton varieties under the conditions of Bulgaria.

Material and Methods

Eleven Bulgarian varieties - Chirpan-539, Beli Iskar, Veno, Trakia, Helius, Avangard-264, Perla, Vega, Natalia, Darmi and Colorit, four Turkish – Nazilli-84/5, Nazilli-663, Nazilli-954 and Barut-2005, and one Macedonian - 5140 were included in a trial carried out in 2008-2010 in 4 replications and harvested plot of 20 m^2, with sowing design 60×10×1. As standards were used Bulgarian cultivars Chirpan-539 (for productivity) and Avangard-264 (for fiber quality). The varieties were evaluated on the grounds of obtained data for the most important economic characters: September and total seed cotton yields; boll weight; fiber length; lint percentage and height of first fruit-branch setting. Statistical program ANOVA was applied for statistical data processing. Hierarchical cluster analysis based on the studied characters was also applied. The varieties were clustered using the Ward's method (Ward 1963).

Results and Discussion

Cotton production in our country is developed under conditions of limited temperature resources and unstable rainfall security, and therefore its economic productivity is highly dependent on agro -meteorological condition s during the vegetation period.

Table 1. Agro-meteorological characteristics of the region during the growing season of cotton in the period 2008-2010 compared to the long-term means

Years	Months						Σ IV-IX	Σ VI-VIII	Σ V-IX
	IV	V	VI	VII	VIII	IX			
Temperature sum, Σ t⁰C									
1928 – 2007	343	519	622	720	711	561	3476	2053	3133
2008	386	522	636	717 7	92 5	55	3608	2145	3222
2009	357	569	648	751 7	25 5	71	3621	2124	3264
2010	364	554	625	706 7	98 5	82	3629	2129	3265
Rainfall, Σ mm									
1928 - 2007	45	63	65	52	41	34	300	158	255
2008	66	36	95	36 3 9		1	327	134	261
2009	17	16	14	89 3	5 5	8	229	138	212
2010	63	27	82	114	22	48	356	218	293
Hydro-thermic coefficient (by Selyaninov)									
1928 - 2007	1.31	1.21	1.05	0.72	0.58	0.61	0.86	0.77	0.81
2008	1.71	0.69	1.49	0.50 0	.04 1	.64	0.91	0.63	0.81
2009	0.48	0.28	0.22	1.19 0	.48 1	.02	0.63	0.65	0.67
2010	1.73	0.48	1.31	1.62 0	.28 0	.83	0.98	1.02	0.90

The data for agro-m eteorological conditions of the region during the years of study are given in Table 1. As a whole 2008 was hot in term s of te mperature and middle dry in rainfall supply. Prolonged dr ought during the period of flowering and boll formation – the second part of July a nd August, affected a dversely the yield and fiber length. In term s of tem perature a nd rainfall supply 2009 was also hot and dry. Temperature sum during the vegetation period (1.V.-30.IX.) was 3264 ^{o}C, which was 138 ^{o}C m ore than the long-term mean. Rainfall sum was 211 *mm*, or 47 *mm* below the average of m any years. There were tw o stress periods - drought f rom April to June and sem i-drought in August. Semi-drought in August, in com bination with higher average tem perature com pared to of m any years, accelerated th e flowerin g and boll form ation period and brought about to shortening of th e vegetation period. In this year cotton m atured at the end of August, while in nor mal years it usually matures in the m iddle of Septe mber. Shor tening of the flowering and boll opening period had a strong ad verse effect on seed co tton yield and fiber quality, s tronger expressed for the qualitative varieties having a longer vegetation period. In term s of temperature security 2010 was hot, by 132 °C higher temperature sum during the vegetation period and 76 °C higher in the summer months, compared to the average values of many years. The rainfall during the growing season was more than 38 *mm* over the norm and for the summer months it exceeded the average of many years by 60 *mm*. This year was humid, with a dry period in May.

Table 2. Two-factor data analysis of the economic characters of Bulgarian and foreign cotton varieties tested at the Field Crops Institute in Chirpan, 2008-2010

Source of variation	Degree of freedom	Sum of squares	Sum of squares, %	Dispersion	$F_{exp.}$
		September yield			
Varieties - A	15	4776300	78.0	318420	112.8^{+++}
Years-B 2		290245	4.7	145123	51.4^{+++}
Interaction A×B	30	659005	10.8	21909	7.8^{+++}
Errors 1	41	397920	6.5	2822	
		Total yield			
Varieties - A	15	2011850	29.6	134123	40.5^{+++}
Years-B 2		3786350	55.7	1893175	571.6^{+++}
Interaction A×B	30	531310	7.8	17710	5.3^{+++}
Errors 1	41	467010	6.9	3312	
		Boll weight			
Varieties - A	15	13.3	32.1	0.883	11.3^{+++}
Years-B 2		9.9	23.9	4.923	63.2^{+++}
Interaction A×B	30	7.2	17.7	0.239	6.1^{+++}
Errors	141 11	.0 26	.6	0.078	
		Fiber length			
Varieties - A	15	145.6	24.8	9.7	28.7^{+++}
Years-B 2		312.8	53.3	156.4	462.4^{+++}
Interaction A×B	30 80	.7 13	.8	2.7	7.95^{+++}
Errors 14	1	47.7	8.1	0.34	
		Lint percentage			
Varieties - A	15	769.3	35.6	51.3	75.5^{+++}
Years-B 2		1147.3	53.0	573.7	844.5^{+++}
Interaction A×B	30	151.3	7.0	5.0	7.4^{+++}
Errors 14	1	95.8	4.4	0.68	

Two-factor data analysis of the economic characters in 2008-2010 (Table 2) showed that the effect of genotypes was highly significant for all the traits, which means that the genotypes significantly differed. The varieties had the highest participation in the tota l varia tion of the Septem ber yield and boll weight. This means that the phenotyp ic exp ression of these two characters m ainly depended on the genotypes of varieties. For the othe r characters variation by years was with greater involvem ent showing a high influence of envir onmental conditions on their expression and it was m ore strongly expr essed for the total yield. Genotype-environment inter action was signif icant f or all characters, which m eans that th e genotypes interacted with the environmental conditions.

Table 3. Econom ic characters of Bulgarian a nd foreign cotton varie ties tested at th e Field Crops Institute in Chirpan, 2008-2010 (average data for 3 years)

Variety	Total yield *kg/ha*	In % to Chirpan-539	September yield *kg/ha*	In % to Chirpan-539	Boll weight *g*	Fiber length *mm*	Lint percent %	Height of the1st fruit-branch *cm*
Chirpan-539 2	307	100.0	1835	100.0	5.3	26.6	39.8	16.8
Beli Iskar	2264	98.1	1795	97.8	5.4	26.5	38.4^{0} 15	.6
Veno	2131	92.4^{0}	1710	93.2	5.4	26.7	38.3^{0} 14	.8^{000}
Trakia 2	367	102.6	2048	111.6^{++} 5.	4	26.3	38.0^{0} 16	.1
Helius 2	466	106.9^{+} 2	152	117.3^{+++} 5.	4	26.4	38.1^{0} 15	.7^{0}
Avangard-264	2183	94.6	1845	100.5	5.4	28.0^{+++} 36	.3^{000} 14	.6^{000}
Perla-267 2	387	103.5	2088	113.8^{+++} 5.	3	28.1^{+++} 36	.3^{000} 17	.1
Natalia 2	483	107.6^{+} 2	138	116.5^{+++} 5.	3	28.0^{+++} 37	.7^{000} 17	.0
Darmi	2519	109.2^{++} 2	208	120.3^{+++} 5.	2	28.0^{+++} 37	.4^{000} 17	.4
Colorit	2349	101.8	2043	111.3^{++} 5.	6^{++} 27	.7^{+++} 37	.0^{000} 18	.5^{++}
Vega	2423	105.0	2047	111.5^{++} 5.	5^{+} 27	.9^{+++} 37	.0^{000} 17	.9^{+}
Nazilli 84/5	1774	76.9^{000}	978	53.3^{000} 5.	8^{+++} 28	.1^{+++} 42	.1^{+++} 22	.5^{+++}
Nazilli 663	1446	62.7^{000}	793	43.2^{000} 6.	3^{+++} 28	.5^{+++} 42	.6^{+++} 25	.0^{+++}
Nazilli 954	1613	69.9^{000}	758	41.3^{000} 5.	8^{+++} 29	.0^{+++} 41	.1^{+++} 24	.7^{+++}
Barut 2005	1803	78.1^{000}	1012	55.1^{000} 5.	8^{+++} 28	.5^{+++} 40	.9^{+++} 19	.5^{+++}
5140	2352	102.0	1957	106.6	5.6^{++} 26	.5	36.7	16.8
GD 5 %	147	6.4	135	7.4	0.2	0.5	0.7	1.1
GD 1%	194	8.4	179	9.7	0.3	0.6	0.9	1.4
GD 0.1 %	250	10.8	230	12.5	0.4	0.8	1.1	1.9

The total yield, average for three years, ranged from 1446 *kg/ha* to 2519 *kg/ha* (Table 3). Darm i, Natalia and Helius va rieties showed the highest yields and exceeded the standard variety Chirpan-539 by 6.9 to 9.2%. Other Bulgarian varieties were equal with the standard, except for the var iety Veno whi ch was inferior by 7.6%.

Macedonian variety 5140 produced 102% to the standard and in 2010 exceeded it by 12.4%, in 2008 - by 3.1%, but in 2009 was inferior by 13.3% (data are not given here). All Turkish varieties in total yield were inferior to the standard by 21.9% to 37.3%, average of the three years. Among them, the highest yield was found for Barut-2005 and it was followed by Nazilli-84/5. Statistical data proceeding showed high significance of the differences between all Turkish varieties and the standard variety Chirpan-539.

The September yield, analyzed for its relationship to earliness, average for three years, ranged from 758 *kg/ha* to 2208 *kg/ha* and was the highest for Darmi, followed by Helius and Natalia. The Macedonian variety 5140 was equal with the standard - Chirpan-539, but was inferior to most Bulgarian varieties. Turkish varieties were late in maturity and produced lower September yields.

As for the boll weight the Turkish varieties showed higher values - 5.6-6.3 *g* as against 5.2-5.6 *g* for the Bulgarian ones (average for three years). The biggest boll weight was found for the variety Nazilli-663.

The fiber length (average for three years) ranged from 26.3 *mm* to 29.0 *mm*. The Turkish varieties had fiber length 28.1-29.0 *mm*, Bulgarian ones - 26.3 -28.1 *mm*. The longest fiber was found for the Turkish variety Nazilli-954. Of Bulgarian varieties, Chirpan-539, Beli Iskar, Veno, Trakia and Helius had short fiber (26.3-26.7 *mm*), while the others had longer fiber (27.7-28.1 *mm*). The Macedonian variety 5140 in fiber length (26.5 *mm*) was equal with the Bulgarian varieties having short fibers.

In 2009, as a result of drought stress in August the fiber length was shortened compared to 2008, by 2.9 *mm* and 3.9 *mm* for the Turkish varieties Barut-2005 and Nazilli-84/5, and by 1.7- 2.1 *mm* for the Bulgarian varieties Chirpan-539, Veno and Avangard-264.

The Turkish varieties had higher lint percentage (40.9-42.6%) than the Bulgarian ones (36.3-39.8%). Chirpan-539, Beli Iskar, Veno, Trakia and Helius varieties showed lint percentage of 38.0-39.8%, while the others, having longer fiber, had lower lint percentage - 36.3-37.0%. Macedonian variety 5140 had also lower lint percentage (36.7%).

All Turkish varieties characterized by a high setting of first fruit-branch - 19.5-25.0 *cm*. Of the Bulgarian varieties, Colorit and Vega showed significantly higher setting of the first fruit-branch (17.9-18.5 *cm*). The other varieties set up the first fruit-branch at height of 14.6-17.4 *cm* and by this character were equal with the standard (16.8 *cm*) or inferior. Height less than 13 *cm* is considered to be critical for the cotton mechanical picking.

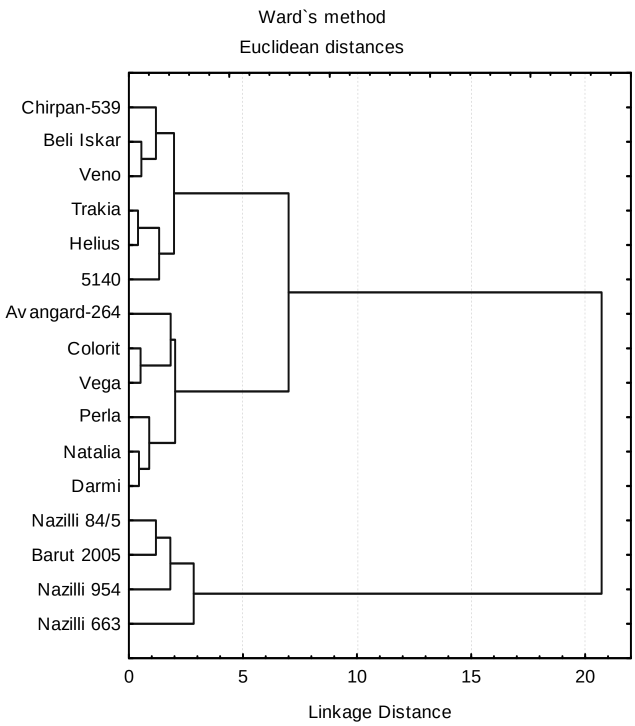

Figure 1. Dendrogram of 16 cotton varieties by six characters on average data for three years (2008-2010)

Based on the data of analyzed characters in Table 1 cluster analysis of tested varieties was performed. The dendrogram on Fig. 1 shows that the varieties formed two major clusters. The first cluster included all Bulgarian varieties and the Macedonian variety 5140, while the second one included all Turkish varieties.

The Bulgarian varieties divided into two groups, each of them subdivided into still smaller groups, indicating that there were genetic differences at the lowest level of division. The varieties Beli Iskar, Veno, Trakia, Helius and 5140 (Macedonian) were in one group together with the standard variety Chirpan-539. These varieties were obtained by intraspecific hybridization within the *G. hirsutum* L. species

(Chirpan-539, Beli Iskar, Veno) and experimental mutagenesis (Helius and Trakia). The Varieties Trakia and Helius were genetically very similar. Of them, the Macedonian variety 5140, possessing lower lint percentage, detached as an independent. The varieties Beli Iskar and Veno were also very similar. Of them, Chirpan-539, possessing higher productivity and higher lint percentage, separated as an independent.

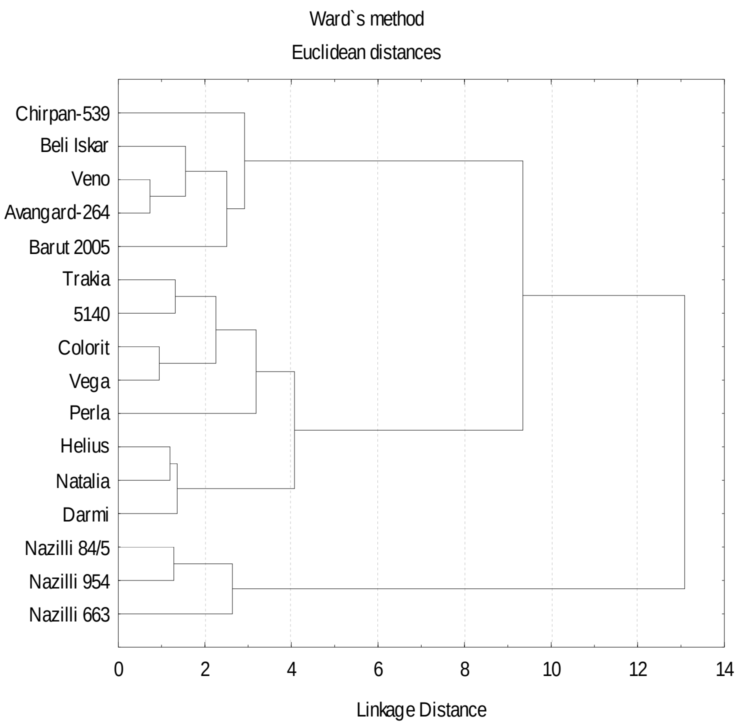

Figure 2. Cluster analysis of 16 cotton genotypes by six characters in 2010

The other group included Avangard-264 (standard for fiber quality), Colorit, Vega, Perla, Natalia and Darmi. These varieties were created by interspecific hybridization of the species *G. hirsutum L.* × *G. barbadense L.* (Avangard-264) and hybridization of stabilized lines (*G. hirsutum L.* × *G. barbadense L.*) with promising varieties of the *G. hirsutum L.* spesies. These varieties distinguished by longer fiber and lower lint percentage. The varieties Colorit and Vega were genetically very similar, Avangard-264 separated from them. The varieties Natalia and Darmi were also very similar, Perla separated from them. Differentiation of the Bulgarian varieties into two groups was almost entirely determined by the inclusion of genotypes with germplasm of the *G. barbadense L.* species. Of the Turkish varieties, Barut-2005 and Nazilli-84/5 were very similar, while Nazilli-954 and Nazilli-663 formed separated subgroups.

Clustering of the varieties in 2008 and 2009 was similar to that based on the average data (Figures are not given here) with the exception of Darmi and 5140 in 2009, when they changed their groups.

Fig. 2 presents clustering of the varieties in 2010. Three Bulgarian varieties - Avangard-264, Trakia and Helius, and Macedonian 5140 changed their groups. Turkish variety Barut 2005 has changed its major cluster and was in one group with Chirpan-539, Beli Iskar, Veno and Avangard-264. The varieties Avangard-264 and Veno were genetically very similar. In this group the variety Chirpan-539 was more distinct, probably because of its higher yield and higher lint percentage. In the other group similarity was found for the varieties Trakia and 5140 as well as for Natalia and Helius.

The moving of genotypes from one cluster to another one at the environmental conditions changes was probably due to genotype-environment interaction which was significant for all characters. When the genotypes were clustered on the average data their stability by characters and years probably was partially included.

Bulgarian and foreign varieties reacted more specifically to the environmental conditions in 2010 compared to the previous two years in terms of the studied characters. Of Turkish varieties, Nazilli-84/5 and Nazulli-954 matured earlier than Barut 2005, which manifested as the earliest among them in 2008 and 2009, and they were on a level with the standard variety Chirpan-539 in seed cotton yield due to prolonged growing season.

The Bulgarian varieties Beli Iskar, Veno, Trakia and Helius which usually have shorter fiber and higher lint percentage than other ones formed a comparatively longer fiber (especially Veno) and lower lint percentage. Turkish varieties usually have higher lint percentage than Chirpan-539, but they were equal with it. Of the qualitative varieties, Darmi formed shorter fiber and by this property was equal with the varieties Trakia and Helius. The heavy rainfall during the summer months June and July advantaged the formation of longer fiber at the early varieties, but affected adversely their lint percentage because of the seeds weight increasing. Different behavior of the varieties in this year, compared to the previous two, gave impact on their clustering, but did not affect strongly the clustering based on the three years average data.

Conclusions

1. During the first two years of study (2008-2009) there was a sufficient temperature sum and insufficient rainfall security for the cotton. Rainfall in September did not compensate the lack of moisture during the summer months, only prolonged the vegetation period.

2. The varieties had the greatest impact on the September yield and boll weight. Other characters were affected most strongly by the year conditions.

3. Under the conditions of Bulgaria, Darmi, Helius and Natalia varieties appeared to be the best and exceeded the standard variety Chirpan-539 in seed cotton yield by 6.9-9.2%. Darmi and Natalia had longer fiber than Chirpan-539 by 1.4 *mm*.

4. Cluster analysis based on the average data confirmed the genetic differences between Bulgarian varieties which were realized in the frame of two differently purposeful cotton breeding programs - for productivity and fiber quality.

5. Turkish varieties are not suitable for direct use in the Bulgarian cotton production because of their lateness and insecure yields. They are, however, characterized by longer fiber, higher lint percentage, larger bolls and set higher first fruit-branch, which makes them very valuable for the cotton breeding in our country.

6. In view of the fact that varieties interact with the environmental conditions the clustering should base on average data or environments relevant to the purposes of selection.

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ORAL PRESENTATION

Effect of Drought Stress on Leaf Area in Cotton (*Gossypium hirsutum* L.)

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Abstract

The objective of this study was to determine the effect of drought stress on cotton leaf area characteristic. The experiment was carried out at the GAP International Agricultural Research and Training Center in 2010 cotton growing season with the aim of evaluating 12 cotton genotypes for leaf area development under irrigated and water stress conditions. The experiment was laid out as a randomized split block design with four replications. Significant differences were observed among genotypes, treatments and genotypes x treatments interaction for leaf area. The mean leaf area of genotypes changed from 67.15 to 82.02 cm ^{2}, mean of control was 84.82 cm ^{2}, while the mean of water stress treatment was 62.59 c m^2. The result of this study indicated that leaf area decreased approximately 30% under drought stress condition.

Keywords: *Cotton (Gossypium hirsutum L.), Drought Stress, Leaf Area.*

Introduction

Water stress is the most important factor limiting crop productivity that adversely affects fruit production, square and boll shedding, lint yield, and fiber quality properties in cotton (El-Zik and Thaxton, 1989). As the global climate changes continue, water shortage and drought have become an increasingly serious constraint limiting crop production worldwide.

The demand for drought tolerant genotypes will be exacerbated as water resources and the funds to access them become more limited (Longenberger et al., 2006). Previous studies revealed that 2-4 °C increase in temperature and the expected 30% decrease in precipitation may adversely affect crop productivity and water availability by the year 2050 (Ben-Asher et al., 2007). Thus, screening cotton varieties for resistance to drought stress conditions and improving cotton tolerance to this stress conditions will be mitigate negative consequences of this adversity. Cotton is normally not classified as a drought tolerant crop as some other plants species such as sorghum which is cultivated in areas normally too hot and dry to grow other crops (Poehlman, 1986). Nevertheless cotton has mechanisms that make it well adapted to semi-arid regions (Malik et al., 2006). An understanding of the response of cultivars to water deficits is also important to model cotton growth and estimate irrigation needs (Pace et al., 1999). Previous studies reported variation in drought resistance among and within species (Penna et al., 1998). Water-deficit stress adversely affects plant performance and yield development throughout the world (Boyer, 1982).

Table 1. Plant height, stem and leaf dry weight, leaf area, and node number in drought stressed and well-watered control plants of Stonevelle 506 and Tamcot HQ95 at the end of the drought, 49 days after planting. The drought treatment was imposed by withholding water for 13 d. (From Pace *et al*., 1999).

Plant Part	**Treatment**	
#	Drought	Control
Plant height (cm) #	20.0*#	27.9#
Stem dry weight (g)#	1.13*#	1.39#
Leaf dry weight (g) #	1.41*#	2.16#
Leaf area (cm^2) #	56*#	153#
Node number #	7.8*#	9.4#

* Means in a row are significantly different at the 0.05 probability level.
The objective of this study was to determine the effect of drought stress on cotton leaf area characteristic.

Leaf area is a determinant factor in radiation interception, photosynthesis, biomass accumulation, transpiration and energy transfer by crop canopies. It is also important with respect to crop-weed competition and soil erosion (Jonckheere et al., 2004). Therefore, leaf area is measured in many different studies. There are plenty of investigations on relationship between drought and leaf area or leaf area index in cotton. Water-deficit stress reduces cell and leaf expansion, stem elongation, and leaf area index (Jordan *et al.*, 1970; McMichael and Hesketh, 1982; Turner *et al.*, 1986;

Ball *et al*., 1994; Gerik *et al*., 1996). Genotypes with smaller leaf area have an advantage under condition of water stress (G. S. Chaturvedi et al,.2012). Leaf, stem and root growth rate are very sensitive to water stress because they are dependent on cell expansion (Hsiao, 1976; Hearn, 1994). Krieg and Sung (1986) reported that water stress caused a reduction in the whole plant leaf area by decreasing the initiation of new leaves, with no significant changes in leaf size of leaf abscission. Both the main stem and sympodial branches developed significantly less leaves; however, the effect was less severe on the main-stem leaves. Impaired mitosis, cell elongation and development result in reduced plant height, leaf area and crop growth under drought (Nonami, 1998; Kaya *et al*., 2006; Hussain, 2008). Pettigrew (2004) reported that water-deficit stress resulted in a decrease in leaf size. Available reports showed that drought tolerant species reduced the water loss either by reducing the leaf area or limiting stomatal opening (Gillani,. 2010). Crop cultivars selected for yield under water-limited environments often have constitutively reduced leaf area associated with smaller leaves (Blum 2005). In many cases, water deficit reduces growth, and leaf area development and duration (Alishah et al,.2009).Significantly fewer nodes and lower dry weights of stems and leaves of water-stressed plants compared to those of the control were reported by Pace *et al* (1999)(Table 1).

Materials and Methods

The experiment was carried out at the GAP International Agricultural Research and Training Center's experimental area during 2010 growing season in Diyarbakir/Turkey. In the study, twelve cotton genotypes were observed in terms of leaf area characteristic under water stress and non-stress conditions. Eight advanced cotton lines (BMR-25, SMR-15, TMR-26, BST-1, SER-21, SST-8, CMR-24, SER-18) developed for tolerance to drought stress, and four commercial cotton varieties (Stoneville 468, BA 119, GW-Teks and Sahin 2000) were used as plant material.

The experiment was carried out under field condition as a randomized split block design (RSBD) with two blocks, one well watered and the other water stress applied, with four replications in each block. Genotypes were randomized within each of the main blocks and replications. Each sub plot consisted of four rows of 12 m length, between and within the row spacing were 0.70 m and 0.20 m respectively.

Between main plots 4.2 m space is left for avoiding edge interference between the treatments.

Seeds of these cotton genotypes were planted with combine cotton drilling machine on 7th May, 2010 and all plots were treated with 20-20-0 composite fertilizer to provide 70 kg N ha-1 and 70 kg P_2O_5 ha-1. Just before flowering, 70 kg N ha-1 were applied as ammonium nitrate as an additional N dose. Herbicides were used twice in both the years. In both years, insect were monitored throughout the experiment and no insect control was necessary during these growing season. Plants were grown under recommended cultural practices for commercial production; the experiment was thinned and hoed three times by hand and two times with a machine.

Experimental plots were irrigated by drip irrigation method. Water treatments consisted of two regimes, one of the well watered and the other water-stressed. Throughout the growing season, 378 mm water was given in water stress treatment and 756 mm water was given in non-stress treatment. In the stress application, plants were subjected to water stress from flowering stage to 10% boll opening period.

Measurements were taken on five leaves per plot with the average of the five leaves used for statistical analysis. For measuring leaf area five plants were selected randomly from each plot and labeled. 80 days after planting (peak flowering stage) fifth fully expanded leaf below the terminal was cut from each plant and copied on the pages, later copied pages were scanned and leaf area calculated as cm^2 $leaf^{-1}$ with Net.Cad 5.1 GIS computer program.

Plots were harvested twice by hand and the obtained seed cotton from the four rows of the plots were weighed and calculated for seed cotton yield and fiber yield. The first harvest was 7th October, 2010 and the second harvest was done on 9th November, 2010. After the harvest, seed cotton samples were ginned on a mini-laboratory roller-gin for lint quality. Fiber quality properties were determined by High Volume Instrument (HVI Spectrum). Statistical analysis were performed using JMP 5.0.1 statistical software (http:// www.jmp.com) and the means were grouped with $LSD_{(0.05)}$ test.

Results and Discussion

The analysis of variance of the investigated characteristics and the obtained findings from the cotton genotypes are presented in Table 1. Significant differences were obtained among genotypes and treatments for seed cotton yield, fiber yield and leaf area. Treatment x genotype interactions was non-significant for all the measured traits. Seed cotton yield, fiber yield and leaf area were consistently affected by water treatment.

Table 1. Average values of seed cotton yiel ds, fiber yields and leaf area of cotton genotypes

Genotypes	Seed Cotton Yield (kg ha^{-1})			Fiber Yield (kg ha^{-1}) Leaf			Area (cm^2 $leaf^{-1}$)		
Stress		Normal	Avarege	Stress	Normal Avarege		Stress	Normal	Avarege
BMR-25 2076,	2	2764,8 2420,	5 cd	865,9	1143,5	1004,7 c	57,92	86,85	72,38 bd
SMR -15	1835,4	2968,0 2401,	7 cd	728,1	1141,9	935,0 cd	70,70	86,72	78,71 ab
TMR-26 2003,	9	2840,1 2422,	0 cd	812,7	1152,8	982,8 cd	65,27	90,90	78,08 ab
BST-1 1962,	9	2622,7 2292,	8 cd	806,6	1069,0	937,8 cd	65,62	85,55	75,59 bc
SER-21 1945,	8	2780,6 2363,	2 cd	807,9	1144,6	976,3 cd	62,58	74,89	68,74 d
SST-8 2064,	4	2815,9 2440,	1 cd	826,9	1142,1	984,5 cd	53,26	85,59	69,43 cd
CMR-24 1935,	5	2542,3	2238,9 d	790,2	1060,5	925,4 d	62,57	80,06	71,31 cd
SER-18 2307,	5	3147,9 2727,	7 ab	946,9	1288,2	1117,5 b 68,	20	95,84 82,	02 a
STV 468	2419,0	3246,3	**2832,6 a**	1081,0 1439,	4	**1260,2 a**	60,99 73,	54	**67,26 d**
BA 119	2184,2	2834,6 2509,	4 bc	968,9 1269,	3	1119,1 b	56,94	77,37	**67,16 d**
TEKS 1849,	4	2724,5	2286,9 cd	793,6	1164,9	979,3 cd	64,26	86,08	75,17 bc
SAHIN 2000	1980,2	2733,8	2357,0 cd	807,4	1088,5	948,0 cd	62,79	94,47	78,63 ab
Mean	2047,0 b	2836,7 a	2441,9	853,0 b	1175,4 a	101,42	62,59 b	84,82 a	73,71
CV (%)	9,24 9,			03			9.53		
LSD $_{0,05}$									
Genotype	22,44** 7,			18**			6,37**		
Treatment	9,15** 2,			93**			2,89**		
G x T.	NS NS						NS		

Among the genotypes, highest seed cotton yield was obtained from SER-18, Stoneville 468 BA 119 and SST-8 in water stress conditions. Stoneville 468 also had the highest yield under well watered conditions. This situation indicates drought tolerance of these genotypes (SER-18, Stoneville 468 and SST-8) as compared to others. These genotypes also maintained higher fiber yield under stress conditions. These seed cotton yield and fiber yield reductions are similar to those reported by (El-Fouly et al., 1971; Marur, 1991; Cook and El-Zik, 1993;Rajamani, 1994; Pettigrew, 2004b; Bolek, 2007;Alishah and Ahmadikhah, 2009).

Significant differences were observed among genotypes and treatments for leaf area. The mean leaf area of genotypes changed from 67.15 to 82.02 cm^2, mean of control was 84.82 cm^2, while the mean of water stress treatment was 62.59 cm^2. These results indicated that there was nearly 30% of reduction in leaf area when comparing the stress and non-stress treatment. Similar results were reported by Jordan *et al*., 1970; McMichael and Hesketh, 1982; Turner *et al*., 1986; Ball *et al*., 1994; Gerik *et al*., 1996; Krieg and Sung,.1986; Nonami, 1998; Kaya *et al*., 2006; Hussain, 2008; Pettigrew, 2004; Gillani,. 2010; Alishah et al,.2009; Pace *et al.*,1999.

Conclusion

From this study, it can be concluded that the water stress significantly affected cotton yield, fiber yield and leaf area characteristic. Leaf area decreased almost 30% due to water stress treatment. As seen in this study the leaf area can be the indicator of stress in terms of physiological studies. Physiological parameters such as leaf hairiness, leaf water content, root length, fast root growth, root/shoot ratio, chlorophyll content, photosynthesis and stomatal conductance should be measured in order to learn the mechanism of the drought stress.

Acknowledgement

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ORAL PRESENTATION

Evaluation of Germination Ability of Cotton Cultivars under Artificial Stress Conditions (*Gossypium hirsutum* L.)

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Abstract

Eleven cotton cultivars were evaluated for germination efficiency concerning both, the relevant percentage and the germination rates. Seeds from the selected cultivars were placed for seven days, in conditions of increased osmotic pressure achieved by gradually increasing concentrations of polyethylene-glycol solutions.

A differentiation in cultivars behavior concerning the percentage and the germination rate was observed. Among the eleven cultivars tested "HERMES" was the least and "SANDRA" was the most affected concerning the two measured parameters. The remaining cultivars are graded in intermediate order. In all cases the cultivar x polyethylene-glycol interaction was significant.

Keywords: *Cotton, Polyethylene glycol, germination..*

Introduction

Cotton plant has the most complex structure of any major field crop while the germination and seedling establishment is one of the most critical stage for plant development.

The cotton varieties differ in their levels of resistance to adverse environmental conditions, namely in germination under dry and hot conditions. The selection of appropriate genotypes that are better adapted to these conditions, based on genetic variability, is the most effective and the most economical way to improve cotton (Wayne και Cothren 1999).

Germination seeds are particularly prone to chilling injury due to early planting dates and in addition to this, water stress, oxygen deficiency and soil compaction may result in reduced germination rates and poor quality seedlings. The sharp temperature increases causes soil compaction and as a result delay and even the failure of germination. On behalf of these circumstances the watering is unavoidable with increase of cultivation cost (Hake et al., 1996).

Early sowing and use of cotton varieties resistance to drought is of great importance for countries like Greece, because it is in the margins of cotton belt with usually cool temperatures and high moisture at planting time.

Polyethylene glycol (PEG) has been used worldwide, in order to estimate the resistance of various seeds to germinate under drought laboratory conditions (Hadas 1977, Ashraf and Abu - Shakra 1978, Somers et al., 1983). PEG when dissolved in water then prevents the intake of the plants. The denser is a solution, the greater negative pressure needed for the plant to absorb water. Hadas (1977) compared the results of germination rates of many species in the laboratory using PEG solutions and found that there is a very close relationship with the results in the field.

Somers et al. (1983) also used PEG, in order to create drought conditions in the laboratory and select genotypes of sunflower that grows best under dry and hot conditions. In solutions of 20g to 40g PEG molecular weight 20000/100ml H_2O, which created environment from -6 to - 21 bars, the same researchers found wide variation in the percentage germination. Their results were subsequently confirmed in the field.

Aim of this study was the evaluation of germination efficiency concerning both, the relevant percentage and the germination rates of eleven cotton cultivars with the use of different concentrations of PEG solutions.

Materials and Methods

Cotton seeds of eleven commercial varieties, with great market share in Greece over the last three years, were used in a laboratory experiment in Cotton and Industrial Plant, Thessaloniki Greece. Fifty seeds from each variety plated in petri, with 10ml of PEG molecular weight 6000. The concentrations of PEG used were 0, 40, 80, 120, 160 g/100m l H_2O. The petris were placed covered in growth cham bers at 28^0C for seven days, in order to avoid impact of environment moisture.

The Split-p lot design was used, which allows the testing o f two f actors in combination. The m ain effect was the c oncentrations of PEG and serves as a replication for the se cond factor, the cultivars. The analysis of variance is sim ilar to that used with the experimental design completed randomized (CR).

Within each repetition random ized levels of the first factor A (solution PEG 0, 40, 80, 120, 160 g/100m l H2O) used and s ubsequently at each level was the randomization of levels of the second factor B (11 varieties). As the aim of this study was to m easure the resp onse of particular varieties they are placed in su bfragments, where the experimental error is smaller and the comparison more accurate (Steel and Torrie 1980).

Germination percentage m easurements were m ade every day the sam e tim e and a seed with a radicle > 0.5 cm was considered germ inated. In each repetition there was a blank. The germination rate measured by the type

Ve = Snx / dx proposed by Ca margo and Vaughan (1973) for sorghum. In this equation nx is th e num ber of seed s germ inated on day x and dx the num ber of days from the beginning of germination till x days.

Data obtain ed were an alyzed for s ignificance by testing the difference of means LSD (P=0.05).

Results and Discussion

Table 1 sh ows the res ults f rom the sta tistical analy sis o f variance of the percentage germination and germ ination rate of eleven cotton varie ties. The effect of PEG is sta tistical s ignificant bo th f or the ge rmination percen tage a nd f or the germination rate. The varieties have statistically significant differences for both these measurements. The interaction between vari eties and PEG was also significant, and all v arieties didn' t r eact in the s ame way in the incr eased osm otic pr essure environments.

Examining the external means (A), with $LSD_{0.5}$ = 5.02 (between two averages A) we obs erve that the differences we re signif icant am ong all tre atments. The general m ean value of blank percentage germ ination in all varieties was 83.7%, significantly higher than the corresponding m ean value of the seeds germ inated in

40g PEG/100ml H_2O solution. In 80g PEG/100ml H_2O solution, the mean value of all varieties reduced to 57,6% while in 120g PEG/100ml H_2O solution the germination percentage was 30,2 % and only 2,2% in160g PEG/100ml H_2O solution. The negative effect in germination percentage is directly related to the concentration of PEG as observed also from Sharma 1973 and Smith et al. 1989.

Table 1. Analysis of variance of germination percentage and rate of cotton seeds in indifferent PEG solutions.

Source of variance	Degrees of freedom	Mean square Germination		F Germination	
		Percentage	Rate	Percentage	Rate
PEG (A)	4	11611.7	2306.3	**	**
Error A	15	30.5	7.6		
Varieties (B)	10	355.7	97.5	**	**
Interaction	40	75.3	10.5	**	**
Error A	150	11.4	2.8		
Total	219				

** $P < 0,01$

Table 2. Mean values of germinated cotton seeds in different PEG solutions.

PEG (A)	Varieties (B) CELIA	BOLINA	HERMES	NOVA	OPAL	ELINA	CARMEN	ETHIAGE - 1	VOLCANO	SANDRA	MIDAS	Average
Blank	84.0	85.0	83.0	84.0	84.0	83.0	84.0	83.0	83.0	84.0	84.0	83.7
40g/100ml H_2O	79.0	78.5	85.5	61.5	68.0	71.5	77.5	45.5	81.0	45.0	66.5	69.0
80g/100ml H_2O	66.5	70.5	81.0	38.5	49.5	61.0	69.5	49.5	66.0	37.5	44.0	57.6
120g/100ml H_2O	42.5	43.0	57.0	7.0	26.0	28.5	46.5	24.0	33.0	13.5	11.0	30.2
160g/100ml H_2O	3.0	3.5	1.0	2.0	5.5	5.0	0.5	1.0	2.0	1.0	0.0	2.2
Average	55.0	56.1	61.5	38.6	46.6	49.8	55.6	40.6	53.0	36.2	41.1	

$LSD_{0,5}$
5,02 between two A averages,
4,22 between two B averages,
9,44 between two B averages in the same A level,
10,31 between two A averages in the same or diffeerrent B level.

Table 2 presents the mean values of germinated cotton seeds in different PEG solutions.

Examining the external means (B), with $LSD_{0.5}$ = 4.22 (between two averages B) we observe that variety HERMES had the higher germination percentage in all concentrations. Varieties Bolina, Carmen, Celia and Volcano had high germination percentage with no statistical significant differences while Midas, Ethiage 1 and Nova presented the lower percentage with the lower percentage in Sandra variety. These results shown that drought conditions caused by PEG, reduced the germination ability of all tested varieties with statistical significant differences between them.

PEG concentrations of 120g and 160g /100ml H_2O reduced the germination ability with no practical interest in the field. On the other hand, the conditions of 40g/100ml H_2O and 80g PEG/100ml H_2O more simulated with the field conditions.

In the concentration of 40g PEG/100ml H_2O observed great variety differentiation and varieties Hermes, Volcano, Celia, Bolina and Carmen show high percentage germination with no significant differences (LSD_{05}=9,44 between two B averages in the same A level). The comparison of the mean values of the above varieties with the values of control (LSD_{05}=10.31 between two A averages in the same B level) shown no statistical significant differences. This means that low levels of drought have no effect on these varieties. On the other hand to the germination percentage of varieties Nova, Opal, Elina, Ethiage 1, Sandra and Midas observed statistically differences in comparison with the control. This means that the lack of moisture at levels similar to 40g PEG/100 ml H2O has no effect to the first group of varieties but to the second group of varieties there will be a need for replanting to the field.

To the next concentration level of 80g PEG/100ml H_2O observed a statistical significant differentiation between the varieties. Germination percentage of Hermes variety was 81%, no statistically different both from the prior concentration and from the control. Instead of this Sandra variety has only 37.5% germination statistical lower from the other varieties, except Midas and Nova.

The 120g PEG/100ml H_2O concentration has as result the germination decrease and in some varieties at the level of zero. Hermes variety germinated to the higher observed level of 57% and Nova variety to the lower 7%.

Finally with 160g PEG/100ml H_2O the germination percentages of all varieties minimised with no statistical differences between them.

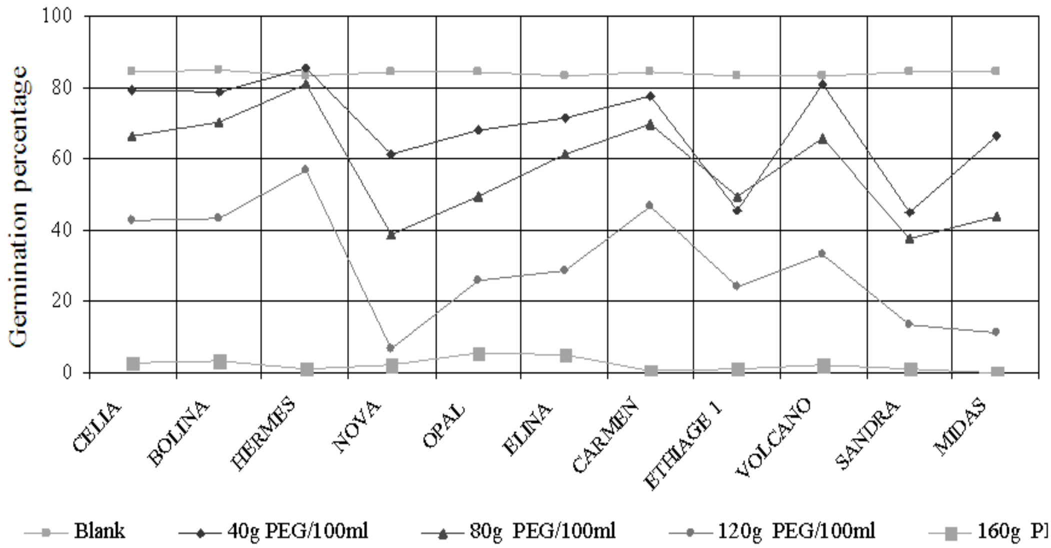

Figure 1. Effects of different PEG solutions in germination cotton seeds percentage.

Table 3. Mean values of ge rmination rates of cotton s eeds in polyethylene glycol solutions.

PEG (A)	Varieties (B)										
	CELIA	BOLINA	HERMES	NOVA	OPAL	ELINA	CARMEN	ETHIAGE - 1	VOLCANO	SANDRA	MIDAS
Blank	18.1	19.2	22.8	14.3	13.4	18.9	19.2	14.0	19.9	13.7	18.1
40g/100ml H_2O	16.8	16.4	22.2	13.2	14.6	17.5	17.6	10.1	17.3	10.8	15.5
80g/100ml H_2O	12.3	11.9	17.1	7.9	10.0	14.1	14.4	10.9	11.5	8.9	10.5
120g/100ml H_2O	5.9	4.7	10.4	1.2	3.5	6.3	7.5	4.8	5.2	2.3	2.7
160g/100ml H_2O	0.3	0.3	0.2	0.5	0.7	0.8	0.1	0.1	0.2	0.2	0.0
Average	10.7	10.5	14.5	7.4	8.4	11.5	11.7	8.0	10.8	7.2	9.3

$LSD_{0,5}$
1,25 between two A averages,
1,05 between two B averages,
2,34 between two B averages in the same A level,
2,41 between two A averages in the same or diffeerrent B level.

Figure 1 shows the interaction betw een variety and PEG concentration. The varieties reacted different to th e treatments used. 40g PEG/100m l H_2O has no effec t to som e varie ties ge rmination percentage but caused a 50% reduction to others. Almost zero germ ination occurred at 160 PEG/100m l H_2O. In general, a differentiation in cultivars behavior c oncerning the germ ination percentage was observed and the negative effect was directly related to the concentration of PEG.

Table 3 pr esents th e germ ination rate of seeds in PEG solutions . The examination of external mean values (A) with LSD_{05}=1.25 (between two A averages) shows that the germ ination r ate re duced statistically signif icant as lo ng as the concentration of PEG increase. The control mean value germination rate was 17.4, in 40g PEG/100ml H_2O was 15.6 and to the 160g PEG/100ml H_2O was only 0.3.

The external mean values with LSD_{05}=1.05 (between two B averages) shows that Hermes variety grew with high er rate in comparison with th e others, while the varieties Carmen, Elina, Volcano and Celia followed.

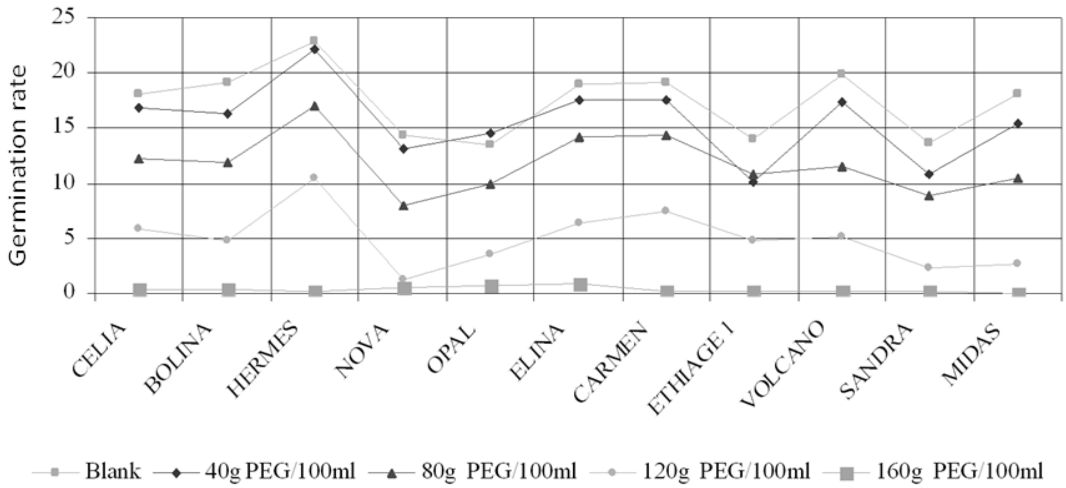

Figure 2. Ef fects of different PEG solutions in germ ination rates of ele ven cotton cultivars.

The com parison of m ean values in the sam e PEG level ha s m ore prac tical interest because Herm es variety germ inated faster, Volcano, Bolina, Carm en, Elina, Celia and Midas with an intermediate rate and the lower germination rate observed to varieties Nova, Ethiage 1, Sandra and Opal.

40g PEG/100ml H_2O concentration has no effect to Hermes variety while varieties Sandra and Ethiage 1 showed the lower rates. Also to the concentration of 80g and 120g PEG/100ml H_2O, Hermes variety has the higher germination rate. In 160g PEG/100ml H_2O the germination rate reduction was so important that no differentiation was observed and the data showed that this high concentration has no practical interest in the field.

Figure 2 shows the interaction of variety and PEG concentration to germination rate. The cultivars behavior concerning the germination rate was different in the various concentrations of PEG with the concentration of 40g PEG/100ml H_2O to have the lower effect and 160 PEG/100ml H_2O the greater effect with almost zero germination rate.

Conclusions

Germination ability of cotton cultivars reduced under artificial stress conditions with the use of PEG. The negative effect is directly related to the concentration of PEG. In all cases the cultivar x polyethylene-glycol interaction was significant.

A differentiation in cultivars behavior concerning the percentage and the germination rate was observed. Among the eleven cultivars tested "HERMES" was the least and "SANDRA" was the most affected concerning the two measured parameters.

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ORAL PRESENTATION

Effect of Heat Stress on Leaf Area in Cotton (*Gossypium hirsutum* L.)

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Abstract

Fifteen upland cotton (Gossypium hirsutum L.,) were evaluated for heat tolerance based on leaf area, leaf temperature, canopy temperature and seed cotton yield under field conditions, where temperature exceed 40 °C in July and August. Genotypes, showed statistically significant differences for leaf area and seed cotton yield, however non-significant differences were observed in term of leaf temperature and canopy temperature. Seed cotton yields ranged from 1794.00 (Fiber Max 958) to 3783.96 (AGC 85) kg ha^{-1} among the genotypes and AGC 85, AGC 375, Stoneville 474 and DP 396 had the highest values for seed cotton yield and shared same statistically group. Leaf area ranged from 56.06 to 101.20 $cm^2 leaf^{-1}$. Fiber Max 819, Fiber Max 958 and AGC 208 had the lowest leaf area, while Stoneville 453 and SJ-U 86 had the highest leaf area. Leaf temperature ranged from 36.20 to 41.17, and canopy temperature ranged from 25.27 to 29.37, and non-significant differences were obtained from both of this traits. Correlation analysis showed that leaf area was positively correlated with seed cotton yield, on the other hand leaf temperature and canopy temperature were negatively correlated with seed cotton yield, which indicated that lower leaf and canopy temperatures are a good indicator under stress conditions.

Keywords: *Cotton, heat tolerance, leaf area, leaf temperature.*

Introduction

Cotton is one of the most important strategic crops playing a key role in economic and social development of Turkey. Cotton is produced in about 76 different countries, covering more than 34 million hectares across a wide range of environmental conditions (USDA, 2012). In 2010 /2011 growing season in Turkey 542.000 ha cotton area was planted and approximately, 954.600 tons fibers were produced (Turkish Statistical Institute, 2011). About 60% of Turkish cotton comes from Southeastern Anatolia Region, where climate is semi-arid. Cotton is known especially adapted to semi-arid and arid environments, but cotton is grown under fully irrigated conditions in Turkey. The temperature increase is expected to continue 1.5-5.9 °C within the next century because of global warming (Hodges ve McKinion, 1996). Thus, if global warming occurs as projected, cotton production in the future will be reduced, due to cotton sterility and boll retention problems (Reddy et al., 1992b). The effects of high temperature on germination, seedling growth, vegetative growth and crop development have been well documented (Oosterhuis and Snider., 2011). Although adverse temperatures can affect all stages of development, the crop seems to be particularly sensitive to adverse temperatures during reproductive development (Oosterhuis, 2002). High temperature stress also leads to a series of physiological and biochemical changes that adversely affect plant growth and productivity (Yildiz and Terzi, 2007). Although generally regarded as a crop of the hot, cotton is sensitive for high temperature stress during the growing stage, especially flowering and boll-formation period. The earlier studies revealed that maximum number of bolls and squares retain occurred at 30/22°C day/night temperatures (Reddy et al., 1992a) with the optimum for photosynthesis at 28 °C (Burke et al., 1998). It is well known that high temperature has a strong negative correlation with lint yields, with yield decreased about 110 kg ha^{-1} for each 1 °C increase in maximum day temperature (Singh et al., 2007). Leaf area is a determinant factor in radiation interception, photosynthesis, biomass, accumulation, transpiration and energy transfer by crop canopies (Akram -Ghaderi and Soltani., 2007). Leaf area development is highly sensitive to temperature. The optimum temperature for leaf growth is about 30° C (Hodges et al., 1993). Bibi et al., 2004 suggested wild type of cotton due to more tolerant than the commercial cultivars. They reported that the percentage change in leaf extension growth of plants that were subjected to temperature regime compared to the plants grown at the control temperature 29 °C showed that there were no significant differences among the genotypes at 32 °C. Once temperatures reach about 35°C, growth rate and photosynthesis of cotton begins to decrease. Follow up studies indicated that yield improvements in modern genotypes were associated with improved heat tolerance due to stomatal conductance, smaller leaf size and lower leaf temperature (Lu et al., 2006; Pettigrew and Meredith., 2012). Leaf area is a complex traits which controlled by the genes acting additive x additive, additive x dominance and dominance x dominance interactions (Hussain et al., 2008). The objective of this study was to determine the effect of high temperature stress on the leaf area of cotton under field studies and to use efficiently for screening tools to improve yield.

Material and Methods

Field study was conducted at the GAP International Agricultural Research and Training Center's experimental area during 2010 cotton growing season. The experimental field is located (37º55' 36" N, 40º13'49" E) at 670 m above sea level. Generally, this region is characterized by a semi-arid continental climate with very hot and dry summers and cold with rainfall or snowy winters. The long-term average annual temperature is 15.8 ºC, total rainfall is 491 mm and the average relative humidity is about 29.9%. The experiment was laid out as randomized complete block design with four replications. Fifteen cotton varieties were used as plant material some of which selected for their tolerance to heat stress in the literature and represent a range of leaf shapes. Seeds of these cotton genotypes were late planted (on 17th May) for coincide with of flowering time to high temperature. The plots consisted of four rows, 12 m in length with a 0.70 m spacing between rows. Plots were initially over-seeded and then hand thinned to a final population density of approximately 79.000 plants ha^{-1}. Before sowing total herbicide (200 ml da^{-1} doses) were applied for weed control and once herbicides at the doses 60 ml/da was applied after emergence. All plots were treated with 20-20-0 composite fertilizer to provide 70 kg N ha^{-1} and 70 kg P_2O_5 ha^{-1}. Just before flowering, 70 kg N ha^{-1} were applied as ammonium nitrate as an additional N doses. Insect were monitored throughout the experiment and no insect control was necessary during these growing season. Plants were grown under recommended cultural practices for commercial production; the experiment was hoed three times by hand and two times with a machine. Experimental plots were irrigated by drip irrigation method. Adequate irrigation was provided for minimizing effect of drought stress during cotton growing stage, especially in reproductive stage. In the study, five plants were selected randomly for observations in each plot. Leaf area of this plants were measured 80 days after planting, the time of peak flowering and fruiting. For measurement of leaf area on the fifth fully expanded leaf below the terminal were cut and copied on pages and then scanned and measured with a Net-CAD 5.1. computer program. Leaf temperature was measured by Infrared Thermometer (DT-8811H). This measurement was taken between 11.00 to 14.00 hours in mid-day. Then plots were harvested twice by hand and yield of four rows of plot were weighed and calculated for seed cotton yield. First harvest was done on 22 October; second harvest was done on 10 November in 2010. Statistical analysis were performed using JMP 5.0.1 statistical software (http://www.jmp.com) and the means were grouped with LSD $_{(0.05)}$ test.

Results and Discussion

The analysis of variance of the investigated traits indicated that there were significant differences (*P ≤ 0.01*) among the genotypes for seed cotton yield and leaf area, but non-significant differences were observed for leaf temperature and canopy temperature.

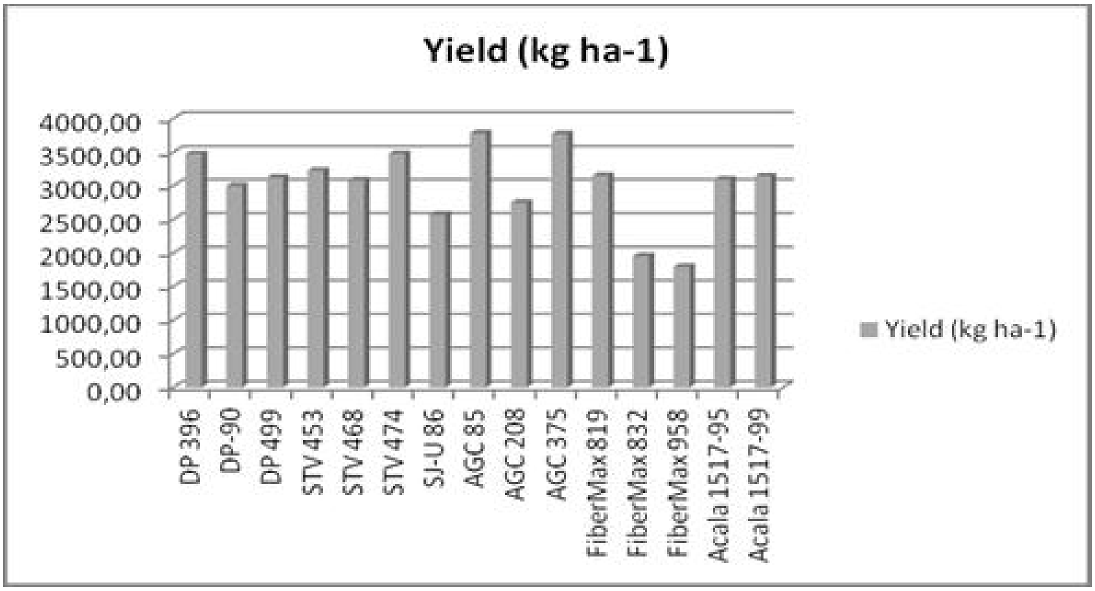

Figure 1. Seed cotton yield of different fifteen cotton genotypes.

Seed cotton yield of genotypes ranged from 1794.00 (Fiber Max 958) to 3783.96 kg ha $^{-1}$ (AGC 85) as shown in Figure 1. Among the genotype screened, AGC 85, AGC 375, Stoneville 474 and DP 396 had the highest seed cotton yield, while Fiber Max 958 had the lowest yield. The two okra leaf type genotypes (Fiber Max 819 and Fiber Max 832) used in this study did not exhibit higher yield, this may be come from different genetic backgrounds in addition to different leaf types. Similar findings has been reported previously by some authors (Pettigrew, 2003).

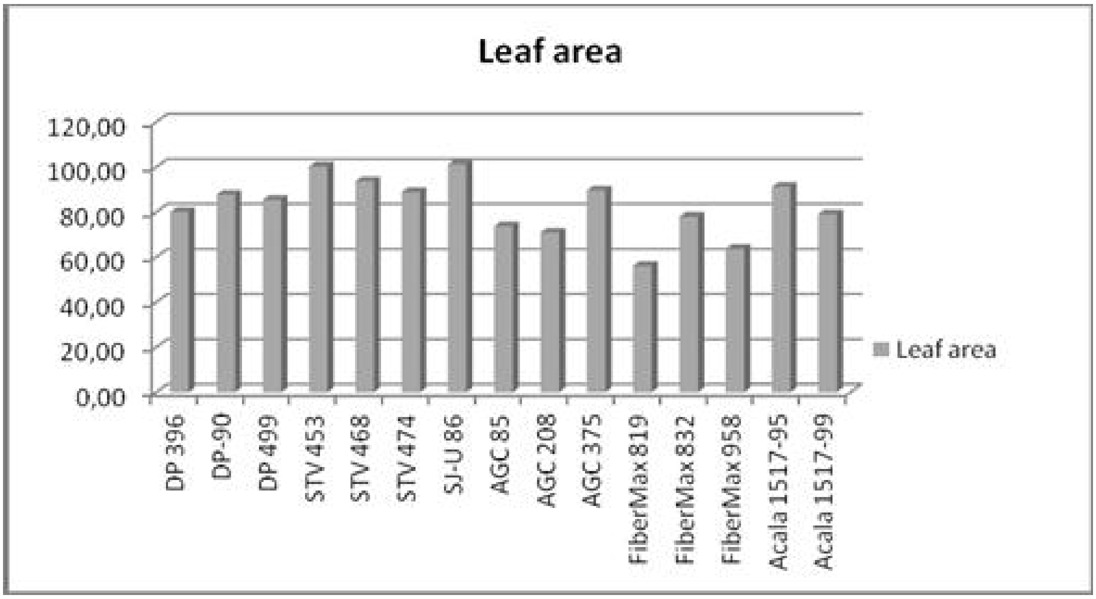

Figure 2. Leaf area of different fifteen cotton genotypes

Leaf area ranged from 56.05 (Fiber Max 819) to 101.20 c m^2 leaf^{-1} (SJ-U 86) and differences among genotypes were statistically significant at ($P \leq 0.01$) probability level (Figure 2). In this study, Fiber Max 819, Fiber Max 958, AGC 208 and AGC 85 genotypes had lower leaf area than the other genotypes. Similar results confirmed these findings, Pettigrew 2004, revealed that the okra leaf trait reduced individual leaf area 37% relative to the comparable normal leaf type leaves.

Earlier studies indicated that smaller leaf area plays a crucial role to their sun-tracking ability (Lu et al., 1997). These findings may be useful to create a new germplasm in order to combine smaller leaf area and higher seed cotton yield.

In the present study, non-significant differences were obtained among genotypes in terms of leaf temperature and canopy temperature, leaf temperature values of genotyped ranged from 36.20 to 41.17 ºC and canopy temperatures ranged from 25.27 to 29.37 ºC as shown in Figure 3.

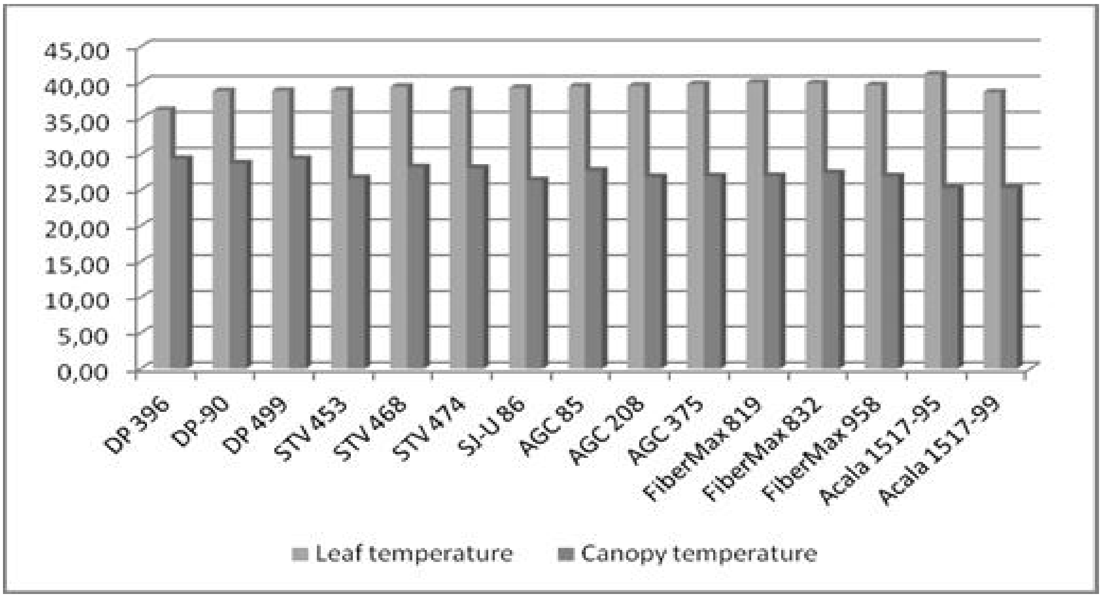

Figure 3. Leaf temperatures and canopy temperatures of different fifteen cotton genotypes

Table 1. Correlation coefficients between leaf area, leaf temperature, canopy temperature and seed cotton yield

	Leaf area	Leaf temperature	Canopy temperature	Yield (kg ha-1)
Leaf area	1,0000	0,1457	0,1029	0,2843
Leaf temperature		1,0000	0,3135	-0,2325
Canopy temperature			1,0000	-0,0107
Yield (Kg ha-1)				1,0000

Correlation coefficient between investigated traits are presented in Table.1 Leaf area was positively correlated with seed cotton yield, leaf temperature and canopy temperature, however leaf temperature and canopy temperature was negatively correlated with yield, which indicated that lower leaf or canopy temperature is a good indicator to high yielding capacity under heat stress.

Conclusion

The present investigation has revealed that significant level of phenotypic variation for leaf area and seed cotton yield was available in used genotypes. Among the genotypes AGC 85 and DP 396 showed higher yielding capacity and lower leaf area, these cotton genotypes may be useful for using as parent in cotton breeding program for heat tolerance. In addition, it was found positive correlation between leaf area and seed cotton yield, and negative correlation between leaf temperature, canopy temperature and seed cotton yield, which indicated that lower leaf and canopy temperatures are good indicator for heat stress tolerance. The results of this study consisted of one year's data, so further researches are needed for the future.

Acknowledgement

I would like to thanks Mr. Hikmet OGURLU for measuring leaf area by NetCad 5.1 GIS computer program.

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ORAL PRESENTATION

Effect of Drought Stress on Water Use Efficiency and Leaf Temperature of Two Cotton Genotypes

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Abstract

Even though cotton is known as a drought-tolerant crop, severe drought conditions lead to slower plant growth, decrease in boll size and may cause shedding. A pot experiment in glasshouse was conducted to determine alterations in water use efficiency, leaf temperature and total dry weight of two different cotton genotypes under drought conditions. Plants were subjected to two different water regimes: well watered and drought. Total dry weight of plants significantly reduced as a response of drought conditions. Water use efficiency (WUE) of the genotype Chirpan-433 was higher in well-watered conditions whereas amphidiploid genotype had higher WUE under drought conditions. Leaf temperatures increased 14.3 % with drought stress in amphidiploid genotype and 13.9 % in Chirpan-433.

Key words: *Cotton, drought, water use efficiency, leaf temperature, total dry weight.*

Introduction

Crop yield is determined by genetic and as well as environmental factors, which exert the major effect on yield formation during growing season (Bibi et al., 2003). Several studies suggested that alterations in cotton germplasm during past thirty years may have resulted in a reduction of tolerance level of modern cultivars to environmental stresses (Brown et al., 2004). Accordingly, variability in cotton yield is a major concern for global production and recent literatures indicate that this variability is mostly related to extreme environmental conditions, particularly high temperatures and drought (Bibi et al., 2003).

Although cotton is well adapted to semi-arid conditions, it responds well to sufficient water by producing lint proportional to amounts of irrigation supplied. Especially, three key periods of cotton growth, which are stand establishment, pre-bloom and shortly after boll set should be supplemented with moisture. Main effects of drought on cotton plants are slow plant growth, smaller bolls and shedding. Amount of irrigation during stand establishment and pre-bloom has great effects on total yield whereas insufficient water supply following bloom and boll development significantly reduces lint quality (McWilliams, 2003).

Drought tolerance is a complex agronomic characteristic with multigenic components, which interact in plant systems (Cushman and Bohnert, 2000). Limited water supply decreases cotton production in many regions. Therefore, selection for drought tolerance is a fundamental interest of plant breeders in cotton. Previous studies on drought tolerance have focused mainly on plant physiological characteristics (Kumar and Singh, 1998; Kasperbauer, 1999; Pace et al., 1999). Wealthy of data indicated that drought tolerance is related to ability of plant to reduce water loss by stomatal or morphological structures (Fambrini et al., 1995; Franca et al., 2000).

The purposes of the present study were to evaluate the effects of drought on water use efficiency, leaf temperature and total dry weights of two different genotypes.

Material and Method

A pot experiment in a glasshouse was conducted in Ege University, Faculty of Agriculture, Department of Field Crops to determine alterations in water use efficiency, leaf temperature and total dry weight of two different cotton genotypes under drought conditions. The genotypes used as plant materials were an amphidiploid (Chirpan-433 *G.hirsutum* x *G.sturtii*) which is considered as more drought tolerant, and the variety Chirpan-433 (*G.hirsutum*). The drought tolerance of amphidiploid is derived from the wild progenitor species *G. sturtii*.

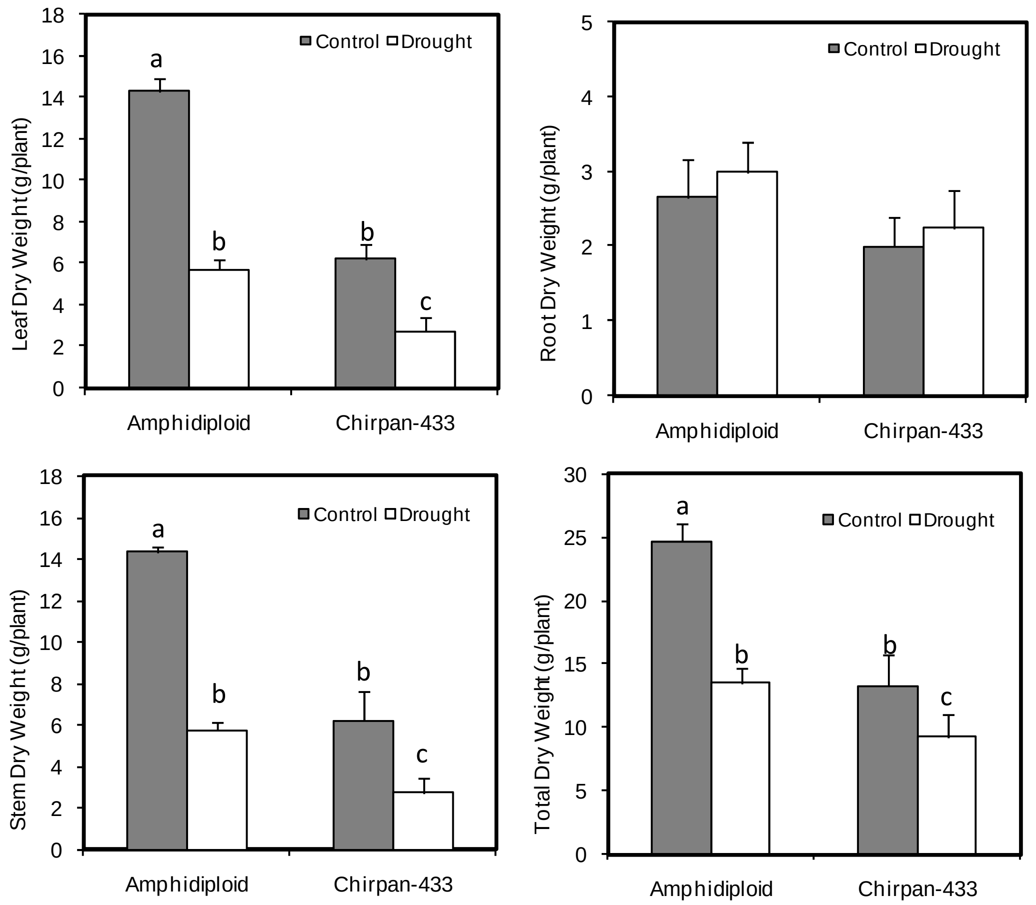

Figure 1. Leaf, stem and root weight values of two different genotypes (Amphidiploid and Chirpan-433) under well watered and drought conditions.

The trial was run in a Randomized Parcel Design with 4 replications. For each genotype eight pots were used. Plants were grown in pots (28 cm high, 30 cm diameter), each carrying approximately 9 kg of soil (mixture of peat in ratio 3:1). Irrigation was performed through a pipe directly to the bottom of the pot. A single plant was planted in each pot. All plants were grown at optimal water supply (70-75 % Water Holding Capacity-WHC) until beginning of blooming stage. Half of the plants were grown at the same watering regime until harvesting (Control Treatment).

The other half of plants was subjected to a gradual decrease of water supply after bloom (Drought Treatment). The moisture content of soil reached to 30 % WHC after 5 days of drought treatment. Total dry weight (leaf, stem and root weights), leaf temperatures and water use efficiency of the plants were determined.

Results and Discussion

Dry weight reduction of cotton plant was suggested to a key factor in order to understand response of cultivars to drought conditions (Pace et al., 1999). In the present study, leaf and stem dry weight were found significantly higher in amphidiploid cotton under drought and well watered conditions whereas root weight was not significantly differ under both conditions (Figure 1). Total dry weight decreased as a result of drought stress for both genotypes (Figure 1). However amphidiploid cotton had higher total dry weight relative to cv. Chirpan in both conditions.

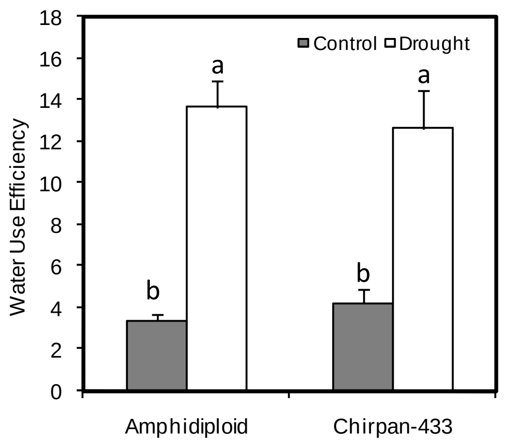

Figure 2. Water use efficiency of two different genotypes (Amphidiploid and Chirpan-433) under well watered and drought conditions.

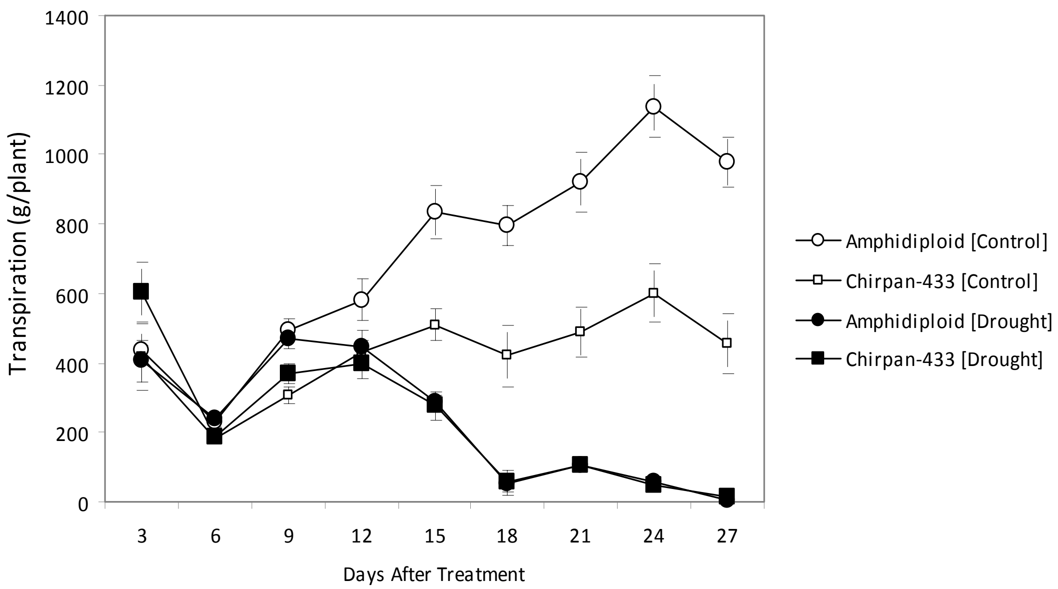

Figure 3. Transpiration amount of two different genotypes (Amphidiploid and Chirpan-433) under well watered and drought conditions.

Water use efficiency is described as dry matter production per transpiring water by plants and known as related to drought tolerance of crops (Hslao and Acevedo, 1974). Water use efficiency of the plants were determined after drought treatment in the present study. Water use efficiency of cv.Chirpan-433 was higher under well-watered (control) conditions whereas amphidiploid cotton had higher WUE under drought conditions (Figure 2). Total transpiration of the plants was also evaluated until harvesting time. The transpiration of amphidiploid cotton was significantly higher under control conditions. However, both genotypes had similar transpiration amounts under drought conditions (Figure 3). But relative reduction in transpiration amount of amphidiploid cotton was more pronounced.

The early results with infrared thermometers caused scientists to recognize a direct measurement of plant responses to the environmental changes (Jackson, 1982). Leaf temperature was determined for a period of 17 days and 14.3 % increase in amphidiploid cotton and 13.9 % increase in cv.Chirpan-433 was recorded under drought relative to control conditions (Figure 4).

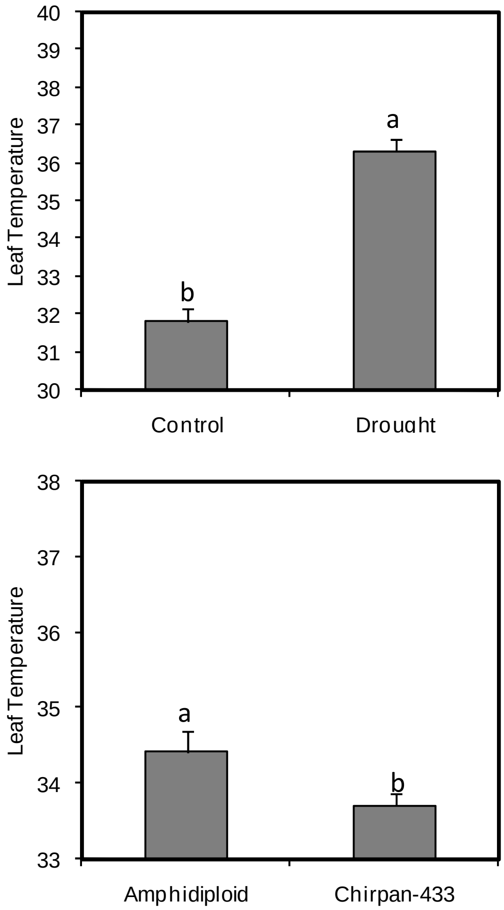

Figure 4. Leaf tem perature of two differe nt genotypes (A mphidiploid and Chirpan-433) under well watered and drought conditions.

Conclusion

In conclusion, dry m atter production and water use efficiency of were found slightly h igher under d rought cond itions. Th erefore better adaptation capacity o f amphidiploid cotton relative to cv.Chirp an-433 m ight be attributed to these parameters. However tolerance level of the genotype could be supported with the further physiological analyses.

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ORAL PRESENTATION

Incidence of Cotton Bacterial Blight on Sudanese Open Cotton Cultivars in Comparison With Introduced Open and *Bt* Cotton Cultivars in The Rahad Scheme

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Abstract

The incidence of bacterial blight (BB) was evaluated in Rahad scheme especially in Blocks 1, 2 and 3 with representative samples from blocks 7 and 8at the Rahad scheme. The experimental sites at Rahad research station and China Technology Demonstration Centre (Block 4) were included. The survey was conducted in seasons 2006/2007 and season 2011/2012. All our popular cotton cultivars were found to be susceptible to the disease under Rahad conditions at least for block 4. The occurrence of new race or races of the disease in the Rahad scheme is claimed for. Our released cotton varieties have not been evaluated against the disease under Rahad conditions. Disease incidence was 100%, the percent of infected leaves was 71.7, over all disease severity was 2.3 and the percent of infected bolls was 8.0%. In the second survey the disease was only reported in block 4 which was 52.3% for disease incidence, 25.7% for infected leaves, 0.5% for over all disease severity and 0.5% for infected bolls. The Rahad research station reported 97.8% for disease incidence, 56.9 % for infected leaves, 1.1% for over all disease severity and 13.7% for infected bolls. Concerning the introduced cultivars the hybrid cotton cultivar BB incidence was 53.5 and the open pollinated *Bt* cultivar was 86.7 percent of infected plants. 16.7 % and 22.2 % as incidence of infected leaves for Hybrid *Bt* and OPV cultivars respectively. With overall disease severity of 0.2 and .04 as well for the two introduced *Bt* cultivars.

Key words: *Bacterial blight, cotton, Rahad scheme, Sudan.*

Introduction

Bacterial blight, incited by *Xanthomonas campestris pv malvacerum*, is potentially very destructive disease of cotton. It occurs in most areas of the world where cotton is grown. It is the major disease affecting cotton production in Sudan, it can affect all the above ground parts of the crop and under severe conditions it is responsible for heavy shedding of the leaves and fruits. Development of the disease is favored by warm humid conditions and spreads through plants by rainstorms and splashes, hence severity of the disease declines after the rains faze out. Seed cotton loss can vary according to the disease severity which is dictated by whether conditions, variety cultivated and other possible control measures adopted. Destructive outbreaks of the disease occurred in the early beginnings of the Gezira scheme (1930-31) and at that time it was thought this disease might prevent growing cotton in the Gezira. Reduction in seed cotton by 14-21% due to the disease was reported (Elnur, 1970).

Disease management in Sudan

In the early thirties flooding proved to be effective for inactivation of the disease, seed disinfectants such as acid delimiting was also practiced since 1927. The first resistant cotton variety Bar XL1, aB^2 B^3 Lamber type became the most important variety in the irrigated areas in the late 1950 (Mohamed, 2000). The B_2B_6 gene combination was incorporated into Barakat variety (Siddig, 1973) and Barac (67) B (Kheiralla, 1970) proved to be effective against the disease. Resistance to the disease has been broken down by a new race of the pathogen where all our cotton varieties became susceptible to, this race is then refer to as Post-Barakat race (Ahmed *et al*. 1997). Recently, two new cotton varieties resistant to races of the pathogen, Hamid with $B_2B_3B_6B_7$ and Knight with $B_2B_3B_6B_7B_9$ gene combinations were released (Mustafa *et al*. 2004). More recently , Abdeen cotton variety which possesses ($B_2B_3B_6B_7$) gene combination was released as resistant against the disease (Ahmed, 2007).The disease is also known to be managed through chemical seed dressing and a lot of seed dressings were known to be released by the ARC scientists against the disease. Disease management in Sudan nowadays developed to be achieved through adopting a combination of resistant cultivars, chemical seed treatment, sowing date and legislative measures.

Cotton bacterial blight in the Rahad scheme

Rahad scheme was one of the sites that were chosen for the national cotton variety to be tested in; however, no assessment for the disease was done to the tested or released cotton varieties. Since 2005; two surveys were carried out for cotton bacterial blight in the scheme. The first survey was for the growing season 2006/07 and the cultivated cotton variety grown was Barac (76) B while the second one was for the season 2011/12 and the cotton variety grown was Hamid.

Methodology

In this survey, the ten blocks of the scheme were covered and each block was represented by two villages. From each village two hawashas (5 feddans each) were chosen and each hawasha was represented by 3 samples 15 plants each. Two upper, two middle and two lower leaves and the bolls were assessed for the disease in each plant. Disease assessment was recorded as percentage for infected plants, leaves and bolls and the disease rating of 0- 5 was used for the overall disease severity , Where,

0 = No infection
1 = 1- 10% of the leaf area is affected
2 = 11- 20% of the leaf area is affected
3 = 21 – 30% of the leaf area is affected
4 = 31 – 40% of the leaf area is affected
5 = ≥41% of the leaf area is affected.

Methodology for the second season

Blocks 1, 2 and 3 were chosen to represent the southern part of the scheme while blocks 7 and 8 represented the northern part of the scheme. The central part was represented by block 4. The experimental sites Rahad research station and China Technology Demonstration Centre (Block 4) were included in the survey.

Results

In the first survey, disease incidence was 100%, a percent infected leaf was 71.7, over all disease severity was 2.3 and a percent infected boll was 8.0%. In the second survey the disease was only reported in block 4 which was 52.3% for disease incidence, 25.7% for infected leaves, 0.5% for over all disease severity and 0.5% for infected bolls. The Rahad research station reported 97.8% for disease incidence, 56.9 % for infected leaves, 1.1% for over all disease severity and 13.7% for infected bolls. Rain fall in the second survey ranged 150-300 mm/annum.

Discussion

The cotton variety Barack 76 (B) was known to be grown in the scheme since the early eighties, while Hamid cotton variety was introduce to the scheme as commercially in the season 2007/08. Both cultivars have been released as resistant cultivars for cotton bacterial blight. Although rainfall were not higher for both surveys all disease parameters were higher in the first survey, this mainly explained the highest susceptibility of the cultivated variety to the current bacterial race. For the first survey the spread of the disease was all over the scheme, this may indicate the spread of a virulent race of the bacterium throughout the scheme which led to the breakdown of the resistant cultivar Barack 76 B (grown for more than twenty years.), while the scientific wisdom says that: Growing a cotton variety in one locality should not exceed ten years and hence it should be replaced by another one. The second reason for high spread of the disease may be attributed to the in adequate of the use of chemical seed treatment against the disease where only 10% of the seeds was treated with Kruzer/Starner. (Eltayeb and Ali, 2007).

For the second survey the disease was reported only in block 4 in the newly introduced commercial cotton variety Hamid (grown all over the scheme) this came after five years of the introduction of the variety. The higher mean of disease incidence (97.8 %) reported in the second survey in Hamid, Abdeen and Wagar which were recently released as resistant varieties (Not Wagar) raise up the assumption of the occurrence of virulent race or races of the disease the site. Disease symptoms of old and new races were reported in both surveys. The lower disease levels reported in the Sudan China Centre may be attributed to the delay in the sowing date (July 23). Although, the Rahad scheme is generally not known of high rainfall location, however the spread of the disease in the scheme put us under great challenge with the regard to the susceptibility of our release resistant varieties.

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Table 1. Rahad Agricultural Scheme (Season 2006/07)

Block NO	% infected plants	% infected leaves	Over all disease severity	No of bolls/ plant	% infected bolls	Sowing date	% total leaf shedding	Total rain fall (mm)
1	100	80.0	2.5	6.4	12.6	-	35.3	
2	100	69.4	2.3	6.1	6.0	-	26.3	
3	100	57.2	1.2	7.0	4.8	-	10.2	
4	100	77.0	1.9	12.3	4.5	10/7	25.8	
5	100	70.6	2.1	8.8	3.6	-	36.7	
6	100	68.9	2.1	4.4	9.0	20/7	15.7	
7	100	73.3	2.3	9.4	4.9	-	27.5	
8	100	77.3	2.1	10.5	5.4	30/6	26.8	
9	100	74.4	1.8	4.6	16.5	15/7	15.3	
10	100	67.2	2.2	4.9	12.3	20/7	10.2	
Mean	100	71.5	2.3	7.4	8.0		23.0	

Table 2. Rahad Research Station (2006/07)

Variety	% infected plants	% infected leaves	Over all disease severity	No of bolls/ plant	% infected bolls	Sowing date	Total rain fall (mm)
Nur	100	36.6	0.5	9.1	0.0	10/7	359

Table 3. Rahad Scheme (2011/12)

Block (B)	Village No.	% infected plants	% infected leaves	Over all disease severity	No of bolls/ plant	% infected bolls	Sowing date	Total rain fall (mm)
1	4	0.0	0.0	0.0	9	0.0	15/7	160
2	7	0.0	0.0	0.0	7	0.0	12/7	-
3	13	0.0	0.0	0.0	8	0.0	1/7	150
7	33	0.0	0.0	0.0	15	0.0	22/6	300
8	38	0.0	0.0	0.0	12	0.0	27/6	-
4	17 S	0.0	0.0	0.0	11	0.0	10/7	191
4	17 W	86.7	14.1	1.0	11	1.2	15/7	191
4	18 E	100	61.1	1.2	8	2.6	15/7	199
4	18 E	73.3	27.8	0.3	8	0.0	18/7	199
4	18 N	0.0	0.0	0.0	11	0.0	15/6	200
4	19	53.3	24.4	0.5	10	1.4	5/7	272
B4 Mean		52.3	25.7	0.5	10	0.9		209

S = South W = West E = East N = North

Table 4. Rahad research station farm (Block 4) (2011/12)

Cultivar	% infected plants	% infected leaves	Over all disease severity	No of bolls/ plant	% infected bolls	Sowing date	Total rain fall (mm)
Hamid	93.3	50.0	1.0	7	14.7	2/7	
Abdeen	100	65.5	1.2	4	30.0	2/7	224
Wagar	100	61.1	1.2	6	6.5	1/7	
Mean	97.8	56.9	1.1	6	13.7		

Table 5. Sudan China Technology Demonstration Centre (Neighboring Rahad Station)

Cultivar	% infected plants	% infected leaves	Over all disease severity	No of bolls/ plant	% infected bolls	Sowing date	Total rain fall (mm)
Hamid	73.3	22.2	0.3	0.2	0.0	23/7	
Abdeen	46.7	14.4	0.2	0.3	0.0	23/7	
Bt hybrid	53.5	16.7	0.2	1.3	0.0	23/7	224
Bt OPV	86.7	22.2	0.4	1.5	0.0	23/7	
Mean	65.1	12.9	0.3	0.8	0.0		

ORAL PRESENTATION

Study of Cotton-Second Crop Rotation in Antalya

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Abstract

Cotton is intensely cultivated in South eastern Anatolia, Aegean, Cukurova and Antalya region of Turkey. In these regions cotton growing is monoculture or wheat rotation. These caused reduction in cotton yield and increasing soil-born disease and pest density. Cotton producers who want to improve the efficiency use excessive nitrogenous fertilizer. This situation changes soil physical structure and decreases organic matter of soil. In this study, cotton is planted after wheat, second crop corn, and sesame and soybean rotation system to determine the most appropriate in between 1992-1997. Results in this study showed that second crop corn, soybean and sesame has been found high yield of seed cotton.
Keywords: *Cotton, crop rotation, seed cotton yield.*

Introduction

World cotton area and production is estimated 35.8 million hectares and 26.7 million tons in 2011/12. Turkey is the eight largest producer in the world with 2.6 million tons seed cotton production at 542 000 hectares (Anonymous 1a).

In Turkey, cotton is generally cultivated in South-eastern Anatolia Region, Cukurova, Aegean and Antalya Region as mono culture or with wheat crop rotation. Crop rotation is the mutually support and complement of different crops that are cultivated in sequence in the same agricultural area taking into account of the climate of the region and soil properties in order to harvest high-efficient and high-quality crops. Production in the cotton fields without crop-rotation, soil-borne disease agents and pests increase, and soil organic matter content decreases through activation. The producers use great amount of nitrogen fertilizers to increase the level of cotton harvest or to maintain the yield level and thus, the nitrogenous fertilizers that are used in large quantities cause environmental pollution and soil infertility.

Each plant cannot uptake the same amount of nutrients from soil. Some plants uptake some certain nutrients more than others. Mono-cultural cultivation results with the decrease of soil nutrients for the same plant. Today, although there is no difficulty in providing the needs of nutrients of plants with the possibilities of advanced fertilization, plants with different root depth feed on plant nutrients in different soil depths. The plant nutrients in different soil depths are utilized via growing plants with different root depth in crop rotation.

Numerous studies have been done to determine the plants that can be rotated with cotton plant. In the Southeastern parts of the United States, peanut (*Arachis hypogaea* L.) is an alternative product that is frequently used (Johnson et al., 2001). In the Mid-southern parts of the United States, corn and grain sorghum (*Sorghum bicolor*) has been determined as crop-rotation plant with cotton (Wesley et al., 2001). In the higher parts of southern Texas, cotton has been grown in rotation with cereals and grain sorghum. In the Florida USA, the crop rotation of cotton-corn for 15 years has resulted with 35 percent of more cotton yield compared to continuous cotton cultivation. In New Mexico, harvest yield has been more in cotton-alfalfa crop rotation compared with crop rotation of the cotton-legume or cotton-cereal (Aydemir, 1982).

Compared to other crops, cotton's yield response to crop rotations is relatively small. Long term rotation research, initiated at the turn of the century in Alabama, stressed growing legumes in rotation to provide the nitrogen needed for cotton production. Current (1978 to 1987) cotton yields in this ongoing study indicate an 11 % increase in cotton yield with legume-cotton rotations compared to continuous cotton. These yield increases seem rather small when compared to 95 years of continuous cotton.

In the mid 1970's, declines in cotton yields Beltwide were attributed to the absence of crop rotation. However, another Alabama study (initiated in 1979) comparing continuous cotton with I-year rotations of corn, soybeans or double crop wheat-soybeans has shown only small yield benefits since its inception. The largest lint yield increase (average 6%) resulted with the wheat-soybean rotation (Hake et al, 1991).

40% of cotton yield increase was obtained by the 15-year-old studies conducted in Turkey, Adana Cotton Research Institute on rotation of cotton cultivation experiments based on continuous alternations of cotton-wheat. The alfalfa-cotton-wheat rotation studies conducted by Nazilli Cotton Research Institute identified a decrease on loss wilt disease (Aydemir, 1982). Between the years of 1993-1996 Sanliurfa GAP Regional Development Administration Koruklu Agricultural Research Station conducted a project naming "The Applicable Crop Rotation Systems Project in the Irrigated Fields in GAP Region". According to this project, barley - grain sorghum - cotton, wheat - grain sorghum - cotton, wheat - corn - cotton systems are more promising compared to continuous cotton systems; thus cotton was not a good pre-plant for itself (Saglamtimur et al., 1999).

Saglamtimur et al. (1993), in order to determine the appropriate rotation systems in the Southeastern Anatolia Region, conducted a study. They determined that in cotton-wheat-corn and cotton-wheat-sorghum rotations, seed cotton yields were higher than the continuous cotton system.

Eren et al. (1999), soybean as second crop rotation after wheat has identified a positive impact on the crop yield after soybean in Antalya province.

The objective of this study was to compare the effects of different crop rotation systems on seed cotton yield and to determine the most suitable crop rotation system in Antalya conditions.

Materials and Methods

Material

This study has been carried out in Bati Akdeniz Agricultural Research Institute in the field of sandy loam in 1992–1997. Trial location was 35 m above the sea level and has a warm climate. The average annual rainfall in Antalya is 1200 mm and the average temperature is 20 ^{0}C.

The average of rainfall, temperature and humidity in the trial area in 1992 to 1997 are shown in table 1. The total amount of rainfalls in 1992, 1993, 1994, 1995, 1996 and 1997 were 646, 943, 1037, 1206, 1432 and 1200 mm, respectively. In the same years the average temperature was 16.9 °C, 17.6 °C, 19.4°C, 17.9° C, 18.2°C, 18.7 °C and humidity was 62.5%, 64.4%, 64.8%, 66.8%, 66.8% and 63,6%, respectively.

The average yearly temperatures were similar during the long period of years. The amounts of rainfalls were different by years. These rainfalls were not sufficient for the growth. The rest of the water that was needed for the growth of the cotton was provided by irrigation water.

Table 1. The average sum of rainfall, the average temperature and humidity in the trial area in 1992-1997.

Years	The last10 years	1992	1993	1994	1995	1996	1997
Temperature	19,9	16,9	17,6	19,4	17,9	18,2	18,7
Humidity	64,0	62,5	64,4	64,8	66,8	66,8	63,6
Total rainfall	1200	646	943	1037	1206	1432	1200

Some of the physical and chemical analysis results made from the soil samples taken from 0-30 cm deep from the trial area at the beginning of the experiment are given in Table 2.

Table 2. Soil samples taken from cotton field (0-30 cm) some physical and chemical properties

PH	**Lime (%)**	**EC x 10^3 25C**	**Loam (%)**	**Clay (%)**	**Silt (%)**	**Struc-ture**	**Org matter (%)**	**P ppm (olsen)**	**K ppm**	**Ca ppm**	**Mg, pmm**
7,5-8,4	21,5	0,072	8,8	48	43,2	Silt-clay	1,7	23	265	2340	480
Alkalinity	Very high	No salinity					less	High	High	Medium	High

The soil texture of the trial area was silt and loamy and was rich in potassium and phosphorus but poor in organic matter and the percentage of lime was high. There is no problem of salinity and pH of these soils ranged from 7.5-8.4.

In this study, "Cukurova 1518" was used as a cotton variety, and the wheat variety “Series 82”, soybean variety "Mitchell", sesame variety "Muganli 57" and maize variety "Ant 90" were used.

Method

The research was initiated in 1992 as randomized complete block design with three replications based on five treatments lasting for six years. The experiment was carried out in 5 treatments as shown in Table 5.

Cotton seeds were sown with pneumatic sowing machine with the space (75 x 25 cm), in May. In the sowing time, 8 kg of pure nitrogen, 6 kg of phosphorus and 6 kg of potassium were given and at the first irrigation 6 kg of pure nitrogen was added.

Table 5. Cotton rotation treatments including wheat as a main crop and soybean, sesame and corn as second crops in 1992-1997

No	Treatment
1	Wheat -Cotton- Wheat -Cotton - Wheat –Cotton-…
2	Cotton-Cotton-Cotton-Cotton- Cotton-Cotton-…
3	Wheat+ Soybean -Cotton- Wheat+ Soybean –Cotton-…
4	Wheat+ Sesame- Cotton- Wheat+ Sesame- Cotton-…
5	Wheat +Corn -Cotton- Wheat +Corn –Cotton-…

Wheat (*Triticum aestivum* L.) as a winter cultivation was planted between September 15 to October 1 and corn, soybean and sesame as second crop were sown from last week of June to the first weeks of July after wheat harvest. Cotton crop was rotated wheat + second crops. Cotton + cotton rotation was used as control.

Wheat seeds of the study was planted depth of 4-6 cm with 20 cm row spacing 475 seed.m^{-2}. Corn, soybean and sesame as second crops after wheat harvest were planted with sowing machine in 70, 50, and 80 seeds in m^2, respectively. Plot size of all crops of experiment was 45 m^2. The experiment was established according to split plot arrangement in randomized complete block design. The averages are grouped according to LSD.

Results and Discussion

Cotton Yield

The variance analysis result of various crop rotation treatments in the years 1992 through 1997 was given in Table 4.

Table 4. The variance analysis of crop rotation treatments on seed cotton yield

VAT	SD	SM	F	Prob
Rep	2	1486.1331	0.89	0.4160
Treatment	4	14738.8395	8.85	<.0001
Error 1	8	1976,1	1,19	
Year	5	99336.3274	59.66	<.0001
Treatment x year	20	7264.9921	4.36	<.0001
Error 2	50	83253,46	1665,1	
Total 8	9	802962,70		

There were significant differences am ong crop rotations on seed cotton yield and interactions between year and crop rotation system s were also significant. In the years 1992-1997, the seed cotton yield in rotation systems are given in Table 5.

Table 5. Average seed cotton yields of crop rotation system in 1992-1997

No Treatment		Means (kg .da^{-1})
5	Wheat +Corn -Cotton-	420,5A
3	Wheat+ Soybean -Cotton-	403,1 A
4	Wheat+ Sesame- Cotton-	396,8 AB
2	Cotton-Cotton-	363,2 BC
1	Wheat -Cotton-	351,9 C
Average of means		387,1
CV (%)		10,5
LSD		34,2

No. 5(wheat +corn –cotton), No.3 (w heat +soybean –cotton) and No. 4 (wheat +sesame –cotton) rotation systems have been the highest yields of seed cotton (Table 5). The rotation systems above gave higher seed cotton yi elds compared with continuous cotton and cotton-wheat rotation systems. Average s eed cotton yields ranged from 420,5 kg.da^{-1} (No.5) to 351,9 kg.da^{-1} (No.1).

In the studies of rotation, cereals after legumes had increases in yields (Forbes and Watson, 1992). Rushell (1961) has indicate d that yields of cereals after legum es increased s eed yields and yield in creases cou ld change according to the legume crops.

Other studies found that m aize sown af ter leguminous crops increased grain yield (Aydin and Tosun, 1993; Temu and Aune, 1995). Eren et al. (1999), soybean as second crop rotation after wheat has iden tified a positive impact on the crop yield after soybean in Antalya province.

Saglamtimur et al. (1993), in order to determ ine the appr opriate rota tion systems in the Southeastern Anatolia Region, conducted a study. They determ ined that in cotton-wheat-corn and cotton-wheat -sorghum rotations, seed cotton yields were higher than the continuous cotton system.

Conclusion

To determ ine the different crop rota tion system s for cotton m onoculture farming in Antalya conditions, this study s howed that crop rota tion is required in order to obtain high quality products, soil exhaustion, a nd disease and pest prevention.

Corn, soybean and sesame are the most suitable second crops that can be used for rotation in the cotton f ields also c oncerning the climate, soil properties and marketing conditions of the region.

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ORAL PRESENTATION

Productivity and Economic Effect for Cotton Cultivated under Different Inter-Row Spaces and Irrigation Rates

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Abstract

During in the last decades was increased the deficit and grow up the value of irrigated water. In this situation is necessary that steps should be taken to reduce of cotton irrigation depth, with a view to receiving to a high effect from unit of irrigated water and unit of area.

Field trial on cotton (Vega cultivar) was carried out during 2007-2011 on leached vertisols under irrigation regime of sprinkling – 75 % of the field moisture capacity (FMC) for the soil layer of 0 – 40 cm. The trial included the following variants: factor A) Irrigation with lower rates:1). Single irrigation of 600 mm /ha at the interphase period blooming-boll formations; 2). Two irrigations of 450 mm /ha – the first one at the blooming stage and the second – at the boll formations period; 3).Two irrigations of 600 mm /ha – the first one at the blooming and the secon – at the boll formations period; 4). Non-irrigated variant – for standard. Factor B) Width of inter-row space: 1). 60 cm. 2).80 cm.

It was established that the best results were obtained at the variant where cotton cultivated of 80 cm inter-row space and with second time irrigation with 600mm - with 939 kg/ha more that non-irrigated control and with 11.9 % more than variant with irrigated norm 600 mm/ha. In reference of net profit of 1000 m^3 irrigated water the best results were realized after single irrigation norm of 600 mm/ha.

In respect of width of inter-row space the yield from a unit of area with inter-row space 80 cm we receive with 4.6 % more than sowing of 60 cm inter-row space.

Key words: *Cotton, irrigation rate, inter-row space, water deficit, cotton yield.*

Introduction

For Bulgarian cotton wore defined optimal and rational irrigation regimes, pre irrigation soil humidity, the soil depth humidity, period of watering. It was found out a single irrigation quantity a nd irrigation rate during the ye ars with different rainfall provision for the main soil type – Pelic vertisols and Chromic cambiosols (by FAO).

During in the last 20 ye ars was increased the deficit of irrigation water and grow up the value of irrigated water. This situation is necessary that step s should be taken to reduce of cotton irrigation depth, w ith a view to receiving to a high effect from unit of irrigated water and unit of area. The studies to this effect were carried out in USA (McMichael Hesketh 1982; Ga rrot, Punymeier, Husman, 1988; Gerik et all 1996); Gruce (Danalotos et al 1998; Paschalidis Stavrikos , 2006); Uzbekistan (Bezborodov, 1995), Bulgaria (Nikolov, 1994) and others authors (Spenser, 1998).

Standard inter-row space for cotton in Bulgaria is 60 cm . Because of let up quantity of rainfalls on the summer period (from May to September) with 8.0 – 12.0 %, in comparison with of long year period was tested to cultivate cotton on inter-row space of 80 cm - Nikolov, G.(1988), Saldzhiev, I., Nikolov G. (2004).

Herewith investigate set the task of ascertaining of rational irrigation regime under conditions of regulated water deficit fo r cotton. It was tested sown fields of cotton under irrigation and non-irrigation regime at width of inter-row spaces respectively of 60 and 80 cm.

Material and Methods

During the period 2007-2011 a field trial was set by the standard method in 4 replications with size of the plots - 20 m^2. The following variants were tested: factor A) Irrigation with lower rates:1). Single irrigation of 600 mm/ha at 75 % FMC in soil layer 0-40 cm in the interphase period bl ooming-boll formations; 2). Two irrigations of 450 mm /ha at 75 % FMC in soil layer 0-40 cm – the first one at the bloom ing stage and the second – at the boll form ations period; 3).Two irrigations of 600 mm/ha at 75 % FMC in soil layer 0-40 cm – the first one at the bloom ing and the secon – at the boll formations period; 4). N on-irrigated variant – for standard. Factor B) W idth of inter-row space: 1). 60 cm - standard. 2).80 cm . The tests were conducted at an irrigation regime of sprinkling on variety Vega, in two crop rotation (durum wheat - co tton), at f ertilization ra te of N_{180} and crops density of 170 000 plants per 1 ha.

The soil type was Pelic vertisols w ith hum us horizon – 70 -115 c m, with humus content of 1.8 – 3.5 % and clay m inerals 60 %, wilting moisture 18-20 %. FMC for layer 0-50 cm was 34.2 %, 51-100 cm was 31.6 % and 101-200 cm – 28.7 %. The productive m oisture for layer 0- 60 cm was 96 mm, for layer 0-100 c m was 181 mm and 101-200 cm – 99 mm.

About the sum of tem perature (Table 1) 2007 and 2011 w ere warm years, 2008 2009 and 2010 were m oderate warm . In respect of the rainfall sum for the period June – August was characterized years 2007 and 2011 as dry, 2008 and 2009 as moderate, and 2010 as humid.

Table 1. Climatic conditions for the 2007 – 2011 period.

Years	Mounts						Σ IV-IX	Σ VI-VIII	Σ V-IX
	IV V		VI	VII	VIII	IX			
			Sum of temperature Σ t ^{0}C						
1928 – 07	343	519	622	720	711	561	3476	2053	3133
2007 3	51	579	693	825	753	527	3728	2271	3377
2008 3	86	522	636	717	792	555	3608	2145	3222
2009 3	57	569	648	751	725	571	3621	2124	3264
2010 3	64	554	624	706	798	582	3628	2128	3264
2011 5	35	538	645	772	743	558	3791	2160	3256
			Rainfalls - mm						
1928 - 07	45	63	65	52	41	34	300	158	255
2007 1	9	53	39	0	62	128	301	101	282
2008 6	6	36	95	36	3	91	327	134	261
2009 1	7	16	14	89	35	58	229	138	212
2010 6	3	27	82	114	22	48	356	218	293
2011 4	6	46	31	24	58	50	255	113	209

Making production expenses under non-ir rigation conditions was in amount of BGN 1857.50/ha or € 928.75 pe r ha. The buy up cost of seed cotton was 1300 BGN/t (0.50 BGN/kg subsidy + 0.80 BGN/kg re deem price). Middle price of stick up by pom p irrigation w ater was 0.30 BGN per 1 m^3 and 200 BGN/ha for expenses service. In production expe nses not-include incom e, interests of credits and amortizes assign-ments.

Results and Discussions

September yield which expressed cotton earliness for the irrig ated v ariants during the dry years (2007 and 2011) was sign ificantly higher than the non-irrigated control – with 17.3-19.5 %. For the m oderately hum id years (2008 and 2009) the yields of the irrigated variants were 7.1 – 13.8 % higher than the non-irrigated cotton. During the hum id years (2010) the average re sults showed that the irrigated variant exceeded th e non-irrig ated variants with 118.0 kg/ha and b y total yield s outweigh with 48 – 358 kg/ha more.

Table 2. Seed cotton yields under different inter row spaces and different irrigation regimes – by years and average. Mostly influence of factors.

Variants		Total yields by years - kg/ha					Average		
		2007 2	008	2009 2	010 2	011	kg/ha	%	±D
Inter - row space									
60 cm		2246 3	153	2355 2	660 2	472	2577	100.0	-
80 cm		2560 3	220	2441 2	743 2	612	2715	105.4	138^{++}
	5.0 %	90 14	2 30		80	94	112	4.7	112
GD	1.0 %	124	197 4	1 1	08	130	135	6.0	135
	0.1 %	172	274 5	6 1	46	158	161	6.9	161
Irrigated norms									
Non irrigated		1975 1	863	1989 2	515 1	972	2063	100.0	-
1200 mm		2890 3	780	2648 2	873 2	833	3004	145.5	941^{+++}
900 mm		2434 3	633	2577 2	854 2	730	2846	138.0	783^{+++}
600 mm		2205 3	469	2379 2	563 2	633	2650	128.5	587^{+++}
	5.0 %	110	201	43	113	112	288	4.3	288
GD	1.0 %	152	279	58	153	153	386	5.6	386
	0.1 %	211	388	78	207	206	430	6.3	430

The highest Septem ber yield from non-irrigated vari ant was realized averag e of 2042 kg/ha (98.98 %) then total yield. Decrease of irrigation norm from 1200 m^3/ha with 25 % and 50 % at cotton field not bring about to adequate change in yields – the drop in this case is with 319 kg/ha (89.4%) and 163 kg/ha (94.6 %).

During the dry years (2007 and 2011) the earliness of the irrigated variants was within the lim its of 79.3 – 84.9 % of th e total yield am ount. For m oderate years (2008 and 2009) this percentage was within 72.7 – 82.7 %, and for hum id – 60.8-

69.1 %. For the non-irrigated controls this ratio was respectively 91.2 %, 85.1 % and 74.7 %. Average for the period 2007-2011 the ea rliness of the irri gated variants was within the limits of 82.6 – 84 % and 83.7- 100 % for non-irrigated control - Table 2.

The cotton yields from non-irrigated variants vary in the course of years and have an effect of specific of cli matic special feature during cotton vegetation. In humid 2010 year from non-irriga ted variants was realized the heist yields, because was formed average from 7 to 9 cotton-balls (capsules number) of plant. The variants grew under irrigation and top the norm s of rainfalls during vegetation, for med capsules, disposed in the top floors of plant and form ed 10- 12 cotton-balls, who don't ripened and was given low yields – hardly 1,9 – 14,2 % m ore than non-irrigated cotton (Table 2).

During the dry years (2007 and 2011) in creasing of yields of irrigated variants varied from 11.6 % to 46.3%. The bed effect was merited of fact that above the quota amount of rainfalls in m onths August and September further for keeping of cotton-bolls in m iddle levels of cotton-bus h, who ripen and increased the yields. In irrigated va riants inc idence r ainfalls in combination with ir rigation depth prolong vegetation, Septem ber further for keeping from 12 to 16 cotton-bolls, but 6.3 % of them not ripe, who decrease effect of irrigations.

The highest results from irrigation cotton were got at 2008 – f rom 587 to 818 kg/ ha more than no-irrigation cotton – Table 2. At the rate of the period increased of yields was the highest at the irrigated norm from1200 mm. From this variant was realized with 39,7 % more in comparison non-irrigated variants. F rom the rest irrigated regimes were received yields higher with 36.9 % and 28.3 % in com parison with no-irrigation cotton.

With optimized of water factor by differe nt years the yields varied from 2205 BGN/ha to 3780 BGN/ ha, in such at an aver age of five years period under irrigation increased the cotton yields with 28.5 – 45.5 %. The variant with irrigation norm 1200 mm realized average with 941 kg/ha more th an non-irrigated and with 158 kg/ha and 354 kg/ha m ore than o ther irr igated varian ts. Decrease of irr igated no rm from 1200 mm with 25 % (900 mm) and 50 % (600 mm) predetermined decreased of cotton yields average with 158 kg/ha (5.3 % or 205.4 BGN/ha) and 354 kg/ha (11.8 % or 460.2 BGN/ha) - Table 3 and Table 4.

The cotton grown under inter-row space of 80 cm show better yields then crops und er inter-row s pace 60 cm (Tab le 2 and 3). Different of cotton-yields in comparison of cotton grown under inter-row space 80 cm and irrigated norm 1200 mm, 900 and 600 mm was higher than these grown under irrigation and inter-row space 60 cm with 8.68, 6.35 and 3.14 %. Net income from variants with irrigated norms from 1200 and 900 mm was with 161 and 115 BGN/ha more than the same variants planted in 60 cm inter-row space – Table 3 and 4. At the variants of 600 mm irrigation water results show identical net income.

As regards of results of 1 hectare expressed in kilograms. net production and net income (expressed in BGN per 1 hectare), the variants with 1200 mm irrigated norm realized net income from 503 to 664 BGN (3744 – 3905 BGN total output) – Table 4. At the other irrigating variants the results chow values from 3585 to 3700 BGN and 3445 for low norm. This variant realized the best net production and net income.

The effect of 1000 m^3 irrigation water per 1 ha varied from 886.6 to 1342 BGN. Average for the period the highest values were obtained by the variant with one irrigation of 600 mm done in the bolls formation stage.

Table 3. Seed cotton yields under different irrigation norms and different Inter-row space – by years and average. Interaction of factors.

Variants		Total yields by years - kg/ha					Average			
		2007	2008	2009	2010	2011	Kg/ha	%	±D kg/ha	Grade
Inter-row space 60 cm										
Non irrigation		1980	1949	1980	2506	1893	2062	100.0	-	-
1200mm		2491	3755	2590	2809	2753	2880	139.7	818	+++
900mm		2315	3514	2488	2805	2668	2758	133.8	696	+++
600mm		2198	3392	2363	2518	2573	2609	126.5	517	+++
Inter- row space 80 cm										
Non irrigation		1969	1777	1998	2525	2051	2064	100.1	2	-
1200mm		3289	3804	2705	2937	2913	3130	151.8	1068	+++
900mm		2553	3752	2666	2903	2792	2933	142.2	871	+++
600mm		2212	3546	2395	2608	2692	2691	130.5	620	+++
	5.0 %	167	284	60	159	181	218	10.6	218	-
GD	1.0 %	230	394	82	217	250	338	16.4	338	-
	0.1 %	318	548	111	292	346	455	22.1	455	-

Additionally total production from irrigation variants was 517 – 818 kg/ha for inter-row space 60cm and 620 – 10 60 kg/ha for variants at inter-row space 80 cm. Decrease of irrigating norm of 1200 mm with 25 and 50 % brought to go down of total output according with 159 – 229 BGN/ ha for inter-row space 60 cm and 205 – 460 BGN/ha inter-row space 80 cm . Additional charges for irrigation decrease with 90 – 180 BGN/ha. Net profit of 1000 m^3 irrigated water varied from 886.6 to 1120.6 BGN/ha for inter-row space 60 cm and from 1157.0 to 134 2.9 BGN/ha for variants of inter-row space 80 cm. Increased overall dimensions of irrigated norms decrease the effect of this index-Table 4

Table 4. Economic indexes on irrigated variants

Norms of irrigation	Total output BGN/ha	Costs of production BGN/ha	Net production BGN/ha	Net income BGN/ha	Effect of 1000 m^3 irrigated water kg/ha	Net profit of 1000 m^3 irrigated water BGN/ha
Inter-row space 60 cm						
Non irrigated	2681	1857,50	823,50	-	-	-
1200mm 3	744	2417,50	1326,50	503	682	886.6
900mm	3585	2327,50	1257,50	434	868	1128.4
600mm	3445	2237,50	1240,50	384	862	1120.6
Inter-row space 80 cm						
Non irrigated	2682	1857,50	824,50	1	-	-
1200mm 3	905	2417,50	1487,50	664	890	1157.0
900mm	3700	2327,50	1372,50	549	967	1257.1
600mm	3445	2237,50	1207,50	384	1033	1342.9

Conclusions

Under conditions of regulated water deficit, the highest effect was provided by irrigation regime of 75 % FMC in soil layer 0-40 cm, which was realized in two irrigations with irrigation rate of 600 mm. Average for 5 years with this irrigation regime the total cotton yield increased with 941 kg/ha or with 45.5 %, in comparison with non-irrigated variant.

The cotton grown under inter-row space of 80 cm show better yields then crops under inter-row space 60 cm. Different of cotton-yields in comparison of cotton grown under inter-row space 80 cm and irrigated norm 1200 mm, 900 and 600 mm was higher than these grown under irrigation and inter-row space 60 cm with 8.68, 6.35 and 3.14 %.

Additionally total production from irrigation variants was 517 – 818 kg/ha for inter-row space 60cm and 620 – 1060 kg/ha for variants at inter-row space 80 cm. Decrease of irrigating norm of 1200 mm with 25 and 50 % brought to go down of total output according with 159 – 229 BGN/ ha for inter-row space 60 cm and 205 – 460 BGN/ha inter-row space 80 cm.

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ORAL PRESENTATION

Determination of Some Fertility Properties of Cotton Soils in the Antalya Region

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Abstract

This study was carried out to determine the characteristics of some soil productivity in the Antalya region where cotton grown. For this purpose, 78 units in 2000, 36 units in 2002, total 114 soil samples were taken from different places where growing areas in Antalya and arounds cotton. The soil pH, lime ($CaCO_3$), electrical conductivity, texture, organic matter, phosphorus (P) and potassium (K) were analyzed. According to the survey, structure of the soils showed variety from sandy loam to clay loam. Soil pH is usually slightly alkaline and alkaline, and often no salinity. Determined that the majority of soils to become very high and extremely calcareous besides organic matter content was low level. Amounts of soil available P and K levels ranging was found from low level to very high level.
Keywords: *Mediterranean region, cotton, nutritional status, soil fertility.*

Introduction

Cotton is textile raw material that available to mankind for more than five thousand years. Cotton is a cultivated plant that fiber and textile industry, seed and oil industry, which contributes to the employment of agriculture and livestock with pulp.

The world cotton production and planting area is approximately 542 000 ha and Turkey is 8th largest producer with production of 954 600 tons of fibers (Anonymous 1a).

Cotton is grown in the GAP Region, Aegean and Mediterranean coast of our country. The GAP region shows an upward trend over years. Antalya has a declining planting area in recent years. In spite of this, it is still one of the major cotton growing areas.

A well-ventilated loam, sandy clay loam and alluvial soils are suitable for cotton plant. Cotton is sensitive to soil acidity and grows optimally from pH 6 to 8. Cotton growing slows down above pH 8 in the soil and yield decreases. Cotton should not be grown in high levels of ground water in the soil. The cotton plant is tolerant to moderate salinity of the soil. However, the salty soils cause a lot of production losses (Aydemir 1982).

In cotton cultivation, both lack and excess plant nutrients have negative impacts on plant growth and yield. Lack of nutrients deteriorate quality plant fibers and reduce resistance to diseases and pests. Excessed fertilization decreases the amount of production, increases pests and diseases, and causes a delay in harvest (Anonymous 1b).

Cotton cultivation is expected to obtain the product of the plant can be grown conditions required amount depends on the availability of plant nutrients. The cotton plant takes from the soil over calcium then nitrogen and potassium follows it. In addition, in terms of micro-nutrients in the soil, iron, manganese, zinc, copper, magnesium, and sulfur were removed. Seed cotton to 250 kg/da remove 15.6 kg N, 3.6 kg P_2O_5, K_2O 15.1 kg, 4 kg of Mg, Ca 16.8 kg, 0.6 kg S from soil. Nitrogen intake is relatively small in the beginning of cotton, but after the next 70^{th} day from planting is rapidly increase and again nitrogen intake decreases that time to close of harvest as possible. Phosphorus uptake as nitrogen, at the beginning is poor but then when the boll formation increasing phosphorus uptake and excessive from the soil. Potassium intake is close to the amount of nitrogen and accumulates to the vegetative organs of the plant. Potassium deficiency manifests itself in the old leaves. In the lack of potassium, appearing symptoms of special cotton leaf redness (Gurel et al., 2006).

In this study, the major cotton production area of cotton grown in the Antalya region was carried out to determine the status of some soil productivity.

Material and Methods

Material

Research materials was taken 78 soil samples from Topalli (3), Alayli (2), Yurtpinar (3), Kundu (8), Karacali (4), Yenidumanlar (5), Gokdere (2), left (3), Abdurrahmanlar (2), Gebiz (3), Akcapinar, Boztepe (3), Kozagaci (2), A. Kocayatak, Kumkoy (4), Kayaburnu, Karincali (4), Canakci (2), Candir (4), Tasagil, Bereket (5), Denizyakasi (2), Gundogdu (2), Peri (7), Colakli, Gundogdu, Aspendos and Cumali in 2000 and 36 soil samples from Solak, Yeni dumanlar (3), Yurt pinar, Aksu, TRT, Aspendos, Bereket (4), Sofular, Sarisu, Evrenseki, Manavgat (3), Tasagil, Belkis (2), Kemer Agzi (2), Kara Calli (2), Kundu (8), Bati Akdeniz Agricultural Research Institute (3) in 2002, in Antalya Aksu, Serik and Manavgat towns.

Method

Soil samples were taken from a depth of 0-20 cm. pH of the soil samples according to Jackson in 1/2.5 soil /water mixture (Jackson, 1967), CaCO3 content by using Scheibler's calsimeter (Evliya, 1964), electrical conductivity according to Soil Survey Staff (1951), organic material according to modified Walkey-black method (Black, 1965) were determined. Available phosphor according to the Olsen (Olsen, 1982) and variable Potassium in 1 N ammonium acetate solution (pH = 7) (Kacar, 1972) was performed.

Results and Discussion

The results of analyzes of total 114 soil samples taken from 0-20 cm depth were given in Table 1. In addition, soil samples were classified according to the limit values and Table 2 were prepared.

pH of the soil samples ranged from 7.2 to 8.3. According to Kellog (1952), the soil samples were 8.8% neutral, 58.8% slightly alkaline and 32.5% alkaline. Ozturkmen et al. (2005) detected that the nine of the 10 soil samples were alkaline in the Harran Lowland and one of them was very strong alkaline with 9.35 pH value. Ulgen et al. (1988) reported that 85.9% to the soils of the Mediterranean was mildly alkaline and pH value between 7.0 and 7.9.

Table 1. Soil samples taken from cotton field in 2000 and 2002, minimum, maximum and average values of some physical and chemical properties

		2000 2002				
Soil properties	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
pH 7.20		8.30	7.53	8.00	8.60	8.25
CaCO3 (%)	2.25	37.76	25.55	10.6	41.4	25.3
EC (dS/m)	370	950	586	126	597	306
Texture 30–50		70–110	50–70	30–50	70–110	50–70
Org. matter (%)	0.35	5.49	1.47	1.10	5.40	2.25
P (kg/da)	0.82	13.19	3.18	3.2	9.4	5.6
K (kg/da)	6.33	73.89	29.78	20	78	41
Ca (ppm)				1810	2815	2473
Mg (ppm)				191	975	564

The CaCO3 contents of soil samples ranged from 2.25% to 41.4% in this study. When the results of analysis to $CaCO_3$ is classified according to Evliya (1964) these soil samples have 0.88% low, 2.6% limy, 1.8% high, 18.4% very high, 76.3% excess limy. The results show accordance with Anonymous 1b. The amount of lime (CaCO3) of cotton production areas is generally higher. Depending on the height of the amount of soil lime, pH value is often above 7 and 8.

In the case of pH value 8, fertilizer utilization efficiency of the cotton plant decreases. In addition, especially, the uptake of the micro elements such as iron (Fe) and zinc (Zn) decrease. In this case, sulfate fertilizers would be recommended reducing pH and the high rate of lime.

Organic matter (%) content of these soils ranged from 0.35% to 5.59%. The amount of soil organic matter is very low in Antalya. Ulgen et al. (1988) reported that 24% of the Mediterranean region soil was less than 1% level of and 47.1% of these soils ranged between 1 and 2% in organic matter.

Salt content of these soils ranged from 0.042% to 0.56%. By Soil Survey Staff (1951), the soils have been 64.9% salt, 32.5% of mild salt and 2.6% in the medium salty. In Antalya, Soils of cotton production have been found high saline. Ozturkmen et al., (2005) were showed that variation of total salt soil from 0:20 to 2:48 mmhos/cm in the Harran Plain conditions. Cotton is a plant tolerant to soil salinity. When the value of salinity is higher than 7-8 (dS / m) 25 ^{o}C., occurred loss of cotton yield. While salt value increase ever 1 unit the yield of cotton decrease

6.6%. Reasons of increasing to the salinity of the soil were ground water, the quality of irrigation water, excessive irrigation, high temperatures and evaporation. In regions of salinity or ground high water effect may increase to salinity with excessive irrigation, besides caused soil to wash nutrients (Ekmekci et al., 2005).

Soil samples are 22.8% loamy, 57.0% then clayish loamy and 11.4% clayish (Black, 1957). Soil with medium-structure such as sandy loamy, silty loamy, loamy, and clayish loamy is ideal for the cultivation of cotton (Anonymous 1b). Results of analysis show a good structure for cotton with 57% clayish loamy soil structure.

Available phosphorus content of soils in Antalya varied between 0.82 kg/da and 13.19 kg/da. Olsen and Sommers (1982) explained that soil has plant-available phosphorus 6.1% very little, 18.4% little, 19.3% medium, 19.3% much and 36.8% very much. In general, the accumulations of phosphorus in the soil are high in Antalya. This situation may be a result of the P fertilization unconsciously done by farmers every year. Alagoz, et al. (2006) reported that accumulation of phosphorus in the soil may affect Fe and Zn uptake.

Available potassium content of soils varied between 6.33 kg / da and 78 kg / da, in Antalya. According to Pizer (1967) soils contain 14.9% low, 62.3% enough and 22.8% much of potassium in plant-available. Approximately 15% of the land under cotton cultivation is poor in potassium and yield and quality of cotton decrease in the areas of insufficient potassium.

Redness of leaves and wilt disease caused by potassium are major problem in cotton areas grown in both the Aegean Region and Antalya (Gurel et al., 2006; Ozkahya, 1976). In cotton, wilt disease and leaf redness symptoms leads to interference and misleading practices from time to time. In calcareous soils this element uptake by the plant is difficult. Thus, it should be checked whether taken by the leaf analysis and if necessary, leaf fertilization should be done (Anonymous 1b).

In 2000, it was observed that according to soil samples taken is a very good amount of Ca and Mg in the soil and does not constitute a problem in terms of cotton production areas.

Table 2. Classification of limit values for soil samples from cotton fields in Antalya

Soil Property	Limit Value	Evaluation	Year 2000 number of samples	%	2002 number of samples	%	Total number of samples	%
pH	5.1–5.5	Strong Acid	-	-	-	-	-	-
	5.6–6.0	Medium Acid	-	-	-	-	-	-
	6.1–6.5	Slight Acid	-	-	-	-	-	-
	6.6–7.3	Neutral	10	12.8	-	-	10	8.8
	7.4–7.8	Slight Alkali	67	85.9	-	-	67	58.8
	7.9–8.4	Alkali	1	1.3	36	100	37	32.5
Lime (%) ($CaCO_3$)	0–2.5	Low	1	1.3	-	-	1	0.88
	2.6–5.0	Limy	3	3.8	-	-	3	2.6
	5.1–10.0	High	2	2.6	-	-	2	1.8
	10.1–20.0	Very High	13	16.7	8	22.2	21	18.4
	20.0<	Excessive	59	75.6	28	77.8	87	76.3
% Salt	0-0.15	Saltless	45	57.7	29	80.6	74	64.9
	0.15–0.35	Slight Salty	30	38.5	7	19.4	37	32.5
	0.35–0.65	Medium Salty	3	3.8	-	-	3	2.6
	0.65<	High Salty	-	-	-	-	-	-
Organic Matter (%)	0–1	Very few	7	9,0			7	6,1
	1–2	Few	65	83,3	15	41,6	80	71,2
	2–3	Medium	5	6,4	17	47,2	22	19,3
	3–6	High	1	1,3	4	11,2	5	4,4
	up to 6	Very High						
% Constitutive by Saturasyon	< 30	Sandy	-	-	-	-	-	-
	30–50	Loamy	20	25.6	6	16.7	26	22.8
	50–70	Clayish Loamy	50	64.1	15	41.7	65	57.0
	70–110	Clayish	8	10.3	5	13.9	13	11.4
	> 110	Heavy Clayish	-	-	-	-	-	-
Available Phosphorus (kg/da)	< 1.3	Very few	7	9.0	-	-	7	6.1
	1.3–2.6	Few	21	26.9	-	-	21	18.4
	2.7–3.9	Medium	21	26.9	1	2.8	22	19.3
	4–6.5	Over	19	24.4	3	8.3	22	19.3
	>6.5	Very Over	10	12.8	32	88.9	42	36.8
Available Potassium (kg/da)	< 17	Few	17	21.8	-	-	17	14.9
	17.1–50	Enough	50	64.1	21	58.3	71	62.3
	50.1–83	Over	11	14.1	15	41.7	26	22.8
	>83	Very Over	-	-	-	-	-	-
Ca (ppm)	<714	Very Poor	-	-				
	715–1433	Poor	-	-				
	1434–	Medium	36	100			36	100
	2866>	Good	-	-				
Mg (ppm)	<55	Poor	-	-				
	55–116	Medium	-	-				
	116>	Good	36	100			36	100

Conclusions

Generally, soil texture in the cotton fields of Antalya were found loamy and clayish loamy, however, 10% of the cotton soil is clayish. Loamy and clayish loamy texture is good for cotton plant and farmers.

Organic matter was found poor in almost the all cotton area. Organic matter affects soil by direct or indirect ways. Organic-based fertilizers and forage crops cultivation can be offered for the production of a sufficient amount of organic matter.

In nearly all the soil samples the problem of salinity were not found by analysis. This shows quality of irrigation water and good drainage in our region.

More than half of soil samples are high calcareous and high pH values. For this reason, the pH of the soil may be recommended to reduce by use of acid fertilizers.

Available phosphorus content of soils is generally higher. This situation shows that phosphorus is used unconsciously. By analyzing phosphorus in soils, unnecessary use can be prevented.

Levels of potassium of soils are usually enough, but 15% of cotton growing areas not enough. Especially wilt disease contaminated and calcareous soils should be made additional fertilization.

According to the results of soil analysis, suitable time and dose of fertilizer use for cotton plant provides economic production.

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ORAL PRESENTATION

Chlorophyll Fluorescence Characteristics and Seed Yield of Bulgarian Cotton Cultivars Grown in Rainfed Conditions

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Introduction

Cotton (*Gossipium hirsutum* L.) is one of the most important fiber producing crops in the world. In Bulgaria cotton is traditionally cultivated in rainfed conditions and therefore it expresses good tolerance to drought (Bojinov et al., 2000). Nevertheless, the drought reduces significantly its potential yield. There is substantial evidence that soil water deficits during critical growing stages, such as reproductive stage, can significantly affect growth and yield (Kaur and Singh, 1992; Marur, 1991). We established that the boll productivity of pot-grown cotton plants exposed for 20 days at 35-40% of field water capacity was diminished by 23-35% (Koleva and Vasilev, 2010). The decrease of yield was accompanied by significantly depressed both net photosynthetic rate and photosynthetic pigments quantity of cotton plants (Vasilev and Koleva, 2011).

An opinion exists that several photosynthetic and leaf gas exchange parameters, namely photosynthetic rate, pigments content, transpiration intensity, stomata conductance, etc., may be used as indicators for tolerance of cotton genotypes to drought (Pettigrew, 2004; Ullah et al., 2008; Soomro et al., 2011). The results of other authors have not confirmed this statement (Massacci et al., 2009). Therefore, there is not general opinion and enough evidence concerning the usefulness of photosynthetic parameters for the screening studies for drought tolerance as well as selection criteria.

Chlorophyll fluorescence is widely accepted as suitable stress indicator for plants. At normal (physiological) temperatures it originates from photosystem II (PSII), which is susceptible to different stresses, including drought. Many *in vivo* studies have demonstrated that water deficit resulted in damages to the oxygen evolving complex of PSII and to the PSII reaction centers associated with the degradation of D1 protein (Lawlor, 1995; Yordanov et al., 2003; Zlatev and Yordanov, 2005). On the other hand, chlorophyll fluorescence measurements can be performed *in situ* and quickly with portable devices, which are very important for screening studies and breeding programs. Furthermore, parameters of chlorophyll fluorescence may also serve as physiological criteria for indirect selection for high yielding genotypes. For now there are limited and contradictory information about correlation between seed cotton yield and chlorophyll fluorescence inhibition in cotton (Dumka et al, 2004; Pettigrew, 2004).

Therefore, we have decided to study physiological performance of Bulgarian cotton cultivars grown in rainfed conditions using some chlorophyll fluorescence parameters in order to search for existence of correlations with the yield as a final goal.

Material and Methods

Experimental set-up

In the investigation are involved 13 cotton cultivars genotypes created in the Field Crops Institute – Chirpan, Bulgaria (Table 1). The genotypes were cultivated in field conditions during 2011 and 2012 in the experimental field station Field Crops Institute – Chirpan. The trial was conducted as a randomized block design in four replications, on leached smolnitza soil type, with harvesting plots of 20 m^2.

Chlorophyll fluorescence measurements

Physiological performance of cotton plants was studied using a pulse amplitude modulation chlorophyll fluorometer MINI-PAM (Walz, Effeltrich, Germany). The top fully developed attached leaves were used for the measurements. During the flowering-boll formation plant stage in 2011 and 2012 the fluorescence parameter – actual yield of photochemical energy conversion (Y) (Genty et al., 1989) were measured in several days - time scale. In addition, in 2012 several other basic fluorescence parameters were determined, namely F_0, F_m, F_v/F_m, qP and qN. Minimal fluorescence, F_0, was measured in 30 min dark-adapted leaves using weak modulated light of < 0.15 μmol m^{-2} s^{-1} and maximal fluorescence, F_m, was measured after 0.8 s saturating white light pulse (>5500 µmol m^{-2} s^{-1}). Maximal photochemical efficiency of PSII (F_v/F_m) for dark adapted leaves was calculated using equation $F_v=F_m–F_0$ for variable fluorescence. In light adapted leaves present fluorescence (F) before and maximal fluorescence (F_m`) after saturation pulse (0.8 s white light pulse, > 5500 µmol m^{-2} s^{-1}) were determined. Photochemical (qP) and non-photochemical (qN) quenching parameters were calculated according following van Kooten and Snel (1990).

Table 1. Used Bulgarian cotton cultivars and their parentage

№ Genotypes	Parentage
1. Chirpan–539	Beli izvor × Garant [G. hirsutum L.× G. hirsutum L.]
2. Avangard–264	C – 460 × C – 6030 [G. hirsutum L.× G. barbadense L.]
3. Perla	Garant × Progres [G. hirsutum L.× (G. hirsutum L.× G. barbadense L.)]
4. Natalia	№ 65 × T – 073 [(G. hirsutum L.× G. barbadense L.) × G. hirsutum L.]
5. Darm i	№ 268 × C–9070 [(G. hirsutum L.×G. barbadense L.) × G.barbadense L.]
6. Ko lorit	№ 266 × Balkan [(G. hirsutum L.× G. barbadense L.) × G. hirsutum L.]
7. Vega	№ 266 × Ogosta [(G. hirsutum L.× G. barbadense L.) × G. hirsutum L].
8. Dorina	T – 89/92
9. Nelina	Perla – 267 × T – 073
10. R umi	№ 268 × Deltapine 20
11. Helius	C – 6530 [irradiated with Y rays]
12. Boyana	Chirpan – 603 × C – 9070 [G. hirsutum L.× G. barbadense L.]
13. Viki	C – 9070 [irradiated with Y rays]

Data analysis

The results obtained were processed by the dispersion analysis method using one-way and two-way ANOVA (for P < 0,05).

Results and discussion

Climatic conditions during the vegetation periods in 2011 and 2012 are characterized by different combinations of climatic factors. 2012 year is distinguished by extremely low amount of precipitation during the vegetation period of cotton – May – September compared with an average amount of precipitation for long period of time and can be described as severely dry (data not shown). The data for the quantity of available water content in different soil layers up to 1 meter is presented in Table 2. It is a pparent that in the upper 20 cm the quantity of available water is too low and during the long peri ods (second decade July – first decade August 2011 and whole August 2012) is com pletely missing. It is due the absence of rain tog ether with c omparatively high temperatures leadi ng to significant evapotranspiration and drying of upper soil la yers. It is known that the m ajor part of cotton roots is occupied in 50-cm layer and the central root is able to reach and even go further the 1-meter zone. Obviously, based on the presented data the water supply to cotton plants during the two vegetati on periods has been ensured through the deeper soil zones.

Table 2. Available water content (mm) in different soil layers at flowering-boll formation stage of cotto n plants gro wn in rainfed condition s during 2011 and 2012

Soil layer, cm	**0 - 10**		**0 - 20**		**0 - 50**		**0 - 100**	
Date	2011	2012 2	011	2012 2	011 2	012	2011	2012
21-30 VI	0	4	3	17 3	6 6	4	109	154
1-10 VII	2	0	3	9	23	52	91	133
11-20 VII	0	0	0	6	20	34	86	109
21-31VII 0		0	0	2	11	20	73	89
1-10 VIII	0	0 0		0 8		15	63	74
11-20 VIII	7	0 1	7	0 4	2 6		93	55
21-31 VIII	2	0	6	0 2	5 9		75	47
Average productive moisture (1956-2007)	89 mm				181 mm			

The data for actual yield of photochem ical energy conversion (Y), presented in the F igure 1, gives evidence to what exte nt soil water a vailability has influenced the physiological perform ance of cotton plants. The data showed that values, with small exceptions (last m easurement in 2012 an d sporadic ones in 2011 in cultivars Perla and Natalia) have exceeded 0.500. T he lower values of Y from the last measurement during 2012 could be explaine d by leaf senescence as well as growth retardation in the end of vegetation, while the sporadic lower values in 2011 could be a result from technical error.

The conductance of fluorescence m easurements on the selected cotton cultivars in dynam ics (4-6 tim es per st udied periods) were based on the hypothesis that, the ev entual p recipitation during the vegetation coul d allow differentiation of the used cultivars by their physiological response to the changes of soil water regime.

Unfortunately, a stable moderate drought existed during the studied periods in both years, which did not give a possibility to check this hypothesis. Therefore, the data given in Figure 1 do not show significant variation in Y values of different cultivars during the studied periods in 2011 and 2012.

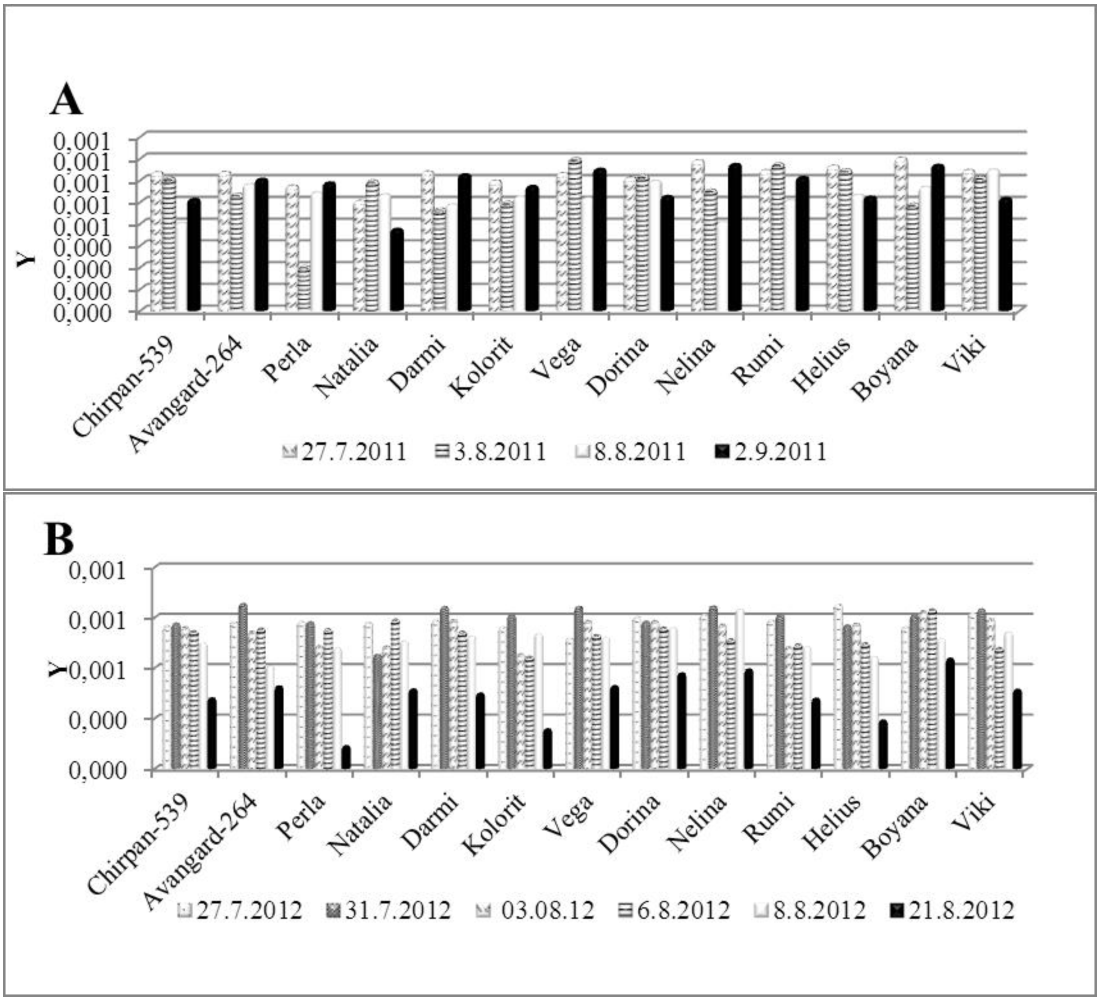

Figure 1. Actual yield of photochemical energy conversion (Y) in the leaves of Bulgarian cotton cultivars grown in rainfed conditions at flowering-boll formation stage during 2011 (A) and 2012 (B)

In our previous experiments with drought-exposed cotton plants we have obtained similar Y values and concluded that primary photochemical processes in these plants were not disturbed (Vasilev and Koleva, 2011). These results are in a good correspondence with the conclusions belonging to Genty et al. (1987) and Inamullah and Isoda (2005) who studied the photosynthetic performance of drought-stressed cotton plants.

To understand the reason for the relatively well saved photochemistry in rainfed cotton plants we performed quenching analysis of chlorophyll fluorescence in the first decade of September 2011. The data obtained are presented in Table 3.

The quenching analysis allows distinguishing two fundamentally different pathways of absorbed light energy conversion. qP reflects the fractions of open PS2 reactions centers and denotes the proportion of excitation energy trapped by them, while qN is a result of various processes that are responsible for thermal dissipation of excess energy in the photochemical apparatus - high-energy state, state transitions and photoinhibition (Bolhar-Nordenkampf and Oquist, 1993). qN has an important function in regulation of dissipation / utilization of excitation energy.

Table 3. Chlorophyll fluorescence parameters in leaves of Bulgarian cotton cultivars grown in rained conditions at flowering-boll formation stage during 2012

Cultivars	**F_v/F_m**	**Y**	**qP**	**qN**
Chirpan-539	0.819 ± 0.030	0.590 ± 0.039	0.878 ± 0.105	0.526 ± 0.083
Avangard-264	0.843* ± 0.012	0.629 ± 0.039	0.897 ± 0.049	0.562 ± 0.035
Perla	0.832 ± 0.006	0.592 ± 0.094	0.867 ± 0.055	0.554 ± 0.104
Natalia	0.831 ± 0.011	0.527 ± 0.069	0.837 ± 0.044	0.631 ± 0.129
Darmi	0.772°° ± 0.035	0.383 ± 0.182	0.911* ± 0.106	0.825 ± 0.094
Kolorit	0.795 ± 0.026	0.528 ± 0.103	0.862 ± 0.156	0.508 ± 0.260
Vega	0.823 ± 0.016	0.493 ± 0.083	0.741 ± 0.114	0.501 ± 0.218
Dorina	0.804 ± 0.014	0.551 ± 0.068	0.873 ± 0.051	0.548 ± 0.158
Nelina	0.816 ± 0.017	0.519 ± 0.159	0.892 ± 0.060	0.626 ± 0.218
Rumi	0.804 ± 0.010	0.379 ± 0.181	0.704 ± 0.315	0.616 ± 0.219
Helius	0.810 ± 0.026	0.396 ± 0.143	0.638° ± 0.234	0.586 ± 0.147
Boyana	0.813 ± 0.021	0.548 ± 0.046	0.841 ± 0.068	0.563 ± 0.093
Viki	0.817 ± 0.015	0.490 ± 0.082	0.976 ± 0.169	0.739 ± 0.118
5 %	0.024	0.136	0.19	0.20
GD 1 %	0.033	0.181	0.26	0.27
0. 1 %	0.044	0.237	0.33	0.34

The maximal photochemical efficiency of PSII (F_v/F_m) for dark-adapted cotton leaves varied from 0.77 to 0.84, which according to Bolhar-Nordenkampf and Oquist (1993) is in the norm for healthy leaves (Table 3). The values of qP were relatively high, giving an evidence for good us e of the trapped excitation energy for photosynthetic processes. qN values were lower that qP ones.

The results regarding seed cotton yiel d from com parative varietals trial, conducted during two years are presented in fig. 2

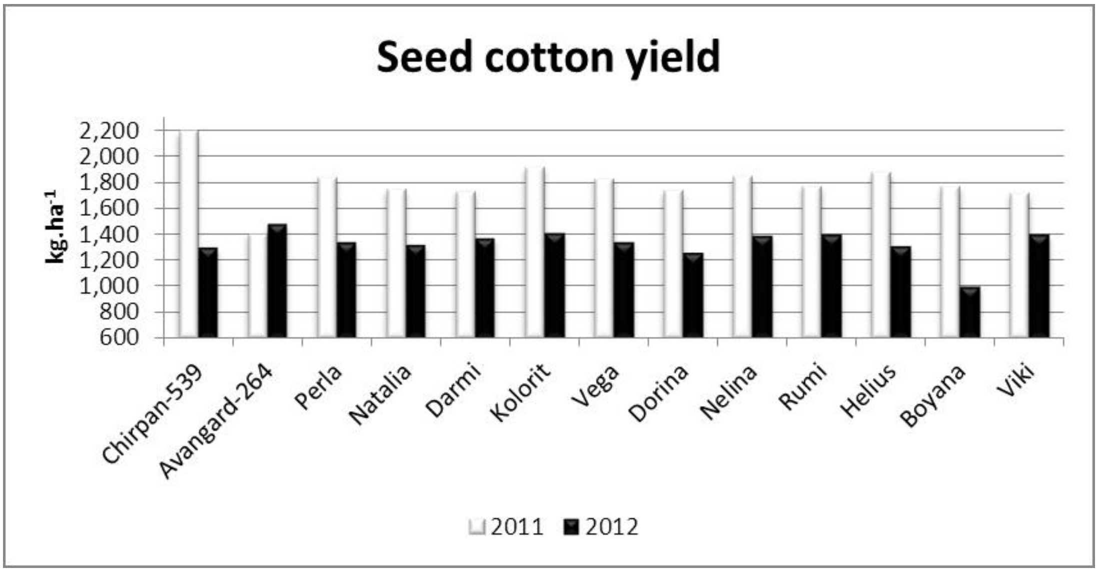

Figure 2. Seed cotton yield of Bulgarian cotton cultivars grown in rainfed conditions during 2011 and 2012

Table 4. Analysis of variance of yield

Source of variation	df	MS	SS	η^2 %
Total 103		3139	78476.8	100
Genotype	12	670.8	8050	8.4
Environment	1	58162	58162	60.7
Interactions	12	1022.1	12264.8	12.8
Error 75		230.1	17262.8	18.0

The applied analys is of varian ce rev eals the prese nce of statistically significant difference in the amount of yield due to of both studied factors – genotype and year an d the in teraction between them. (Table 4). The variation of yield in our varietals trial is to the greatest extent, due to the year of cultivation with 60.7 % from the total variation. The influences of genotype – 8.4 % and interaction between year and genotypes – 12.8 % are vastly less, although the variances of both factors are statistically significant.

Based on the meteorological data and results of analyses of variance it can be concluded that both years of cultivation are vastly differ and the reduction in yield in the second year of cultivation is due to the severe drought. Under water stress conditions during 2012 the yield decreases at all studied varieties to varying degrees. The reduction in yield is highest in cultivars – Chirpan-539 and Boyana and lowest in cultivars Viki, Darmi and Rumi. Furthermore at cultivar Avangard-264 yield has increased by 4% compared to 2011, probably this cultivar is characterized by better agronomical drought tolerance.

Conclusion

Bulgarian cotton cultivars have relatively high tolerance to soil drought. At rainfed conditions leading to significant decrease of the productive soil moisture in the upper layer (till 50 cm), the cotton plants from all used cultivars expressed relatively good photosynthetic performance judged by chlorophyll fluorescence parameters. The maximal photochemical efficiency of PSII (F_v/F_m) in their leaves was in the norm typical for healthy leaves and the actual yield of photochemical energy conversion (Y) was high enough for plants grown in water-limited conditions. Seed yield of the used cotton cultivars at rainfed conditions were lower than the potential yield. In 2012 all varieties realize lower yield compared with the yield in 2011. Solely variety Avangard-264 show better agronomic drought tolerance in severely dry 2012.

At the present stage of the study, we did not find significant differences in the physiological status of the used cotton cultivar, which could be attributed to their specific tolerance to drought.

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ORAL PRESENTATION

The Role of Entomofauna in The Cotton's Agrocenosis

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Abstract

Studies were conducted in 2009 – 2011 in the field of the Field Crops Institute – Chirpan. The species composition of enemies inhabiting cotton and aphidophag agrocenosis, found standard entomological methods – visual observations, soil excavation, route surveys, mowing with a bag and entomological laboratory definitions. The investigation conducted during the periods: outside the growing season of cotton; from stage of germination to flowering stage of cotton and from flowering stage to maturity stage of cotton.

In the cotton agrocenosis there are established forty-six species: from which thirty-two are harmful insects and mites belonging to seven types: Coleoptera, Heteroptera, Hemiptera, Thysanoptera, Trombidiformes, Lepidoptera and Orthoptera and seventeen families: *Elateridae, Tenebrionidae, Chrysomelidae, Curculionidae, Coccinellidae, Pentatomidae, Aphididae, Miridae, Cicadellidae, Membracidae, Thripidae, Tetranychidae, Noctuidae, Pyralidae, Gelechiidae, Acrididae* and *Tettigoniidae* and fourteen are beneficial insects belonging to five orders: Coleoptera, Heteroptera, Neuroptera, Diptera and Hymenoptera and five families: *Coccinellidae, Nabidae, Chrysopidae, Syrphidae* and *Aphidiidae*.

The survey of entomofauna in cotton agrocenosis will help to develop good plant protection practice. Protection of cotton pests a prerequisite for increasing the interest in its cultivation.

Keywords: *Entomofauna, cotton, good plant protection practice*.

Introduction

Cotton fiber is an essential and important oilseed crop. Its wide distribution is explained by its use as a raw material for the textile, chemical and food industries.

When processed cotton seeds produced moderate 20% cottonseed oil, which is one of the most - important semi oils. The refined cottonseed oil has a very high nutritional value and is thus used in cooking and canning. Terms of cottonseed oil is used in industry for making soap, stearine, glycerin, dynamite, etc. Animal food, which is derived from oil and mining industry represents 40 to 42% by weight of the seed is a valuable food for animals as it is rich in protein (40-43%).

Enemies of cotton in Bulgaria with the economic importance are: cotton aphid - Aphis gossypii Glover (Hemiptera; Aphididae), tobacco trips - Thrips tabaci Lind. (Thysanoptera; Thripidae), Tetranychus urticae L. (Trombidiformes; Tetranychidae), Helicoverpa armigera Hub. (Lepidoptera; Noctuidae) and others. (Radev, 1972).

Key pest is cotton aphid, which even in years the least - attack leads to a reduction in yield to 10%.

In recent years, due to the current extreme conditions, the regulatory role of useful entomofauna become particularly relevant. To some extent, population number of cotton aphid is governed by afidofag family Coccinellidae, Syrphidae, Chrysopidae and Nabidae (Pelov 1972; Grigorov, 1977). The authors indicate Coccinella septempunctata L. the most - important parasitoid of the enemy.

Dimitrov and others., (1995, 1996) have found that an important role in regulating the population density of the cotton aphid, a family Nabidae, family Coccinellidae, family Chrysopidae and family Syrphidae. With the advent of aphids, species and family Nabidae - Coccinella septempunctata L. enter agrocenosis cotton and implement regulatory activity by the enemy falling into depression. Representatives of the family Chrysopidae, family Syrphidae u is multiply only during peak development of cotton aphid.

In San Diego, Capinera (2001) found that the natural enemies of cotton aphid are ladybirds (Coleoptera; Coccinellidae), hoverflies (Diptera; Syrphidae) and wasps (Hymenoptera; Braconidae).

According to Josep et al., (2009), cotton agrocenosis Spain predatory ladybirds (Coleoptera; Coccinellidae) and types of families Hemiptera, Diptera and Neuroptera, influence the development and multiplication of cotton aphid.

Parasites of the order Hymenoptera preferentially parasitize aphids to size - from 1.48 to 1.75 mm (Frazer and Gill, 1981; Chau and Mackauer, 2001) and colors - yellow (Losey et al., 1997; Harmon et al., 1998).

Materials and Methods

Studies were conducted in 2009 – 2011 in the field of the Field Crops Institute – Chirpan. The species composition of enemies inhabiting cotton and aphidophag agrocenosis, we found by standard entomological methods – visual observations, soil excavation, route surveys, mowing with a bag and entomological laboratory definitions. The investigation conducted during the periods: outside the growing season of cotton; from stage of germination to flowering stage of cotton and from flowering stage to maturity stage of cotton.

Results and Discussion

In areas for sowing cotton in the region of Chirpan were made soil excavations and were found: of the order Coleoptera, family Elateridae - Agriotes lineatus L., Agriotes sputator L. and Agriotes obscurus L. Representatives of the family Tenebrionidae - Opatrum sabulosum L. and family Chrysomelidae - Phyllotreta atra F. and of the order Heteroptera, family Pentatomidae - Eurydema ornata L., Eurydema oleraceum L. and Dolycoris baccarum L. were found at the end of March and beginning of April, weed - Sinapis arvensis L., Cirsium arvensis L. and Capsella bursa-pastoris Med. (Table1).

During the development of cotton - from phase germination to flowering phase, the following types were identified: the following species of the order Hemiptera, family Aphididae – Aphis gossypii Glover, of the order Thysanoptera, family Thripidae – Thrips tabaci Lind. of the order Trombidiformes, family Tetranychidae - Tetranychus urticae Koch., from the order Lepidoptera, family Noctuidae - Scotia segetum Schiff., Scotia ypsilon Root., Euxoa temera Hb., Euxoa tritici L., Helicoverpa armigera Hb. and Laphygma exigua Hb. and family

Gelechiidae - Pectinophora malwella Hb., of the order Orthoptera, family Acrididae - Dociostaurus maroccanus Thung. and family Tettigoniidae - Tettigonia viridisima L. (Table 2).

Table 1. Insects established before sowing of cotton during 2009 - 2011

Order Family		**/Species**
Order Coleoptera	Family Elateridae	Agriotes lineatus L.
		Agriotes sputator L.
		Agriotes obscurus L.
	Family Tenebrionidae	Opatrum sabulosum L.
	Family Chrysomelidae	Phyllotreta atra F.
Order Heteroptera	Family Pentatomidae	Eurydema ornata L.
		Eurydema oleraceum L.
		Dolycoris baccarum L.

The entomofauna in cotton agrocenosis is influenced by the growing vicinity of its plants. In the case of maize, corn - tonka mix or cereal in the periphery of the blocks were established pests of the order Coleoptera, family Chrysomelidae - Oulema melanopa L. , Leptinotarsa decemlineata Say., Aphthona euphorbiae Schrank.

The weed in cotton agrocenosis consists of annual dicotyledonous weeds – Solanum nigrum L., Amaranthus retroflexus L. and Hibiscum trionum L., annual cereal - Echinochloa crus-galli L., Setaria viridis and Setaria glauca L. and perennial weeds - Convolvulus arvensis L., Cynodon dactylon Pers., Cirsium arvensis L. and others. As a result, you develop and species: of the order Coleoptera, family Curculionidae - Tanymecus palliatus F., the family Coccinellidae - Subcoccinella vigintiquatuorpunctata L. and family Chrysomelidae - Spilosoma mentastri Esp , of the order Lepidoptera, family Pyralidae - Loxostege sticticalis L. and Ostrinia nubilalis Hb. and of the order Hemiptera, family Miridae - Adelphocoris lineolatus Goeze and from the family Cicadellidae - Empoasca ssp. and family Membracidae - Stictocephala bubalus F.

Harmful fauna in cotton agrocenosis from flowering phase to phase maturation is - poorly developed (Table 3). This period covers the months of July and August, which are characterized by extremely high temperatures and low relative humidity.

Table 2. Insects found in cottonseed agrocenosis from phase germination to flowering phase during 2009 – 2011

Order	**Family/Species**	
Order Coleoptera	Family Curculionidae	Tanymecus palliatus F.
	Family Coccinellidae	Subcoccinella vigintiquatuorpunctata L.
	Family Chrysomelidae	Oulema melanopa L.
		Leptinotarsa decemlineata Say.
		Aphthona euphorbiae Schrank
		Spilosoma mentastri Esp.
Order Orthoptera	Family Acrididae	Dociostaurus maroccanus Thung
	Family Tettigoniidae	Tettigonia viridisima L.
Order Lepidoptera	Family Noctuidae	Scotia segetum Schiff.
		Scotia ypsilon Root
		Euxoa temera Hb.
		Euxoa tritici L.
		Helicoverpa armigera Hb.
		Laphygma exigua Hb.
	Family Pyralidae	Loxostege sticticalis L.
		Ostrinia nubilalis Hb.
	Family Gelechiidae	Pectinophora malwella Hb.
Order Hemiptera	Family Miridae	Adelphocoris lineolatus Goeze
		Lygus rugulipennis Popp.
	Family Aphididae	Aphis gossypii Glover
	Family Cicadellidae	Empoasca ssp.
	Family Membracidae	Stictocephala bubalus F.
Order Thysanoptera	Family Thripidae	Thrips tabaci Lind.
Order Trombidiformes	Family Tetranychidae	Tetranychus urticae Koch.

During the study of the fauna in cotton areas there were identified thirty-two species of harmful insects and mites belonging to seven orders: Coleoptera, Heteroptera, Hemiptera, Thysanoptera, Trombidiformes, Lepidoptera and Orthoptera and seventeen families: Elateridae, Tenebrionidae, Chrysomelidae, Pentatomidae, Aphididae, Thripidae, Tetranychidae, Noctuidae, Gelechiidae, Acrididae, Tettigoniidae, Curculionidae, Coccinellidae, Pyralidae, Miridae, Cicadellidae and Membracidae.

Table 3. Pests found in cottonseed agrocenosis flowering phase to phase ripening period 2009 – 2011

Order	**Family/Species**	
Order Orthoptera	Family Tettigoniidae	Tettigonia viridisima L.
Order Hemiptera	Family Aphididae	Aphis gossypii Glover
	Family Membracidae	Stictocephala bubalus F.
Order Trombidiformes	Family Tetranychidae	Tetranychus urticae Koch.

Figure 1 shows the types of useful entomofauna established cotton agrocenosis near Chirpan: the order Coleoptera, family Coccinellidae - Coccinella septempunctata L., Coccinella quinquepunctata L., Adonia variegata Gz., Propylaea quatuordecimpunctata L. and Stethorus punctillum Ws.; order Heteroptera, family Nabidae - Himacerus apterus F. and Nabis ferus L.; order Neuroptera, family Chrysopidae - Chrysopa carnea Steph., Chrysopa septempunctata Wesm. and Chrysopa formosa Br.; order Diptera, family Syrphidae - Scaeva pyrastri L. and parasites of the order Hymenoptera, family Aphidiidae - Diaeretiella rapae M. Int., Lysiphlebus fabarum March. and Aphidius matricariae Hal.

The emergence and dynamics of population density of predators and parasites in cotton agrocenosis is associated with the development of the main pests - cotton aphid. With the advent of her cotton crop plants was detected following types: Coccinella septempunctata L., Coccinella quinquepunctata L., Adonia variegata Gz., Propylaea quatuordecimpunctata L. and Stethorus punctillum Ws. and representatives of the family Nabidae - Himacerus apterus F. and Nabis ferus L. Increasing the density of cotton aphid in cotton areas (more than one ball) led to an increase in the number of Coccinella septempunctata L. and Himacerus apterus F. (32% and 22% of the total number of identified species), Chrysopa carnea Steph. (7%) and Scaeva pyrastri (7 %). Maximum density of these entomophag was noted during peak multiplication of the enemy. During this period the yellow form of the species were found, and vermin Diaeretiella rapae M. Int., Lysiphlebus fabarum March. and Aphidius matricariae Hal.

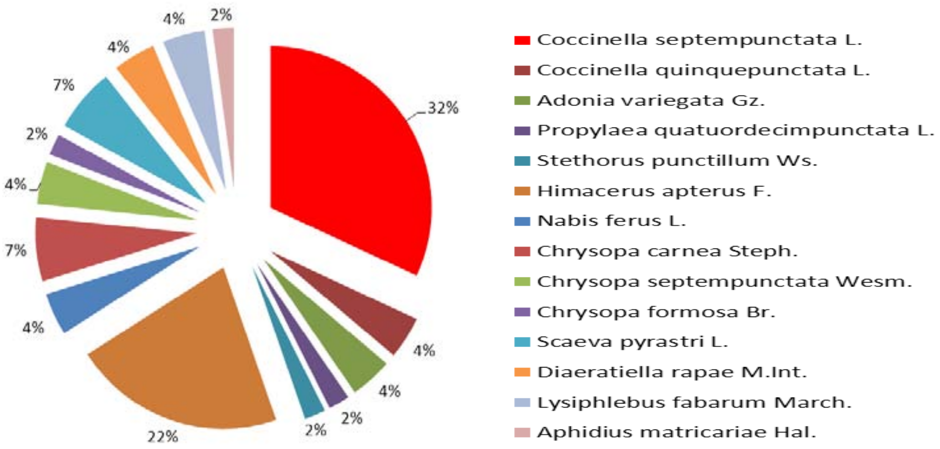

Figure 1. Useful entomofauna in cotton agrocenosis period 2009 - 2011

Diapauses falling into the cotton aphid reduce the size and useful entomofauna in cotton crops. With the advent of the common plant Tetranychus urticae Koch. was found the presence of Stethorus punctillum Ws.

In cotton agrocenosis there are identified fourteen species are beneficial insects belonging to five orders: Coleoptera, Heteroptera, Neuroptera, Diptera and Hymenoptera and five families: Coccinellidae, Nabidae, Chrysopidae, Syrphidae and Aphidiidae.

Conclusions

In cotton agrocenosis there are established forty-six species: thirty-two of which are harmful insects and mites belonging to seven orders: Coleoptera, Heteroptera, Hemiptera, Thysanoptera, Trombidiformes, Lepidoptera and Orthoptera and seventeen families: Elateridae, Tenebrionidae, Chrysomelidae, Curculionidae, Coccinellidae, Pentatomidae, Aphididae, Miridae, Cicadellidae, Membracidae, Thripidae, Tetranychidae, Noctuidae, Pyralidae, Gelechiidae, Acrididae and Tettigoniidae and fourteen beneficial insects belonging to five orders: Coleoptera, Heteroptera, Neuroptera, Diptera and Hymenoptera and five families: Coccinellidae, Nabidae , Chrysopidae, Syrphidae and Aphidiidae.

The survey of entom ofauna in cotto n agrocenosis will help to develop good plant protection practice. Protection of co tton pests a prerequisite for increasing interest in its cultivation.

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ORAL PRESENTATION

Photosynthetic Efficiency in *G. hirsutum* Cotton Hybrids under Summer Irrigated Conditions

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Abstract

A field experiment was carried out to study the photosynthetic efficiency in cotton hybrids (*Gossypium hirsutum* L.) at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (MS). The experiment was laid out in randomized block design (RBD) with three replications and ten hybrids. The physiological basis for differences in seed cotton yield amongst the high and low yielding hybrids was mainly due to the variation in magnitude of the morphological and physiological characters along with yield contributing characters. Higher magnitude of mean values of plant height, leaf area, dry matter production and its partitioning, photosynthetic rate and yield contributing characters are important physiological traits in ideotype for achieving higher productivity in cotton. The cotton hybrids NHH-44, Phule-492, RHH-516, RHH-707 and Ankur-651 were observed to be photosynthetically more efficient thereby resulting in to the higher yield. These hybrids were also found to be superior in respect of photosynthetic rate, stomatal conductance, chlorophyll content, dry matter production and its partitioning.
Key words: *Cotton, physiology, photosynthetic efficiency, yield, G. hirsutum.*

Introduction

Cotton (*Gossypium Sp.*) is one of the most important cash crop cultivated in India. It is mainly grown for fibre purpose to supply the raw material to textile industries. Apart from its fibre, it contributes to play a pivotal role in paper and cardboard industries in coming decades. The productivity of cotton in Maharashtra is

310 kg per ha in terms of lint which is very low and mainly attributed to cultivation of cotton under rainfed condition. Also limited use of fertilizers and its high price contributes to the low productivity. Now a days human population is increasing at a faster rate in the world over and demand for clothing are increasing. To fulfill the increasing needs of clothing, special attention needs to be given to increase the yield per unit area of cotton, which would be achieved by the use of best quality seed, timely and sufficient quantities of irrigation water, proper application of fertilizers and timely application of plant protection measures.

Various morpho-physiological and yield contributing characters determine the productivity of the crop. There are some hybrids having specific characters which are responsible for higher productivity. On successful completion of vegetative phase, the crop starts reproductive growth. However, it is established that excessive vegetative growth may not result in proportionate higher yield (Dastur, 1949). Moreover, it would affect the harvest index adversely. Different hybrids of cotton show different growth pattern during different periods of growth as estimated by physiological growth determinants or functions. A number of workers have reported the effect of different agronomic practices like spacing, irrigation, fertilizers and their effects on yield of hybrids but very few attempts were made to identify the physiological parameters which contribute towards yield directly or indirectly. Therefore, present investigation was undertaken to study photosynthetic efficiency in different hybrids of cotton (*Gossypium hirsutum* L.).

Materials and Methods

The experiment was conducted during the *kharif* season of year 2010 at Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra). The experiment was laid out in a randomized block design (RBD) with three replications and ten hybrids *viz*., RHH-707, RHH-523, RHH-216, RHH-202, RHH-516, RHH-622, RHH-520, Phule-492, NHH-44 and Ankur-651. The observations on various growth and yield attributes such as plant height, leaf area, number of sympodial branches per plant, total dry matter and seed cotton yield per plant and per ha. were recorded periodically. The physiological observations *viz*., periodical mean photosynthetic rate (µmol $m^{-2}s^{-1}$), periodical mean transpiration rate (µmol $m^{-2}s^{-1}$), periodical mean stomatal conductance (mol $m^{-2}s^{-1}$), and periodical mean photosynthetically active radiation (µmol $m^{-2}s^{-1}$) were recorded at 60 and 120 days after sowing (DAS) on the leaves of fully expanded leaflets from observational plants from the net plot by using portable IRGA (Infra Red Gas Analyser) Parkison Photosynthesis system Model (IRSA- I). Instantaneous water use efficiency was worked out by the formula (Farquhar *et al.*, 1989) and total chlorophyll content was calculated by using formula as suggested by Sadasivam and Manickam (1996). The data obtained was analyzed statistically as per Panse and Sukhatme (1985).

Results and Discussion

Morphological observations

Significant differences were observed amongst the hybrids for mean values of plant height, sympodial branches per plant, leaf area, total dry matter and seed cotton yield per plant and per ha. The observations on various growth characters were recorded periodically at 60, 120 DAS and at harvest. The data presented in Table 1 revealed that at all the crop growth stages, none of the hybrid recorded significantly higher plant height over all the checks. However, the hybrid RHH-516 recorded the highest plant height (72.00 and 139.46 cm) among all the hybrids and at par with the best check NHH-44 (74.43 and 134.20 cm) at 60 and 120 DAS, respectively. At harvest, none of the hybrid recorded significantly higher plant height over the best hybrid check NHH-44 (158.16 cm). The hybrid (NHH-44 and RHH-516) which showed the highest plant height recorded the higher seed cotton yield and the hybrids with lowest plant height recorded the lower seed cotton yield. Similar trend was also observed by Patil and Zode (1988).

The mean number sympodial branches per plant increased with advancement of age of the crop. There were no significant differences in mean number of sympodial branches per plant at 60 DAS and 120 DAS. However, significant varietal differences were observed only at harvest. At harvest, none of the hybrid produced significantly higher sympodia over the best check NHH-44 (34.38). It could be noticed from Table 1 that, among the tested hybrids, RHH-516 had higher mean number of sympodial branches per plant at all the growth stages and this hybrid also produced the higher seed cotton yield (1784.33 kg) per hectare (Table 2). These results are in agreement with the findings of Bhatt and Nathan (1983).

Table. 1. Seed cotton yield (per plant and per ha) and yield com ponents in different cotton hybrids recorded at 60, 120 DAS and at harvest.

Sr. No.	Treatment	Plant height			Number of sympodia per plant		
		60 DAS	120 DAS	At harvest	60 DAS	120 DAS	At harvest
1	RHH-707	65.50	118.13	139.50	14.78	20.83	30.16
2	RHH-523	55.53	116.63	142.10	13.00	19.16	27.33
3	RHH-216	54.70	125.03	123.60	14.00	18.17	25.00
4	RHH-202	56.40	127.70	150.36	14.16	20.17	29.16
5	RHH-516	72.00	139.46	153.13	15.33	21.00	33.66
6	RHH-622	64.56	137.76	144.20	13.06	20.83	29.83
7	RHH-520	60.63	134.26	141.80	12.66	18.16	28.16
8	Phule-492(c)	72.20	132.73	149.53	14.83	20.50	31.33
9	NHH-44(c)	74.43	134.20	158.16	16.00	22.83	34.38
10	Ankur-651(c)	71.03	127.46	136.23	14.33	19.33	28.16
Mean		**64.70**	**129.64**	**143.86**	**14.22**	**20.10**	**29.72**
SE ±		**2.79**	**3.85**	**2.89**	**0.90**	**1.20**	**1.05**
C.D. at 5%		**8.29**	**11.44**	**8.58**	**N.S.**	**N.S.**	**3.12**

Sr. No.	Treatment	Leaf Area (dm2) per plant			Mean total dry matter (g/plant)			Seed cotton yield	
		60 DAS	120 DAS	At harvest	60 DAS	120 DAS	At harvest	Per plant (g)	Per ha (kg)
1	RHH-707	51.13	58.86	55.76	82.46	210.63	278.26	145.53	1560.00
2	RHH-523	41.03	54.13	52.80	82.36	177.93	241.86	134.86	1353.50
3	RHH-216	56.33	63.80	59.10	84.63	160.70	228.13	131.26	1328.66
4	RHH-202	56.96	74.13	57.13	77.36	193.50	260.13	140.43	1452.00
5	RHH-516	61.83	76.76	65.83	124.83	257.30	339.56	191.60	1784.33
6	RHH-622	59.76	73.66	63.16	101.83	217.96	290.66	142.93	1529.66
7	RHH-520	53.00	71.10	60.86	94.10	180.43	239.00	133.60	1375.00
8	Phule-492(c)	54.20	63.96	57.96	109.63	230.36	307.20	196.20	1648.66
9	NHH-44(c)	64.16	80.76	70.23	125.80	281.60	369.13	223.16	1985.66
10	Ankur-651(c)	57.33	75.46	61.73	110.76	222.36	288.03	175.15	1552.33
Mean		**55.57**	**69.26**	**60.46**	**99.38**	**216.28**	**284.20**	**161.48**	**1556.98**
SE ±		**1.88**	**2.20**	**1.75**	**2.49**	**3.16**	**3.57**	**4.716**	**57.43**
C.D. at 5%		**5.59**	**6.54**	**5.21**	**7.39**	**9.39**	**10.59**	**14.01**	**170.55**

Table 2. Physiological properties of different *Gossypium hirsutum* hybrids at 60 and 120 DAS

Sr. No.	Treatment	Photosynthesis rate (µmol/m^2/sec.)		Mean transpi-ration rate (µmol/m^2/sec.)		Mean stomatal conductance (mol/m^2/sec.)	
		60 DAS	120 DAS	60 DAS	120 DAS	60 DAS	120 DAS
1	RHH- 707	23.10	24.50	0.59	1.76	1.177	0.018
2	RHH- 523	18.40	21.00	1.41	2.21	0.410	0.310
3	RHH- 216	16.93	17.96	1.65	2.97	0.340	0.290
4	RHH- 202	20.40	22.96	1.18	1.11	0.800	0.200
5	RHH- 516	25.13	26.83	0.49	1.46	1.360	0.090
6	RHH- 622	21.40	23.96	0.61	1.81	1.203	0.083
7	RHH- 520	20.20	21.70	1.10	2.54	0.867	0.210
8	Phule- 492(c)	24.06	25.50	0.42	1.27	1.253	0.130
9	NHH-44(c)	27.16	29.50	0.36	1.05	1.530	0.067
10	Ankur -651(c)	22.10	26.10	0.81	2.22	1.047	0.140
Mean		**21.89**	**24.00**	**0.86**	**1.84**	**0.99**	**0.15**
SE ±		**1.28**	**0.98**	**0.04**	**0.06**	**0.06**	**0.04**
C.D. at 5%		**3.82**	**2.91**	**0.12**	**0.17**	**0.16**	**0.11**

Sr. No.	Treatment	Mean instante-neous water use efficiency		Mean Photosyntheti-cally active radia-tion (µmol/m^2/sec.)		Total chlorophyll content (mg/g)	
		60 DAS	120 DAS	60 DAS	120 DAS	60 DAS	120 DAS
1	RHH- 707	39.46	14.17	758.00	794.83	0.915	2.263
2	RHH- 523	13.07	9.59	743.33	658.06	0.597	1.751
3	RHH- 216	10.21	6.10	660.33	550.53	0.540	1.677
4	RHH- 202	17.26	21.07	1193.33	664.53	0.676	2.153
5	RHH- 516	52.73	17.96	1640.33	954.96	0.978	2.365
6	RHH- 622	35.05	13.08	1283.33	665.20	0.847	2.361
7	RHH- 520	18.44	8.62	1318.66	681.83	1.175	2.090
8	Phule- 492(c)	58.29	20.25	1535.33	914.43	0.901	1.977
9	NHH-44(c)	66.20	26.20	1742.66	987.66	1.381	2.449
10	Ankur -651(c)	26.39	12.00	1420.00	736.40	1.364	2.123
Mean		**33.71**	**14.90**	**1229.53**	**760**	**0.94**	**2.12**
SE ±		**2.94**	**0.66**	**185.32**	**65.30**	**0.01**	**0.01**
C.D. at 5%		**8.75**	**1.95**	**550.38**	**193.93**	**0.04**	**0.03**

Physiological observations

The data on physiological observations as influenced by hybrids are presented in Table 2. All the hybrids differed significantly in respect of photosynthetic rate during all the growth stages. Among the hybrids tested, none of the hybrid recorded significantly higher mean photosynthetic rate over the best hybrid check NHH-44 (27.16 and 29.50) at both 60 and 120 DAS, respectively. The hybrid RHH-516 (25.13 and 26.83) recorded highest mean photosynthesis rate in all hybrids and at par with the best check NHH-44. The hybrid NHH-44, RHH-516, Phule-492 and Ankur-651 recorded higher values for photosynthetic rate than other hybrids and simultaneously produced higher dry matter per plant (g) and seed cotton yield per plant (Table 1). The results obtained in the present investigation are in consonance with the findings of Wullscheleger (1992).

The transpiration rate was low at initial growth stages and it was increased gradually at advanced stages of crop (Table 2). At 60 DAS the hybrids *viz*., RHH-216 (1.65), RHH-523 (1.41), RHH-202 (1.18) and RHH-520 (1.10) recorded significantly higher mean transpiration rate over all the checks. The hybrid RHH-216 (2.97) and RHH-520 (2.54) recorded significantly higher transpiration rate over all the checks. The control of stomatal aperture is one of the important method through which water loss from the plant can be regulated. The mean stomatal conductance among the hybrids was gradually decreased at later growth stages. The maximum stomatal conductance was observed in hybrid NHH-44 and RHH-516, which might have helped in increased photosynthetic rate, more dry matter production and ultimately higher yields. The water use efficiency was higher at initial growth stages and there after decreased during further growth stages. At 60 and 120 DAS, none of the hybrid recorded significantly higher mean instantaneous water use efficiency over the best check NHH-44 (66.20 and 26.20, respectively). The higher WUE was exhibited by the hybrids *viz*., NHH-44, Phule-492 and RHH-516. These three hybrids also had higher seed cotton yields, photosynthetic rate and low transpiration rate. Xu *et al*. (1995) stated that, low soil water status increased water use efficiency by decreasing transpiration.

Photosynthetically active radiation (PAR) plays an important role in different physiological processes. The high PAR with optimum temperature resulted in higher yield. The result of the hybrids differed significantly in respect of PAR during all the growth stages. The data revealed that the PAR was higher at 60 DAS and there after decreased during 120 DAS stage. The hybrid check NHH-44 and RHH-523 had higher PAR and also had higher seed cotton yield.

The physiological processes like photosynthesis has great relationship with chlorophyll content of the plant. It is expected to provide raw material and energy required for growth and development. Among the hybrids tested at 60 and 120 DAS, none of the hybrid recorded significantly highest total chlorophyll content over the checks NHH-44 (1.38 and 2.45 mg/g, respectively). At 120 DAS, the hybrid RHH-516 (2.365 mg/g) was at par with the check NHH-44 (2.449 mg/g).

The physiological basis for differences in seed cotton yield amongst the high yielding and low yielding hybrids was mainly due to the variation in magnitude of the morphological and physiological characters. The hybrids produced higher seed cotton yield mainly due to higher photosynthesis rate, higher dry matter production and its effective translocation from source to sink and also higher values for combination of yield contributing characters. On the contrarily, low yielding hybrids showed lower mean values for plant height, leaf area, dry matter production and also combination of yield contributing factors. In light of above, the hybrid NHH-44 was observed to be photosynthetically more efficient there by resulting in to the higher yield and hybrid RHH-216 was found to be low yielding.

Photosynthetic efficiency is a combine effect of photosynthetic rate, stomatal conductance, instantaneous water use efficiency and photosynthetically active radiation. The cotton hybrids NHH-44, Phule-492, RHH-516, RHH-707 and Ankur-651 were observed to be photosynthetically more efficient thereby resulting into higher yield. The higher plant height, leaf area, photosynthesis rate, PAR, stomatal conductance, total dry matter and number of sympodia are the desirable characters for developing the ideotypes and obtaining the higher seed cotton yield in the cotton.

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ORAL PRESENTATION

The Effect of Plant Growth Regulators on Seed Cotton (*Gossypium spp.* L.) Yield and Lint Quality under East Mediterranean Climatic Conditions

Lale EFE

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Abstract

This study was carried out in 2010 under east Mediterranean climatic conditions (in Kahramanmaras-Turkey) to determine the influence of three plant growth regulators (PGR) on seed cotton yield, yield components and major lint quality properties of four cotton (*Gossypium hirsutum* L.) varities. The study was established according to experimental design of split plots with three replications. Cotton vareties were in main plots, plant growth regulators were in subplots. As plant material cotton varieties of Agdas-3, Agdas-17, Maras-92 (*G. hirsutum* L.) and Agdas-21 (*G. barbadense* L.) were used. Pix (100 cc/da, at the beginning of flowering), Turbonik (75 cc/da at the beginning of flowering + 75 cc/da 10 days after first treatment) and Cytokin (60 cc/da at the beginning of flowering + 60 cc 10 days after first treatment) were used as commercial preparation of plant growth regulators and there were control (untreated) plots.

In the study, plant height (cm), sympodial number, boll number per plant, seed cotton weight per boll (g), seed cotton yield (kg ha^{-1}), ginning outturn (%), 100 seed weight (g), fiber length (mm) (2.5 % S.L.), fiber fineness (micronaire), fiber strength (g/tex), elongation (%), uniformity index (%), reflectance degree (Rd), yellowness (+b), colour grade (CG), short fiber index (SFI) (%), trash area (%) and trash count were investigated. Obtained data were analysed using SAS statistical package and means were compared according to Duncan's multiple comparison test.

Keywords: *Cotton, Gossypium spp. L., plant growth regulators (PGR), seed cotton yield, ginning outturn, lint quality.*

ORAL PRESENTATION

The Determination Effects of Potassium and Zinc Application to Rate of Photosynthesis, Fiber Yield and Quality on Cotton

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Abstract

In this study was conducted to determine the effects of different potassium and zinc application to rate of photosynthesis and fiber yield and quality of Berke cotton varieties in experimental area of Dicle University Faculty of Agriculture in 2010. Rate of photosynthesis, plant height, number of monopodial and sympodial branches ginning, fiber properties (fiber diameter, fiber length, fiber uniformity, short fiber content, fiber strength, fiber brightness, fiber elasticity), were investigated.

According to the results, for all traits studied doses of potassium×zinc application and interaction were significant. Effects of Potassium ×zinc aplications were determined significant to properties of plant height, photosynthesis rate, the number of sympodial branch, boll number, ginning percentage, fiber fineness, fiber brightness, short fiber, the fiber strength. Effects of Potassium aplications were significant to fiber length, fiber uniformity and fiber elasticity; effects of zinc aplications were significant to number of sympodial branch.

Keywords: *Cotton, potassium and zinc application, photosynthesis, yield, quality.*

POSTER PRESENTATION

Introduction of Set Seed Company

Fehmi GULYASAR

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Abstract

Set Seed Company has been established in January 2010 at Adana Organized Industrial Zone in Turkey. Our goal is to produce cotton seed by using latest Technologies and provide service to the country agriculture. After integration of Deltapine Inc. to Monsanto in 2007, seed production strength of the company increased, and became World's largest cotton seed producer. With the licence agreement between Set Seed Company.and Monsanto, Deltapine Cotton seed demands of Turkish farmers are provided by our company.

Keywords: *Set Seed Company.*

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POSTER PRESENTATION

Comparision of Different Methods to Determine the Leaf Area Index (LAI) of Cotton (*Gossypium hirsitum* L.)

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Abstract

The leaf area index is one of the main measurement which is used to carry out the physiological and morphological determinations such as photosynthetic activity, transpiration and some growth parameters in many crops. However, measurments of leaf area in field studies with many leaf samples is time consuming and less reliable to determine photosynthetically active canopy area In this study, some rapid estimation techniques are compared with digital scanning method to determine the leaf area index (LAI) of cotton. The study was carried out during 2012 growing season in the experimental fields of Ege University Faculty of Agriculture Department of Field Crops and Plant Physiology Laboratory. Different canopy structures of cotton are provided with four different sowing dates. LAI was determined by digital scanning, calculation of width-height-coefficient and vertical digital photography. The results indicate that there is a significant positive relationship (R^2=0.956) between scanning technique and the width-height-coefficient method. On the other hand, vertical digital photography is also important to support the other two techniques in terms of determination of the photosynthetically active area, especially when the overlapping leaves in the canopy are considered.

Keywords: *Cotton, leaf area index, digital photography.*

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POSTER PRESENTATION

Combined Effects of Drought and Heat Stress on *Gossypium hirsutum* L. and *Gossypium barbadense* L.

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Abstract

Cotton is most widely grown during summer period in arid and semiarid regions where water is limited and high temperature is often restrict productivity. Although drought and heat stress genarally appears simultaneously in field conditions, their spesific effects become more important if irrigation is availble under unfavoruble high temparatures. A comperative study was conducted in a controlled environment to evaluate the effect of drought and heat stress on dry matter pattern of two different cotton genotypes, cv.Giza (*Gossypium barbadense* L.) and cv.Carmen (*Gossypium hirsutum* L.). The completely randomize design was performed with three factors and three replications. Soil water content of plants subjected to drought was 25% of water holding capacity whereas 75% in well watered condition. Atmospheric temparature was increased up to 40°C in a growth chamber while control condition was 25°C. Both drought and heat stress were resulted in a significant decrese in total dry matter production for both cv.Giza and cv.Carmen. However relative reduction in total dry matter of cv.Giza was more pronunced as a result of combined effect of drought and heat stress than cv.Carmen though cv.Giza had better performance under sole drought effect. Spesific effect of heat stress on cv.Giza can be attributed to relatively higer reduction in leaf dry matter in high temparatures.

Keywords: *Cotton, heat stress, drought, Gossypium hirsutum L. and Gossypium barbadense* L.

Economy - Fiber and Yarn Technology

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ORAL PRESENTATION

Assessment of Technological Fiber Properties of New Bulgarian Cotton Varieties by HVI and AFIS

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Abstract

The aim of this research was to study the fiber technological properties of new Bulgarian cotton varieties. In 2008 the fiber technological qualities were measured by HVI and AFIS at the Textile Research Institute in Lodz, Poland, while in 2008 and 2009 they were measured with HVI in BTEX, Burgas, Bulgaria. In 2008 the prolonged drought during the period of flowering and boll formation – the second part of July and August, reflected unfavorably on the fiber length. In terms of temperature 2009 was also hot and dry as regards rainfall supply. The phase of flowering and boll formation passed rapidly and this had a very adverse effect on the fiber length, stronger expressed for qualitative varieties having a longer growing season. It was found that in fiber length (26.03-27.80 *mm)* the Bulgarian varieties belong to "medium staple cotton" and in micronaire (4.0-4.6 *mic*) they refer to "medium fine cottons". The varieties Avangard-264, Perla, Vega, Colorit, Darmi and Natalia, possessing germpalsm of *G. barbadense L.* species, differed by longer and finer fiber. All varieties had strong fibers (28.0-29.8 *cN/tex)* with average uniformity (81.0-82.8 *%*). They had moderate to low fiber elongation. The finest fiber was found for the variety Avangard-264, but it was the strongest for the varieties Darmi, Veno and Trakia.

Key words: *Cotton, G. hirsutum L., varieties, fiber technological properties.*

Introduction

Creating of early and productive varieties and varieties with improved fiber quality are priority directions in the breeding of cotton in Bulgaria. In the recent years ten new cotton varieties Beno (Bozhinov, Bozhinov, 2008), Trakia, Helius (Valkova, 2009), Boyana (Valkova, Bozhinov, 2010) with high genetic potential for yield, Darmi, Colorit, Natalia (Stoilova, Saldzhiev, 2008a; 2008b; 2010), Dorina (Stoilova, Nistor, 2012), Rumi (Stoilova, 2012) with higher quality of fiber, Izabell with natural brown coloured fiber (Stoilova *et al.*, 2010) were approved by the Executive Agency for Variety Trials, Aprobation and Seed control.

Cotton fiber properties can largely vary based on different reasons: genetic, environmental factors - growing area, soil and agro-climatic conditions, growing technology, and others. Variety is the most important factor that determines almost all parameters of the fiber and most of the economic qialities.

In the world there are many methods and instruments for determining technological properties of the cotton fiber. Methods for measureing the physical and mechanical properties of cotton constantly are developed on an international scale (ASTM Standards, 1993; The classification of cotton, 1995; Kluka, Matusiak, 2000; USDA, Cotton Classification - Understanding the data, 2004; Frydrych, 2005; Buyers Guide, Cotton Council International, 2008; Official Cotton standards, 2009, 2010).

Since 1996, HVI calibration cotton standards for length, strength and uniformity of fiber have been used. The new standards were named Universal HVI Calibration Cotton Standards and today are the most used. In Bulgaria HVI was introduced in 2006 into BTEX in Bourgas.

The aim of this study was to determine the technological fiber properties of new Bulgarian cotton varieties and classify in conformity with the international standards.

Material and Methods

Eleven Bulgarian cotton varieties - Chirpan-539, Beli Iskar, Veno, Trakia, Helius, Avangard-264, Perla, Vega, Colorit, Darmi and Natalia, one Macedonian - 5140 and four Turkish – Barut-2005, Nazili -84/5, Nazilli-663 and Nazilli-954 were the objects of the study. Bulgarian varieties Chirpan-539, Beli Iskar and Veno were obtained by interspecific hybridization within the species *G. hirsutum L.*, Trakia and Helius - through experimental mutagenesis, Avangard-264 – by interspecific hybridization of *G. hirsutum L.* × *G. barbadense L.* species, the other five varieties - after hybridization of the species *G. hirsutum L.* and stabilized lines of *G. hirsutum L.* × *G. barbadense L.* origin. In 2008-2009, a comparative variety trial was carried out by the block method in four replications and harvested plot of 20 m^2. The varieties Dorina (approved in 2011) and Nelina (2012) and two promising lines – Nos. 47 and 67 were included in the trial in 2008 only. After picking and ginning of cotton a representative sample of 350 *g* was taken of each variety. Ginning of seed cotton was made on a small laboratory gin.

In 2008, technological fiber properties of the studied varieties were measured by HVI and AFIS at the Textile Research Institute in Lodz, Poland, in 2008 and 2009 - by HVI in BTEX, Bourgas, Bulgaria.

The fiber properties measured by HVI were: the Upper Half Mean length (UHML) - the average length of the longest ½ fibers in the sample and is expressed in *inch*; Uniformity - a ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage (ML/UHML); Micronaire - it is a measure of fiber fineness and maturity and is expressed as "micronaire" or "*mic*"; strength – in *cN/tex* and elongation whch is expressed as a percentage.

The fiber properties defined by AFIS system were: Mean Length by weight - L(w), *mm*; Length Variation by weight - L(w) CV %; Mean Length by number - L(n), *mm*; Length Variation by number L(n) CV %; 5 % - Length by number (it is a length of 5 % of the longest fibers in measured sample), *mm*; 2.5% - Length by number, *mm*; Mean value of Upper Quartile Length by weight - UQL(w), *mm*; Fineness (Fine, *mtex*); Maturity Ratio (Mat); Immature Fiber Content – IFC %; Short Fiber Content by weight - SFC (w) % and Short Fiber Content by number - SFC (n) %; Total Nep Count per gram - NepCnt in *Cnt/g* and Total Nep Mean Size in *μm*. Fiber properties of the varieties were compared with the 1997 Uster Statistics.

The years of study were characterized in the following way: 2008 was hot in temperature supply and middle dry in rain fall. The strong and prolongation drought during the period of flowering and boll formation – the second part of July and August, gave strong negative effect on yield and fiber length. Rainfall in September worsened quality of fiber; 2009 was also hot in temperature supply and dry as regards rainfall. Drought in August in combination with higher average temperature compared to of many years, accelerated the flowiring and bolls formation and brought about to shortening of the growing season. In this year cotton matured at the end of August, while in normal years it usually matures in the middle of September. Shortening of the flowering and boll opening period had an adverse effect on the fiber length, stronger expressed for the qualitative varieties having a longer growing season.

Results and Discussion

The results obtained from the fiber technological analyses perforemed with HVI in BTEX, Bourgas, Bulgaria are given in Table 1. The Bulgarian varieties showed micronaire values of 4.0-4.6 *mic* (medium fine fiber). The Turkish varieties had higher micronaire values (4.7-5.2 *mic*). The finest fiber was found for the variety Avangard-264. The Bulgarian varieties fiber strength was 28.0-29.*8 cN/tex* (medium strong to strong), and of the Turkish ones it was 28.0-30.2 *cN/tex*. The strongest fibers were found for the varieties Nazilli-84/5 (Turkish) and 5140 (Macedonian). Among the Bulgarian varieties, Darmi, Veno and Trakia had higher values of the fiber strength (29.2-29.8 *cN/tex*). The average HVI fiber length was 26.03-27.80 *mm* for the Bulgarian varieties and 26.17-27.64 *mm* for the Turkish ones. Of the Bulgarian varieties, Avangard-264, Perla, Vega, Colorit, Darmi and Natalia, with germplasm of the *G. barbadense L.* species, showed higher values of the fiber length (27.27-27.80 *mm*). Among the Turkish varieties the longest fiber was found for Nazilli 954 (27.64 *mm*).

The results from the fiber technological analysis performed on HVI in 2008 at the Textile Research Institute in Lodz, Poland showed that the Bulgarian varieties had micronair values of the fiber from 3.5 to 4.0 *mic*, length - from 25.2 to 28.1 *mm* (Table 2). The finest fiber was found for the variery Natalia and the longest one was found for the variety Dorina. Avangard-264, Natalia, Colorit and Vega varieties had also longer fibers. As for the fiber strength higher values were measured - 28.4-30.8 *cN/tex* (medium strong to strong) than those measured in Bourgas in 2008 (26.4-29.0 *cN/tex*). The strongesr fibers were found for the varieties Colorit and Vega. The fiber uniformity was in the limits of 82.1-85.4% (medium to high). About the fiber elongation, the values w ere lower - 5.2-5.4% (low) than those m easured in Bourgas in 2008 - 8.1-9.2 (high).

Table 1. Fiber properties of the varietie s m easured by HVI in BTEX, Bourgas, Bulgaria. Avarage data for two years - 2008 and 2009

Variety	Micronaire *MIC*		Strength *cN/tex*		Length *mm*		Uniformity %		Elongation %	
	Mean	**S.D .**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Chirpan-539 4	.6	0.09	28.9	0.89	26.19	0.55	81.0	1.23	9.6	1.36
Beli Iskar	4.3	0.06	28.0	1.05	26.64	0.85	81.5	1.18	9.5	0.85
Veno 4.	4	0.05	29.2	1.53	26.03	0.80	81.9	0.95	9.1	0.74
Trakia 4.	5	0.07	29.0	1.54	26.04	1.10	81.2	1.07	9.3	0.78
Helious 4.	3	0.06	28.4	0.84	26.04	0.51	82.2	0.88	9.4	0.60
Avangard-264 4.	0	0.06	28.2	0.61	27.32	0.88	82.8	0.84	9.1	0.68
Perla 4.	2	0.08	28.7	1.11	27.62	0.56	82.6	0.94	10.1	1.39
Vega 4.	1	0.05	28.4	1.00	2 7.27	0.85	81.2	0.86	8.8	0.74
Colorit 4.	3	0.07	28.7	1.47	27.30	0.74	82.0	1.34	9.5	0.96
Darmi 4.	2	0.05	29.8	1.14	27.80	1.01	81.2	1.30	9.4	0.82
Natalia 4.	2	0.05	28.5	1.07	27.72	0.51	82.4	1.42	9.0	0.71
5140 4	.4	0.05	30.2	1.38	25.95	1.04	82.0	1.31	9.7	1.66
Barut-2005 4.	8	0.06	28.0	1.13	26.50	0.76	81.1	1.40	10.0	0.85
Nazilli-84/5 4	.8	0.09	30.2	1.06	26.17	2.70	82.7	2.36	8.8	0.73
Nazilli-663 5	.2	-	28.2	-	26.65	-	81.9	-	8.2	-
Nazilli-954 4	.7	0.06	29.1	0.56	27.64	0.53	82.3	0.92	9.7	0.87

Table 3 sh ows the re sults ob tained f rom the techno logical fiber an alysis performed with AFIS at the Textile Research Institute in Lodz, Poland. The AFIS fiber lengths showed higher values for th e varieties Avangard-264, Natalia, Colorit, Vega and Dorina. The finest fibers were found for the varieties Natalia and Darm i, which had less fiber maturity (0.87%). The fiber maturity ranged from 0.87 to 0.91% and shows that the fibers of all varietie s were enough m atured. All varieties showed medium to high variation of the fiber length, by weight - L (w) CV (28.3-31.4%) and by num ber - L (n) CV (35.6-40.6%). The pr esence of short fibers by weight expressed by SFC (w) was 4.1-8.0 % and by number expressed by SFC (n) was 12.2-20.3%. The variety Helius had the highest co ntent of short fibe rs. The varieties having longer fibers showed low content of short fibers, w hch is a favorable trend. Natalia and Darmi varieties showed the lowest percentage of mature fibers (0.87).

Table 2. Fiber properties of Bulgarian varieties, measured by HVI at the Textile Research Institute in Lodz, Poland, 2008

No Lot	Area %	Cnt	Len mm	Un %	Str cN/tex	El %	Mic	Rd	b
1. Chirpan-539	0.42	52	26.5	83.6	29.3	5.3	3.9	70.8	11.1
2. Trakia	0.58	72	25.2	82.1	28.8	5.3	3.8	68.1	11.0
3. Helius	0.93	80	25.8	82.2	29.3	5.3	3.8	66.6	10.4
4. Avangard-264	1.08	74	27.6	84.2	29.4	5.3	4.0	69.4	8.2
5. Natalia	0.97	93	27.4	83.4	29.9	5.3	3.5	67.6	8.7
6. Darmi	0.70	60	26.8	83.0	28.9	5.2	3.7	69.8	10.6
7. Colorit	0.96	69	27.5	85.4	30.8	5.4	3.8	70.4	9.5
8. Vega	0.73	62	27.5	84.4	30.8	5.2	3.7	70.7	10.1
9. Dorina	0.68	65	28.1	84.4	28.4	5.3	4.0	70.0	10.5
10. Nelina	0.53	56	26.5	82.9	28.9	5.3	4.0	70.9	10.6
11. Line 47	0.33	47	27.1	83.9	29.4	5.4	3.9	71.6	10.5
12. Line 67	1.00	79	26.5	84.2	29.8	5.4	3.6	69.2	10.4

Table 3. Technological fiber properties of Bulgarian cotton varieties determined by AFIS at the Textile Research Institute in Lodz, Poland, 2008

Lot	L (w) mm	L(w) CV %	UQL (w) mm	SFC (w) %	L(n) mm	L(n) CV %	SFC (n) %	5 mm	2,5 mm	Fine mtex	IFC %	Mat %	Nep Size µm	NepCnt Cnt/g
Chirpan-539	24.5	29.6	28.2	5.3	21.5	37.5	15.0	31.9	34.8	161	6.4	0.90	818	226
Trakia	23.3	30.7	27.2	7.1	20.2	39.1	18.3	30.9	33.5	159	6.7	0.88	843	299
Helius	22.8	31.4	26.9	8.0	19.6	40.6	20.3	30.4	32.9	160	6.7	0.88	872	384
Avangard-264	25.2	29.7	29.6	5.2	22.0	38.3	15.0	33.6	36.2	162	5.9	0.91	724	113
Natalia	25.4	31.0	29.8	5.7	21.9	40.1	16.3	34.0	36.9	149	7.4	0.87	860	355
Darmi	24.7	31.2	29.0	6.3	21.2	40.6	17.5	33.0	36.1	149	7.4	0.87	676	120
Colorit	25.6	28.3	29.4	4.1	22.7	35.6	12.2	33.3	35.6	157	6.4	0.89	682	114
Vega	25.8	29.9	29.8	4.6	22.6	37.7	13.6	34.3	37.8	152	6.7	0.89	682	133
Dorina	25.3	29.9	29.6	5.4	22.0	39.2	15.8	33.6	36.2	160	5.8	0.91	740	152
Nelina	24.0	30.3	28.1	6.4	20.8	39.8	17.7	32.0	34.4	163	5.8	0.90	834	349
Line 47	24.7	29.3	28.6	5.3	21.7	37.9	15.2	32.3	35.0	163	5.9	0.90	862	294
Line 67	25.0	29.2	28.7	5.0	22.0	36.9	14.1	32.8	35.9	153	6.9	0.88	667	120

Six varieties had large size and high content of neps. Small size (667-740 mμ) and low content (113-152 Cnt/g) of neps were found for the varieties Avangard-264, Darmi, Colorit, Vega, Dorina and line 67.

Based on the data in Table 1 the varieties were clustered by five technological properties. The dendrogram in Fig. 1 shows that the varieties formed two major clusters**.** The first cluster included the Bulgarian varieties Chirpan-539, Trakia, Veno and Helius, the Macedonian variety 5140 and the Turkish varieties Barut-2005, Nazilli-84/5 and Nazilli-663. These varieties showed a shorter fiber during the period of study. The second cluster included the Bulgarian varieties Colorit, Vega, Darmi, Avangard-264, Natalia, Perla, distinguished by finer and longer fiber, Beli Iskar and Nazilli-954 (Turkish).

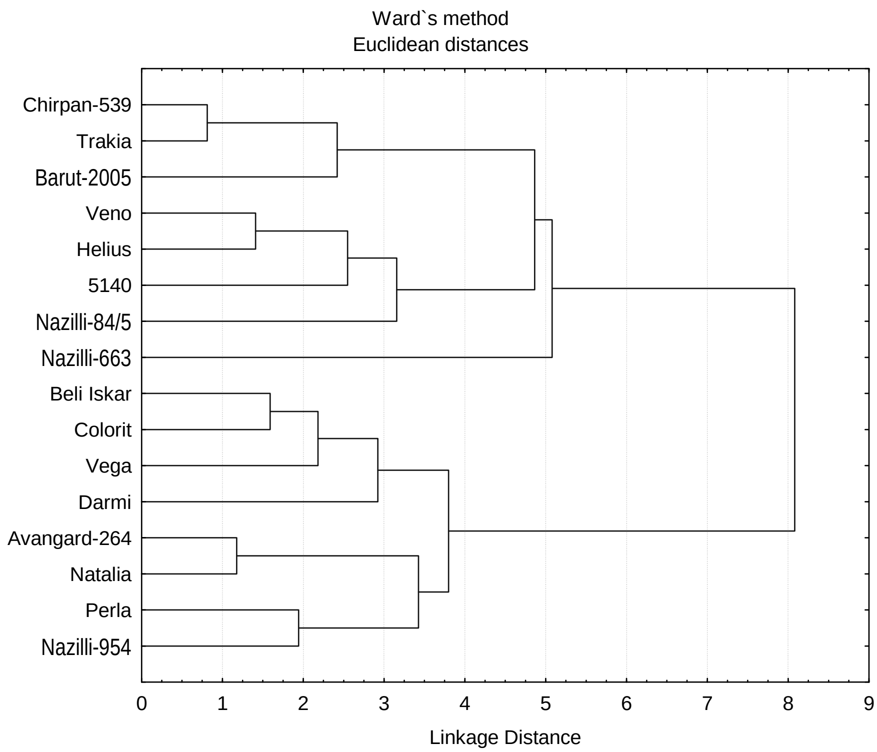

Figure 1. Dendrogram of 16 cotton varieties by 5 technological fiber properties determined with HVI by BTEX in Burgas, Bulgaria, 2008-2009

Figure 2 presents cluster analysis based on the technological fiber properties measured by AFIS. The varieties Trakia and Helius detached from all genotypes and formed a separate group, suggesting that genetically they were most distant from the others. The other varieties at the lower level of division divided into two groups and each of them subdivided into two still smaller groups, including similar genotypes.

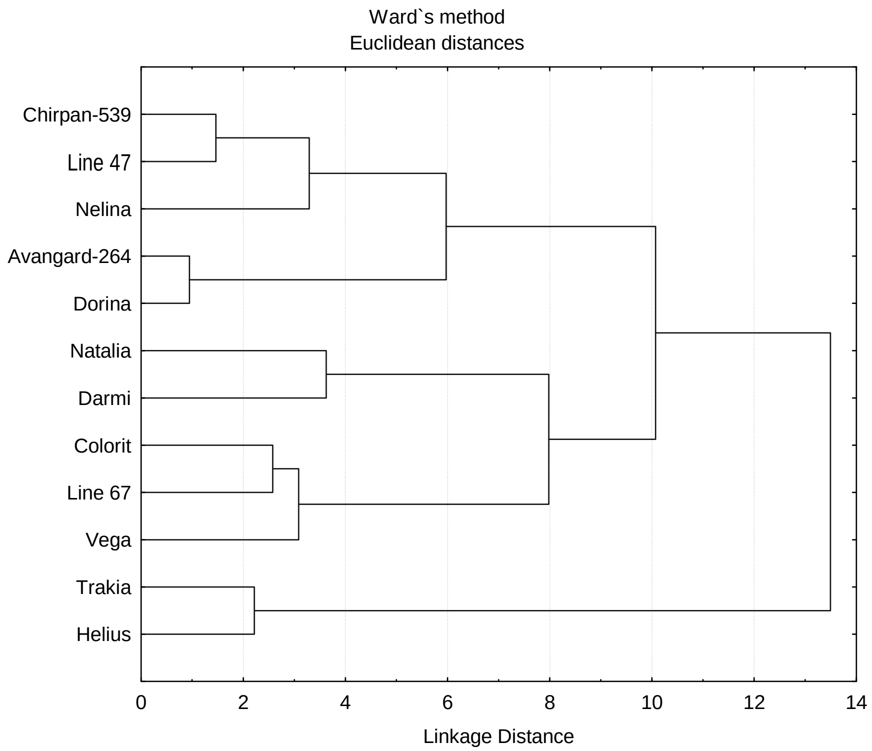

Figure 2. Dendrogram of 12 cotton varieties by 5 technological fiber properties, determined by AFIS at the Textile Research Institute in Lodz, Poland, 2008

The results from the cluster analysis showed that there were genetic similarity and genetic remoteness between the varieties. Genetic differences between the genotypes existed at the smallest levels of division. The Bulgarian varieties with germplasm of the *G. barbadense L.* species formed a separate cluster or detached into a distinct group. These varieties had finer and longer fiber than the other Bulgarian ones which were obtained through intraspecific hybridization or experimental mutagenesis within the *G. hirsutum L.* species.

In years with insufficient rainfall supply, such as 2008 and 2009 were, these varieties do not realize their longer fiber. The Turkish varieties also do not realize the fiber quality parameters under our conditions. It was found that the critical period for fiber length development depending on rainfall was during July 11 to August 10 and July 11 to August 20 for the varieties which mature later, such as Avangard-264, Colorit, etc. (Stoilova, 2011). Rainfall during this period is most important for the maximum fiber length increase. Dependency of yield and fiber length on rainfall in July-August, a period of summer drought, determines the selection of cotton varieties tolerant to drought and high stress temperatures.

Results from the analyses showed that the Bulgarian varieties, according to the international standards, beloneged to the group of " medium fine", micronaire values were from 4.0 to 4.6 *mic*. Cottons with micronaire value below 3 apply to the group of “finest or very fine”, and over 6 refer to the group of “rough or very coarse” (The Classification of Cotton, 1995; Uster Statistics, 1997).

Micronaire value as a complex indicator is directly dependent on two factors: maturity (degree of thickeness of the cell wall) and linear density (mass per 1000 *m* fibers, expressed in *m/tex*, a function of the diameter and thickness). Comparison of various fibres in fineness can be done if their maturity is at a similar level.

Maturity Ratio according to AFIS expresses the average cotton fibers circularity coefficient. Cottons are considered as mature when their Maturity Ratio is in the range from 0.86 to 0.95. According to international requirements our varieties belonged to the group of "mature" cotton. Their Maturity Ratio varied from 0.87 to 0.91.

The cotton with strength (in *g/tex*) 31 and above is considered as very strong, 28-30 – strong, 25-27 – medium, 22-24 weak, 21 and below - very weak. In 2008, according to the data of BTEX, Bourgas, the varieties showed average strength (26.4 - 28.1 *cN/tex*). The variety Veno (29 *cN/tex*) was relevant to the group of strong (“healthy”) cottons. According to the data of the Textile Research Institute in Lodz, Poland the varieties refer to the group “strong” cottons (28.4-30.8 *cN/tex*).

Conclusions

1. The Bulgarian varieties according to the fiber length (26.03-27.76 *mm*) belonged to “medium staple cotton” and according to the micronaire value (4.0 -4.6) they

refered to "medium fine cottons". The varieties Avangard-264, Perla, Vega, Colorit, Darmi and Natalia differed by longer and finer fiber.

2. All Bulgarian varieties possessed average to strong fiber (28.0-29.2 cN/tex) with intermediate uniformity (81.0-82.8 %). They had moderate to low fiber elongation (5.2-5.4 %) on the data of Textile Institute in Lodz, but it was high (8.2-10.0%) on the data of BTEX in Bourgas.
3. The cluster analysis based on the studied fiber technological properties confirmed the genetic differences between the varieties, which have been realized in the frame of two differently purposeful breeding programs.

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ORAL PRESENTATION

Production of Carded Compact Cotton Yarn of Comparable Quality to The Combed Conventional Ring Yarn

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Abstract

The objective of this study was to determine the influence of cotton type in order to find out if it is possible to produce a carded compact yarn of comparable quality to the combed conventional yarn. Marzoli spinning frame was used to produce combed and carded cotton yarns with linear densities of 14.76 tex (40 Ne), 19.68 tex (30 Ne), and 29.53 tex (20 Ne), at constant twist multiplier 4.3, were manufactured from the same LS cotton (Giza 80 and Giza 90, as Egyptian cotton and MLS, Greece "Upland" cotton. Combing was carried out 18% noils during the combing process. Within the tests carried out, the following quality parameters were analyzed of fiber and yarn quality properties such as single yarn strength, elongation, mass irregularity, yarn faults, and hairiness.

Yarns spun on the Olfil carded compact spinning frame were found to have the following advantages when compared to those spun on the combed ring spinning frame: higher strength and elongation at break, somewhat equivalent or higher yarn unevenness, and a significantly lower number of yarn faults such as thin, thick places and neps, as well as a lower hairiness. This study also revealed that compact spinning could be used for producing coarse and medium yarn counts from 20's to 40's, from Long staple Egyptian cotton with comparable quality to the combed conventional ring spun yarns .

Keywords: *Cotton, yarn, quality.*

Introduction

The main goal of any spinning company is to achieve improved yarn quality that will ensure better competitiveness and higher price. Therefore, it was felt useful to compare the quality of conventional and compact spun yarns so as taking into account the production costs, to explore whether the quality parameters of compact yarns are improved significantly enough to justify the purchase of new machines, or a clapping of drafting equipment of the existing ring spinning frames.

Compact spinning is a revolution in spinning technology. Over recent years, the system of compact spinning has constituted a rapidly developing technological trend in most countries. The spinning triangle that occurs while the yarn is formed is the reason why many fibers leave the drafting roving, or become partly spun into the yarn with one end only. This causes a greater waste of fibers, a lower exploitation of fiber tenacity in yarn, a poorer appearance and a greater hairiness of the spun yarn, (Nicolic et al. 2003).

Compact spinning forms fibers into a narrow sliver by drafting in a virtually tension-free process within a compacting zone. The compact sliver is twisted in a very small spinning triangle, thereby eliminating peripheral fibers, (Artzt 2000).

The compact spinning system enables nearly all of the fibers to be twisted. Thus, the enhanced incorporation of the fiber characteristics into the yarn structure would allow optimal exploitation of the raw material with increased yarn strength. Since the compact spinning system has been introduced commercially onto the market, a large number of studies have been conducted related to the short-staple and long-staple compact spinning techniques, each of which claims to offer advantages, dramatically increased production speeds, (Artzt, 1997,Olbrich, 2000; Stalder, 2000 El-Sayed and Sanad 2007).

The end breaks in compact spinning are approx. 50% fewer, which permits the reduction of the number of fibers in the cross-section, or to spin a finer yarn count. Reducing the possibility of the number of fibers in the cross- section enables the use of lower-priced tops with coarser fibers. Campen (2002). Celik and Kadoglu (2004), reported that In compact yarns, fibers are uniformly oriented and joined into the yarn right after the end of the drafting arrangement. Therefore, better tenacity, elongation, and hairiness properties can be ensured. The better tenacity properties of compact spun yarn provide opportunities to work with lower twist coefficients, resulting in an increase in production rate, and also better handling properties of the end-product

To compare the yarn parameters obtained from conventional ring-spinning frame with those produced by compact spinning; Krifa and Ethridge (2003) reported that the compact spinning technology has the potential of improving both the quality and profitability aspects of cotton yarn manufacturing. Depending on the objectives of the textile manufacturer, different approaches are available. One approach could be to reduce the cost of the raw fiber while maintaining yarn quality. Another could be reducing twist while using the same raw fiber. Yet another – as emphasized in this report – is to eliminate some or all of the combing while still producing acceptable yarn quality. According to expert estimates (Egbers, 1999). The combing operations account for nearly 9 % of the total production cost of a 30 Ne combed cotton yarn. This represents approximately 21 % of the processing cost. While the compact technology is promising, there are still major questions to be answered. These include the following:

- In order to produce a carded compact yarn with comparable performance to the combed conventional one, what type of raw cotton fiber should be used?
- Do the fiber quality requirements vary depending on the yarn production sequence? If so, what are the fiber properties that are most crucial for the alternative process?
- Is it possible to overcome the yarn evenness problems by optimizing the preparation (especially carding) or by selecting raw fiber with specific parameters?
- Given the new, enhanced structure of compact yarns, are these evenness defects as critical as they were for the conventional yarns?

The main objective of this study was to investigate the influence of cotton type in order to produce a carded compact yarn with comparable performance to the combed conventional one

Materials and Methods

Giza 80 and Giza 90 as Long Staple Egyptian Cottons, and a Medium Long Staple Upland Greece cotton, were manufactured to combed and carded yarns on both the compact and the conventional spinning frame “Olfil RST1 Marzoli machine, Two in One”. The linear densities of the spun yarns obtained were 14.76 tex (40 Ne), 19.68 tex (30 Ne), and 29.53 tex (20 Ne) at constant twis t m ultiplier “4.3”. The carded and com bed yarns were m anufactured from the sam e cotton, the elim inated 18% of noils during combing process.

Table 1. HVI and Micromat fiber data of the raw cotton

Fiber Properties	Giza 80	Giza 90	Upland cotton (Greece)
Upper Half Mean (mm.)	31.0	30.0	27.8
Uniformity Index (%)	85.6	85.5	79.2
Strength (cN/Tex)	38.4	37.8	33.5
Elongation (%)	7.4	7.5	7.4
Short Fibers (%)	5.7	6.3	10.2
Micronaire value	4.2	4.1	4.1
Maturity 0.94		0.92	0.83
Fineness (milltex)	167	153	155
Reflectance (Rd%)	63.7	65.7	73.4
Yellowness (+b)	12.6	11.8	9.4

Table 2: Mean values (3 counts and 3 varieties) of yarn quality properties, combed conventional vs. carded compact.

		A B C			D	E	F	G	H
	Carded	19.00	7.03	5.2	12.54	30 67	52		4.04
Ring	Combed	19.95	6.27	5.7	11.42	22 32	29		3.65
	Carded	20.13	6.03	6.2	12.09	13 51	48		3.73
Compact	Combed 21	.89	5.3	6.2	11.31	7	23	24	3.42
LSD at 5%		0.26	0.74 0.	39 0.	15 2.	76	4.2	5.44	0.03

A: Strength (cN/Tex), B: Cv Strength (%), C: Elongation (%), D: Eveness (C.V %), E: Thin places, F: Thick places, G: Neps, H: Hairiness

Within this resea rch wo rk, th e qua lity pa rameters of th e fibers wer e tes ted, using the HVI and Microm at testers. The s pun yarns were t ested for the fol lowing parameters: single yarn stre ngth “cN/tex”, yarn strength c.v. “%” elongation at break “%” using Statimat ME. Mass irregularity, hairiness, and yarn faults were also measured via Uster Tester 3, at a yarn f eeding of 400 m/min. The obtained results of yarn quality param eters were compared with the Uster Statistics, (2007). Fiber quality par ameters f rom the thre e c ottons obtained from t he HVI and Microm at testers are presented in Table 1.

The obta ined data we re sub jected to sta tistical ana lysis in com pletely randomized factorial d esign with six rep lications accord ing to Drap er and Sm ith 1966.

Table 3. Yarn quality properties of conventional ring, compact for different cotton types.

Cotton types	**Strength (cN/Tex)**		**Cv Strength (%)**		**Elongation (%)**		**Eveness (C.V %)**	
	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed
Giza 80	21.30	21.23	5.85	5.84	6.0 5.4	11.54		11.11
Giza 90	20.43	20.22	5.84	6.22	6.1 5.9	11.87		11.17
Upland 18.66		18.39	6.41	6.76	6.6 5.7	12.86		11.97
LSD at 5%	0.45		1.29		0.7		0.27	
	Thin Places		**Thick places Neps**				**Hairiness**	
Com	pact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed
Giza 80	13	16	15 13 14 5				3.54	3.55
Giza 90	11	22	53 15 46 8				3.64	3.59
Upland	16	30	90 69 84 75 4.03					3.83
LSD at 5%	4.79		7.3		9.44		0.05	

Table 4. Yarn quality properties of conventional ring, compact for different yarn count.

Yarn count	**Strength (cN/Tex)**		**Cv Strength (%)**		**Elongation (%)**		**Eveness (C.V %)**	
	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed
20's 21.10		20.59	5.64	5.53 7.0		6.4	11.21	10.66
30's 20.25		20.29	6	6.26	6.3	5.6	12.19	11.51
40's 19.07		18.96	6.46	7.03 5.5		5.0	12.87	12.07
LSD at 5%	0.45		1.29		0.7		0.27	
	Thin Places		**Thick places Neps**				**Hairiness**	
Com	pact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed	Compact Carded	Ring Combed
20's	5	5 15 8			6	2	3.52	3.4
30's	14	26	55 34 62 32				3.57	3.65
40's	21	37	84 54 77 54				4.12	3.91
LSD at 5%	4.79		7.3		9.44		0.05	

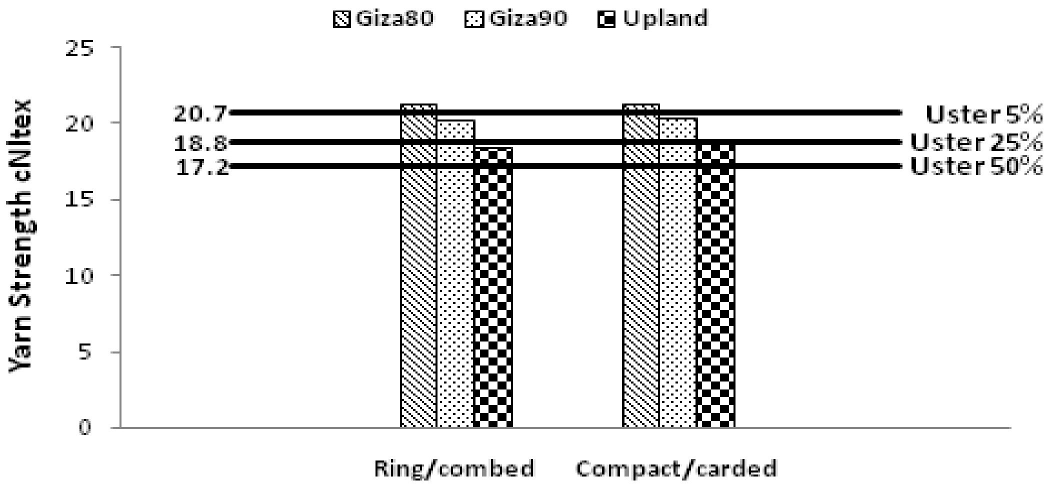

Figure 1: Yarn strength conventional combed RS yarn vs. compact carded yarn compared with Uster 100% Co combed ring yarn

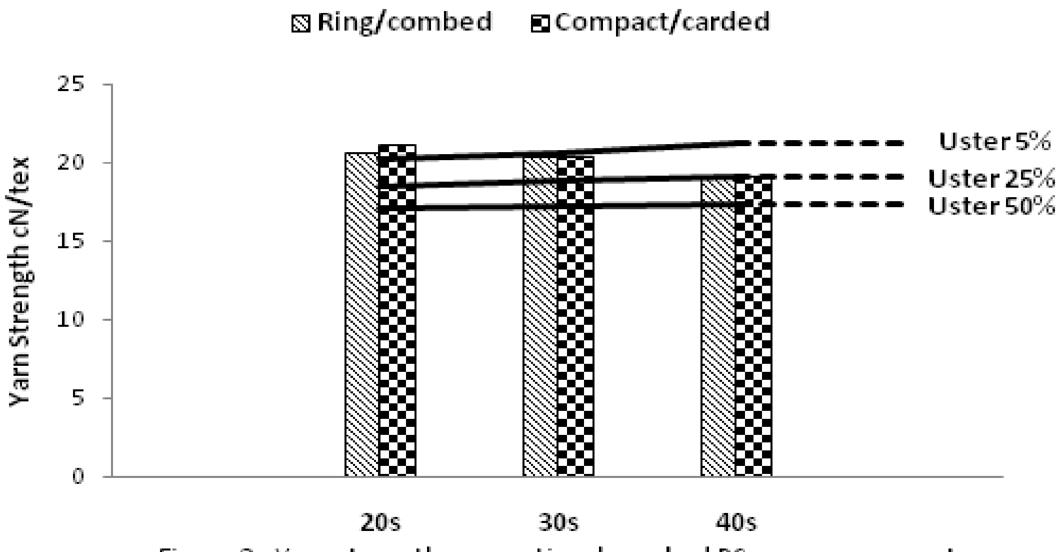

Figure 2: Yarn strength conventional combed RS yarn vs. compact carded yarn count compared with Uster 100% Co combed ring yarn

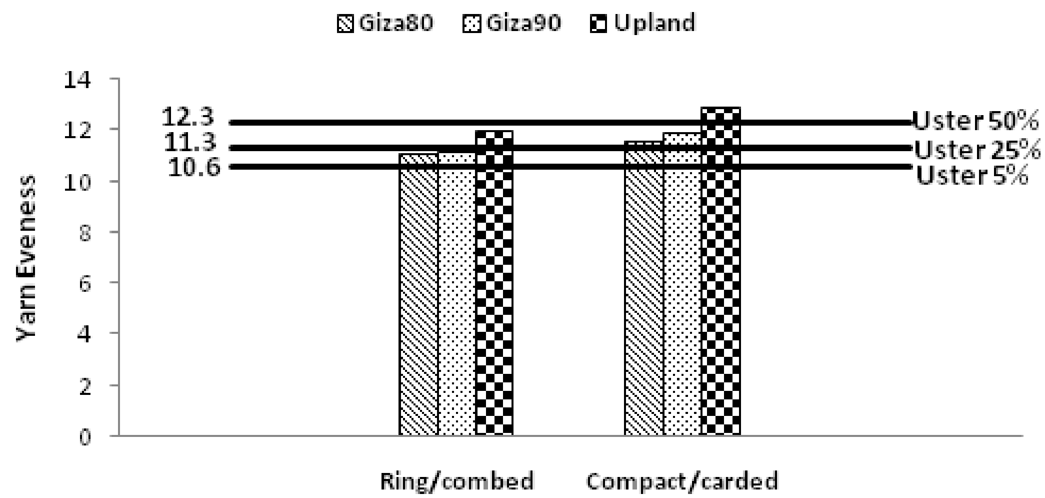

Figure 3: Yarn evennessh conventional combed RS yarn vs. compact carded yarn in compared with Uster 100% Co combed ring yarn

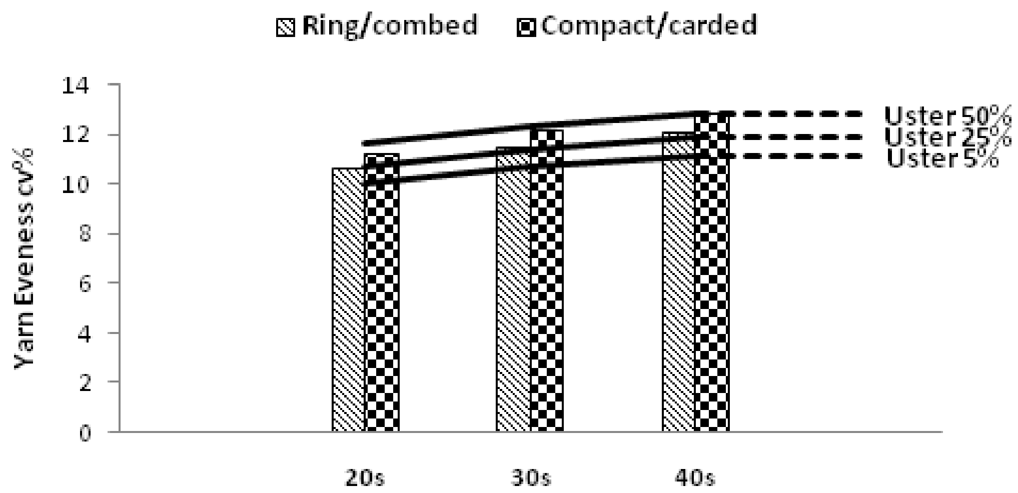

Figure 4: Yarn evenness conventional combed RS yarn vs. compact carded yarn count compared with Uster 100% Co combed ring yarn

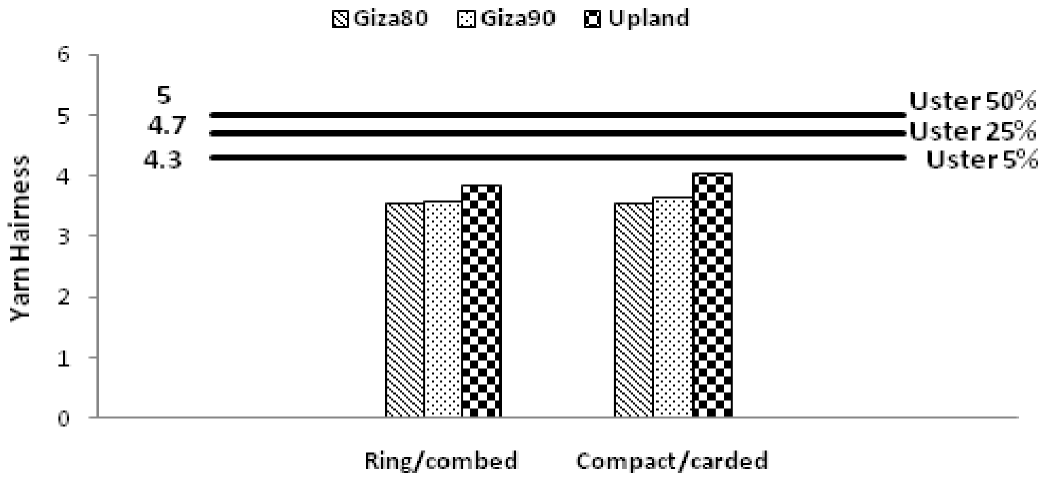

Figure 5: Yarn hairiness conventional combed RS yarn vs. compact carded yarn in compared with Uster 100% Co combed ring yarn

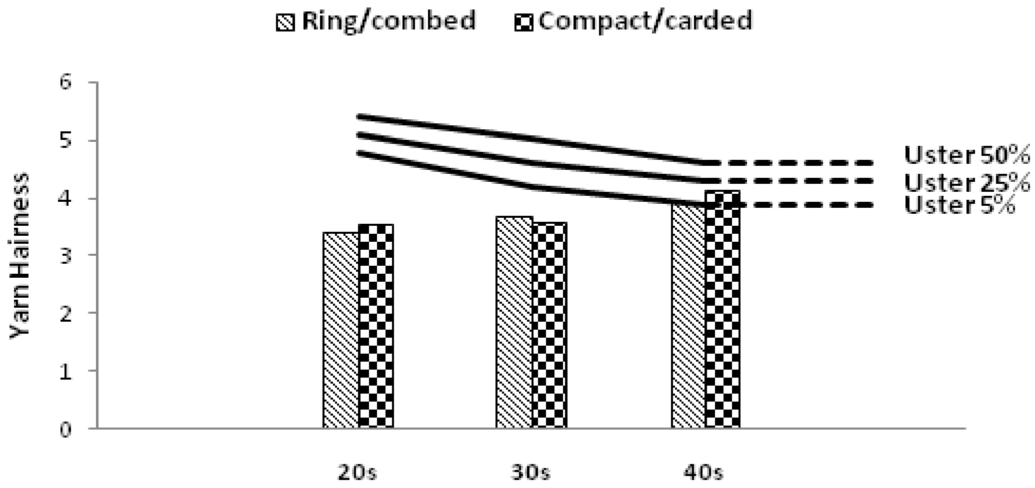

Figure 6: Yarn hairiness conventional combed RS yarn vs. compact carded yarn count compared with Uster 100% Co combed ring yarn

Results and Discussion

Yarn strength and elongation

Data in table 2 indicated that the difference in single yarn strength between carded compact yarns and the conventional combed ring yarns was not statistically insignificant. For all cotton varieties, the single yarn strength and elongation (%) values of compact carded yarns were slightly higher than those of the conventional combed ring yarns. The evaluations of statistical analysis results of the difference of two systems were significant, as shown in Table 3.

When single yarn strength was examined, there was an important difference between compact and conventional ring yarns which were produced from the three cotton varieties under the studied three yarn counts. The compact-spun yarns' strength and elongation (%) values are higher than the conventional ones. In this respect, Giza 80 and Giza 90 Egyptian Long staple cotton showed higher strength and elongation (%) than the Upland cotton. Thus, it appears that the ability of compact spinning to compensate for the beneficial effect of combing as it tends to reduce the short fibers and increase the orientation of the fibers and eliminates many impurities and seed coat fragments remaining in the fiber after the carding process.

The differences between the two spinning systems were found to be significant with regard to single yarn strength and elongation (%) values for 20's, 30's and 40's yarns. Thus, compact spinning made it possible to produce a 20's, 30's and 40's Ne carded yarn having tensile properties comparable to those of a combed yarn spun on the conventional frame. Furthermore, yarn hairiness levels were significantly lower for a great majority of the compact spun yarns. A lower difference in yarn strength and elongation (%) between the carded compact yarns and combed conventional yarns produced on the ring spinning machine can be explained with the construction of the drafting system that enables maximum fiber condensation all the way up to the clamping line in the compact drafting system.

Comparison of the obtained yarn quality parameters obtained with the Uster Statistics (2007) presented in Figures 1 and 2 which depict the differences in the levels of single yarn strength between the compact carded yarn and the conventional combed ring yarn compared with Uster Statistics in both different cotton varieties and yarn counts. It could be stated that the individual parameters have reached the following levels.

- Single yarn strength of compact carded yarns of Giza 80 and Giza 90 below 5%, while Upland compact carded yarn was at the level of 25%.
- Ne 20's and 30's for all cotton varieties substantially below or equivalent at the level of 5%, while Ne 40's compact carded yarn recorded the same level of 25%.

This revealed distinct patterns, depending on the cottons, and the differences between the two processing sequences. Among the three cottons under study, Giza 80 and Giza 90 showed a carded compact yarns with equivalent or higher strength levels than the combed conventional ones.

Yarn evenness

The carded compact spun yarns had higher yarn unevenness values - irregularity, thin and thick places and nep values, than the conventional combed ring spun yarns for all cotton types and consequently yarn counts as shown in in Tables 3 and 4.

The Uster evenness CV%, thin and the thick place values of both compact carded yarns and conventional combed ones were found to have a statistically significant difference for all cotton types "Giza 80, Giza 90 and Upland cotton" and yarn counts "20's, 30's and 40's" (Tables 3 and 4 and Figures 3 and 42). Giza 80 and Giza 90 were somewhat higher evenness than Upland cotton

The differences of compact-spun and conventionally-spun yarns which were produced from both cotton types and yarn counts, in terms of the Uster Statistics (2007) were presented in Figures 3 and 4.

In this respect Krifa and Ethridge (2003) explained that in addition to removing short fibers, the combing operation eliminates many impurities remaining in the fiber after the carding process. Some of these, are fiber neps and seed-coat fragments (SCFs), are known to significantly deteriorate yarn evenness and increase its defects (Krifa et al., 1999; 2000). Without combing, these particles remain problematic, and the compact spinning is not likely to overcome them. It is not surprising, then, that the carded compact yarns did not compare favorably to the combed conventional yarn when considering the evenness aspect. As shown in Figures 3 and 4. The differences between the compact carded yarn and the conventional combed ring yarn compared with Uster Statistics in both different cotton varieties and yarn counts which could be stated that:

- Mass variation "evenness CV%" of compact carded yarns of Giza 80 and Giza 90 was between25% and 50%, while Upland compact carded yarn was at the level of higher than 50%;
- With regard to yarn count, Ne 20's, 30's and 40's for all cotton varieties were substantially below or equivalent to the level of 50%.

These evenness results could limit the application of carded compact yarns in traditionally combed yarn markets. However, there are ways to improving the evenness problem, meaning that using Egyptian Long Staple cotton varieties which characterized by lower short fiber index and higher maturity.

Yarn hairiness

The Uster hairiness (H) of carded compact yarns is significantly higher when compared with the hairiness of conventional ring combed yarns in both cotton types and yarn counts (Tables 3 and 4).

Comparison of the obtained yarn hairiness obtained with the Uster Statistics (2007) presented in Figures 5 and 6 which depicted in the differences levels between the compact carded yarn and the conventional ring combed yarn compared with Uster Statistics in both different cotton varieties and yarn counts it could be stated that;

- Yarn hairiness of compact carded yarns of Giza 80 and Giza 90 and Upland cottons were below 5% Uster level
- With regard to yarn count, Ne 20's and 30's for all cotton varieties were substantially below the level of 5%, while in 40's yarn count the conventional ring combed yarn was equivalent of 5% Uster level, on the other hand, 40's compact carded yarns was substantially below the level of 25%.

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ORAL PRESENTATION

The Prediction of Yarn Strength of Cotton Sirospun Yarns from AFIS Fiber Properties by Using Linear Regression Analysis

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Abstract

This paper is part of a work concerning the experimental research and the modeling of the mechanical behavior of the cotton sirospun yarn. For this purpose different cotton blends were selected and their properties were measured with AFIS (*Advanced Fibre Information System*). Yarn count, twist coefficient and strand spacing were also selected as predictors because of their considerable effects on the yarn properties. In summary, approximately 270 types of sirospun yarns were produced on the same ring spinning machine under the same conditions at Ege University. Linear multiple regression method were used for the estimation of yarn quality characteristics. Statistical evaluation showed that our equations had a large R^2 and adjusted R^2 values.

Key words: *AFIS, cotton fiber, regression analysis, ring spinning, sirospun yarns, yarn strength.*

Introduction

Modeling and prediction of the yarn properties has been very attractive for the textile engineers, therefore several mathematical, statistical and empirical models have been developed to yield limited success in terms of prediction accuracy and general applicability. These interactions are critically important for the spinners for raw fiber selection.

Cotton, known as "white gold", is one of the most important commercial agricultural products that have various utilization areas in agricultural, industrial and trade sectors. Although the synthetic fiber production is increased in the world, cotton fiber remains its important between other raw materials used in world textile industry. Parallel to the world population increase, rise of prosperity increases individual fiber demand and accordingly world cotton consumption in developed and industrialized communities. But several reasons such as declining of arable lands, necessity of food production against fiber production, involving special climate for cotton fiber production and water shortage reduces cotton harvesting. In the coming days, the problem will grow up since raw material reserves will move backwards and synthetic fiber production cannot meet the increasing demands.

According to the reasons mentioned above, cotton has reached its highest price this year. As the raw material costs constitute the majority of the yarn production costs, it is critically important to know the desirable fiber characteristics that we need for our yarn characteristics and for the selection of the suitable cotton blend. When the factors such as decreasing of the cotton fiber supply, appreciation of the fiber and increasing of its' price, are take into account, using modern spinning systems which improves yarn properties and prediction of the yarn properties from fiber properties is becoming more important.

AFIS instrument is based on single fiber testing. The AFIS test provides detailed information regarding important fiber properties including, neps, trash, dust counts and several length parameters. AFIS instrument provides average fiber properties, distributions and variation from the fiber to fiber. Although lots of the researches were focused on HVI fiber properties and a very limited research can be found related to the estimation of yarn properties by using AFIS test results. This system is quick and reproducible counting of neps in raw material and at all process stages of short staple spinning mill. It is thus possible to give early warning information to practically eliminate subsequent complaints with respect to finished product [1].

In recent years, due to the demand of quality improvement studies, some of the developments are subject to certain modifications of the ring spinning frame to produce yarns with different structures. The sirospun system enables to produce a special spin-twisted yarn directly on a conventional ring spinning machine. Sirospun yarns are less hairy and more extensible compared to two-plied yarn. Besides, it has better evenness, hairiness, abrasion resistance and tenacity compared to single yarn with same linear density [2].

Sirospun spinning system can be installed on conventional ring spinning system with low investment costs. Sirospun yarns have higher tenacity, lower hairiness and better evenness values compared to ring spun yarns with same linear density due to the doubling effect, smaller spinning triangle and well-embedded fibers into the yarn structure. Besides, system offers advantages such as eliminating doubling and twisting processes. System provides production increase, lower energy and air conditioning costs, lower production costs, savings on place and staff due to eliminating some processes and avoids possible yarn damages because of transporting materials to those eliminating processes (Figure 1).

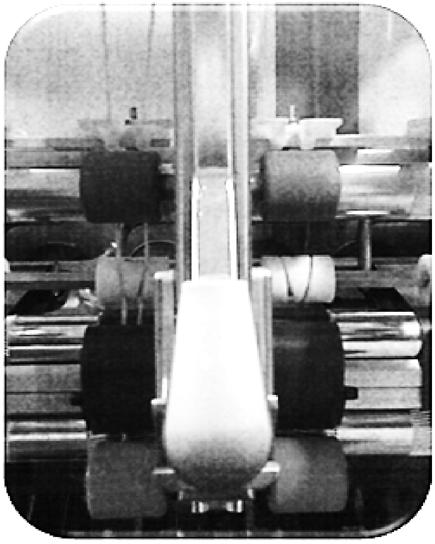

Figure 1. Sirospun system [1].

Yarn strength depends upon various fiber parameters. The inherent breaking strength of individual cotton fibers is considered to be the most important factor in determining the strength of the yarn spun from those fibers. But fiber strength cannot be measured by AFIS. Instead of strength, mean fiber length becomes the foremost property among those of AFIS, in addition we found very high positive correlation coefficient between mean fiber length and yarn strength ($r = 0.836$). This correlation means that the higher the mean fiber length, the higher the yarn strength [3].

Since the tensile properties of a yarn directly affect the winding, knitting and weaving efficiency, they are very important in determining the quality of the yarn. For this purpose, it is important to know which fiber and yarn production parameters influence yarn tensile properties and introduce the functional relationship between them [4]. For decades, various mathematical and empirical models have been established for the prediction of single yarn strength and CSP (Count Strength Product) using fiber properties and some yarn production parameters. A summary of some empirical relationships are given in Table 1 and Table 2.

The count strength product (CSP) is obtained by multiplying the yarn count with the leas strength and is used to compare the strength values of the yarns with similar linear density. CSP value changes with twist factor and yarn count [5].

Table 1. Some empirical equations for single yarn strength.

Hafez, 1978	$Tt[2,83(2logL_m+2logS_o+logT)-13,07]$
Gutkneckt, 1984	$8,28+0,029(S_{3,2}*L_{50})-0,49Mic$
Iyengar and Gupta, 1974	$[(L_m-10)/\sqrt{Mic}]S_{3,2}$
	$[(L_m-10)/\sqrt{Mic}]S_{3,2}U_r$
Ramey et al, 1977	* $-3,9+0,039\ S_{3,2}-0,175E+0,39L_m$
Sasser, 1994	** -381-7,9 Mic+51,6L+4,2UI +2,75 Str+0,66 Rd+0,69(+b)-0,24 Tr
Duerst, 1951	$111K\sqrt{ut} * L_1S_1$
Louis et al, 1968	$S_{3,2}*W*(1-E)*Y*K^i$
Ureyen, 2006	-19,883+0,701 STR+1,88 (α_e) -3,504 E +0,287 UNF-0,089 Yarn (Ne)-0,687 Roving CV%+0,556 UHML-2,639 Roving cnt (Ne)-1,145 Mic
Ureyen, 2007	61,515+4,577 D(n)+0,17 Nepcnt+ 0,303Yarn (tex) +0,01 Yarn twist+0,175 UQL(w)-0,009 Dust cnt

t; twist in turns/m, T; Yarn linear density (tex), L_m ; mean fiber length (cm), S_o; zero gauge bundle tenacity (gf/tex), $S_{3,2}$; bundle tenacity at 1/8 " gauge (gf/tex), U_r; length uniformity, L_m; mean fiber length (cm), K constant, t; twist, L_1; effective staple length, S_1; number of working fibers in the yarn cross-section, S_1;$0,75u^2-u$, u; number of fibers in the yarn cross section, W; % Effective weight based on 5/ 16", E; Fiber bundle elongation (%), Y; Yarn linear density (tex), K^i; $Y(0,27+\sqrt{Y}/16,4)/20,83$, * For 27 tex ring yarn, ** For 22 Ne ring yarn (lbs).

Generally, the best prediction of yarn strength can be provided preferably with 50% span length/ mean length, bundle tenacity and fiber fineness/ maturity. Besides fiber length variations such as uniformity index, uniformity ratio and short fiber content have undeniable effects. In the earlier researches, the effects of fiber fineness, slipperiness/ friction, strength and yarn twist on yarn strength was exposed.

Balls introduced the " Intrinsic strength" of a yarn and defined as hair strength per equivalent weight. It is defined as the maximum possible strength achievable [6].

Table 2. Some empirical equations for CSP.

Bogdan, 1956-1967	$\frac{160}{1+BM^2}[\frac{P}{C}\{1-10^{-0,13(M-T)^2}\}-F]$
Louis and Fiori, 1966	-2884,06+5676,81L_{50}-86,98Mic +51,73S_o+ 22,62E+98,65Tr+0,94r
Gutkneckt, 1984	6,03+0,022($S_{3,2}$*L_{50})-0,34 Mic
Chellamani et al, 1999	$\frac{250\sqrt{L_{50}*S_{3,2}}}{Mic}+590-16C$
Chellamani et al, 1990	$320\frac{\sqrt{L_{50}*S_{3,2}*Mc}}{Mic}-16C$
Chellamani et al, 1990	$393+270\frac{\sqrt{L_{50}*S_{3,2}}}{Mic}-15C$
Anon,1990	$275\frac{\sqrt{L_{50}*S_{3,2}}}{Mic}+320-13C$

B; Fiber obliquity parameter = 0,14, P; Intrinsic yarn strength parameter, C; Cotton count (Ne), M; twist multiplier (Ne system), T; in effective twist multiplier = 4,5-0,15P, F; drafting parameter = 2,1/P-8, S_o; zero gauge tenacity (mgf/tex), E; bundle elongation (%), Tr; trash content (%).

Material and Methods

As the raw material costs constitute the majority of the yarn production costs, it is critically important to know the desirable fiber characteristics that we need for our yarn characteristics and for the selection of the suitable cotton blend. This paper is part of a work concerning the experimental research and the modeling of the mechanical behavior of the cotton sirospun yarns which aims to find out correlation between the properties of fibers. Previous researches showed that, yarn properties are particularly influenced from fiber properties and this effect becomes more influential in the case of finer yarns. Generally fiber length and maturity have increasing effects whereas short fiber content and fineness have increasing effects on yarn hairiness.

For predicting yarn strength, different cotton blends were selected from different spinning mills in Turkey and their properties were measured with AFIS. Yarn count, twist coefficient, strand spacing and roving properties were also selected as predictors because of their considerable effects on the yarn properties. In siro spun system, as two roving were fed through the drafting system, the roving must be half of the fineness of the roving, using to produce ring-spun yarns with same linear density. All samples were spun into yarns on a Rieter Model G30 ring spinning machine at a yarn count of Ne 20, Ne 30, Ne 40 and Ne 50. Each yarn count was spun at three different twist multipliers (αe 4, αe 4,5 and αe 5). For each yarn count and twist multiplier, three different strand spacing (3mm, 6mm and 9 mm) were adjusted. Consequently, approximately 270 spinning trials were done. Appropriate main draft and break draft were adjusted on the ring spinning machine for each sample and other spinning conditions were kept constant. Orbit rings and appropriate travelers for each yarn count were used. For each yarn sample ten cops were produced and tested. Experimental plan is given in Figure 3 [7].

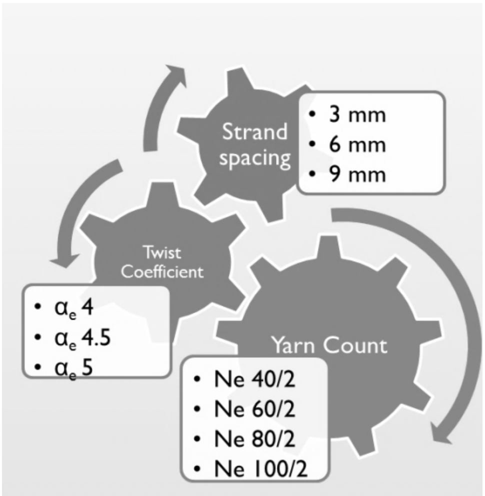

Figure 2. Experimental plan.

Spinning operations can affect fiber properties in different ways, depending on the machinery line and adjustments etc. For the elimination of these effects, fiber properties were measured from roving by using an Uster AFIS instrument. The main test results of fiber properties in different blends (from B1 to B11) are given in Table 3.

Table 3. Fiber properties obtained from AFIS.

Fiber property	Unit	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Neps	cnt/g	4	19	24	8	5	7	152	12	19	25	17
Mean length by weight	mm	29,5	28,1	25	30,3	26,8	27	24,8	26,1	26,3	28	25,5
Upper quartile length by weight	mm	35,2	33,9	30,7	36,6	32	32,6	30,9	31	31,2	33,9	30,6
Short fiber content by number	%	2,3	3,7	6,2	2,4	3,8	4,6	9,9	3,7	4,6	3,9	5,1
Mean length by number	mm	25,8	24,2	21,5	26,4	23	23,3	20,2	22,9	22,7	24,3	22,2
Short fiber content by number	%	8,5	11,6	15,1	9	11,3	13,2	25,5	11	12,8	11,4	14,2
%5 span length	mm	40,9	39,9	36,7	42,4	37,3	38,2	35,6	36,1	36,9	39,1	35
Total	Cnt/g	8	11	14	7	29	16	84	5	14	9	9
Trash	Cnt/g	0	0	0	0	0	0	11	0	2	0	2

Yarn unevenness and hairiness tests were performed on an Uster Tester 5, whereas the tensile properties of the yarns were evaluated on an Uster Tensorapid tensile testing machine. Statistical analyses were performed using Minitab and Gretl software.

Results and Discussion

Regression analysis is a common statistical tool for the investigation of relationships between two groups of variables. The fitted model can be used either to merely describe the relationship between dependent and independent variables, or to predict new values. The multiple regression analysis and ordinary least squares method was selected to learn the relationship between several independent or predictor variables and a dependent or criterion variable. Because yarn characteristics are influenced by several factors such as fiber properties, production parameters, machine settings, the spinning conditions etc. Initially, the types of relationship between independent variables (selected parameters) and dependent variables (yarn properties) were checked by using curve estimation and correlation analysis. Statistical analysis demonstrated that there was a nearly linear relationship between fiber properties measured in AFIS and siro spun yarn properties. Because of this, the linear multiple regression analysis method was chosen for this study [8].

Firstly, collinearity which is defined as a linear relationship between two explanatory variables is tested and it is found that there is an exact linear relationship between some variables such as length measurements by weight and number based values. Length measurements by weight had a greater effect on yarn strength than number based values, for this reason they were selected as independent variables. Besides, upper quartile length by weight and 5% span length parameters were highly correlated with mean length by weight. As a result, upper quartile length by weight, mean length by number, short fiber content by number and %5 span length parameters, were omitted due to exact collinearity.

Table 4. Possible regression models for predicting yarn strength with AFIS fiber properties.

Number of indep. variable	R^2	Adj. R^2	C-p	S	SS	YC	TWC	NC	L(w)	SFC (w)	Total Count	Trash Count
1	69,9	69,9	3243,6	1,7553					X			
1	41,6	41,5	8648,6	2,4466						X		
2	81,8	81,8	985,3	1,3664		X			X			
2	74,7	74,7	2335,3	1,6103			X		X			
3	84,3	84,3	507,1	1,2687		X	X		X			
3	82,6	82,5	836,5	1,3367		X			X		X	
4	85,1	85,1	361,0	1,2371		X	X		X		X	
4	84,3	84,3	501,9	1,2674		X	X	X	X			
5	86,5	86,5	88,3	1,1761		X	X		X		X	X
5	85,8	85,8	217,7	1,2053		X	X		X	X	X	
6	86,6	86,6	69,8	1,1716		X	X	X	X		X	X
6	86,6	86,5	79,9	1,1739		X	X		X	X	X	X
7	87,0	86,9	9,5	1,1575		X	X	X	X	X	X	X
7	86,6	86,6	69,0	1,1712	X	X	X	X	X		X	X
8	87,0	86,9	9,0	1,1571	X	X	X	X	X	X	X	X

SS: Strand spacing, YC: Yarn count (Ne), TWC: Twist coeff. (αe), NC: Nep Count.

Best Subsets Regression which is a method used to help determine which independent variables should be included in a multiple regression model. This method involves examining all of the models created from all possible combination of predictor variables. Firstly, all models that have only one predictor variable included are checked and the two models with the highest R^2 are selected. This process continues until all combinations of all predictors variables have been taken into account [9]. Possible regression models (best subsets) for prediction yarn strength with AFIS fiber properties and yarn production parameters were given in Table 4.

Adjusted R^2 is used to measure the goodness of fit in the model that contains more than one independent variable. A good model should have a high R^2 and adjusted R^2, small S, and a Mallows' C-p close to the number of predictors in the model and the constant. Therefore, the last model was chosen because of its high R^2 (87%) and adjusted R^2 values (86,9 %), small S value (1,1571) and C-p value close to the number of independent variables.

The relations between yarn strength and predictors were analyzed individually by curve estimation and a polynomial relation was found with short fiber content by weight.

Table 5. Stepwise regression models

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	12.86**	14.41**	-31.08**	-36.06**	-37.99**	-39.86**	-9.732**
Strand spacing (mm)	0.025	0.038	-0.023**	-0.023**	-0.018*	-0.015	-0.020**
Yarn count (Ne)	-0.029**	-0.048**	-0.11**	-0.109**	-0.109**	-0.109**	-0.105**
Twist coeff. (α_e)	1.884**	1.813**	1.166**	1.162**	1.156**	1.164**	1.198**
Nep count		-0.044**	-0.003**	-0.012**	0.0005	-0.026**	0.046**
L(w)			1.813**	1.958**	2.016**	2.091**	1.602**
SFC(w)				0.285**	0.485**	0.508**	-10.84**
Total count					-0.047**	-0.058**	-0.007
Trash count						0.458**	0.234**
$SFC(w)^2$							2.192**
$SFC(w)^3$							-0.138**
Adj. R^2	0.0796	0.1774	0.8433	0.8443	0.8582	0.8692	0.8887
Akaike	12671,2	12392	8258,6	8243,5	8012,6	7811,4	7411,9
Schwarz	12694,4	12421,1	8293,5	8284,3	8059,2	7863,8	7475,9
lnL	-6332	-6191	-4123	-4115	-3998	-3897	-3695

**: is significant for α=0.05

Stepwise regression was used for selecting a model by automatically adding or removing individual predictors, based on their statistical significance. By this method, we can control the details of the process, including the significance level and whether the process can only add terms, remove terms, or both. Regression coefficients and significance level of the independent variables of different models are given in Table 5. Regression coefficient is the constant that represents the rate of change of a dependent variable as a function of changes in the independent variable. P value is used for determining statistically significance.

Model 7 was chosen according to higher adjusted R^2, but lower Akaike and Schwarz values. Another important diagnostic test was applied for seeking if there is a heteroskedasticity in the regression models. The possible existence of heteroscedasticity is a major concern in the application of regression analysis, including the analysis of variance, because the presence of heteroscedasticity can invalidate statistical tests of significance that assume that the modeling errors are uncorrelated and normally distributed and that their variances do not vary with the effects being modeled. Similarly, in testing for differences between sub-populations using a location test, some standard tests assume that variances within groups are equal. White test was used to test homoscedasticity and establish whether the residual variance of a variable in the regression model is constant.

Table 6. Regression coefficients and significance level of the model.

Coe	fficient	Std. Error	t-ratio	p-value
Constant	-18.233 1	.627	-11.2027	<0.00001 ***
Strand spacing (mm)	-0.031 0	.008	-3.7412	0.00019 ***
Yarn count (Ne)	-0.107 0	.002	-46.5413	<0.00001 ***
Twist coeff. (αe)	1.306 0	.045	29.0271	<0.00001 ***
Nep count	0.012 0	.005	2.2049	0.02755 **
L(w)	1.773 0	.035	50.3232	<0.00001 ***
SFC(w)	-8.535 0	.549	-15.5264	<0.00001 ***
Total count	-0.022 0	.004	-5.9009	<0.00001 ***
Trash count	0.302 0	.029	10.2810	<0.00001 ***
SFC(w)^2	1.754 0	.109	16.0521	<0.00001 ***
SFC(w)^3	-0.107 0	.007	-14.8322	<0.00001 ***
Mean dependent variable	20.3154 S.D.	dependent variable		3.1997
Sum squared residual	8754.034 S.E.	of regression		1.8780
R^2	0.8849 A	dj. R^2 0		.8844

: significant for α=0.05, *: significant for α=0.01.

White test's results showed that there is a heteroskedasticity in regression model. A new model was established to solve this problem and regression coefficients of variables, t-values and significance level of each variable of the new model are given in Table 6.

The regression coefficients of the predictor variables were found statistically significant. Signs (+ or -) of regression coefficients of variables indicate the direction of influence. It is found that yarn strength decrease with increasing yarn count (Ne) and strand spacing whereas decreasing twist coefficient, as expected. Among cotton fiber properties, mean fiber length and short fiber content are the main parameters influencing the yarn strength. Increased mean fiber length and trash count increased yarn strength. A polynomial relation between short fiber content and yarn strength was found. Initially, yarn strength decreases with the increasing of short fiber content, up to a limit. After, the increase in the short fiber content causes firstly an increase, then a decrease in the yarn strength [4].

Figure 3 shows the scatter plot of predicted values versus actual values and regression line of our model. A high correlation (r=0,94) was found between actual and predicted strength values.

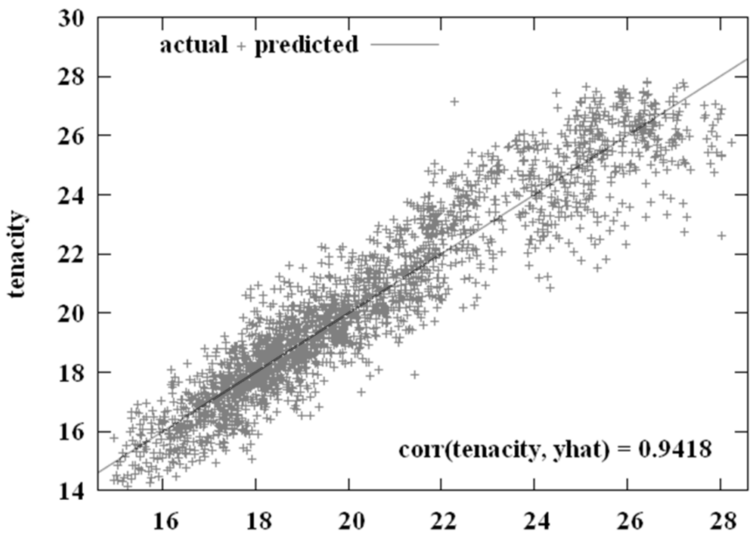

Figure 3. Predicted versus observed yarn strength values.

Conclusion

In this study, we have tried to predict yarn strength, one of the most important yarn parameters of sirospun cotton yarns, by using AFIS fiber properties yarn properties with linear multiple regression analysis. It is found that there is an exact linear relationship between the some variables such as length measurements by weight and number based values. Besides, upper quartile length by weight and 5% span length parameters were highly correlated with mean fiber length by weight. Because of this, upper quartile length by weight, mean length by number, short fiber content by number and %5 span length parameters, were omitted due to exact collinearity.

Yarn strength (cN/tex) = -18,233- 0,031 F.A.M. - 0,107 Yarn count (Ne) + 1,306 (α_e)+ 0,012 Nep Cnt + 1,773 Lw – 8,535 SFCw + 1,754 $SFCw^2$ – 0,107 $SFCw^3$– 0,022 Total Cnt + 0,302 Trash Cnt

It is seen that the most important fiber properties influencing yarn strength are mean fiber length and short fiber content due to their high regression coefficients. Spinners are recommended to select raw materials having lower SFC (w) and total count but higher mean fiber length. Although, they have to take in to consider that, producing coarser yarns, with higher twist coefficients and smaller strand spacing, will provide higher yarn strength. Adjusted R^2 is used to measure the goodness of fit in the model and statistical evaluation showed that our equation had a large R^2 and adjusted R^2 (0.88) values.

Acknowledgement

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POSTER PRESENTATION

Calibrating the Micromat Instrument Using High Volume Instrument (HVI) Output Data

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Abstract

There is a need for an accurate and rapid method for measuring cotton fiber fineness and maturity characters. The main aim of the present investigation was to demonstrated the validity of the Micromat instrument calibration by HVI instrument using the standards described by the two values called PL and Ph. 64 specimens were tested at the Cotton Arbitration and Testing General Organization, (Alexandria, and the laboratories of Cotton Research institute, Agricultural Research Center, Giza, Egypt, in 2011 and 2012 seasons .Results subjected to statistical analysis. The results of T-test, correlation and regression signified that the two instruments were producing statistically similar micronaire data. Hence, they showed similar PL results the differences in maturity ratio and Ph data were within the acceptable range, the congruency of the Micromat and HVI fineness in most the samples indicated the validity of our calibration.

Keywords: *Cotton, Micromat, HVI.*

Introduction

Cotton fiber maturity is a very important fiber characters because it controls dye uptake and nep formation. Also, fineness is important because it controls yarn count and strength.

Because of the importance of both characters scientists developed a lot of instruments to measure them. The most famous one is micronaire instrument which depends on the air permeability. Through the cotton fiber were tested fineness and maturity get it in one reading (Thibodeaux & Evans 1996), (Thibodeaux & Rajasekaran1999), and (Heap 2000) but the combination of both characters in one reading is confused, in fact micronaire instrument reading express the sample specific surface area according to (Abd El Salam 1999) and (Montalvo 2005) who explain that low reading express fine or immature fibers and Vice-versa. So, it was a need to incorporate fineness and maturity tests to high volume instrument (Montalvo 1999) as well as, developing the SDL Micromat tester which is a double compression air flow that measure fineness and maturity separately. Daily calibration is required to have accurate results .As this calibration involves the use of a limited stock of standards cotton, the standards described by two values called PL and Ph (Montalvo, *et al*., 2002) and (Gawrysiak 2007). So, it's an easy way to calculate PL and Ph back using the micronaire and maturity ratio readings from HVI instrument to use them in the calibration when the standard one is not available.

Materials and Methods

The main purpose of this investigation was to verify the validity of using the HVI output data to make a calibration sample for Micromat instrument. Calibrated HVI and Micromat instruments were used in this investigation. Sixteen different genotypes were used each genotype representative by four homogenized specimens which chosen carefully from 2011 and 2012 seasons, also upland cotton calibrations delivered to our laboratories (C n), as well as Bremen round test samples (B n) to cover wide range of micronaire and maturity readings, as possible as, we can to be tested for micronaire and maturity by HVI instrument. The same specimens were subjected to be test on Micromat to get the output printed sheet containing micronaire (mic), maturity ratio (MR) readings, fineness in millitex (Fin) and Ph and PL readings. Sampling and testing were done according to ASTM D: 3818, D: 4605-1986) and ITMF User Guide, 2001. The results of HVI micronaire and maturity were averaged and used to calculate the PL and Ph values from Lord's FMT models. All tests were performed at the Cotton Arbitration and Testing General Organization, (CATGO), Alexandria, Egypt and the laboratories of Cotton Res. Institute, Agricultural Res. Center, Giza, Egypt under constant conditions of temperature (70 ± 2 ^{0}F) and (65% ± 2%) of relative humidity.

Statistical analysis

Simple correlation coefficient, regression equation and T-test were performed using SPSS 11.0 software. T-test was performed to test the "equal means" of cotton fiber fineness and maturity parameters obtained from Micromat instrument vs. and HVI instruments. The null hypothesis was that the mean values of a certain fiber parameter from two treatments were equal. All tests were conducted under the significant level of 99%. T-test was done according the following formulas:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \rightarrow \frac{\text{difference between means}}{\frac{\text{variance}}{\text{sample size}}}$$

where $\bar{x}_1$ = mean of sample 1

$\bar{x}_2$ = mean of sample 2

n_1 = number of subjects in sample 1

n_2 = number of subjects in sample 2

$$s_1^2 = \text{variance of sample 1} = \frac{\Sigma(x_1 - \bar{x}_1)^2}{n_1}$$

$$s_2^2 = \text{variance of sample 2} = \frac{\Sigma(x_2 - \bar{x}_2)^2}{n_2}$$

Sample 1 and sample 2 refers to Micromat and HVI, respectively.

Results and Discussion

During the routine work in cotton fiber Res. Department in cotton res. Institute we keen to calibrate the Micromat instrument every day to attain accurate results. But during the last few years the instrument became age and needs calibration at the every group of samples (the group contains 12 samples as a maximum). The calibration sample is very expensive and not available under our needs. So, we thought to have fast and dependable calibration sample to be used between groups. It's well known that Micromat instrument software based on the Lord's equation to estimate micronaire, fineness and maturity as follows:

Mic= (850/PL+40) +0.6.................................... 1
MR=0.247*PL$^{0.125}$ (PL/Ph) ^{2}……………………… 2
Fin= (60000/ PL)*(Ph / PL) $^{1.75}$………………..… 3

We used the micronaire and maturity ratio readings produced from HVI instrument to calculate back the PL and Ph values which used mainly to calibrate the Micromat instrument as follows:

PL =(1)/(mic-0.6)*(850/1)-(40)…………………. 4
Ph=SQRT (0.247*PL$^{0.125}$/MR)...………………... 5

Means of micronire values obtained by Micromat and HVI of different genotypes are shown in Table 1, its clear that the T-test values did not reach the significant level in both seasons. This is logic and reasonable because the mean values of micromaire readings of both Micromat and HVI instruments are typically equal. This also, are indicated by the excellent correlation r = 0.9907 aforementioned in Figure 1.

Table 2, indicated that the maturity readings of Micromat instrument were slightly higher than that of HVI instrument across 10 genotypes. While, the other 6 genotypes the maturity reading were the same in 2011 season. But in 2012 season the maturity reading of HVI instrument was higher than the maturity reading of Micromat by 0.01 in most the genotypes. This is reasonable because the maturity test principles of both the instruments are different. Nevertheless the correlation and the determining factor between them are high r = 0.8309, R^2 = 0.9115 as shown in Figure 2. Also the difference between the two means is within the acceptable range.

Table 1. # Comparison between micronaire readings obtained from Micromat instrument and HVI instrument

Sample	mic (MICR.)		mic (HVI)	
	2011	2012	2011	2012
C 1	2.6	-	2.6	-
C 2	2.8	-	2.8	-
G 77×P	3.1	3.2	3.1	3.2
G 87	3.3	-	3.3	-
G 92	3.7	3.8	3.7	3.8
G 88	3.8	3.8	3.8	3.8
B 1	3.9	-	3.9	-
G 70	4.0	4.1	4.0	4.1
10229×G86	4.2	3.9	4.2	4.0
G 90	4.3	4.1	4.3	4.1
G89×G86	4.4	4.5	4.6	4.5
G 86	4.5	4.3	4.5	4.4
B 2	4.6	-	4.7	-
C 3	4.7	-	4.7	-
90×Aus.	5.0	4.5	5.0	4.6
C 4	5.3	-	5.3	-
mean	4.01	4.01	4.03	4.06

t :not significant

Table 2. Comparison between maturity ratio readings obtained from Micromat instrument and HVI instrument

Sample	MR (MICR.)		MR (HVI)	
	2011	2012	2011	2012
C 1	0.86	-	0.86	-
C 2	0.88	-	0.87	-
G 77×P	0.95	0.98	0.94	0.97
G 87	0.94	-	0.94	-
G 92	0.96	0.98	0.94	0.98
G 88	0.96	0.96	0.95	0.96
B 1	0.88	-	0.86	-
G 70	0.93	0.94	0.93	0.93
10229×G86	0.98	0.95	0.98	0.94
G 90	0.95	0.93	0.94	0.92
G89×G86	0.99	0.97	0.98	0.96
G 86	1.1	0.98	0.99	0.97
B 2	0.87	-	0.87	-
C 3	0.88	-	0.87	-
90×Aus.	0.96	0.90	0.96	0.89
C 4	0.95	-	0.94	-
mean	0.94	0.95	0.93	0.95

t :not significant

No significant difference was observed between the means of PL in both seasons as shown in Table 3, all the genotypes had the same value expect for the genotype G89 × G86 and B2 sample in 2011 season. This result explained the very high correlation r = 0.9953, and the excellent determining factor R^2=0.9907 mentioned in Figure 3, this is because of that micronaire readings are calculated from the PL readings using the Micromat instrument, Since the two micronaire means of both instruments give the same value, Consequently, the actual PL of the Micromat instrument and the calculated back form the HVI instrument should be the same (formulas no. 1, 4)

Table 3 . Comparison between PL readings obtained from Micromat instrument and PL reading calculated back using HVI instrument

Sample	PL (MICR.)		PL (HVI)	
	2011	2012	2011	2012
C 1	385.0	-	385.0	-
C 2	346.4	-	346.4	-
G77×P	300.0	286.9	300.0	286.9
G87 274.8		-	274.8	-
G92	234.2	225.6	234.2	225.6
G88	225.6	225.6	225.6	225.6
B 1	217.6	-	217.6	-
G70	210.0	202.9	210.0	202.9
10229×G86	196.1	217.6	196.1	210.0
G90	189.7	202.9	189.7	202.9
G89xG86	183.7	177.9	172.5	177.9
G86	177.9	189.7	177.9	183.7
B 2	172.5	-	167.3	-
C 3	167.3	-	167.3	-
G90x Aus.	153.2	177.9	153.2	172.5
C 4	140.9	-	140.9	-
mean	223.4	216.1	222.4	210.0

t :not significant

Table 4. Comparison between Ph readings obtained from Micromat instrument and Ph reading calculated back using HVI instrument

Sample	Ph (MICR.)		Ph (HVI)	
	2011	2012	2011	2012
C 1	299.3	-	299.3	-
C 2	264.5	-	266.0	-
G77×P	218.5	205.2	219.6	206.2
G87	200.1	-	200.1	-
G92	167.1	158.9	168.8	158.9
G88	160.6	160.6	161.4	160.8
B 1	161.4	-	163.2	-
G70	151.2	145.0	151.2	145.7
10229×G68	136.9	155.3	136.9	150.4
G90	134.3	145.7	135.0	146.5
G89×G86	127.1	124.2	120.7	124.8
G 86	116.6	132.2	122.9	128.4
B 2	126.1	-	122.8	-
C 3	122.1	-	122.8	-
G90×Aus.	106.4	128.9	106.4	125.4
C 4	97.8	-	98. 9	-
mean	161.9	150.7	169.6	149.7

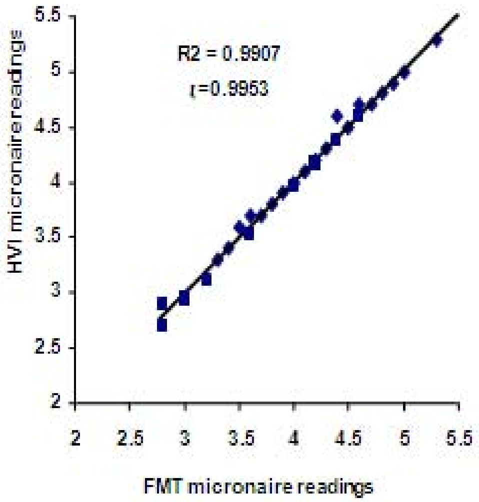
t :not significant

Table 5 . Comparison between fineness readings obtained from micromat and fineness readings calculated back using HVI instruments

Sample	Fin (MICR.) 2011	Fin (MICR.) 2012	Fin (HVI) 2011	Fin (HVI) 2012
C 1	100.3	-	100.3	-
C 2	109.1	-	109.1	-
G77×P	115.9	116.3	115.9	117.3
G 87	126.5	-	125.3	-
G 92	144.5	144.0	144.5	144.0
G 88	148.0	146.7	148.0	146.7
B 1	166. 8	-	166. 8	-
G 70	153.5	164.2	160.7	165.8
10229×G86	164.7	152.9	163.2	159.2
G 90	174.3	165.8	174.3	167.3
G89×G86	176.1	179.5	182.9	181.2
G 86	160.8	168.1	176.4	174.5
B 2	203.0	-	208.6	-
C 3	208.6	-	208.6	-
90×Aus.	212.9	191.7	207.1	199.0
C 4	225.2	-	229.4	-
mean	161.9	158.8	163.8	161.7

t :not significant

Figure 1. The relationship between FMT micronaire and HVI micronaire readings



It's understandable from Table 4, that there wasn't any significant difference between the Ph means of both the two instruments, nevertheless, there is a relatively difference between the genotypes readings. This results were also, indicated by the correlation and regression results shown in Figure 4, this ascribed to that the Ph calculated back using HVI data depended on the PL (formula no. 5) data which calculated from the micronaire data (100 % right) in addition to maturity data. So, the difference in Ph readings was slightly narrow.

Data presented in Table and Figure 5, indicated the reliability of our calibration, science the fineness is calculated using PL and Ph values (formula no. 3) and there was not any significant between the mean values of the Micromat fineness and the calculated ones using HVI instrument adding to that the excellent correlation between them. Then the PL and Ph produced by HVI is successful to calibrate the Micromat instrument.

Figure 2. The relationship between FMT maturity and HVI maturity readings

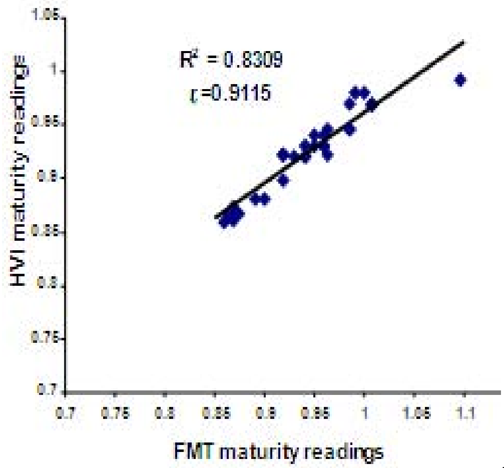


Figure 3. The relationship between FMT PL and HVI PL readings

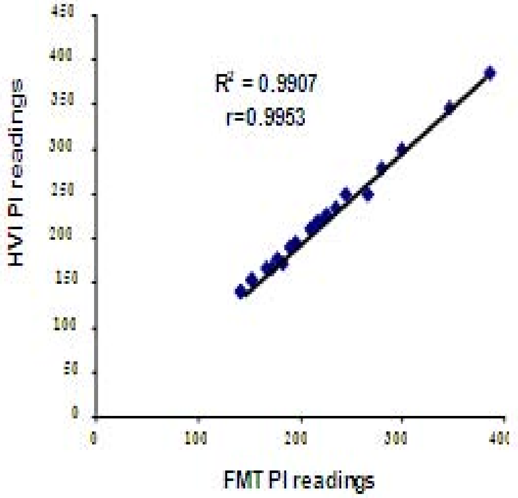


Figure 4. The relationship between FMT Ph and HVI Ph readings

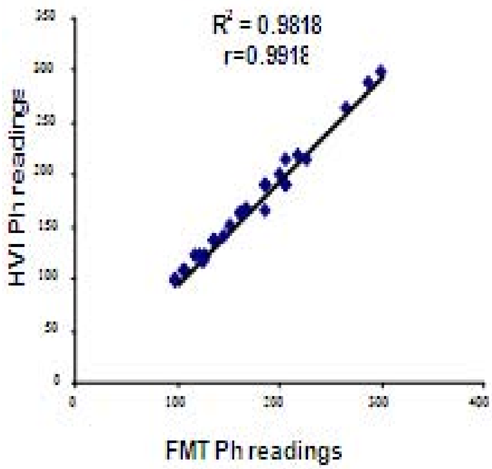
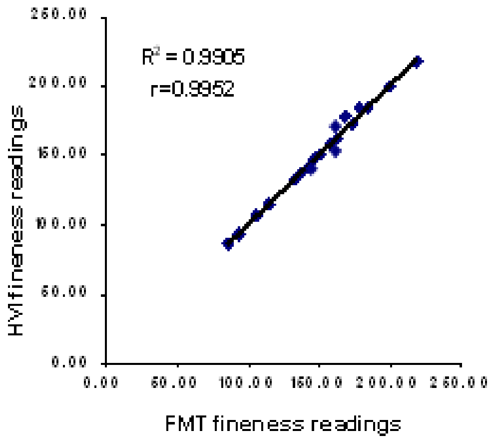


Figure 5. The relationship between FMT fineness and HVI fineness readings



Conclusion

Comparison of micronaire and maturity data of the two calibrated Micromat and HVI instruments proven that the two instruments were providing statistically similar micronaire data. Consequently, they must have similar PL data. The different of the principle of measuring the maturity ratio did not affect the Ph value in a wide range because the formula of calculated the Ph depends on both of the PL and maturity ratio readings .The congruency of true fineness and calculated fineness using HVI Instrument in most the samples indicated the validity of our calibration.

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POSTER PRESENTATION

Properties of Woven Fabrics Made From Compact, Ring and Open-End Rotor Cotton Yarns

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Abstract

The properties of compact, ring and rotor spun yarns produced in constant count from two Egyptian cotton varieties "Giza 86 and Giza80" were investigated. Yarn samples were converted to woven fabrics to determine the physical performances of the yarns in woven form.

The results revealed that compact spun yarns have higher strength, lower hairiness and unevenness and better pilling resistance over ring and open-end rotor spun yarns. The improvement in yarn strength is greater for compact spun than for ring and open-end rotor yarns. The fiber of the compact yarns was much better aligned with the yarn axis than those of the ring yarn, while open-end yarns recorded the last one.

Furthermore, the spun Giza 86 yarn showed high strength, elongation, evenness, lower neps and hairiness values than the equivalent Giza 80 yarn irrespective of yarn formation, which is due to the higher fiber quality of Giza 86. However, the fabrics consisting of compact yarns exhibited much better pilling performance compared to the fabrics produced by conventional ring and open-end spun yarns. Compact yarns are reported to have higher abrasion resistance than ring and open-end yarns in terms of weight loss.

Keywords: *Woven, yarn, fiber properties.*

Introduction

The three currently major yarn production systems are compact, ring and open end spinning. The productivity of yarn formation has increased 8-10 times by open-end spinning as compared to ring spinning system. The qualitative properties of open-end yarn are much better than carded short staple cotton with the exception of lower mean strength. As far as economics is concerned, open-end spinning does not need the roving and winding machine. Because of better uniformity, number of drawing operations is also lowered and it produced equally good yarn from lower grade cotton. The profit margin is higher as compared to ring spinning system with other bonus advantages of less space and labor requirements, (Bacler 2003).

The compact spinning system is a modified ring-spinning process, developed initially for spinning cotton yarn, which belongs to the short staple fiber subgroup. In the compact spinning system, in contrast to the classical ring-spinning system, the fibers are compacted aerodynamically just after the drafting. The fibers become more closely aligned and increasingly parallel within this compacting zone prior to yarn formation. This enables yarn production with a reduced level of hairiness and increased yarn strength (Krifa et al. 2002). Rotor yarns are less irregular than the ring spun yarn because of multiple doubling or back doubling of fibers in the rotor groove and ultimate thickness of rotor spun yarn is made up of many thin layers of fibers. Moreover, rotor spun yarns, being made from sliver and with opening roller drafting, are not as affected by roller drafting wave as ring yarns,(Ghosh 2006).

Celik and Kadoglu (2004), Jackowski et al. (2004) and El-Sayed and Souzan, Sanad (2007) have all conducted and issued several studies comparing the properties of compact spun yarns versus classic ring-spun yarns. These studies revealed the consistent results of reduced yarn hairiness, the ability to produce yarns of enhanced strength and elongation properties even with a lesser amount of twist, which enables increased production speeds to be reached in favor of the compact spinning system.

Ozdil et al. (2005), reported that compact yarns-based knitted fabrics versus ring yarn- based knitted fabrics have divergent visual properties; namely, they are more brilliant , glossier, had finer and smoother handling quality, better bursting strength values, better pilling but the abrasion resistance tests did not reveal any significant difference between the samples. Cankut et al. (2007) Stated that the pilling properties of the fabrics produced with compact-spun yarns and the tensile strength of the fabrics produced with finer compact-spun yarns are better. Tyagi et. al. (2010) indicate that Fabrics woven from compact-spun yarns are less extensible and possess considerably higher bending and shear rigidities and higher formability than equivalent fabrics made from conventional ring-spun yarns.

The aim of the study presented herein was to compare the properties of fabrics produced with open-end, conventional ring- and compact- spun yarns.

Materials and Methods

Two Egyptian cotton varieties were used. The properties of cotton fiber measured on Uster HVI spectrum and Micromat testing instruments are given in Table 1.

100% carded cotton yarn spinning processes were followed. Second passage slivers were converted into roving before spinning into compact and ring spun yarns, while open-end rotor yarns were spun directly from second passage slivers. Compact and Ring yarns in constant count, Ne 30/1 were spun on a Mazoli RST1 compact and ring frame. Open-end rotor yarns were spun in the same yarn count of “Ne 30/1” on a Schlafhorst Autocoro 288 rotor spinning included a 31 mm diameter rotor (cotton type) running at 100.000 rpm.

Table1. Fiber quality properties of Egyptian cotton varieties Giza 86, and Giza 80

Fiber Properties	**Giza 86**	**Giza 80**
Upper Half Mean mm.	32.8	30.1
Uniformity Index (%)	86.5	85.6
Strength cN/Tex)	44.3	38.4
Elongation (%)	6.4	7.4
Micronaire value	4.3	4.2
Maturity (%)	88	85
Fineness 155		167
Reflectance Rd%	65.0	63.7
Yellowness +b	8.5	12.6

Weaving

Yarn samples were separately used to produce plain woven fabrics on a Texmaco shuttle loom by Cairo Secondary School for spinning and weaving.

The construction of the sets of fabrics was kept constant at 24 ends and 22 picks per centimeters (i.e. 60 ends×56 picks per inch) for single 30Ne yarns. In the all fabrics, the warp and weft yarns were of the same combination (compact /Compact; Ring/Ring and Open-end/ Open-end).

Physical and mechanical tests were carried out in weft and warp direction after conditioning of the fabrics for 24 hours under the standard atmospheric conditions. The following tests were carried out according to standard textile testing methods "Table 2":

Table 2. Testing carried out according to standard textile testing methods

Test Instru	ment	Standard
Single yarn strength & elongation	Statimat ME	ISO: 2062:1993
Yarn evenness	USTER Tester 3	ISO:16549:1993
Air Permeability	Air permeability tester -test	ASTM D737
	Spray test method	ISO4920:1981
Fabric Strength and elongation	Asano Kikai Seisaku	ASTM D1682 BS EN ISO13938-2:1999
Pilling Resistance	ICI Pill box tester	BS EN ISO 12945-1:2000
K/S	Data color spectrophotometer SF-600	ISO 9001:2000
Thickness losses after abrasion	(Asano Kikai Seisaku	BS EN ISO12947-1:1998
Thickness mm	Thickness gauge	ASTM D 1777 ISO 5084:1996

The test results related to fabric properties were analyzed for significance in differences, using ANOVA and Tukey and Dunnett T3 post hoc tests at the 95% level of confidence in SPSS 15.0.

Results and Discussion

Yarn properties

Yarn samples were compared on the basis of yarn tensile strength, evenness "CVm%" and hairiness. The differences in mean values of each group were determined by evaluating the level of significance obtained to ANOVA. The results of ANOVA test results i.e., significance level values (p values) are shown in Table 3.

Tensile properties

Tensile properties of yarn samples were illustrated in Figure 1. The test results show that compact spun yarns had the highest tenacity values from Ne 30/1 cotton yarn, while open-end rotor yarns were the weakest. This result is consistent with previous findings, which reported that the twisted core of the compact spun yarns creates a stronger bond between the fibers and results in higher tenacity for compact spun yarns. Moreover, the lack of fiber parallelization in the open-end rotor yarn structure is thought to lead to low tensile values, (soe et. al. 2004).

Table 3. Physical properties of yarn spun on compact, ring and open-end spinning systems

Cotton varieties	Spinning system	Tenacity (cN\tex)	Elongation %	CVm%	Hairiness (H)	No. of Neps/Km
Giza 80	Open-end	14.60	6.62	14.42	4.50	210
	Ring	17.63	5.89	15.78	4.81	293
	Compact	19.38	5.38	14.83	3.99	260
Giza 86	Open-end	15.87	6.49	14.18	4.34	190
	Ring	18.15	5.40	15.96	4.89	246
	Compact	19.83	5.28	15.66	3.94	216
P value		0.947	0.670	1.014	0.146	14.822

The improvement in yarn strength is greater for compact spun than for ring and open-end rotor yarns. The reason for this can be better understanding by referring to the scanning micrographs of the 30/1 Ne compact, ring and open-end yarn as shown in Figure 2. The fiber of the compact yarns was much better aligned with the yarn axis than those of the ring yarn, while open-end yarns recorded the last one. If fibers of a yarn were perfectly aligned with the yarn axis, the proper amount of twist would almost totally translate fiber strength to yarn strength. If fiber alignment is poor, translation of fiber strength to yarn strength will also poor. It could be summarized that in Open-end yarn, the nature of the twist introduced is quite different from that introduced in compact and ring yarns. In open-end yarns, the twist is not uniformity distributed, the central portion of the yarn being more highly twisted than outer sheath, (Lord and Nichols 1974).

Yarn evenness and neppiness

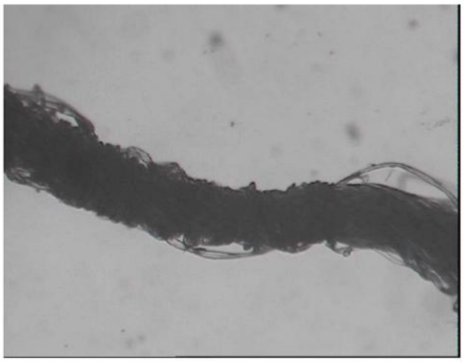
Yarn evenness “CVm%” and neps results are shown in Table 3 and illustrated in Figure 1. In general, CV_m% values express mass variation over a length of about 1 cm with respect to the mean value. The best evenness and neps results were obtained with the open-end spinning system, while ring spun yarns showed the slightly high unevenness and neps results. Open-end rotor spun yarns are stated to be more even and of less neps than ring spun yarns because of opener action and back doubling of fibers in the rotor groove. Quality parameters in terms of evenness and neps values indicated that compact spun yarns appear to fall between ring and open-end rotor spun yarns.

Yarn Hairiness

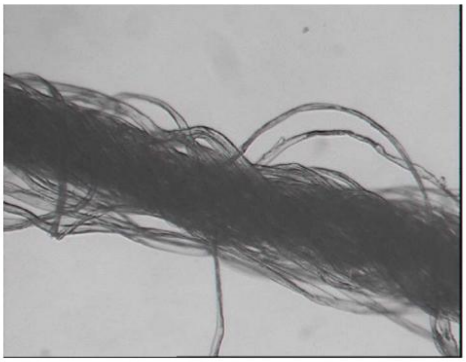
Figure 1 show the test results of yarn hairiness, as the Uster hairiness index (H). Yarn hairiness expressed in the form of “H” gives an average value corresponding to the total length of protruding fibers within the measurement field of 1 cm length of the yarn. The ring spinning system appeared to demonstrate the highest H values for all yarn samples, whereas according to ANOVA results, the differences between Uster hairiness (H) values of compact and open-end rotor spun yarns were not significant.

The spun Giza 86 yarn show high strength, elongation, evenness and lower neps and hairiness values than the equivalent Giza 80 yarn irrespective of yarn formation, which is due to the higher fiber quality of Giza 86.

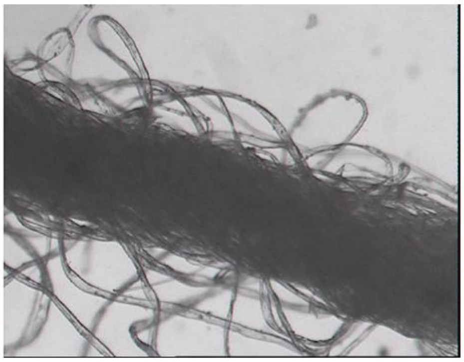
A- Giza 80 Compact yarn



D- Giza 86 Compact yarn

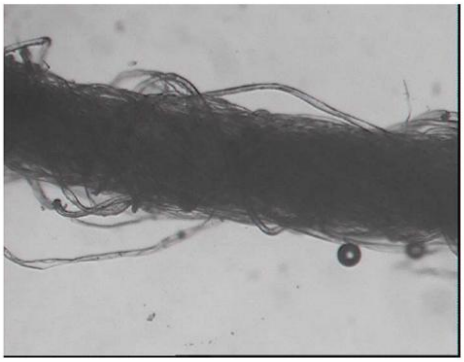


B- Giza 80 Ring yarn



E- Giza 86 Ring yarn

C-Giza 80 Open-End yarn



F-Giza 86 Open-End yarn

Figure 2. Scanning micrographs of the 30/1 compact, ring and open-end yarns with the 4.0 twist multiplier

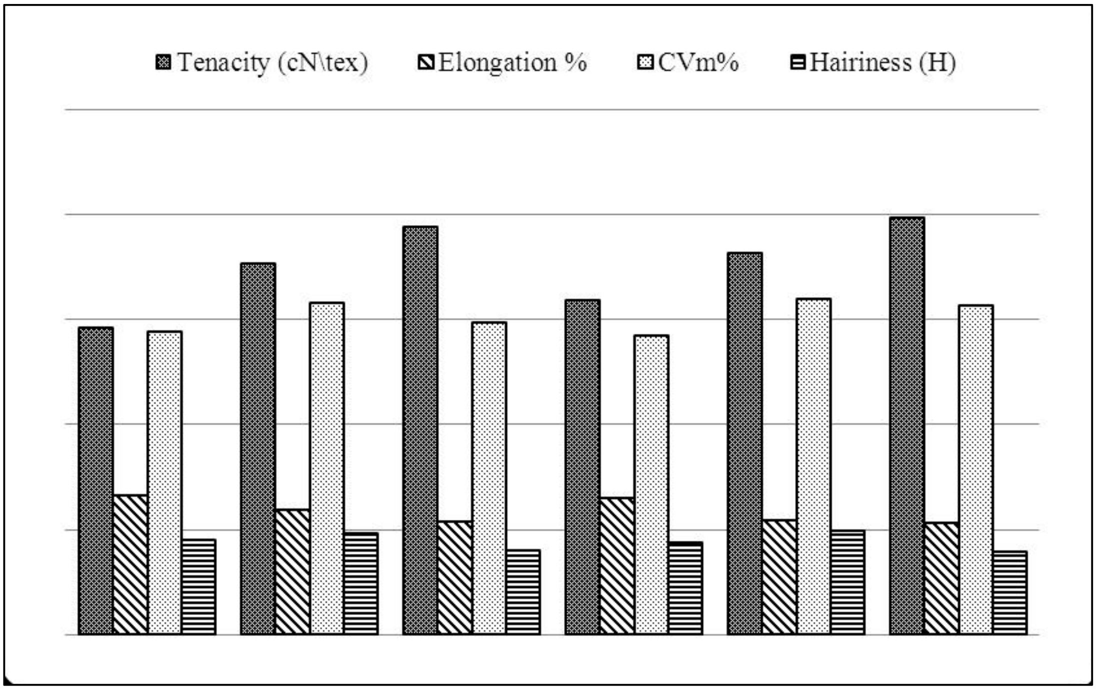


Figure 1. Yarn quality properties of open end, ring and compact spinning

Fabric Properties

- *Air permeability*

In m any fl at textile products, appropr iate air-perm eability is the most important feature. This feature especially refers to fabrics comfort. Air-permeability test resu lts of dyed f abric samples are s hown in Table 4. The tests results indicate that the air-perm eability of the fabrics produced from compact spun yarns were generally higher com pared to the other tw o systems. Lower air-p ermeability values of open-end rotor spun yarns, other than the corresponding ring and compact spun yarns, resulted in bulky yarns of open-end yarns as shown in figure 3.

- *Tensile properties*

The test results indicate that the strength and elongatio n of the fabrics produced from com pact yarns is generally higher than con ventional yarns in both warp and weft direction, as m ight be well expected since compact yarns have higher strength (T able 4). The spun Giza 86 woven fabrics show high strength and elongation values than the equivalent Giza 80 fabric irrespective of yarn for mation, which is due to the higher fiber tenacity and breaking extension of Giza 86. This result indicates that the strength of fabrics is mainly affected by yarn strength, and the cotton variety is also an important factor.

Table 4. Air permeability, breaking strength and elongation

Yarn made from	Fabric made from	Air Permeability cm3/cm2.sec	Breaking force KgF		Elongation %	
			Warp	Weft w	arp	weft
	Open-end 84.33		60.2	57.5	7.8	8.3
Giza 80	Ring 76.33		65.5	64.3	8.6	8.9
	Compact 68.33		66.5	64.6	8.0	8.5
	Open-end 86.33		61.4	59.5	8.7	9.0
Giza 86	Ring 81.33		66.3	64.5	9.3	9.6
	Compact 77.00		68.4	65.5	9.1	9.3
P value		6.963	1.48	1.93	0.492	0.328

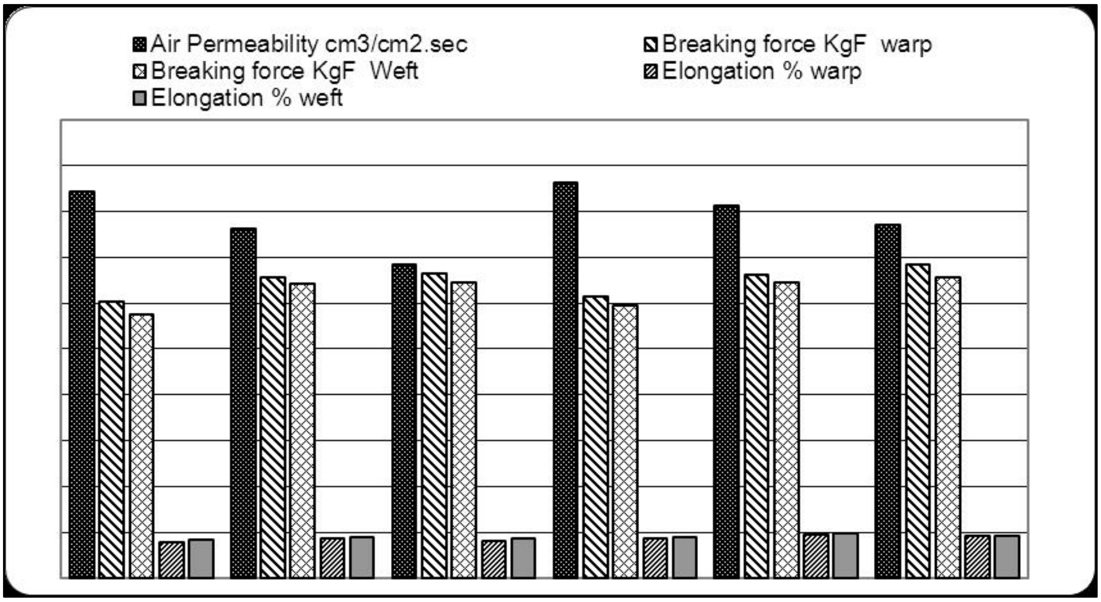


Figure 2: Air permeability, breaking force in warp, weft and elongation in warp and weft from the fabric made of ropen end, ring and compact yarns

- *Pilling resistance*

The extent of pilling is assessed visually by comparison with the arbitrary standards. The pilling test results are shown in Table 5 and figure 4. The results indicate that pilling behavior of all fabric types worsen as the loop lengths of the fabrics are increased, as expected. However, the fabrics consisting of compact yarns exhibit much better pilling performance compared to the fabrics produced by conventional ring and open-end spun yarns. A similar performance in terms of pilling was also reported by a compact yarn spinning machine manufacturer, as indicated below.

Arbitrary standard

No. of Pills	Standard (Grade)
0-4	5
5-10	4
10-20	3
20-40	2
40-60	1
60-above	0

- *Comparison of color*

The test results of color are given in Table 5. The data indicated that there is a slightly significant color difference between the fabrics of compact, conventional ring and open-end spun yarns although they were woven and dyed under identical conditions. The findings indicate that the fabrics of open end yarns have darker shades compared to the fabrics of compact spun yarns, while fabrics of conventional ring yarns were of lighter shade. This result reveal that much less dye can be used for the fabrics of open end yarns, so their dyeing cost might be lower for the same depth of shade, in comparison to the fabrics of conventional ring and compact yarns.

- *Thickness losses after abrasion cycle*

Thickness losses after 1000 abrasion cycle (%) of the fabrics were investigated according to percent weight losses. The weight loss values (%) of the fabric samples after certain cycle numbers “1000 cycles” were calculated. The results are given in Table 5. When the weight loss values (%) obtained at the fabrics after

1000 cycles were considered, the fabrics woven from compact yarns were found to have less abrasion between the ratio of 1.76% and 1.35% than the fabrics woven from ring yarns (2.45% and 2.23%) and ope n-end yarn, (3.07% and 3.01%) for both Giza 80 and 86 respectively, similar to the findings related with yarn tenacity values.

Table 5. Pilling resistance, K/s, thickness loss (%) and thickness (mm)

Yarn made from	Fabric made from	Pilling Res. Grade	K\S	Thickness Loss after 1000 Abrasion cycle (%)	Thickness mm
	Open-end	4 3.64		3.07 0.53	
Giza 80	Ring 4		3.02	2.45 0.44	
	Compact 5		3.15	1.76	0.39
	Open-end 4		3.64	3.01	0.62
Giza 86	Ring 4		2.96	2.23	0.46
	Compact 5		3.28	1.45	0.44
P value		0.122	0.01	0.201	0.11

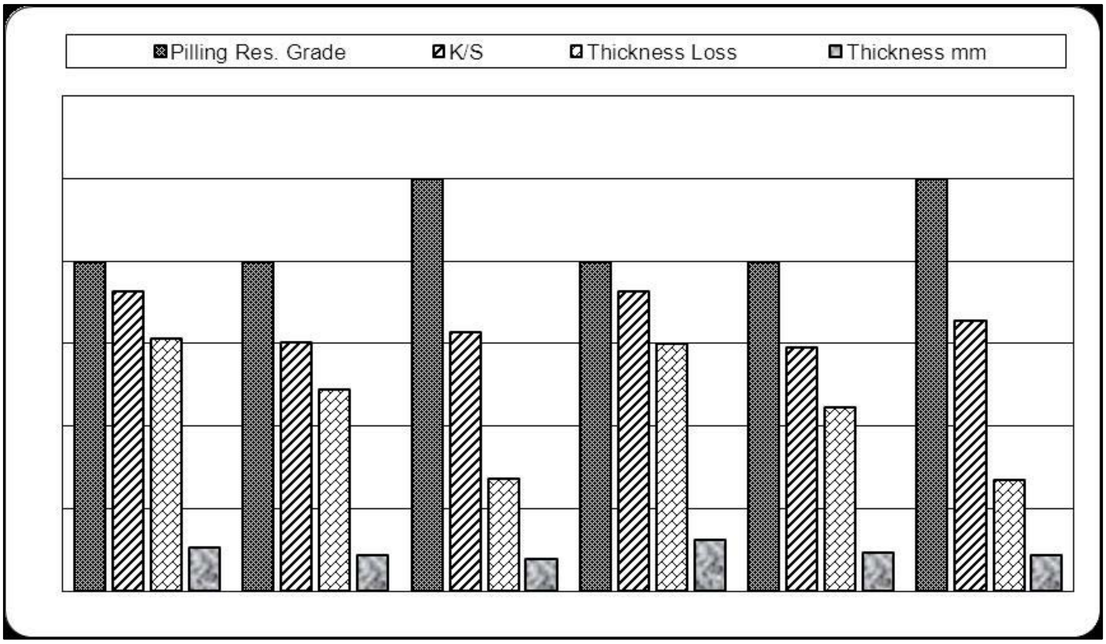


Figure 3: Pilling resistance, color shade, thickness loss and thickness/mm from fabic made of open end, ring and compact yarns

Compact yarns are reported to have higher abrasion resistance than ring and open-end yarns in terms of weight loss. The better abrasion resistance of fabrics produced from Giza 86 yarns than those produced from Giza 80 yarns in turns of weight losses were parallel with the ones noted in fiber and yarn strength.

Thickness

From Table 5, it can be observed that the fabrics made from compact yarn show relatively the same thickness as compared with the equivalent fabrics made from ring and open-end yarns irrespective of cotton variety. Fabric made from open-end yarns shows higher thickness value than all the other fabrics, and this can be attributed to the bulkiness of open-end yarns.

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ORAL PRESENTATION

Bt cotton adoption and variety market development: The Chinese case

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Abstract

In China, Bt-cotton varieties are widely adopted since 1997 to help control attacks of *Helicoverpa armigera*, a major pest on cotton crop. Most studies have related this adoption only to the specific advantages of Bt-cotton, e.g. in terms of reduction in pesticide use. This reason appears not to be sufficient as this specific advantage has been put into question in more recent papers, which also raised the issue of seed prices.

By referring to datasets seldom used in earlier analyses, we argue that Bt-cotton use in China has benefitted a lot from the development of the cotton variety market and it could suffer if this development is not effectively regulated. Since mid-1990s, a favourable legal framework has been set up and it resulted in the development of a competitive variety market. But free-wheel development led to the current stiff competition which is responsible for quality uncertainty and possibly for high seed pricing. The profitability and continued use of Bt-cotton is under threat, as well as the pursuit of the development of the variety market. Actions have been conducted to regulate this market, but their effectiveness is debatable.

Keywords: *Bt cotton, market development, China.*

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