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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 12 (20): 1346-1352, 2009
ISSN 1028-8880

An Evaluation of Eco-Friendly Naturally Coloured Cottons Regarding Seed Cotton Yield, Yield Components and Major Lint Quality Traits under Conditions of East Mediterranean Region of Turkey

Lale Efe, Fatih Killi and Sefer A. Mustafayev
Department of Field Crops, Faculty of Agriculture,
Kahramanmaras Sutcu Imam University, 46100 Kahramanmaras, Turkey

Abstract: In the study carried out in 2002-2003 in the East Mediterranean region of Turkey (in Kahramanmaras Province), four different naturally coloured cotton (*Gossypium hirsutum* L.) (dark brown, light brown, cream and green) lines from Azerbaijan and two white linted cotton varieties (Maras-92 and Sayar-314 (*G. hirsutum* L.)) of the region were used as material. The aim of this study was to determine seed cotton yield and yield components and major lint quality traits of investigated coloured cotton lines comprising white linted local standard cotton varieties. Field trials were established in randomized block design with four blocks. According to two year's results, it was determined that naturally coloured cottons were found similar to both white linted standard cotton varieties for sympodia number and seed cotton yield. For boll number per plant, except green cotton line all coloured cotton lines were similar to standard varieties or even some of them were better than standards. For ginning outturn, dark brown, cream and green cotton lines were found statistically similar to standard Maras-92. But all naturally coloured cotton lines had lower seed cotton weight per boll and generally lower fiber quality than white linted standard varieties. For fiber length and fiber strength cream cotton line was the best coloured cotton. And for fiber fineness only green cotton line was better than both standards. It can be said that naturally coloured cotton lines need to be improved especially for fiber quality characters in the East Mediterranean region of Turkey.

Key words: Naturally coloured cotton (*Gossypium hirsutum* L.), seed cotton yield, yield components, fiber quality

INTRODUCTION

Until recently, chemical dyeing was considered as the only viable way to colour cotton clothing. Almost every industrial dye process involves a solution of a dye in water, in which the fabrics are dipped or washed. After dying a batch of fabric, it's cheaper to dump the used water-dye effluent-than to clean and re-use the water in the factory. So, dye factories across the world are dumping millions of tons of dye effluent into rivers.

The dyeing process which requires several steps, adding to cost as well as most of the dyeing chemicals, creates toxic waste and damages the environment. Since dyeing is costly and produces large amounts of waste water, it is estimated that the elimination of dyeing can save up to one half the manufacturing costs and disposal of toxic dye waste. Also dyes have a hard time adhering to cotton; at least half of the chemicals end up as waste water in rivers and in the soil. Even in small amounts, these heavy metals are lethal (Asai and Chaugule, 2003). Cotton is often bleached before it is dyed and heavy metal mordants are used to adhere the dye to the fabric. The chemicals used to produce dyes today are often highly toxic, carcinogenic, or even explosive. The chemical Anililine, the basis for a popular group of dyes known as Azo dyes (specifically group III A1 and A2) which are considered deadly poisons (giving off carcinogenic amines) and dangerous to work with, also being highly flammable. In addition, other harmful chemicals used in the dying process include 1) dioxin-a carcinogen and possible hormone disrupter; 2) Toxic heavy metals such as chrome, copper and zinc-known carcinogens; and 3) Formaldehyde, a suspected carcinogen.

Aslam *et al*. (2004) reported that textile effluents are high in toxicity to human beings and are also a serious threat to ground and surface water resources. Naturally coloured cotton is an attractive proposition for the textile industry as it will eliminate the need for dyeing (Waghmare and Koranne, 1998). Cottons of different colours have always existed in nature. Because of its

Corresponding Author: Lale Efe, Department of Field Crops, Faculty of Agriculture, Kahramanmaras Sutcu Imam University, 46100 Kahramanmaras, Turkey Tel: 90.344.2191637 Fax: 90.344.2191526

short fibers and inherent weakness, however, they were unable to be processed by modern textile machinery and had limited commercial value. Also, it is noted that production is low, the fibers are not as long as they are in white cotton and colour persistence is not as good as dyed cotton (XinMian and Qui, 1999). With various plant breeding methods, researchers have developed cotton with long fiber and strong colour that can be used commercially. Today, coloured cotton is grown in shades of brown, green, cream and yellow, totally eliminating the need for dyes. In addition since there is no bleaching or harmful dyestuff involved in manufacturing, no waste water is produced.

Freire *et al.* (1997) studied on improvement of coloured cotton in northeastern Brazil and they reported that statistically significant differences occured in final stand density, yield and lint percentage, length, fineness and strength. Song *et al.* (1998) reported that the brown coloured fiber trait was controlled by an incompletely dominant single gene. Gencer (1998) studied on agronomical, physiological and technological properties of brown, green and cream cotton genotypes belonging to *G. hirsutum* L. and *G. barbadense* L. and F_1 and F_2 performances of their hybrids for various properties. Joshi and Chirde (1998) initiated a study in 1993 in Mahyco, India in order to develop coloured linted cotton hybrids with high yield and superior fiber traits. They reported that selected hybrid combinations had better fiber properties than coloured cotton parents. In addition, Janbhale *et al.* (1998) initiated a genetic improvement programme for coloured lint in *G. hirsutum* L. in India. They studied generations of P_1, P_2, F_1, F_2, BC_1 ve BC_2 followed by crossing in two sets between parents with white, brown and green lint. Estimation of gene effects revealed importance of both additive and dominance gene effects and involvement of duplicate epistasis in the control of most of the characters. Researchers noted that selections having brown and green lint colour have been made in F_2 and back cross generations for larger boll size, medium to long staple length and high strength. Tariq (1998) conducted a hybridization study with eight shades in brown colour in order to improve the yield, fiber quality and resistance to disease and insects. Rough and okra leaf characters have been incorporated to lend comparative tolerance to insects. Also the researcher reported that D'Jura green an introduction from USA and local green were crossed producing dark colours between dark green and dark blue. Mustafayev *et al.* (1999) noted that seed cotton yields of naturally coloured cottons were not statistically different from those of white linted standard cotton varieties. Researchers also reported that fiber fineness of naturally coloured cottons were similar to those of standards but fiber length and strength of naturally coloured cottons were lower than standards. Sofuoglu and Gencer (2000) also reported that the investigated agricultural and technological properties could be directly linked to the coloured fiber gene in addition to other genes and that the fiber qualities and yields of coloured lint cottons could be improved through traditional plant breeding methods. Zhang *et al.* (2000) noted that coloured cotton breeding using conventional breeding techniques to improve fiber quality is somewhat problematic. These difficulties include high wax content in fibres of green coloured cotton, which affects fibre specific strength and causes colour changes due to the optical sensitivity. Another problem is that the colour intensity of brown cotton is negatively correlated with quality in genetic linkage. Gurel *et al.* (2001) investigated cultivation possibilities of naturally coloured cottons under Aegean region conditions. Six coloured cotton lines (4 brown and 2 green) and 3 white coloured lines were evaluated in a study conducted in Turkey in 1997 and 1998. Researchers reported that the light brown line had fiber length in the range 33.9-30.2 mm and seed cotton yield between 2900 and 2190 kg ha^{-1} and that the dark brown line had a fiber length of 26.0-25.9 mm and seed cotton yield of 4580-3761 kg ha^{-1} and that green cotton had poorer quality compared to the others. Jiang and Jiang (2001) studied on some progenies from the interspecific hybrid, the natural outcrossed quadruspecies (Upland cotton x *G. bickii* x Upland cotton and The Sea Island cotton x *G. thurberi* x Upland cotton). They reported that through interspecific hybridization the negative effects of the colour gene on fiber quality and yield was offset.

The objective of this study conducted in 2002-2003 under conditions of east Mediterranean region of Turkey (in Kahramanmaras Province) was to determine seed cotton yield and yield components and major lint quality traits of investigated coloured cotton lines comprising white linted local standard cotton varieties.

MATERIALS AND METHODS

In the study carried out in 2002-2003 in the east Mediterranean region of Turkey (in Kahramanmaras province), four naturally coloured cotton lines (light brown, dark brown, cream and green) (*G. hirsutum* L.) from Azerbaijan and two white linted cotton varieties (Maras-92 and Sayar-314 (*G. hirsutum* L.)) of the region were used as material. Field trials were established in randomized block design with four replications in two years (Cochran and Cox, 1957). The climate and soil data of the trial are given in Table 1 and 2, respectively.

Table 1: The climatic data of the experiment location in 2002-2003 cotton growing season

	Temperature (°C)						
Months	Average	Minimum	Minimum average	Maximum	Maximum average	Total rain (mm)	Average relative humidity (%)
2002							
April	14.0	5.2	9.3	25.8	19.3	123.9	71.4
May	19.6	9.8	13.9	33.2	26.1	29.1	90.8
June	25.7	14.4	19.0	41.0	32.8	0.4	54.2
July	29.0	20.0	22.7	42.4	38.4	---	58.2
August	27.4	18.6	21.8	41.8	34.6	0.5	61.9
September	24.8	14.0	18.6	38.0	32.3	1.4	62.6
October	20.3	19.5	13.8	36.0	27.8	23.5	55.3
2003							
April	15.0	5.2	9.9	27.0	20.5	88.7	60.0
May	14.1	11.0	15.4	34.0	29.5	30.4	51.9
June	25.6	14.0	18.9	37.0	33.1	1.6	54.0
July	28.3	19.6	22.3	41.4	36.1	---	58.2
August	29.4	20.2	22.4	41.8	38.0	---	56.6
September	24.3	12.8	17.9	39.8	31.5	22.4	54.7
October	20.3	10.6	14.7	34.6	27.1	39.2	63.2

Source: TR. Ministry of Environment, General Directorate of Turkish State Meteorological Service, Station of Kahramanmaras

Table 2: The chemical properties of the experiment location soil

Chemical properties	Values
Depth (cm)	0-20
Salt (%)	0.059
Saturation (%)	47.3
pH	7.47
CaCO3 (%)	2.04
Organic matter (%)	0.92
P (kg da^{-1})	8.06
K (kg da^{-1})	38.11

Source: KSU, Agricultural Faculty, Soil Science Department Laboratory

Seeds were sown by mechanical planter in four-row plots of 10 m length at a space of 0.65 m on 07 May 2002 and on 13 May 2003. Plants were thinned to 20 cm in rows. During the growing season plants were hoed 3 to 4 times and harrowed 4-5 times. Each year composed fertilizer (20:20:0) was applied presowing as 8 kg da^{-1} N and P_2O_5. Furthermore, 26% of Ammonium Nitrate was applied as 7 kg da^{-1} N by using a fertilizer spreader in inter-rows prior to first and second irrigation. Plants were furrow irrigated 5-7 times until bolls open up to 60%. Plants were hand harvested on 27 September 2002 and 30 September 2003. At harvesting time samples of 20 bolls were taken from each plot. In each plot plant height, sympodia number, boll number per plant were recorded using randomly selected 10 plants in the middle two rows of plot (Gencer *et al*. 1992). Seed cotton weight per boll was determined using the samples of bolls taken from plots. Boll samples were ginned using labour ginning machine and ginning outturn were calculated according to the following formula:

$$\text{Ginning outturn (\%)} = \frac{\text{Lint weight (g)}}{\text{Lint weight (g) +Seed weight (g)}} \times 100$$

Seed cotton yield values per hector were calculated using seed cotton yield taken from 2nd and 3rd rows of each plot using plot size (0.65 m = 1.3 m = 13 m^2) Fiber length, fiber fineness and fiber strength of fiber samples were determined using HVI (High Volume Instruments) analyzer. The data obtained were analyzed by experimental design of randomized block design with four blocks for each year separately and then combined analysis of variance over two years was done by using the SPSS package program and the means were compared using Duncan multiple comparison test (Landau and Everitt, 2003; Efe *et al*., 2000; Bek and Efe, 1995).

RESULTS

According to two year's results, years were statistically significant for sympodia number, boll number per plant, seed cotton weight per boll, seed cotton yield, fiber length, fiber strength. Lines and varieties were statistically significant for plant height, boll number per plant, seed cotton weight per boll, fiber length, fiber fineness, fiber strength. Year×lines/variety interactions were not statistically significant for all traits. The means for each year and two year's means of coloured cotton lines and white linted standard cotton varieties and means of years for investigated traits were given in Table 3-5.

Plant height: Means for plant height of coloured cotton lines and white linted standard cotton varieties and arised groups were given in Table 3. From this Table, it has been revealed that plant height values in 2002 and 2003 were similar. Generally according to two year's results, green cotton line was the longest variety with 97.3 cm. (Table 3). The other coloured lines and Maras-92 variety (standard) followed this. The shortest variety was Sayar-314 (standard) (77.0 cm).

Table 3: Means for plant height (cm), sympodia number and boll number per plant and arised groups

	Traits								
	Plant height (cm)			Sympodia No.			Boll No. Per plant		
Lines/varieties	2002	2003	2002-03	2002	2003	2002-03	2002	2003	2002-03
Dark brown	83.3ab	87.1bc	85.2bc	16.8a	11.1a	13.9a	11.6a	12.9ab	12.2ab
Light brown	92.0a	85.5bc	88.7ab	15.6a	9.3a	12.4a	11.2a	12.0ab	11.6a-c
Cream	87.8ab	93.3ab	90.5ab	15.2a	10.4a	12.8a	12.1a	13.8a	12.9a
Green	91.3a	103.4a	97.3a	15.5a	11.4a	13.5a	10.0a	9.7c	9.8c
Maras-92 (white linted)	90.2a	91.6bc	90.9ab	14.4a	11.0a	12.7a	9.3a	13.6a	11.4a-c
Sayar-314 (white linted)	73.6b	80.4c	77.0c	14.5a	9.9a	12.2a	10.1a	10.7bc	10.4bc
Means of years	86.4a	90.2a		15.3a	10.5b		10.7b	12.1a	
CV (%)	11.0	7.96	9.12	11.58	16.12	14.9	1.69	11.68	15.3

*Means followed by the same letter are not significantly different at 5% level of probability

Table 4: Means for seed cotton weight per boll (g), seed cotton yield (kg ha^{-1}) and ginning outturn (%) and arised groups

	Traits								
	Seed cotton weight per boll (g)			Seed cotton yield (kg ha^{-1})			Ginning outturn (%)		
Lines/varieties	2002	2003	2002-03	2002	2003	2002-03	2002	2003	2002-03
Dark brown	5.2c	5.7a	5.4c	2642ab	3409a	3026a	38.2ab	39.4a	38.8ab
Light brown	5.5bc	5.8a	5.6bc	2337b	3165a	2751a	37.1b	37.4a	37.3b
Cream	5.6bc	6.3a	5.9ab	2381b	2729a	2555a	38.0ab	37.7a	37.9ab
Green	4.6d	5.1b	4.8d	2274b	3429a	2851a	38.1ab	37.8a	37.9ab
Maras-92 (white linted)	6.1a	6.2a	6.2a	2993a	3010a	3001a	38.7a	38.3a	38.5ab
Sayar-314 (white linted)	5.8ab	6.2a	6.0a	2200b	3174a	2687a	39.0a	39.2a	39.1a
Means of years	4.5b	5.9a		2471b	3152a		38.2a	38.3a	
CV (%)	4.78	6.86	6.07	11.11	16.84	15.4	2.13	5.00	3.81

*Means followed by the same letter are not significantly different at 5% level of probability

Sympodia number: Sympodia number is very important in order to form yield. For higher yield more sympodia number is desired. It can be realized that sympodia numbers in 2003 was more than ones in 2002 (Table 3). Also from Table 3, according to two year's results, sympodia numbers of lines and varieties varried 13.9 (dark brown) and 12.2 (Sayar-314) and all lines and varieties were statistically at the same group for this trait. This situation explains the fact that coloured cottons were similar to white linted standard cotton varieties concerning sympodia number.

Boll number per plant: Boll number trait is one of the most important yield components. Means for boll number per plant of coloured cotton lines and white linted standard cotton varieties and arised groups were given in Table 3. From Table, it has been seen that boll number per plant in 2003 was more than ones in 2002 (Table 3). According to two year's results, cream cotton line gave the most boll number (12.9). Dark brown (12.2) and light brown (11.6) cotton lines followed it. The least boll number was taken from green cotton line (9.8). It can be said that except green cotton line all coloured cotton lines were similar to standard cotton varieties or better than them for boll number per plant.

Seed cotton weight per boll: Seed cotton weight per boll, boll number per plant and sympodia number are very important yield components. When we look at two year's mean results, it has been realized that in 2003 seed cotton weight per boll was more than ones in 2002 (Table 4). Investigated naturally coloured cotton lines had generally low seed cotton weight per boll. All coloured cotton lines were behind white linted standard cotton varieties for this trait. The most seed cotton weight per boll was obtained from standard Maras-92 and Sayar-314 varieties (6.2 and 6.0 g) followed by cream (5.9 g), light brown (5.6 g), dark brown (5.4 g) and green (4.8 g) cotton lines, respectively.

Seed cotton yield: Means for seed cotton yield and arised groups were given in Table 4. As seen in Table 4, in 2003 seed cotton yield of coloured cotton lines and white linted standard cotton varieties was more (3152 kg ha^{-1}) than in 2002 (2471 kg ha^{-1}). From Table 4, according to two year's results, seed cotton yields of the coloured cotton lines and white linted standard cotton varieties varied between 3026 and 2555 kg ha^{-1}. All lines and varieties were statistically similar to each other for this trait and were at the same group.

Ginning outturn: From Table 4, it can be seen that ginning outturn values of coloured cotton lines and white linted standard cotton varieties was statistically similar in 2002 (38.2%) and 2003 (38.3%). The highest ginning outturn was taken from standard Sayar-314 (39.1%) followed by dark brown line (38.8%), standard Maras-92 variety (38.5%), cream line (37.9%) and green line (37.9%), respectively. Light brown cotton

Table 5: Means for fiber length (mm), fiber fineness (micronaire) and fiber strength (g tex^{-1}) and arised groups

	Traits								
	Fiber length (mm)			Fiber fineness (micronaire)			Fiber strength (g tex^{-1})		
Lines/varieties	2002	2003	2002-03	2002	2003	2002-03	2002	2003	2002-03
Dark brown	23.1d	25.2b	24.1d	5.2d	5.0b	5.1d	21.2c	25.3b	23.3c
Light brown	25.2c	27.3ab	26.3c	5.0d	4.7ab	4.8cd	21.9bc	27.7ab	24.8bc
Cream	26.2b	28.1ab	27.2bc	5.0d	5.0b	5.0cd	22.8b	28.4ab	25.6ab
Green	25.1c	26.2b	25.6cd	3.0a	4.0a	3.5a	21.7bc	27.4ab	24.6bc
Maras-92 (white linted)	29.4a	28.0ab	28.8ab	4.0b	3.9a	3.9b	25.4a	29.5a	27.2a
Sayar-314 (white linted)	29.6a	30.6a	30.1a	4.5c	4.7ab	4.6c	25.2a	28.9ab	27.0a
Means of years	26.4b	27.6a		4.4a	4.5a		23.0b	27.8a	
CV (%)	2.32	8.14	5.91	6.53	12.28	9.62	3.51	8.23	6.58

*Means followed by the same letter are not significantly different at 5% level of probability

line had the lowest ginning outturn (37.3%). As seen in Table 4, dark brown, cream and green cotton lines were found statistically similar to standard Maras-92 and they took place at the same group with white linted standard Maras-92 variety.

Fiber length: Quality of end product depends on quality of raw material. Also length, fineness and strength of cotton lint are very important fiber traits in order to produce best quality textile products. Table 5, shows that in 2003 fiber length (27.6 mm) was more than ones in 2002 (26.4 mm). According to two year's results, white linted standard Sayar-314 variety had the longest fibers in both years. The other standard variety Maras-92 followed this. Cream, light brown, green and dark brown cotton lines were behind of standard varieties, respectively 27.2, 26.3, 25.6 and 24.1 mm.

Fiber fineness: When two year's results examined, fiber fineness values of naturally coloured cottons and white linted standard cotton varieties were found statistically similar to eachother in both trial years (Table 5). The finest fibers were taken from green cotton line (3.5 micronaire) followed by varieties of Maras-92 and Sayar-314 and light brown, cream and dark brown lines with 3.9, 4.6, 4.8, 5.0 and 5.1 micronaire, respectively.

Fiber strength: Means for fiber strength of the naturally coloured cotton lines and white linted standard cotton varieties and arised groups were given in Table 5. In 2003 (27.8 g tex^{-1}) stronger fibers were obtained than in 2002 (23.0 g tex^{-1}). According to two year's results, for fiber strength white linted standard cotton varieties of Maras-92 and Sayar-314 were the varieties having the most strong fibers with 27.2 and 27.0 g tex^{-1}. Cream (25.6 g tex^{-1}), light brown (24.8 g tex^{-1}) and green (24.6 g tex^{-1}) cotton lines followed them. The least strong fibers were obtained from dark brown cotton line (23.3 g tex^{-1}).

DISCUSSION

Naturally coloured cottons were not behind white linted standard cotton varieties for seed cotton yield in line with results presented by Mustafayev *et al.* (1999). Researchers noted that naturally coloured cotton lines had similar seed cotton yields to standard white cotton varieties. Furthermore, they reported that green cotton line yielded 2500 kg ha^{-1}, that dark brown cotton line yielded 2559 kg ha^{-1} and that cream cotton line yielded 2993 kg ha^{-1}. But some of findings of Gurel *et al.* (2001) were similar to these findings. Researchers reported that the light brown line had seed cotton yield between 2900 and 2190 kg ha^{-1} and that the dark brown line had seed cotton yield of 4580-3761 kg ha^{-1}. Increasing of seed cotton yield values may explain by different climatic and soil conditions or genotypic variations.

Generally it is known that fibers of naturally coloured cottons are not as long as and as strong as white cotton lint (XinMian and Qui, 1999). Also in this study, parallel results were obtained. Naturally coloured cotton lines investigated had shorter and less strength fibers than standard cotton varieties with white fibres. Our findings were found similar to those of Mustafayev *et al.* (1999) who reported that fiber length of naturally coloured cottons varied 25.1-25.6 mm and that fiber strength of naturally coloured cottons varied 22.7-24.2 g tex^{-1}. Some of findings of Gurel *et al.* (2001) supported these findings. Gurel *et al.* (2001) reported that the light brown line had fiber length in the range 33.9-30.2 mm. This values are higher than the values obtained from light brown line (26.3 mm) in this study. This difference may be originated due to genotype or different cultural practices. Essentially, fiber length and fiber strength can vary in different cultivation practices and different environments besides of genotypes. Also researchers noted that the dark brown cotton line had a fiber length of 26.0-25.9 mm. These values are similar to fiber length of our dark brown cotton line (24.1 mm). However, for fiber fineness different

coloured cotton lines and white linted varieties gave different results from each other. This result shows that especially fiber fineness can vary depending on genotypes of cottons. Only green cotton line had finer fibers than white linted standard varieties whereas light brown and cream cotton lines were similar to Sayar-314 standard variety. But dark brown cotton line gave thicker fibers than both standards. Mustafayev *et al.* (1999) reported that fiber fineness values of naturally coloured cottons between 4.5-5.0 micronaire and that they are similar to standards. This findings are similar to our results except for small differences. Gurel *et al.* (2001) reported that green cotton had poorer quality compared to the others. But green cotton line had the finenest fibers (3.5 micronaire) among the all coloured cotton lines and white linted standard varieties. Since fiber fineness is not more affected by environmental conditions this situation may be occured because of differences of genotypes.

CONCLUSION

In conclusion, for sympodia number and seed cotton yield, naturally coloured cottons were found similar to both of white linted standard cotton varieties. For boll number per plant, except green cotton line all coloured cotton lines were similar to standard cotton varieties or even some of them were better than standards. But naturally coloured cotton lines investigated had generally lower seed cotton weight per boll. For ginning outturn, dark brown, cream and green cotton lines were found statistically similar to standard Maras-92. Generally naturally coloured cotton lines had lower fiber quality than white linted standard cotton varieties. For fiber length and fiber strength cream cotton line was the best coloured cotton. And for fiber fineness only green cotton line were better than both standards. It can be said that naturally coloured cotton lines need to be improved especially for fiber quality characters in the east Mediterranean region of Turkey.

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