DEVELOPING A COLOR DIAGRAM FOR THE EGYPTIAN COTTONS

By

M. M. Kamal[1], Dr. Ing.habil G.kugler [2] , Kh .M. Hussein[1], I. A. Ebaido[1] and Y. Sh. Abd-Elrahman[1]

Cotton Research Institute (CRI), Egyptian International Cotton Classification Center (EICCC), Agricultural Research Center (ARC), Giza, Egypt[1]

TEXTECHNO H. Stein GmbH & CO KG, Monchengladbach, Germany[2]

Abstract

In such countries, like USA, Australia, China and Uzbekistan ginners and cotton traders are using since many years in classing centers HVI lines to describe the quality of the cotton fiber varieties. In all these countries the classing of the color grades is done according to USDA color grade diagrams for US Upland and US-Pima cottons.

There is a need for developing a new color diagram for the Egyptian cottons due to the fact that both, i.e. the color diagrams of the American Upland cottons and that of the American-Egyptian Pima cottons, are not applicable to the Egyptian cottons: All the American Upland cottons have an intrinsic white color, while all American – Egyptian Pima cottons have an intrinsic creamy color.

As for the Egyptian cottons they have a very wide range of intrinsic colors extending from the extra white color up to the dark creamy color. In between there are light white, chalky white, light creamy and creamy intrinsic colors.

The content of the paper is to describe the way to develop a complete new color grade diagram what is able to describe in detail the color variations from Extra White, Light White, White, Light Creamy, Creamy and dark creamy of the Egyptian intrinsic cotton varieties.

1. Introduction

Egypt is well known as a country what is growing up cotton varieties with very special, unique properties. Especially the strength, fineness and also the color grades of Egyptian cotton cannot be found anywhere else in the world.

On the other hand surprisingly the classing of the Egyptian cotton is still made by cotton classer's. Until now Egypt does not follow the international trends to perform a classing of the cotton varieties by High Volume Testing devices. In such countries, like USA, Australia, China and Uzbekistan ginners and cotton traders are using since many years in classing centers HVI lines to describe the quality of the cotton fiber varieties. But in Egypt this is not yet the case: CATGO tries to realize such a classification of the Egyptian cotton according to USDA recommendations for US-PIMA cotton varieties, but in fact it fails completely. The possible reason is that some parameters of the Egyptian cotton in fact are much higher – especially for the strength - than the upper limit of the applied HVI calibration cotton what is used to calibrate the HVI lines.

Also for the description of the color of the Egyptian cotton the color grades for Upland- or PIMA US cotton cannot be used. All the American Upland cottons have an intrinsic white color, while all American – Egyptian Pima cottons have an intrinsic creamy color.

In fact – due to the differences in colors – there is a need for developing an own color diagram for the Egyptian cotton varieties due to the fact that both, i.e. the color diagrams of the American Upland cottons and that of the American-Egyptian Pima cottons are not applicable to the Egyptian cottons.

1.1. Target of the research team

The target is to develop a new color grade diagram for the Egyptian cotton. This is not a simple task, it requires a lot of time and a lot of experience. At least it is a linkage of the organoleptic-visual evaluation of the cotton colors by experienced classer's to the values Rd (Whiteness degree) and +b (yellowness degree).

The development has been made in the Cotton Research Centre Giza. Main part of the Centre is a new testing laboratory, which is equipped with a new cotton testing system, the Cotton Classifying System CCS Version 5, manufactured and installed by the German company TEXTECHNO Herbert Stein GmbH / Moenchengladbach.

The advantage of this system, compared to other cotton testing systems, is, that it can be operated in two different testing modes:

a) In HVI testing Mode: In HVI testing Mode, however, the parameters are always determined relatively in comparison to cotton etalons (HVI calibration cotton).

b) Direct testing Mode: In Direct testing Mode all important parameters for the description of the quality of the cotton fibers, are measured as absolute values.

For the development of the new color grades diagram for the Egyptian cottons following ideas have been considered:

- The proposed color classes for the color diagram of the Egyptian cottons which we seek to develop, should reflect differences in the intrinsic color but not the extrinsic color.
- The intrinsic colors are the genuine original colors of the varieties which are genetically controlled. Accordingly, the intrinsic colors are in fact varietal characters which depend basically on the genotype of each variety.
- Our conception is that the different color classes of the proposed color diagram for Egyptian cottons would be used to define precisely the intrinsic colors of the commercial Egyptian cotton varieties as well as the promising hybrids.
- The precise definition of the intrinsic colors of the different genotypes would help a lot to steer clear of the problem of color non-uniformity of some commercial Egyptian cotton varieties and promising hybrids.
- Within each of the proposed color classes of the Egyptian cottons, the degree of lightness or darkness of color in terms of percent reflectance (Rd %) would be used to define the grade of cotton. Lightness or darkness of color (Rd %) depends essentially on the amount and nature of foreign matter (trash) present in cotton. In other words it depends on the degree of cleanliness of cotton which is a fundamental criterion determining the grade of cotton.

2. Materials and methods

Cotton classification by grade is defined as the art and science of describing the quality of cotton in terms of grade according to the official standards. In fact, grading depends basically on the visual inspection and evaluation of raw cotton quality, since it is accomplished chiefly through the sense of sight by integration of the 3 factors of grade, i.e. color, trash content arid preparation or appearance of ginned cotton.

2.1. Planning of the experiments

The planning of the experiments for the design of the new Egyptian Color grades diagram included the following working steps:

1. The first step was the selection of the cotton varieties for what the new color grades diagram should be designed. This selection has been done by experiences Egyptian cotton classer's. Then for these selected cotton varieties (Giza 85, Giza 80, Giza 86, Giza 88, Giza 90 and Giza 92) samples have been collected from all over Egypt.

2. The second step was the definition of the Lint Grades, what should be used in future for the description of the quality of the Egyptian cotton varieties. The classer's what are involved in the design of the new color grades diagram decided to use the existing Lint Grades also in future, i.e. the new color grades diagram needs to be adapted to the existing Lint Grades below :

Denomination Lint	Grade LG	LG No.
Extra	EX	1
Fully Good	FG	2
Good	G	3
Fully Good Fair	FGF	4
Good Fair	GF	5
Fully Fair	FF	6
Fair	F	7

3. After all these decisions for the cotton varieties, what should be tested as well as for the applied Lint Grades, experienced classer's started to evaluate all collected cotton samples organoleptic by using their eyes and their hands in order to find the correct Lint grades (refer chapter 1.2.). During the assessment the samples have been compared to Lint Grade etalons are available in the Cotton Research Center Giza. The evaluation procedure ended in a list in which all assessed samples are noticed and marked with the related Lint Grade found by the cotton classer's.

4. All the evaluated and classified samples have been measured now statistically at the CCS_FIBROCOLOR Station, i.e. every sample has been tested 10 times. The noticed test results were the average values for the CIE Lab color system L*, b*, a* as well as Rd and +b for all tested samples.

5. Now both, i.e. the results of the organoleptic-visual assessment by cotton classer's and the measured values have been evaluated with statistical methods.

6. The obtained results are an enormous amount of data. For the further processing this big data amount needs to be sensible reduced in order to find a correlation between the measured data and the visual assessment of the samples. Therefore only the statistical data average $\underline{X}$ and standard deviation SD will be taken in consideration for the values L*, a*, b*, Rd and +b for the different cotton varieties and the defined Lint Grades.

7. In order to exclude wrong (incorrect) evaluated samples by the cotton classer's, only a limited data range ($\underline{X}$ +/- SD) for the measured values (L*, a*, b*, Rd, +b) of the tested cotton varieties (Giza 85, Giza 80, Giza 86, Giza 90 and Giza 92) is correlated with the above defined Lint Grades. This ensures a high accuracy, i.e. outliers are automatically excluded from further evaluation.

2.2. Objective color determination – CIE Lab color space

The modern High Volume Testing devices are using in fact spectrophotometers to measure colors on base of various color systems (CIE Lab, Hunter Lab, CIE L*C*h*, CMC etc.). Nowadays from all these existing color systems the CIE-Lab color system is the one, what is preferred for color measuring tasks in the textile industry.

The CIE-Lab colour system has following co-ordinates:

L*: Describes the brightness of the colors; L* is always positive (+),

L* = 0 (= ideal black), L* = 100 (= ideal white);

a*: Describes the red/green part of the sample, a* is positive (+) in case the red part is higher, a* is negative (-) if there is more green,

b*:Describes the blue/yellow part of the sample, b* is (+) for yellow colour values, b* is (-) for blue colour values,

Within the Cotton Classifying System CCS-Version 5 at EICCC, the CCS_FIBROCOLOR station is used to measure the colors of the Egyptian cotton samples. While the first testing step the FIBROCOLOR is measuring the CIE – Lab color values for an illumination with Daylight D65 generated by a Xenon flash lamp. On base of the L (D65) and b (D65) values the HVI whiteness degree Rd and HVI yellowness degree +b are calculated as follows (M. Matusiak [1]):

HVI Rd = 2,096 * L(D65) -104,1 **(9)**

HVI +b = 0,9827 * b(D65) + 0,7 **(10)**

2.3. Applied statistical methods

All collected and from the classer's evaluated samples have been sorted according to the lint grades, mentioned in chapter 2.1., topic 2. Then they have been tested on the CCS-FIBROCOLOR Station of the CCS-Version 5-2, i.e. the values L*, b* and a* as well as HVI-Rd and HVI +b have been measured. In order to get a high accuracy, every sample has been tested 10 times. From the individual results the statistical data average ($\underline{X}$), range (R), standard error (SE), standard deviation (SD) and coefficient of variation (C.V%). The statistical analysis of LSD at 5% probability and correlation analysis was made according to the procedure described by Draper and Smith, (1966) and Little and Hills, (1978). The data were statistically analyzed by using the computer statistical software package SAS statistical software V.9.1, (2004).

3. Obtained test results

The measured cotton samples for the CIE Lab color values as well as for the HVI color values (measured my means of CCS_FIBROCOLOR Station) are sorted according to the lint grades, assessed by the cotton classer's.

When we take the measured values in consideration, the limits between the defined Lint Grades cannot been seen easily.

4. Interpretation of the test results

Destination of the interpretation is, to find the area and the position of the area for the several Lint Grades within the color grades diagram HVI-Rd (y-axis) and HVI +b (x-axis) on base of the correlation between the Lint Grades and the related measured values for the tested samples. An accurate definition of the borders between the defined color – and Lint Grades is required.

For finding the location of the area for Lint Grade "j" within the Color Grade diagram, the limits for the measured values L* and b* needs to be calculated according to the regulation 7. of chapter 2.1. separated for the several Egyptian cotton varieties "i".

According to this regulation the center of the color grade area for variety "i" and Lint Grade "j" in the color diagram is defined by [X (L*(i,j)); X (b*(i,j))], where

* X(L*(i,j)) is the average value for L*, calculated from all values for variety i and Lint Grade j what have been classified in to Lint grade j; and
* X(b*(i,j)) is the average value for b*, calculated from all for the variety i and Lint Grade j what have been classified in to that Lint Grade j.

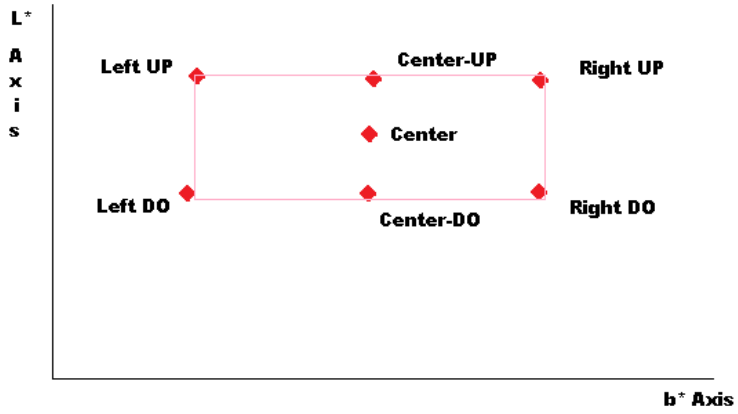


Fig.3 : Color Grade area for cotton variety i for Lint Grade j,
with the following formulas for the calculation of the corners:

(1) Center	:	[X (L*(i,j)); X (b*(i,j))]
(2) Center UP	:	[X(L*(i,j))+SD(L*(i,j)); X (b*(i,j))]
(3) Center DO(wn)	:	[X(L*(i,j))-SD(L*(i,j)); X (b*(i,j))]
(4) Left UP	:	[X(L*(i,j))+SD(L*(i,j)); X (b*(i,j))- SD(b*(i,j))]
(5) Left DO(wn)	:	[X(L*(i,j))-SD(L*(i,j)); X (b*(i,j)) - SD(b*(i,j))]
(6) Right UP	:	[X(L*(i,j))+SD(L*(i,j)); X (b*(i,j))+ SD(b*(i,j))]
(7) Right DO(wn)	:	[X(L*(i,j))-SD(L*(i,j)); X (b*(i,j)) + SD(b*(i,j))]

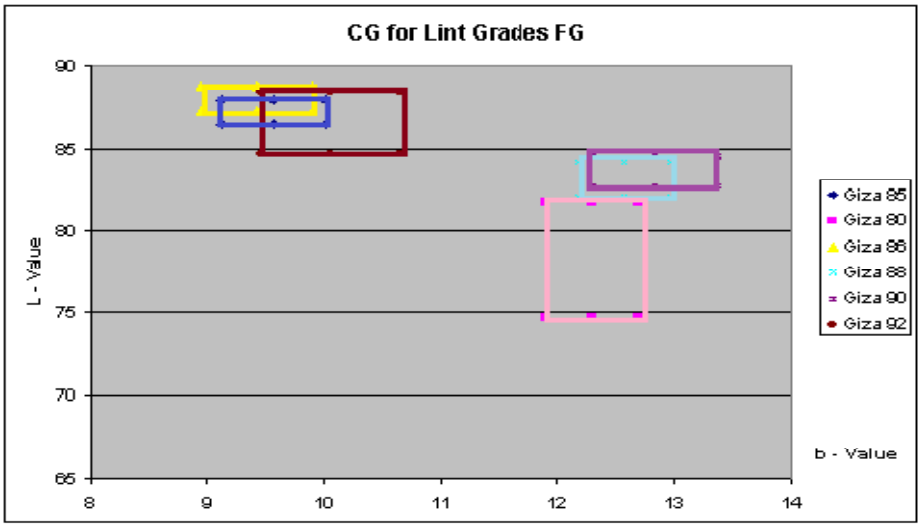
Now the interpretation for all Lint Grades will be shown in the following chapters, starting with the Lint Grade FG (Fully Good).

4.1. Location of the Color Grades – Lint Grade FG is shown as an example

The table 4 shows the calculated values for the corners of the color range for the Lint Grade FG for all tested Egyptian cotton varieties. The diagrams 1 and 2 are showing the location of the area for the Lint Grade FG within the color diagram CD = f (L*, b*).

Color Value	Lint grades	Giza 85	Giza 80	Giza 86	Giza 88	Giza 90	Giza 92
L*	FG AVE	87,15	78,23	87,99	83,11	83,59	86,49
	Left Down	86,4	74,75	87,24	82,04	82,68	84,65
	Right UP	87,9	81,71	88,74	84,18	84,5	88,33
	Left UP	87,9	81,71	88,74	84,18	84,5	88,33
	Right Down	86,4	74,75	87,24	82,04	82,68	84,65
	Center UP	87,9	81,71	88,74	84,18	84,5	88,33
	Center Down	86,4	74,75	87,24	82,04	82,68	84,65
	FG SD	0,75	3,48	0,75	1,07	0,91	1,84
b*	FG AVE	9,57	12,31	9,43	12,58	12,84	10,06
	Left Down	9,13	11,92	8,96	12,19	12,31	9,47
	Right UP	10,01	12,7	9,9	12,97	13,37	10,65
	Left UP	9,13	11,92	8,96	12,19	12,31	9,47
	Right Down	10,01	12,7	9,9	12,97	13,37	10,65
	Center UP	9,57	12,31	9,43	12,58	12,84	10,06
	Center Down	9,57	12,31	9,43	12,58	12,84	10,06
	FG SD	0,44	0,39	0,47	0,39	0,53	0,59

Tab. 1



Dia. 1

From Diagram 1 it is clearly to see, that for the Lint Grade FG are existing 2 clusters: The white colored varieties Giza 86, Giza 85, Giza 92 are forming the “White” cluster and the more creamy colored varieties Giza 80, Giza 88 and Giza 90 are forming the “Creamy” cluster. Within both clusters the whiteness is varying and also yellowness values are different, i.e. increasing from left (White cluster) to right (Creamy cluster) like expected.

The measured values for the variety Giza 80 are outside the expected range for the Lint Grade FG. There might be 2 reasons for this:

1. Complete wrong assessment of Giza 80 samples by the cotton classer's or
2. Big color variation for all samples within Giza 80 variety.

For Giza 80 exists in comparison to all other varieties a quite high CV% value for L*, what means that the 2. item seems to be the reason, i.e. a high variation of the whiteness within the samples for Giza 80 cotton variety.

For the other color grades the way of evaluation was the same.

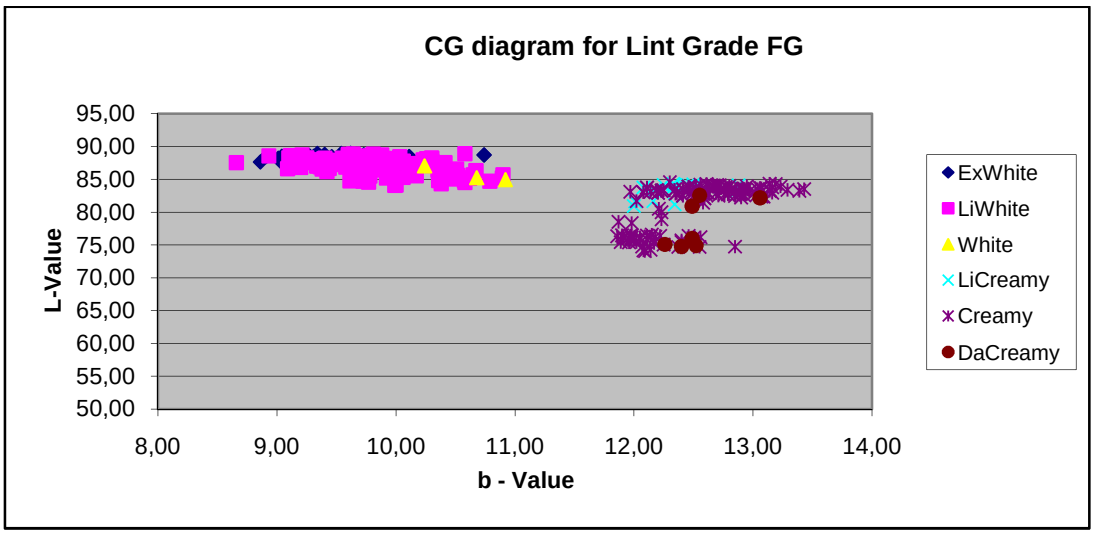
5. Definition of new Color Grade diagram

5.1 Intrinsic colors of Egyptian cotton

Until now we have considered only the position and the range for the cotton varieties in the L* - b* color diagram. Now the next step will be done: We will have a view to the color distribution of the intrinsic colors from white over creamy to dark creamy for the cotton varieties. The way for the definition of this grades, should be the same, like for US Upland cotton according to J. Knowlton [2]: The definition of the colors is done according to the value a* of the CIE Lab color space for the measured samples for the cotton varieties as follows :

Definition of Color	a* Value
Extra White	< 0,5
Light White	0,5 …. 1,0
White	1,0 …. 1,5
Light creamy	1,5 …. 2,0
Creamy	2,0 …. 2,5
Dark creamy	> 2,5

If all measured single samples for the Lint Grade FG are sorted according to the definition above and shown in the L* - b* diagram, then the result is as follows (refer Dia. 2):



Dia. 2

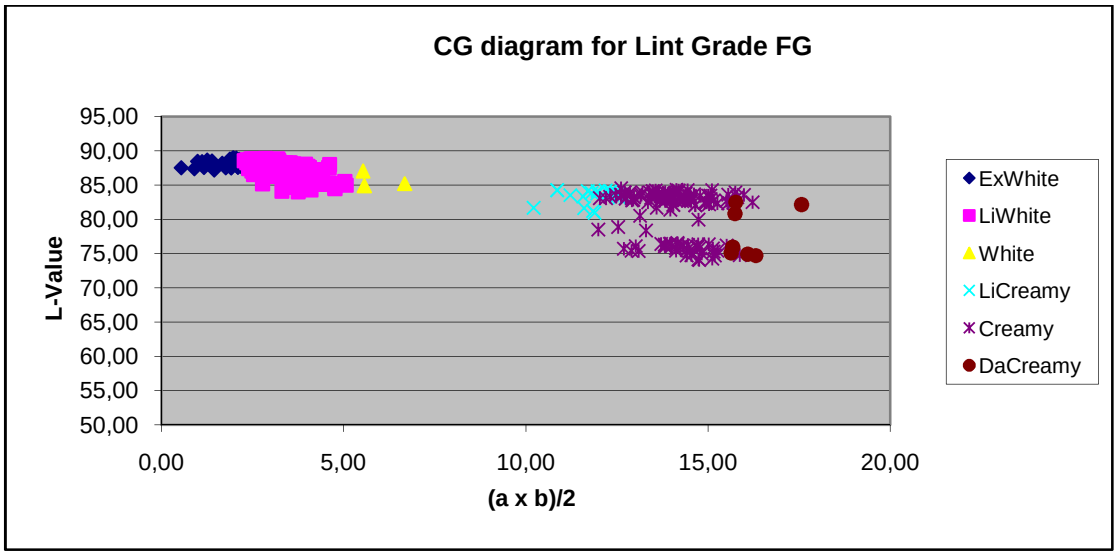
It is clearly to recognize, that – when we use for the x-axis the b* axis only – the distribution of the intrinsic color values cannot be shown exactly: Different color values overlapping each other, for example “creamy” and “light creamy” samples cannot be distinguished from each other. The same situation exists for “Extra White” and “White” colors.

For showing the different color grades, which are representing the intrinsic colors of the Egyptian cottons, a new diagram with a new x-axis needs to be defined.

5.2 Definition of a new x- axis in the color diagram

Finally the best solution what has been found by the research group is to apply the axis (a*x b*)/2. In fact the “Creamy” color has a high percentage of “redness” inside: Surprisingly for all single samples a*-values for the Egyptian cottons between a*= 0.3 … 2.7 have been measured, therefore it is logic, that a* values needs to be taken in consideration for the description of the intrinsic color appearance.

The same samples like shown in Dia. 2 are now displayed in Dia. 3 with the new defined x – axis:



Dia. 3

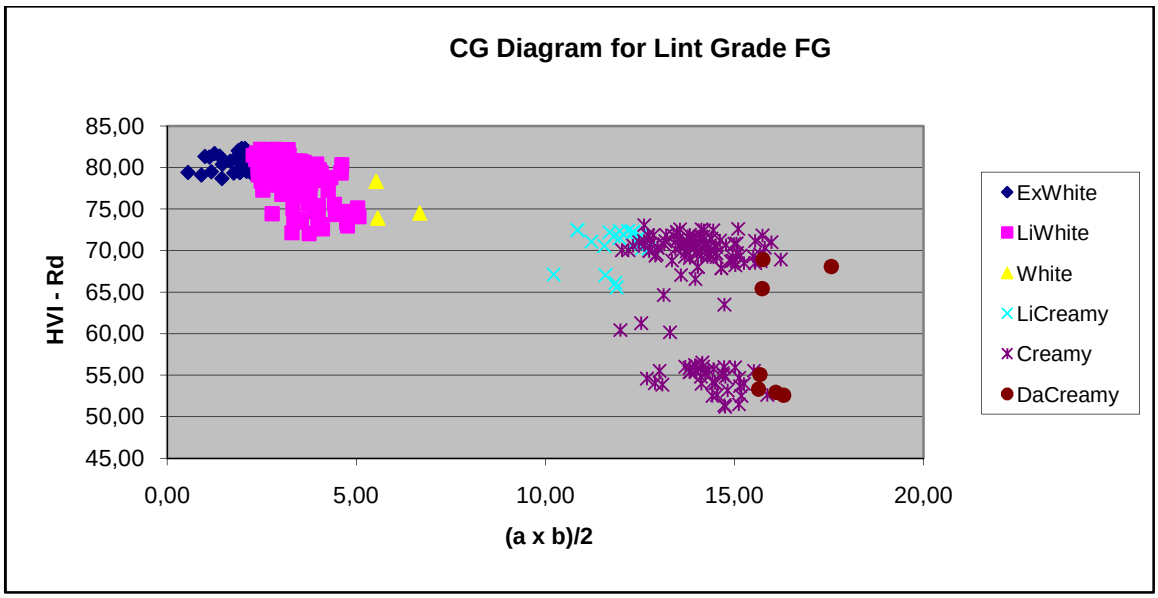
Now the intrinsic color differences are much better to distinguish. The research group proposes to use instead of the b* (or HVI-+b) axis the new defined (a x b)/2 axis as the x-axis for the Color Grade diagram for the Egyptian cottons.

The location of the several intrinsic color values in relation to the new defined x - axis can be described for the Lint Grade FG (Fully Good) as follows:

Extra white range is located at (a x b)/2 < 2.0
Light white range is located at (a x b)/2 = 2.0 …. 5.0
White range is located at (a x b)/2 = 5.0 …. 8.0
Light creamy range is located at (a x b)/2 = 8.0 …. 11.0
Creamy range is located at (a x b)/2 = 11.0 …. 16.00
Dark creamy range is located at (a x b)/2 > 16.0

For other Lint Grades it is to expect, that these limits differ a little bit from the above values for the Lint Grade FG.

Within the next step for the definition of the new Color Grade diagram the y-axis L* is replaced by the HVI – Rd (Whiteness) axis. The final Color Grade Diagram is now shown in Dia. 4:

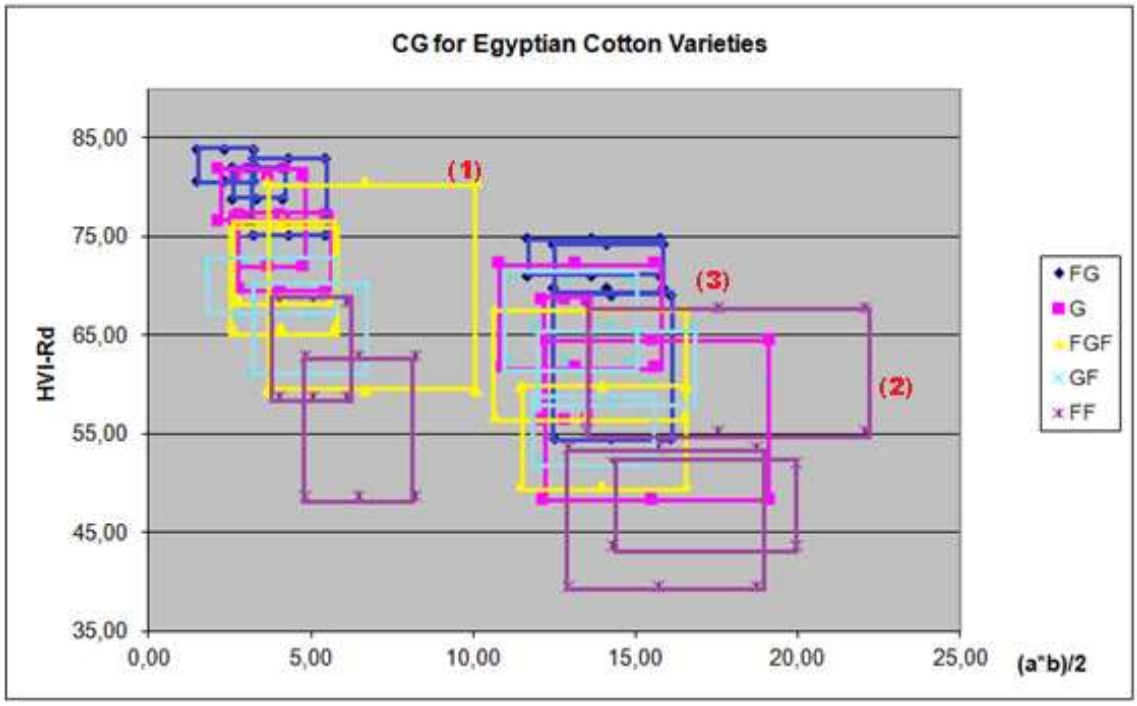


Dia. 4

This new designed color grade diagram with new y axis (HVI-Rd whiteness) and the new x axis ((a x b)/2, i.e. redness multiplied with yellowness, divided by 2) shows the tested samples of the Lint Grade FG with a high resolution, so that intrinsic color grades ranges between extra white, white down to dark creamy can be distinguished quite good.

5.3 Definition of the limits for the Lint Grade ranges

If the color ranges for all tested cotton varieties and for all tested Lint Grades from chapter 4. are shown in the new designed Color Grade diagram with the axis HVI-Rd and (a x b)/2, then the result is shown in the following diagram (Dia. 5):

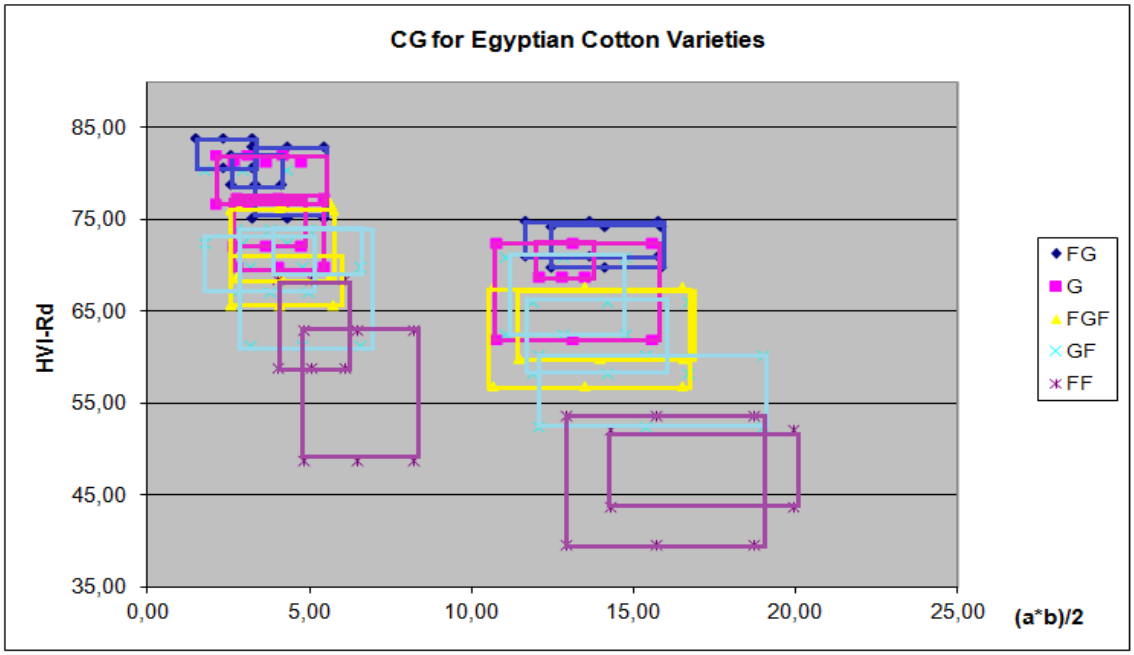


Dia. 5

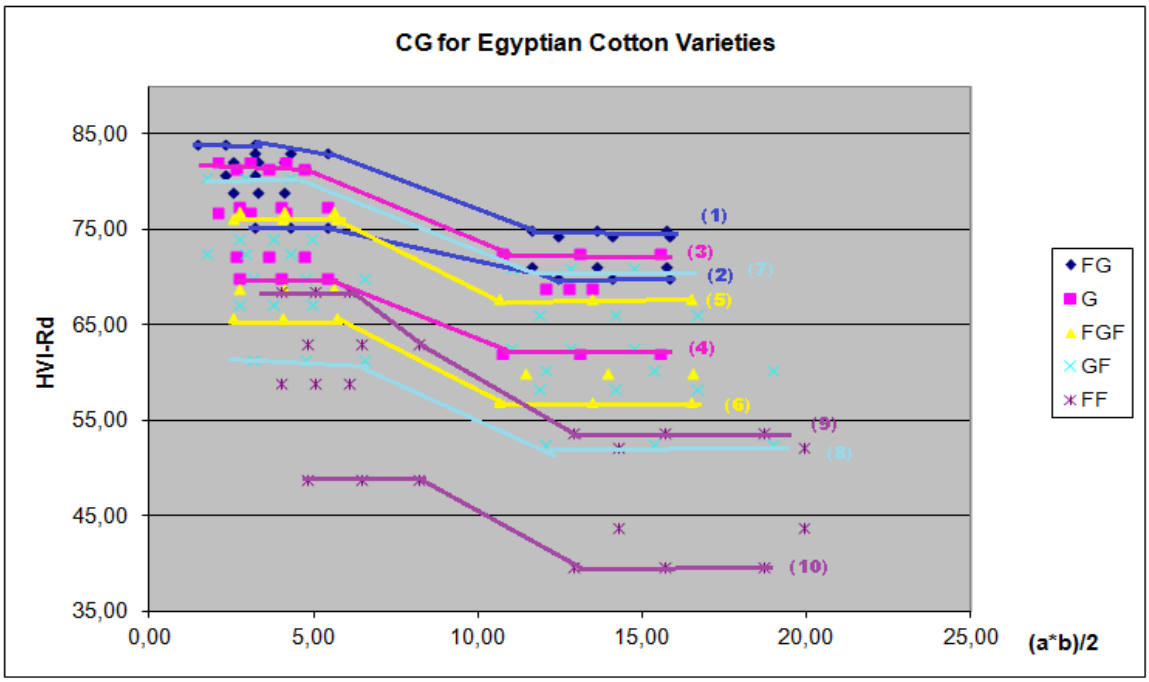
From the first view it is to recognize, that there are a lot of overlapping ranges, especially on the top side, i.e. especially for high whiteness (HVI Rd) values. On the other hand the tendency of lower whiteness values for lower Lint Grades is clearly to see, when the lower borders of the Lint Grade ranges are observed.

If we take the minimum borders for the whiteness degree or the several Lint Grades in consideration, then we can see, that now no more overlapping anymore (refer Dia. 6) are happened. There is still another tendency to recognize: As lower the Lint Grade, as higher the combined yellowness/redness, i.e. the value for (a x b)/2.

Now – on base of the above observations – the borders for the different color grades for the Egyptian cotton varieties and the defined Lint Grades should be defined.



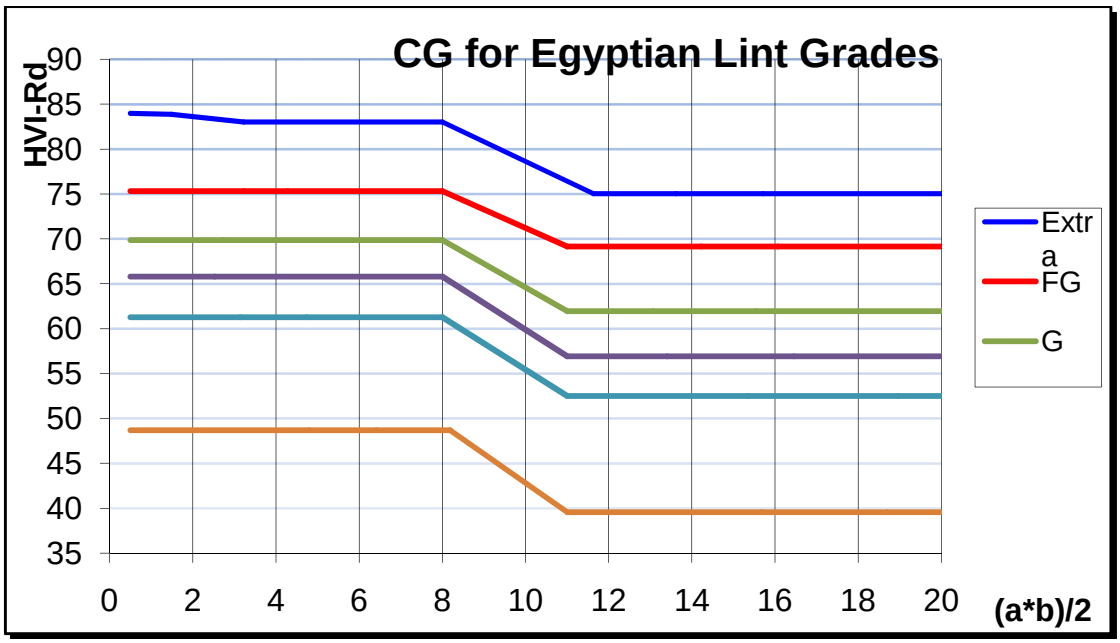
Dia. 6



Dia. 7

For every Lint Grade the upper and lower limit is shown in the above diagram Dia. 7. For example for the Grade FG (Fully Good) the line (1) is the upper limit and the line (2) is the limit below. The same is valid for the Lint Grade G (Good): The line (3) is the upper limit and line (4) the limit below.

Now, for the next step to find the limits between the Lint Grades for the Egyptian cotton varieties, the upper limits are removed and only the lower limits are shown. Then the color diagram obtains the form shown in Diagram Dia. 8.



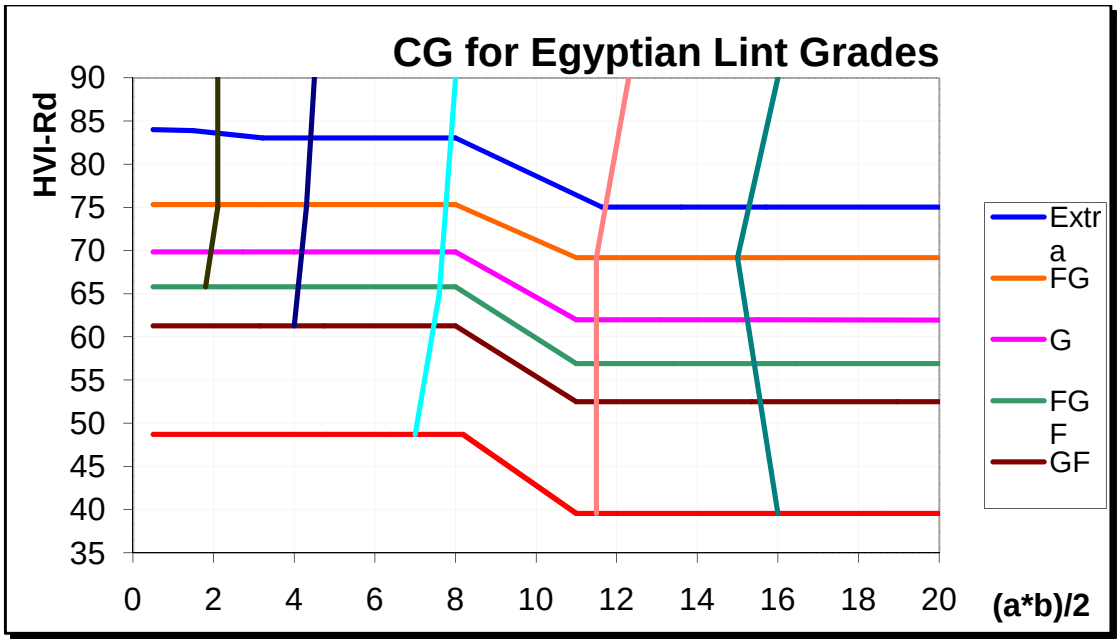
Dia. 8

Now, with this form of the color grade diagram, the limits are exactly defined and the Lint Grades can be distinguished quite well. The range for the several Lint Grades are located as follows:

5.4 Definition of the Color Grade ranges for the color diagram

After the definition of the Lint Grades in chapter 5.3 now the definition of the Color Grades should be finalized. Already in chapter 5.2 are the limits between the different colors from Extra White via creamy to dark creamy defined. Now the related limits need to be drawn in to the color diagram shown in Dia. 17.

The result is shown in the diagram Dia. 9 below.



Dia. 9

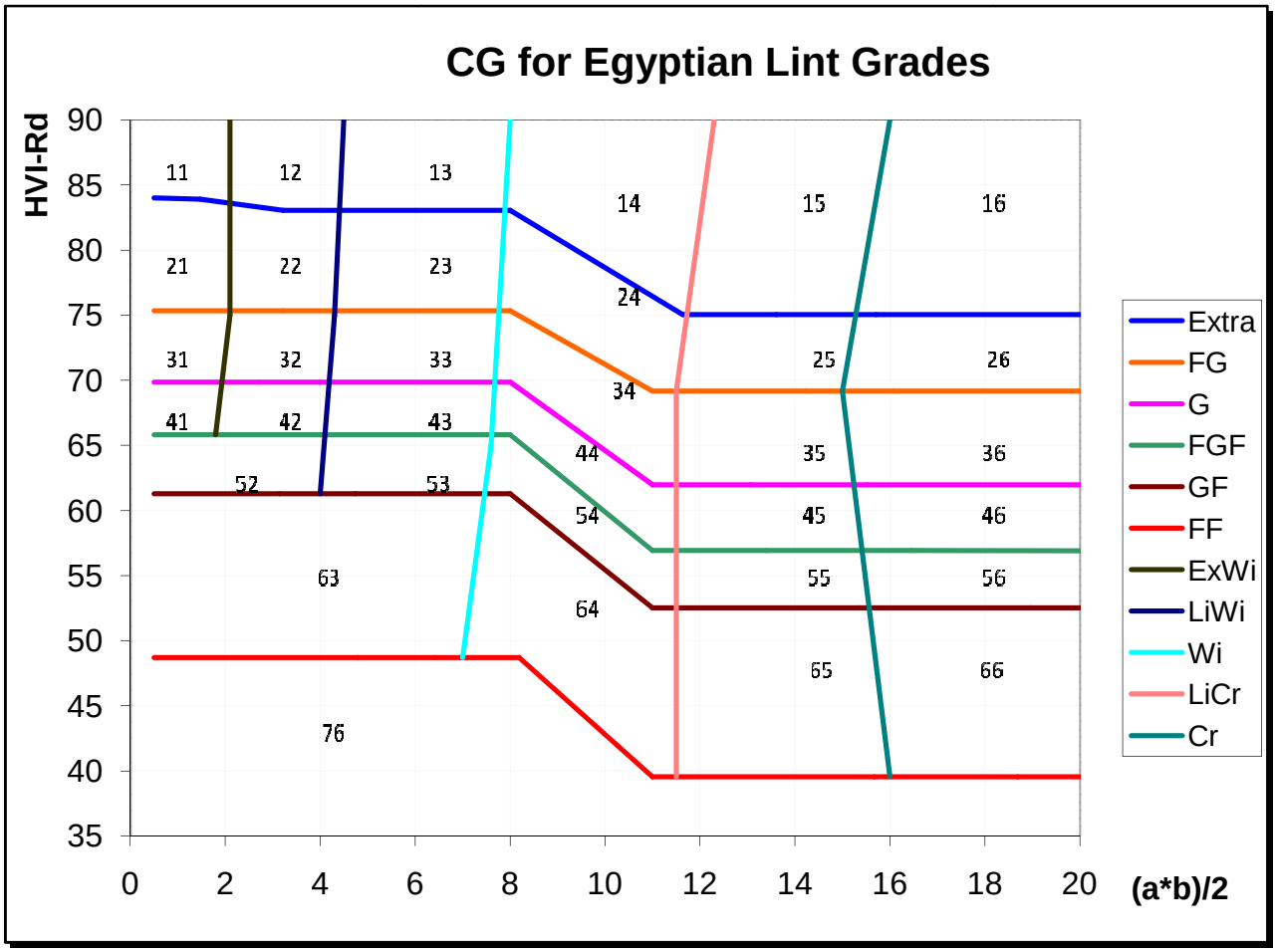
The Lint Grades and Color Grades of the Egyptian cotton varieties are now defined as follows:

Lint grades	LG-No.	Color Grades	CG-No.
Extra	1	Extra White	1
FG (Fully Good)	2	Light White	2
G (Good)	3	White	3
FGF (Fully Good Fair)	4	Light Creamy	4
GF (Good Fair)	5	Creamy	5
FF (Fully Fair)	6	Dark Creamy	6
F (Fair)	7		

Tab. 3: Defined Lint and Color Grades

Depending on the above defined Lint and Color Grades, the following table Tab. 3 shows the defined Classer's Grade for the Egyptian cotton varieties.

Classers Grade	Short	Code	Classers Grade	Short	Code
EXTRA			**FGF (Fully Good Fair)**		
Extra-Extra White	EEW	11	FGF-Extra White	FGFEW	41
Extra-Light White	ELW	12	FGF-Light White	FGFLW	42
Extra-White	EW	13	FGF-White	FGFW	43
Extra-Light Creamy	ELC	14	FGF-Light Creamy	FGFLC	44
Extra-Creamy	EC	15	FGF-Creamy	FGFC	45
Extra-Dark Creamy	EDC	16	FGF-Dark Creamy	FGFDC	46
FG (Fully Good)			**GF (Good Fair)**		
FG-Extra White	FGEW	21	GF-Extra White	GFEW	51
FG-Light White	FGLW	22	GF-Light White	GFLW	52
FG-White	FGW	23	GF-White	GFW	53
FG-Light Creamy	FGLC	24	GF-Light Creamy	GFLC	54
FG-Creamy	FGC	25	GF-Creamy	GFC	55
FG-Dark Creamy	FGDC	26	GF-Dark Creamy	GFDC	56
G (Good)			**FF (Fully Fair)**		
G-Extra White	GEW	31	FF-Creamy	FFC	65
G-Light White	GLW	32	FF-Dark Creamy	FFDC	66
G-White	GW	33	**F (Fair)**		
G-Light Creamy	GLC	34	Fair	F	76
G-Creamy	GC	35			
G-Dark Creamy	GDC	36			



Dia. 10

The diagram Dia. 10 shows the final color diagram for the Egyptian cotton varieties.