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STUDY OF THE RESPONSE OF COTTON FABRIC STRUCTURE TO DYEING WITH A NATURAL DYE (HENNA) COMPARED TO REACTIVE AND VAT DYESTUFFS

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Abstract

Fabrics (made of Giza 83 variety) of different structures responded differently to dyeing treatments with variant dyestuffs (natural (henna), reactive and vat), this differential response did not follow a definite trend. Generally it is concluded that, the natural dye was found to impart the high fastness (C.S.), alkali perspiration (C.C. and C.S.) and dry rubbing. Further, reactive dye proved to bring about the high reponse to color strength, light fastness, wash fastness (C.S.) and dry rubbing. Likewise vat dye appeared to have the most positive influence on fastness to acidic perspiration as well as to alkali perspiration and wash fastness.

INTRODUCTION

Fabrics are manufactured assemblages of yarns which in turn of fibers fabrics have which is closely related to thickness and mechanical strength to give the assembly inherent cohesion that affects fabric response to the chemical treatments.

The nature of yarn or fiber arrangement determines the type of fabric structure, fabric structure would determine appearance which would appear flat, as a series of crosswise ribs, as a series of diagonal lines or ridges, or smooth and lustrous.

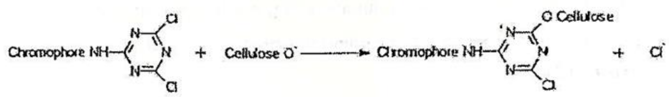
Plain-woven fabrics are fabrics in which the odd warp yarns operate over and under one filling yarn throughtout the fabrics with the even yarns reversing this order to under one over one, throughtout. Twill fabrics are fabrics in which the weave repeats on three or more warp and filling yarn, and diagonal lines are produced on the face of the fabrics. Knit fabrics are composed of intermeshing loops of yarn.

Characterized by the fact that each weft yarn lies more or less at right angles to the direction in which the fabrics is produced as jersey i.e. (single knits).

Reactive, vat and natural dyestuff are the most commonly used dyes, which have commercially significant important in application to various fabric structures. However it is rather interesting to mention that, the technical definition of a dye is a compound that can be fixed on a substance in a more or less permanent state, Joseph, (1988). Reactive dyes are anionic azo dyes which posses one or more chemically active groups capable of forming covalent bonds whith the fiber being dyed , Peters & Freeman (1996). Vat dyes are groups of totally water-insoluble dyes and in this respect they are essentially pigments for application to cellulosic fibers, vat dyes are converted to a water-soluble "leuco" form by an alkaline-reduction process, Christie *et al.* (2000). Natural dye is regarded as a friendly to environment compound. As a matter of fact, world environmental regulations are becoming more strict and forcing shift of technology toward less pollution or practically non-polluting areas of technological development. Although most attention has been paid to modify synthetic dyeing process, the need to realize the importance and explore the technolog of natural dyes is more urgent, Isharat (1993). Angelini *et al.* (1996) mentioned that, *Rubia* and *Tinctorum* plants produce onthroquinone pigments in their roots. One of them is alizarin (1, 2 dihydroxy onthroquinone) which had beed used to dye textiles since 2000 B.C. Industrial assays demonstrated good performance when using a weight of dry powder equivalent to 30% of the weight of material to be dyed for dyeing cotton, wool and silk yarns. Abd El Fattah (1997) found that, natural dyes were successfully applied for dyeing cotton fabrics. All natural dyes required the use of a mordand regardless of the presence of hydroxyl groups in the molecular structure of the material. Amal (2001) reported that, dyeing the scoured and bleached cotton fibers and fabrics with henna and senna were good, expect for perspiration fastness.

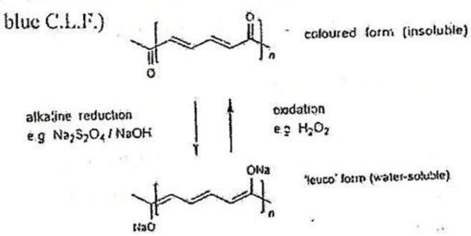
MATERIALS AND METHODS

This study was carried out to investigate the response of different fabric structures to dyeing with, the natural dye Henna which extracted from *Lowsonia alba* according to Amal (2001), reactive dye (reactive blue 19).



Reactive dye fixation to cellulose.

and vat dye (Indanthrene blue C.L.F.)



The chemistry of vat dyeing.

The cotton fabrics used were obtained from Misr Spinning and Weaving Company, El Mehalla El Kubra in 2001 season.

The specifications of cotton fabrics :

All fabrics were woven using yarns spin from the fibers of the long staple Egyptian cotton variety Giza 83. The fabrics considered in the present study are plain, twill and knit fabrics. Their structures are 1/1, 3/1 and single jersey, respectively.

The following pretreatment were applied to cotton fabrics used in the study :

Scouring : Samples were open boiled for 1 1/2 hours in a bath containing NaOH (4% w/w), mercerol (0.5%) was added as a wetting agent.

Bleaching : Hydrogen peroxide (10 % v/v) was used according to Hebeish *et al.* (1971).

Methods of dyeing :

The natural dye was applied by immersing the treated cotton fabrics in a dye bath containing the selected dye extract (50%-70%) at a ratio of 1:50 ml dyeing solution for each gram of the sample, a mordant was added according to Amal (2001).

Reactive dyeing was carreied out according to Chen Keqiang *et al.* (1994).

Vat dyeing was conducted according to Christie *et al.* (2000).

Measurements :

Color strength for the dyed fabrics was measured at The Misr Spinning and Weaving Company, El Mahalla El Kubra, it is expressed as K/S value for the dyed samples by applying the Kubelka-Munk equation as follows :

$$K/S = (I-R)^2/2R - (I-Ro)^2/2\ Ro$$

where :

R = Decimal fraction of the reflectance of dyed samples.

Ro = Decimal fraction of the reflectance of undyed samples.

K = Absorption coefficient.

S = Scattering coefficient.

Color fastness to light and dry rubbing was determined according to A.S.T.M. D 2053-86 (1998), and D 2054-86 (1998).

Color fastness to wash and perspiration was determined according to A.A.T.C.C. (1998) 15-1960 and 36-1961.

The higher values of color change ranging from (1/5 to 5/5 and 1/8 to 8/8) indicates higher fastness and vice versa.

RESULTS AND DISCUSSION

I. Color strength (K/S) :

From Table 1 and Fig. 1 it is quite obvious that, each of the fabric structures considered in this study, i.e. plain, twill and knit, color strength (K/S) values were the highest when the reactive dyestuff was applied, and followed, in a descending order by vat and natural dyes. On the other hand no general trend could be noticed regarding the differential response of the three fabric structures to any given dyestuff. For instance it was apparent that plain fabric structure revealed the slightly higher color strengh relative to the two fabric structures, when it was dyed with either vat or reactive dye. Likewise knit fabric response to natural dye was slightly better than the plain and twill fabric. Also the three fabric stuructures included in the present study were found to have values of color strength generally close to each other, when they were dyed with vat dyestuff.

Table 1. Color strength (K/S) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

	Dyestuffs		
Fabric structures	Natural	Vat	Reactive
Plain	0.47	3.22	8.46
Twill	0.38	3.12	7.23
Knit	0.56	3.06	7.65

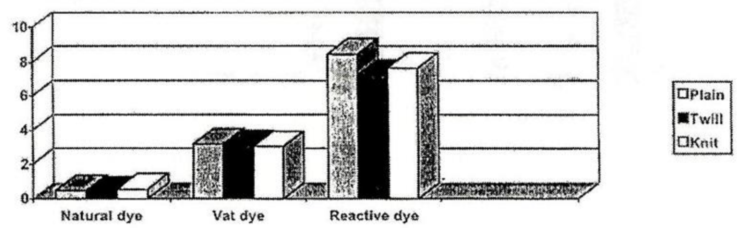


Fig. 1. Color strength (K/S) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

II. Color fastness :

1. Light fastness :

Table 2 and Fig. 2 showed that, good light fastness (4-5/8) in natural dye for the three type of fabrics structure, while the knit fabric showed very good light fastness (6/8), where the plain and twill fabrics showed good to very good light fastness (5/8) in vat dye, but in the reactive dye the plain fabric showed good to very good light fastness (5/8), where the twill and knit fabrics showed very good light fastness (6/8).

Table 2. Light fastness for three types of cotton fabrics dyed with natural, vat and reactive dyes.

	Dyestuffs		
Fabric structures	Natural	Vat	Reactive
Plain	4/8-5/8	5/8	5/8
Twill	4/8-5/8	5/8	6/8
Knit	4/8-5/8	6/8	6/8

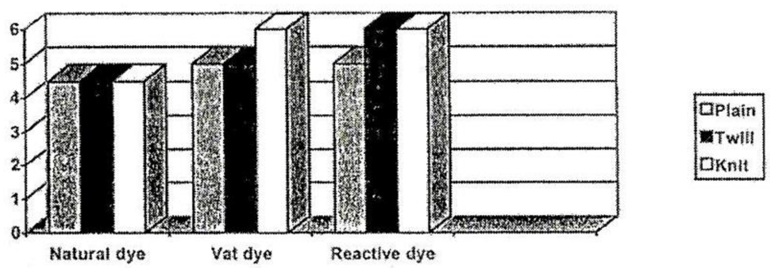


Fig. 2. Light fastness for three types of cotton fabrics dyed with natural, vat and reactive dyes.

2. Wash fastness (color change and staining) :

It is generally clear from the data of Table 3 and Fig. 3 and 4 that, fastness to wash for the plain, twill and knit fabrics differed in conformity with the type of dyestuff applied. It is mentioned that the fastness in such a case was indicated by both color change and color staining. However with regard to color change plain fabric proved to have the highest fastness to wash when natural or vat dye was applied, compared with twill and knit fabrics which showed comparable response to the two dyes. On the other hand, when reactive dye was utilized, twill fabric revealed much lower wash fastness than both plain and knit fabrics which were similar in this regard. As concerns color staining, plain fabric again attained the best fastness to wash when any of the three dyes used in the present study was applied to that fabric twill and knit fabrics were obviously lower than plain fabric in this connection, except in case of applying reactive dye where knit fabic realized the same high level of wash fastness attained by plain fabric. Nevertheless, it is rather interesting to mention in this concern that Joseph (1988) reported that vat dye exhibited excellent color fastness particularly to wash.

Table 3. Wash fastness (color change and staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

Fabric structures	Dyestuffs					
	Natural		Vat		Reactive	
	C.C.	C.S.	C.C.	C.S.	C.C.	C.S.
Plain	4 / 5	4 / 5	5 / 5	4 / 5	3 / 5	4 / 5
Twill	3 / 5	3 / 5	4 / 5	3 / 5	1 / 5	3 / 5
Knit	3 / 5	3 / 5	4 / 5	3 / 5	3 / 5	4 / 5

C.C. = Color change C.S. = Color staining

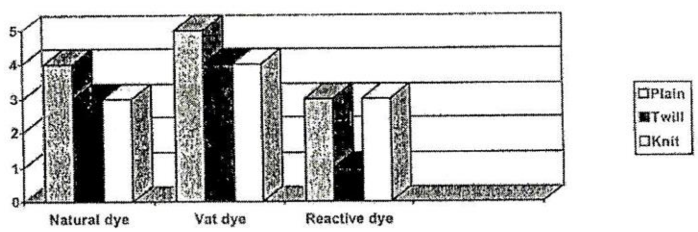


Fig. 3. wash fastness (color change) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

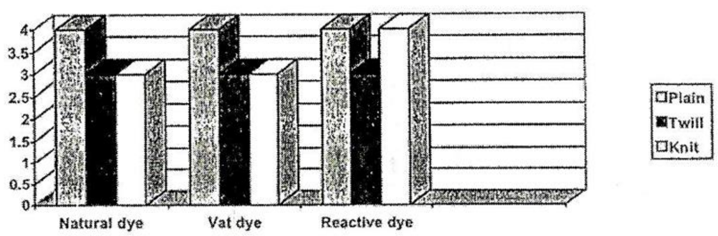


Fig. 4. wash fastness (staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

3. Acidic perspiration fastness (color change and staining) :

Fastness to acidic perspiration for the three types of fabric were ranged from (1/5 to 5/5) for color change, was found to be the least when applying natural dye there were no difference between the three used fabrics, also in the vat dye for all the three types of fabric, Reactive dye appeared to have intermediate effect on fastness to acidic perspiration. All fabric structures had similar response to natural dye in this respect, whereas twill and knit fabrics, were found to have markedly higher fastness to acidic perspiration when applying vat dye. As concerning reactive dye, twill fabric was found to have better response than did either plain or knit fabric. When color staining was considered as an indication for fastness to acidic perspiration Table 4 and Fig. 6 vat dye ranked first in this regard, and followed in a descending order by natural dye and reactive dye.

Table 4. Acidic perspiration fastness (color change and staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

	Dyestuffs					
Fabric structures	Natural		Vat		Reactive	
	C.C.	C.S.	C.C.	C.S.	C.C.	C.S.
Plain	1 / 5	3 / 5	4 / 5	5 / 5	3 / 5	1 / 5
Twill	1 / 5	2 / 5	5 / 5	5 / 5	4 / 5	1 / 5
Knit	1 / 5	3 / 5	5 / 5	5 / 5	3 / 5	1 / 5

C.C. = Color change C.S. = Color staining

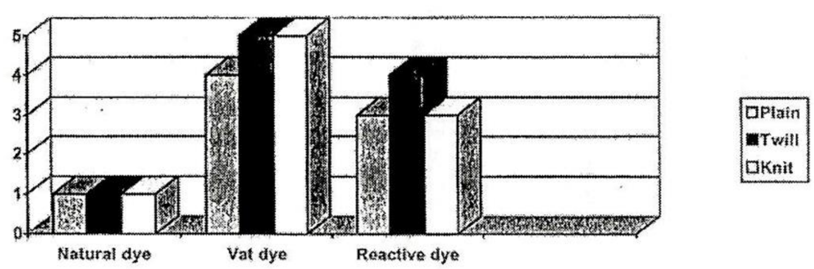


Fig. 5. Acidic perspiration fastness (color change) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

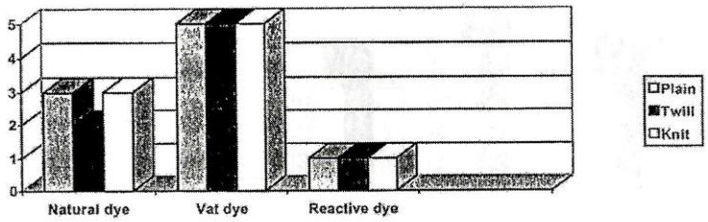


Fig. 6. Acidic perspiration fastness (staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

4. Alkali perspiration fastness (color change and staining) :

Table 5 and Fig. 7 and 8 showed that, fastness to alkali perspiration, as revealed by the color change for the three fabric structures included in this study, was the best when utilizing in the vat dye used and followed in order by natural and reactive dyes. On the other hand, plain and twill fabrics proved to have better fastness to alkali perspiration than knit fabric in case of applying natural or vat dye. As for the reactive dye twill fabric had better fastness (4/5) than both plain and knit fabrics which revealed comparable fastness in this respect (3/5).

Regarding color staining (Table 5 and Fig. 8), vat dye showed the highest fastness to alkali perspiration (5/5) and followed by natural and reactive dyes respectively. All fabric structures used in the present study responded similarly to both natural and vat dyes, i.e. to alkali perspiration. By contrast, a sign of differential response was observed when reactive dye used.

Table 5. Alkali perspiration fastness (color change and staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

	Dyestuffs					
Fabric structures	Natural		Vat		Reactive	
	C.C.	C.S.	C.C.	C.S.	C.C.	C.S.
Plain	4 / 5	4 / 5	5 / 5	5 / 5	3 / 5	1 / 5
Twill	4 / 5	4 / 5	5 / 5	5 / 5	4 / 5	2 / 5
Knit	3 / 5	4 / 5	4 / 5	5 / 5	3 / 5	3 / 5

C.C. = Color change C.S. = Color staining

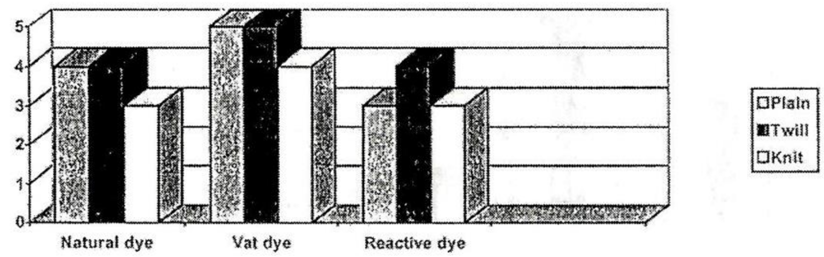


Fig. 7. Alkali perspiration fastness (color change) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

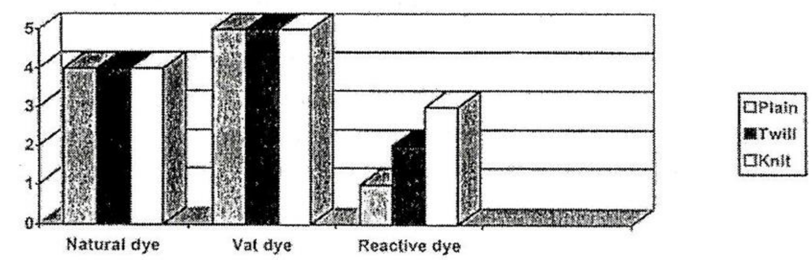


Fig. 8. Alkali perspiration fastness (staining) for three types of cotton fabrics dyed with natural, vat and reactive dyes.

5. Dry rubbing fastness :

From the data presented in Table 6 and Figure 9 it is clear that, fabrics included in this study seemed to have the best fastness to dry rubbing in case of dyeing them with natural dye. Reactive dye ranked second while vat dye ranked third in this study. With respect to natural dyestuff, plain fabric demonstrated better fastness to dry rubbing than both twill and knit fabrics which revealed similar degree of fastness. As for vat dye, both twill and knit fabrics had similar fastness which obviously excelled that of plain fabric. Likewise, knit fabric attained the highest fastness to dry rubbing when applying reactive dye as compared with plain and twill fabrics which showed comparable extent of fastness.

Table 6. Dry rubbing fastness for three types of cotton fabrics dyed with natural, vat and reactive dyes.

	Dyestuffs		
Fabric structures	Natural	Vat	Reactive
Plain	5 / 5	1 / 5	3 / 5
Twill	4 / 5	2 / 5	3 / 5
Knit	4 / 5	2 / 5	4 / 5

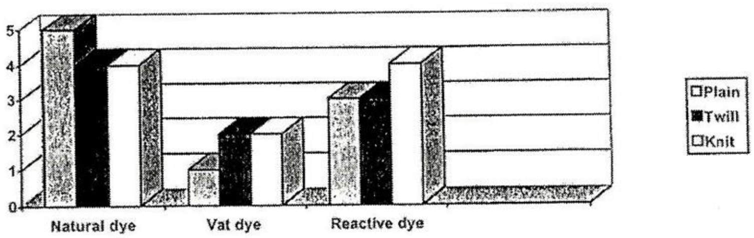


Fig. 9. Dry rubbing fastness for three types of cotton fabrics dyed with natural, vat and reactive dyes.

The findings of this study regarding the response of various fabric structures to dyeing treatments with different dyestuffs, could be summarized in the following table.

Table 7. The ranking of different dyestuffs, in accordance with their effect on dyeing characteristics of various fabric structures.

	Dyestuffs		
	Natural dye	Vat dye	Reactive dye
Color strength	*	* *	* * *
Light fastness	*	* *	* * *
Wash fastness (C.C.)	* *	* * *	*
Wash fastness (C.S.)	* * *	* * *	* * *
Acidic perspiration (C.C.)	*	* * *	* *
Acidic perspiration (C.S.)	* *	* * *	*
Akali perspiration (C.C.)	* *	* * *	*
Akali perspiration (C.S.)	* *	* * *	*
Dry rubbing	* * *	*	* *

The increments of (*) signs connote (implies) enhancements of ranking.

The differential response of the different fabric structures to dyeing with the dyestuffs utilized in this study is most likely dependent on the absorption and adsorption characteristics of the fabrics and their structure. In this respect Joseph (1988) point out that, the amount of dye absorbed depends on two factors, i.e. the size of the dye molecule and the size of the pore opening in the fiber. Also Peters & Freeman (1996) and Christie *et al.* (2000) came to similar conclusions.

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دراسة استجابة التراكيب النسيجية القطنية للصباغة بالصبغة الطبيعية (الحناء) بالمقارنة بصبغات الأحواض والصبغات النشطة

أمل صابر محمد، عزة عبد العزيز محمود

معهد بحوث القطن – مركز البحوث الزراعية

تهدف هذه الدراسة إلى مقارنة اختلاف مدى استجابة بعض التراكيب النسيجية للأقمشة القطنية (سادة – مبرد – تريكو) لصنف جيزة ٨٣ للصباغة بالصبغات المختلفة (طبيعية – أحواض – نشطة) وكانت النتائج كالتالى :

١- **درجة عمق اللون** : كانت بالنسبة للنسيج السادة واحدة مع صبغتى الأحواض والنشطة وانخفضت بالنسبة للصبغة الطبيعية، وللنسيج المبرد كانت واحدة مع صبغتى الطبيعية والنشطة وارتفعت مع صبغة الأحواض، وللنسيج التريكو كان عمق اللون أعلاهم مع الصبغة الطبيعية يليها الصبغة النشطة ثم صبغة الأحواض.

٢- **الثبات للضوء** : كان متساوى للنسيج السادة المصبوغ بصبغتى الأحواض والنشطة وانخفض مع الصبغة الطبيعية، ومع النسيج المبرد كان متساوى للصبغتين الطبيعية والنشطة بينما انخفضت مع صبغة الأحواض ومع نسيج التريكو تساوى للثلاث صبغات.

٣- **الثبات للغسيل** : وجد أنه بالنسبة للنسيج السادة والمبرد واحد مع الثلاث صبغات (التغير فى اللون ونقع اللون) بينما بالنسبة للنسيج التريكو (نقع اللون) كان واحداً مع الثلاث صبغات، فى حين أن (التغير في اللون) كان أعلاهم مع الصبغة النشطة عن صبغتى الأحواض والطبيعية.

٤- **الثبات ضد العرق الحامضى** : بالنسبة (للتغير فى اللون) للنسيج السادة كان متساوى مع صبغتى الأحواض والنشطة ومرتفعة مع الصبغة الطبيعية، وللنسيج المبرد كان متساوى للثلاث صبغات، بينما نسيج التريكو كان متساوى لصبغتى الطبيعية والأحواض ومنخفض مع الصبغة النشطة وبالنسبة (لنقع اللون) للنسيج السادة والتريكو تساوى للثلاث صبغات، وللنسيج المبرد كان متساوى مع صبغتى الأحواض والنشطة ومنخفض مع الصبغة الطبيعية.

٥- **الثبات ضد العرق القلوى** : بالنسبة (للتغير فى اللون ونقع اللون) للنسيج السادة والمبرد والتريكو تساوى لصبغتى الأحواض والطبيعية بينما مع الصبغة النشطة التغير فى اللون كان أعلى من نقع اللون بالنسبة للثلاث تراكيب نسجية.

٦- **الثبات للاحتكاك الجاف** : كان متساوى للنسيج السادة والتريكو بالنسبة لصبغتى الأحواض والنشطة، أما بالنسبة للصبغة الطبيعية كان الاحتكاك الجاف لها أعلى للنسيج السادة عن النسيج الجاف، بينما النسيج المبرد كان الاحتكاك الجاف للصبغتين الطبيعية والنشطة متساوى ومرتفع مع صبغة الأحواض.

من هذه الدراسة وجد أن : أعلى استجابة كانت لصبغة الأحواض يليها الصبغة الطبيعية ثم الصبغة النشطة، وكذلك وجد أن النسيج التريكو سجل أعلى استجابة للثلاث صبغات يليها النسيج السادة ثم النسيج المبرد وذلك يرجع إلى طبيعة التركيب النسيجى وطبيعة تركيب الصبغة.