Determination of the optimum technological criteria under different spinning systems affecting the yarn hairiness

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Abstract:
Yarn hairiness is reflected the amount of free fibers protruding from the spun yarn body towards the outer yarn surface. From a spinning point of view, studying this phenomenon is considered essential step because it influences the post spinning operation and the characteristics of the end textile structure. Many spinning factors are affecting the yarn hairiness. The main objective of this search is to examine the effect of yarn count and twist multiplier on yarn hairiness under six different spinning systems. Accordingly, three yarn counts (40's, 50's and 60's Ne) and three twist multipliers (4, 4.4 and 4.8) were applied. The used spun systems were carded, combed, carded compact, combed compact, jetring carded and jetring combed systems. Three-dimensional response surface graphs were used to easy and faster understand the results. Results indicated that the lowest hairy yarn was spun by jetring combed spinning system with significant differences compared to the other spinning systems. Jetring carded and combed compact ring spinning systems occupied the second order regarding the production of the least hairy yarns with significant differences than the others. Overall the used spun systems, it is indicated that the hairy yarns may be dramatically decreased with increasing yarn count to a certain extent and then slightly decreased while the hairiness was gradually decreased with increasing twist multiplier. However, the percentage of decrease % of hairy yarn with increasing yarn count was greater than that observed by increasing twist multiplier under all spun systems. Multiple regression analysis exhibited that yarn count and twist multiplier explained the most variation of hairiness expressed as high values of coefficient of determination (R^2 %). Also, it is presented that the relative importance % of yarn count toward yarn hairiness was greater than that observed by twist multiplier overall applied spun systems.

Keywords:
Compact
Ring Spinning Systems
Hairiness
Twist Multiplier
Jetring

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INTRODUCTION
The hairiness is a yarn parameter that appears frequently among the main yarn properties, as well as in yarn-quality indices and standards. Hairiness is defined as the number of fibers perpendicular to the yarn surface projected from a unit length of the yarn. Yarn hairiness is, in most circumstances, an undesirable property for the end textile uses. In weaving and knitting, hairiness causes yarns to break and hence stoppages and processing costs increase. In addition, yarn hairiness contributes to hazardous fiber dust and fly generation. On the other hand, hairiness increases pilling tendency which mainly results in an unsightly fabric appearance. In dyeing, yarn hairiness leads to a differential dyeing effect. Therefore, it is important to make more effort to control yarn hairiness **(Yilmaz and Usal, 2012)**.

Altas and Kadoğlu (2012) proved that compact yarns were found to be lower hairiness than conventional ring yarns. The reason behind the lower hairiness in compact spun yarn is the elimination of spinning triangle in spinning system. The superior properties of compact yarns are seen clearly on the fabric quality. Fabrics knitted with compact yarns were found to be better pilling properties and higher bursting strength than fabrics knitted with conventional ring yarns. They added that pneumatic compact spun yarn was found to be better yarn properties than mechanical compact spun yarn. It had less evenness, less imperfections, lower hairiness, higher tenacity and higher elongation values. The reason behind unsatisfactory test results could be the weak compacting power of mechanical compacting system.

Ahmed *et al* (2015) found that rotor spun yarn was about 12% less and air jet was about 21% less than ring spun yarn. The higher hairiness of ring-spun yarns is caused by the uncontrolled passage of edge fibers in roller drafting and friction occurred in balloon control ring. In rotor spinning, the wrapping fibers wound crosswise around the yarn help to "bind-in" loose fiber ends. **Mirzaei *et al* (2012)** created a new method for the reduction of yarn hairiness by attaching a simple effective air suction system to the web detaching zone of a conventional carding machine immediately behind crushing rollers. The ring-spun yarn that was produced was called Vacuum Cleaned Carded yarn or VCC yarn. Results showed that the hairiness of optimum VCC yarn decreases by approximately 20%. They added that the VCC yarn exhibited better spinning stability and was more environmentally friendly than the reference yarn. **Türksoy *et al* (2018)** explained that the used spinning system has a significant influence on the yarn hairiness values. It was seen that hairiness values of air-jet yarns are lower than that of ring yarns for both single and ply-twisted form. More than half of the surface area of air-jet yarns is covered by the layer of wrapper fibers.

The aim of this study was to compare the effects of conventional and modern spinning systems on yarn hairiness and to determine the relative importance of yarn count and twist multiplier as spun factors on yarn hairiness.

MATERIALS AND METHODS

The raw materials used in the current investigation included two commercial Egyptian cotton cultivars namely; Giza 94 and Giza 86 following the Long Staple category according to the local practice in Egypt. The cotton samples of previously mentioned genotypes were taken from 2018 season. Cotton samples were spun using different spinning process being carded, combed, carded compact, combed compact, jetring carded and jetring combed systems. The six spinning systems were graphically illustrated in flow chart as in Figure (1). Under each spinning system, three yarn counts (40's, 50's and 60's Ne) and three twist multipliers (4, 4.4, and 4.8) were applied to study their effects on the yarn hairiness phenomenon. Also, the differences among yarn hairiness produced from the different spinning systems were shown in Figure (2). Yarn hairiness was measured in factory Koudsitex, 10th Ramadan city by a computerized type of Uster Evenness Tester (Uster Tester 5) (UT5) according to the standard methods of testing textile materials.

The collected data were subjected to statistical analysis as a factorial ANOVA which is an Analysis of Variance test with more than one variable (factor). In this investigation, the yarn count is the first factor while the twist multiplier is the second factor according to the procedure outlined by **Snedecor and Cochran (1989).** Whenever F test was significant, the least significant difference (L.S.D.) at 5% level of probability was used to compare the treatments means. The statistical analysis was supported by three-dimensional response surface graphs that were helped to easy and quick understand the results However, multiple regression analysis was applied as outlined by **Draper and Smith (1981)** to estimate the relative importance for each of yarn count and twist multiplier in the yarn hairiness expressed as coefficient of determination (R^2 %).

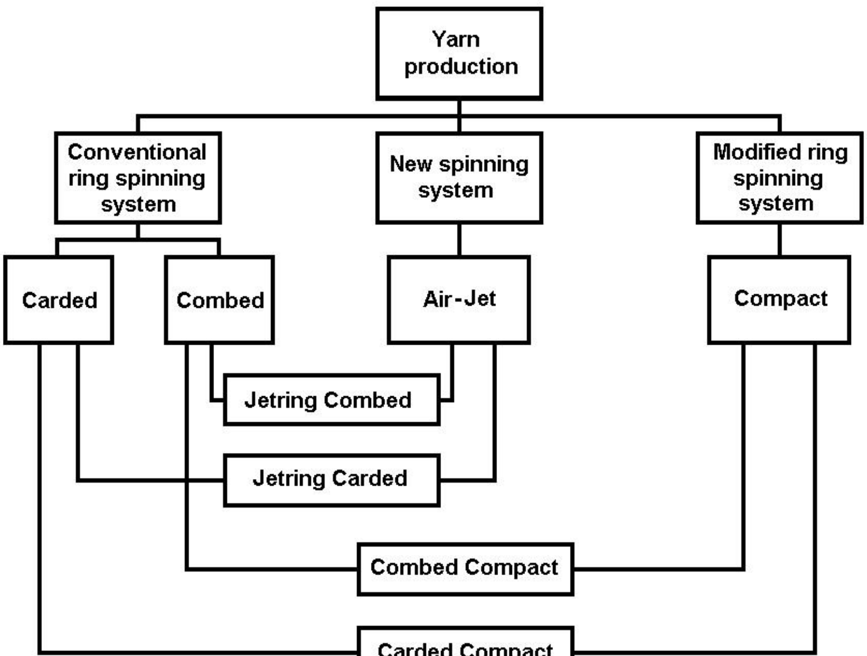
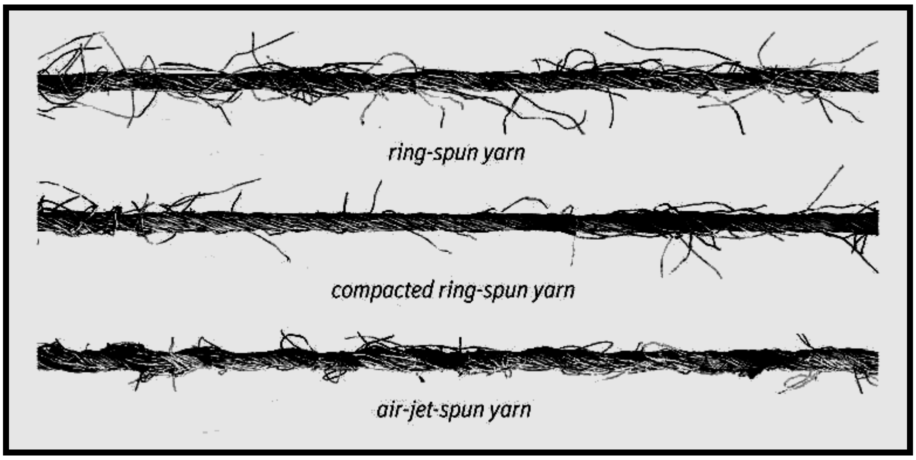


Fig. (1): Flow chart showed the relationships among the used spinning systems.



(2): the yarn hairiness produced from the different spinning systems.

RESULTS AND DISCUSSION

Yarn hairiness was regarded as almost a curious yarn property that sometimes was capable of interfering with textile processes and of creating troubles during weaving and knitting which had to be measured and controlled. Yarn hairiness is influenced by many spinning parameters. The current investigation aimed to produce yarn characterized by low hairiness using the optimum spinning factors. Accordingly, the effects of applied spinning system, yarn count and twist multiplier on yarn hairiness were statistically analyzed and graphically presented. Undoubtedly, graphical presentation is preferred because it is easy and quick to interpret the results and gave more information.

The mean values of yarn hairiness as affected by the used spinning system are depicted in Fig. (3).The statistical analysis proved that spinning system has a significant influence on yarn hairiness. An examination of Figure (3), it is revealed that the least yarn hairiness (4.3) was obtained by Jetring combed ring spinning system with significant differences compared to the other spinning systems. Jetring carded and combed compact spinning systems occupied the second order after Jetring combed regarding the production of the lowest hairy yarns with significant differences than the carded, combed and carded compact spinning systems which recorded the highest yarn hairiness**. El-Sayed and Sanad (2007)** mentioned that the hairiness tests revealed an essential difference between the compact spun yarns and the standard conventional spun yarns. The hairiness of compact yarns is significantly lower with 25 % than the hairiness of conventional yarns. **Yilmaz and Usal (2012)** found that compact-Jet yarns have significantly lower hairiness values than those of the compact and conventional ring spun yarns. The compact-Jet spinning system improves the hairiness by up to 40% in comparison to compact yarns and by 70% in comparison with the conventional ring spun yarns. **Ahmed *et al* (2015)** indicated that yarns spun by Jetring technique were the least hairiness followed by rotor spun yarn which was lower than ring spun system.

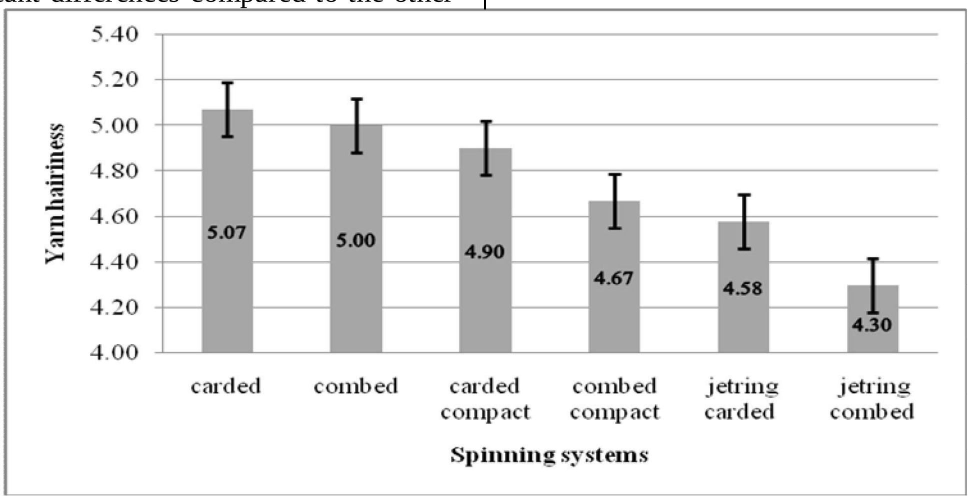


Fig. (3): The effect of applied spun system on the yarn hairiness.

The average values of yarn hairiness as affected by yarn count regardless spin system and twist multiplier are graphically presents in Figure (4). It is shown that yarn count has a negative association with yarn hairiness. Increasing yarn count from 40's to 50's and then 60's leads to a significant decrease of yarn hairiness by 17 and 19.6 %, respectively. Accordingly, yarn hairiness was only reduced by 2.60 % with increasing yarn count from 50's to 60's explaining that no significant difference was detected between them. These results indicated that the hairiness may be dramatically decreased with increasing yarn count to a certain extent and then slightly decreased. **Hager and Hassan (2016)** proved that yarn hairiness was decreased with increasing the yarn count from 80's to 100's. **Sanad *et al* (2011)** cleared that yarn hairiness was substantially decreased as yarn count increased from 20's to 40's.

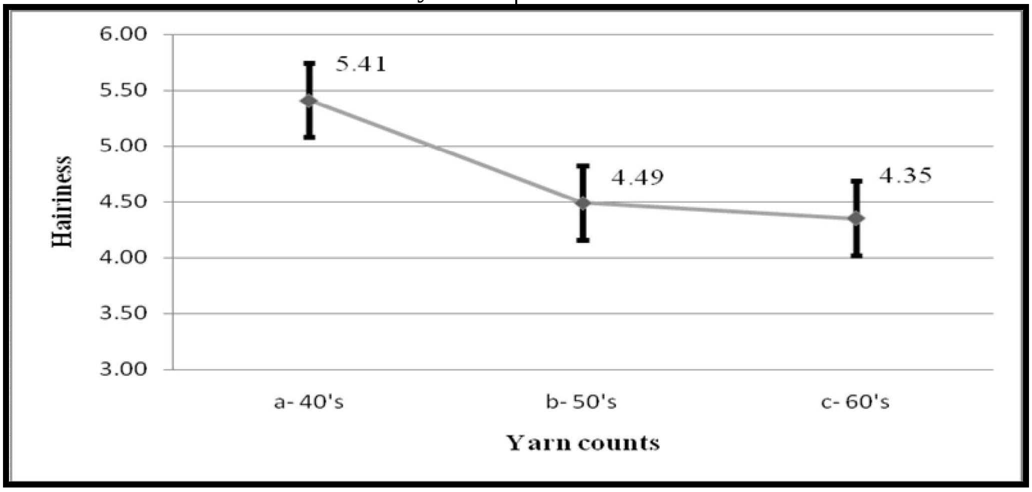


Fig. (4): The effect of yarn count on the yarn hairiness.

Figure (5) explained the yarn hairiness values as affected by twist multiplier across spun system and yarn count. It is obvious that the yarn hairiness was negatively responded to the increasing of twist multiplier. When the twist multiplier increased from 4 to 4.4 and then 4.8, the yarn hairiness was decreased by 3.66 and 6.71 %, respectively. Consequently, it is possible to say that the yarn hairiness was gradually decreased with increasing twist multiplier. As shown from Figure (5), there was significant difference between using twist multiplier 4 and 4.8 in reducing yarn hairiness while no significant differences were detected between twist multiplier 4 and 4.4 or between 4.4 and 4.8. **Shad *et al* (2004)** explained that the yarn imperfections (thin, thick places, neps and hairiness) decreased with the increase of twist multiplier. Similar results were obtained by **El-Sayed and Sanad (2007), and Almetwally and Salem (2010)**.

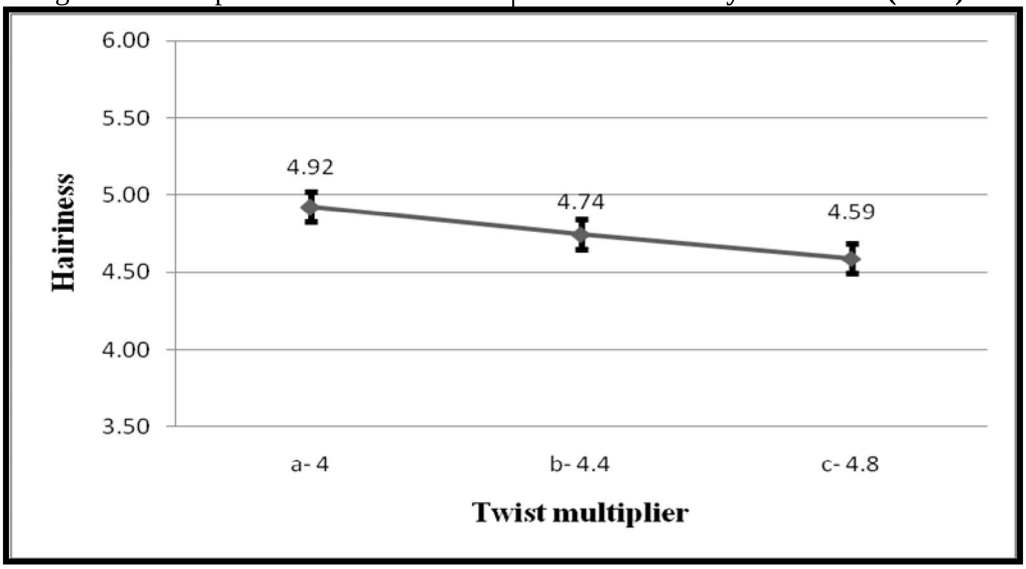


Fig. (5): The effect of twist multiplier on the yarn hairiness index.

The effects of yarn count and twist multiplier on yarn hairiness were individually studied for the used spun systems. The results were supported by 3-dimentional response surface graph which is an effective tool for visual data analysis and gives a complete picture about the interrelationships yarn count and twist multiplier.

<u>1- Carded spinning system</u>

Results presented in Table (1) showed the mean values of hairiness as affected by yarn count and twist multiplier under carded spinning system. There were significant differences among yarn English counts, twist multiplier and their interaction effect. Generally, it is obvious that the yarn hairiness was negatively responded to increasing each of yarn count and twist multiplier. Increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 17.85 and 18.72 % compared to yarn count 40's, respectively. Accordingly, yarn hairiness was only reduced by 2.60 % with increasing yarn count from 50's to 60's indicating that no significant difference was detected between them. When the twist multiplier increased from 4 to 4.4 and then 4.8, yarn hairiness was decreased by 3.08 and 4.62 % compared to twist multiplier 4, respectively. There was significant difference between using twist multiplier 4 and 4.8 in reducing yarn hairiness while no significant differences were detected between twist multiplier 4.4 and 4.8.

Regarded the interaction effect, the yarn hairiness under the three yarn counts (40's, 50's and 60's) declined with increasing twist multiplier from 4 to 4.4 and then 4.8, but the percentages of decrease were markedly varied. The hairiness values were decreased by 4.94, 2.06 and 1.07 % using yarn counts (40's, 50's and 60's), respectively under twist multiplier 4.4 as compared to 4 while the corresponding percentages of decrease for twist multiplier 4.8 were 10.05, 5.35 and -3.22, respectively. Accordingly, the low hairy yarn could be obtained using yarn English count 50's and twist multiplier 4.4. Based on the current results, it is noteworthy to point out that the hairiness decreases with increasing each of yarn count and twist multiplier but within a particular range or levels, which is termed "critical region". The reversal of this trend may be obtained under high yarn count and twist multiplier levels. Therefore, further studies contain high levels of yarn count and twist multiplier may be a necessary step to get more confident conclusion.

Concerning Figure (6), it is evident that the decrease of yarn hairiness is much sharp when yarn count increased from 40's to 50's while weak decrease was observed when yarn count increased from 50's to 60's. On the other hand, the decline percentage of hairy yarn with increasing twist multiplier was lower than that observed by increasing yarn count. **Hussein *et al* (2009)** appeared that yarns manufactured by the carded ring spinning frame are characterized by higher hairiness mean values in in comparison with those of carded compact frame.

Table (1): The average values of hairiness as affected by yarn count and twist multiplier under carded spinning system.

Yarn count (C)	**Twist multiplier (T)**			**Mean**
	4	**4.4**	**4.8**	
40's	6.07	5.77	5.46	5.77
50's	4.86	4.76	4.60	4.74
60's	4.66	4.61	4.81	4.69
Mean	5.20	5.04	4.96	5.07
LSD $_{0.05}$	C = 0.14 T = 0.14 C x T = 0.24			

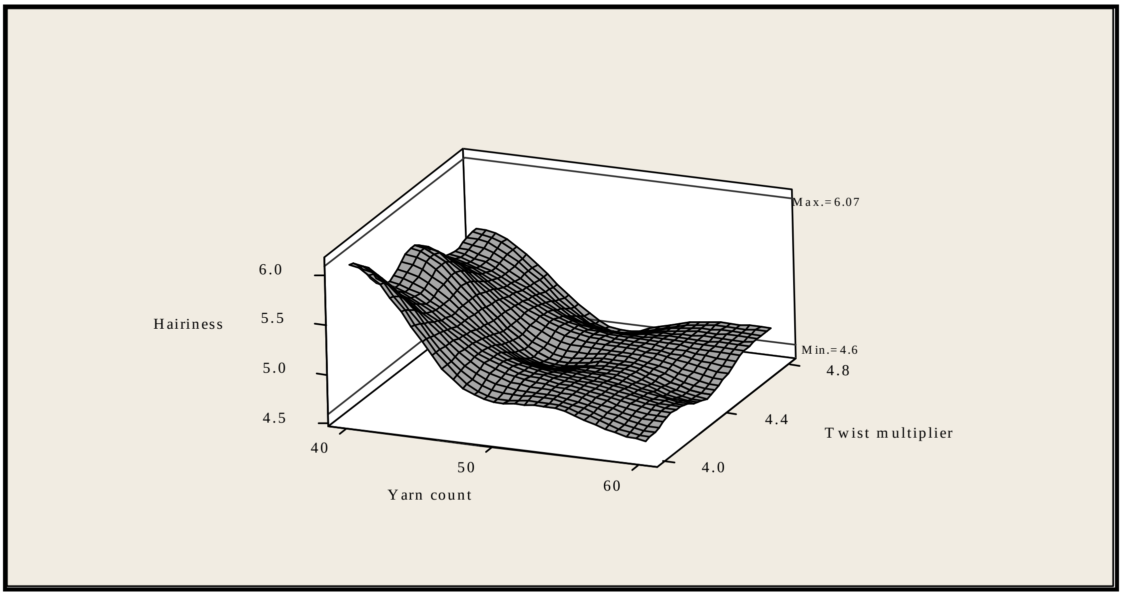


Fig. (6): Surface Plot of hairiness vs. yarn count and twist multiplier under carded spinning system.

2- Combed spinning system

Table (2) showed the hairiness mean values of as affected by yarn count and twist multiplier under combed spinning system. Results cleared that there significant differences were obtained among yarn English counts and among twist multipliers while interaction effect was not significant. It is obtained that increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 17.85 and 16.67 % compared to yarn count 40's, respectively. With respect to the effect of twist multiplier, the yarn hairiness was not decreased when increasing twist multiplier from 4 to 4.4 but the hairiness was decreased by 5.70 % with increasing twist multiplier from 4.4 to 4.8. These results exhibited that there was significant difference only between twist multiplier 4.4 and 4.8 in reducing yarn hairiness while no significant differences were detected between twist multiplier 4 and 4.4. Although the interaction effect was no significant, the hairiness decreased gradually for the three twist multiplier under each yarn count except under the yarn count 60's where the hairiness increased from 4.59 to 4.94 with increasing twist multiplier from 4 to 4.4 and then the hairiness decreased to 4.56 under yarn count 60's. These results are clearly shown in Figure (7) which indicated that the decrease percentage of yarn hairiness with increasing yarn count was greater than that observed by increasing twist multiplier. The current results are in agreement with those obtained by **Sanad *et al* (2011)**.

Table (2): The average values of hairiness as affected by yarn count and twist multiplier under combed spinning system.

Yarn count (C)	Twist multiplier (T)			Mean
	4	4.4	4.8	
40's	5.89	5.68	5.37	5.64
50's	4.80	4.68	4.48	4.65
60's	4.59	4.94	4.56	4.70
Mean	5.09	5.09	4.80	5.00
LSD $_{0.05}$	C = 0.20 T = 0.20 C x T = NS			

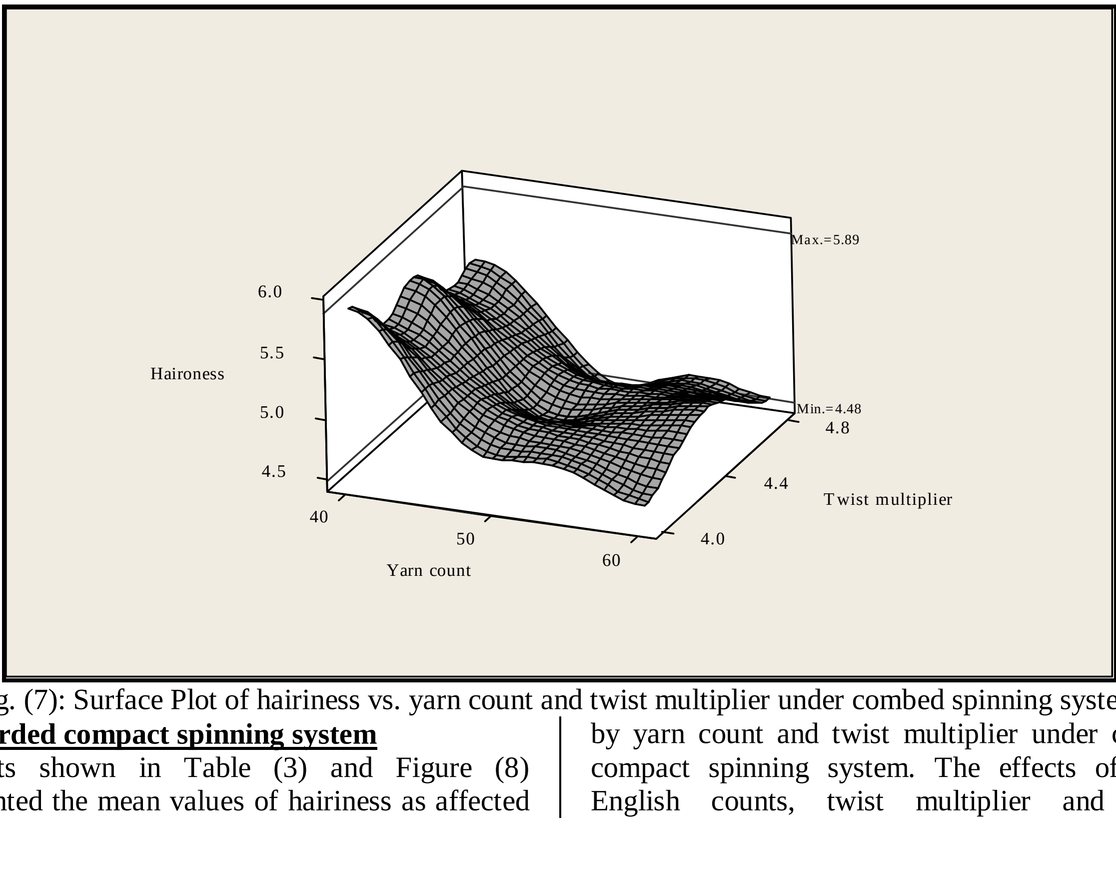


Fig. (7): Surface Plot of hairiness vs. yarn count and twist multiplier under combed spinning system.

3- Carded compact spinning system

Results shown in Table (3) and Figure (8) presented the mean values of hairiness as affected by yarn count and twist multiplier under carded compact spinning system. The effects of yarn English counts, twist multiplier and their interaction on hairiness were significant. Obviously, it is appeared that the yarn hairiness was negatively associated with each of yarn count and twist multiplier but to certain limit. Increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 14.44 and 16.64 % compared to yarn count 40's, respectively. In accordance, yarn hairiness was only reduced by 2.19 % with increasing yarn count from 50's to 60's. When the twist multiplier increased from 4 to 4.4 and then 4.8, yarn hairiness was decreased by 5.85 and 7.41 % compared to twist multiplier 4, respectively meaning that yarn hairiness was only reduced by 1.56 % with increasing twist multiplier from 4.4 to 4.8.

Concerning the interaction effect, the yarn hairiness under the three yarn counts declined with increasing twist multiplier but the percentages of decrease were differed. The hairiness values were decreased by 12.44, 0.84 and 2.15 % using yarn counts (40's, 50's and 60's), respectively under twist multiplier 4.4 as compared to 4 while the corresponding percentages of decrease for twist multiplier 4.8 were 11.60, 5.23 and 4.52, respectively. Figure (8) cleared that the hairiness values were strongly decreased with increasing yarn count from 40's to 50's and then it slightly decreased with increasing yarn count from 50's to 60's. **Krupincová and Meloun (2013)** pointed out that yarns produced from the same fiber material with similar level of yarn twist are compared, it can be expected that increase of yarn count leads to decrease the yarn hairiness because of lower number of fibers in yarn cross-section. They added that when yarns produced from the same fiber material with same level of yarn count are compared, it can be also expected that increase of yarn twist leads to decrease of yarn hairiness.

Table (3): The average values of hairiness as affected by yarn count and twist multiplier under carded compact spinning system.

Yarn count (C)	Twist multiplier (T)			Mean
	4	4.4	4.8	
40's	5.95	5.21	5.26	5.47
50's	4.78	4.74	4.53	4.68
60's	4.65	4.55	4.44	4.56
Mean	5.13	4.83	4.75	4.90
LSD $_{0.05}$	C = 0.07 T = 0.07 C x T = 0.11			

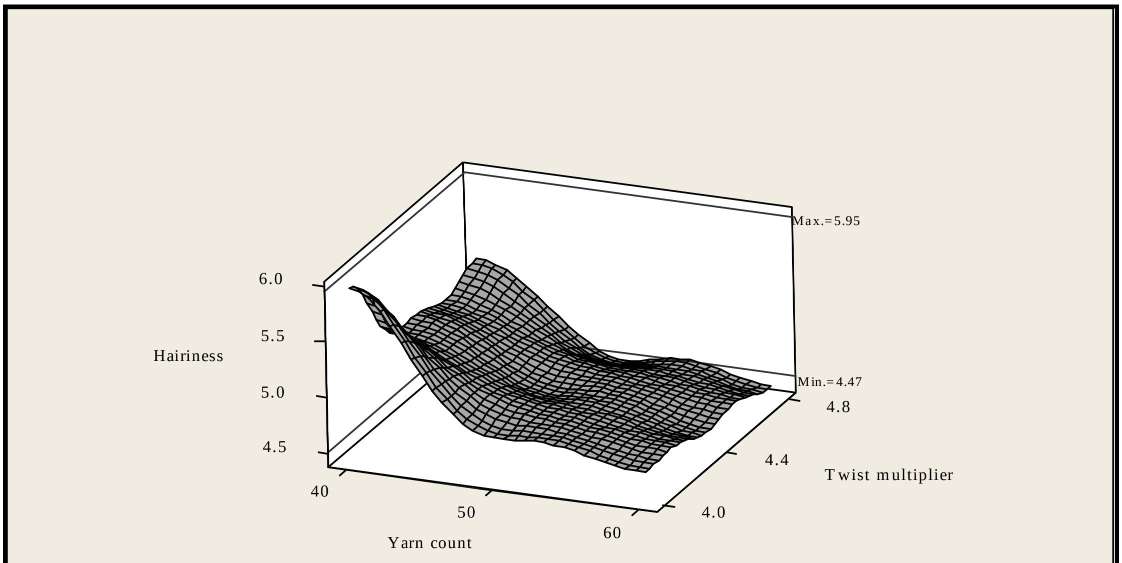


Fig. (8): Surface Plot of hairiness vs. yarn count and twist multiplier under carded compact spinning system.

4- Combed compact spinning system

The effects of yarn counts, twist multiplier and their interaction on hairiness under Combed compact spinning system are discussed in Table (4) and Figure (9). Results showed significant effects for each of yarn counts, twist multiplier and their interaction. It is illustrated that increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 15.46 and 17.56 % compared to yarn count 40's, respectively. Therefore, yarn hairiness was only reduced by 2.10 % with increasing yarn count from 50's to 60's. When the twist multiplier increased from 4 to 4.4 and then 4.8, yarn hairiness was decreased by 4.12 and 7.22 % compared to twist multiplier 4, respectively with yarn hairiness reduced by 1.56 % when increasing twist multiplier from 4.4 to 4.8.

The significance of interaction effect indicated that the yarn hairiness under the three yarn counts reduced with increasing twist multiplier but the percentages of decrease were varied. The hairiness values were decreased by 7.64, 3.07 and 0.92 % using yarn counts (40's, 50's and 60's), respectively under twist multiplier 4.4 as compared to 4 while the corresponding percentages of decrease under twist multiplier 4.8 were 5.77, 2.26 and 0.69, respectively. Figure (9) explained that the decrease percentage of hairy yarn with increasing twist multiplier was lower than that observed by increasing yarn count. According, the yarn count is more effective in controlling hairiness phenomenon compared to the twist multiplier. **El-Sayed *et al* (2011)** confirmed that finer cottons create less yarn hairiness or increasing yarn count would decrease yarn hairiness. **Al Mamun *et al* (2017)** found that less hairy and more even yarns were produced by compact spinning than conventional ring spinning.

Table (4): The average values of hairiness as affected by yarn count and twist multiplier under combed compact spinning system.

Yarn count (C)	**Twist multiplier (T)**			**Mean**
	4	**4.4**	**4.8**	
40's	5.63	5.20	4.90	5.24
50's	4.56	4.42	4.32	4.43
60's	4.36	4.32	4.29	4.32
Mean	4.85	4.65	4.50	4.67
LSD $_{0.05}$	C = 0.14 T = 0.14 C x T = 0.24			

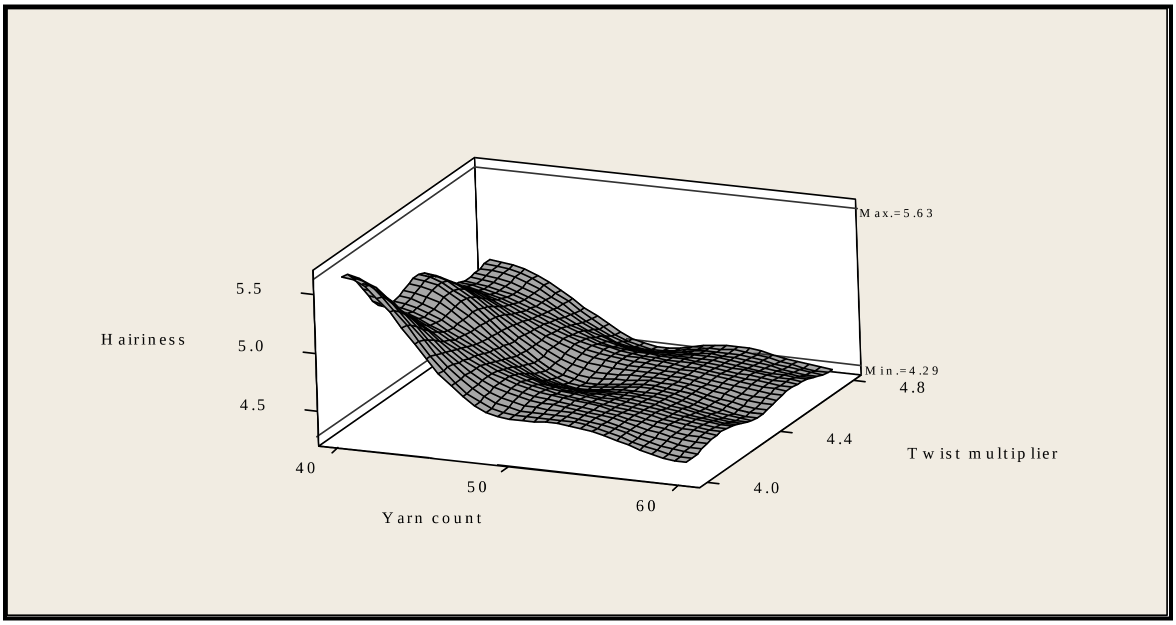


Fig. (9): Surface Plot of hairiness vs. yarn count and twist multiplier under combed compact spinning system.

5- Jetring carded spinning system

Table (5) contained the hairiness mean values as affected by yarn count and twist multiplier under Jetring carded spinning system. Results showed that the effects of yarn English counts, twist multipliers and their interaction effect were significant. It is obvious that increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 15.73 and 17.48 % compared to yarn count 40's, respectively. Therefore, yarn hairiness was weakly decreased by 1.08 % with increasing yarn count from 50's to 60's indicating that no significant difference was detected between them.

Regarding the effect of twist multiplier, the yarn hairiness gradually decreased by 4.19 and 7.76 when increasing twist multiplier from 4 to 4.4 and then 4.8, respectively compared to twist multiplier 4 with significant differences among them.

Considering the interaction, the yarn hairiness under the three yarn counts declined with increasing twist multiplier but the percentages of decrease were differed. The hairiness values were decreased by 7.93, 2.25 and 1.39 % using yarn counts (40's, 50's and 60's), respectively under twist multiplier 4.4 as compared to 4 while the corresponding percentages of decrease for twist multiplier 4.8 were 13.69, 5.39 and 2.78, respectively. The previous results were clearly expressed in response surface graph (Figure 10) which facilitated understanding them. **Abdel-Ghaffar *et al* (2019)** found in their studies on commercial blends between the imported cotton and the upper Egyptian varieties that the yarn hairiness was gradually decreased with increasing yarn count from 15's to 30's. **Türksoy *et al* (2018)** pointed out that hairiness values of jetring yarns are lower than that of ring yarns. Specific structure of jetring yarns having wrapper fibers could be said to be responsible for the considerably low amount of hairs. Furthermore, the difference between hairiness values of different jetring systems are found statistically insignificant.

Table (5): The average values of hairiness as affected by yarn count and twist multiplier under Jetring carded spinning system.

Yarn count (C)	Twist multiplier (T)			Mean
	4	**4.4**	**4.8**	
40's	5.55	5.11	4.79	5.15
50's	4.45	4.35	4.21	4.34
60's	4.31	4.25	4.19	4.25
Mean	4.77	4.57	4.40	4.58
LSD $_{0.05}$	C = 0.09 T = 0.09 C x T = 0.16			

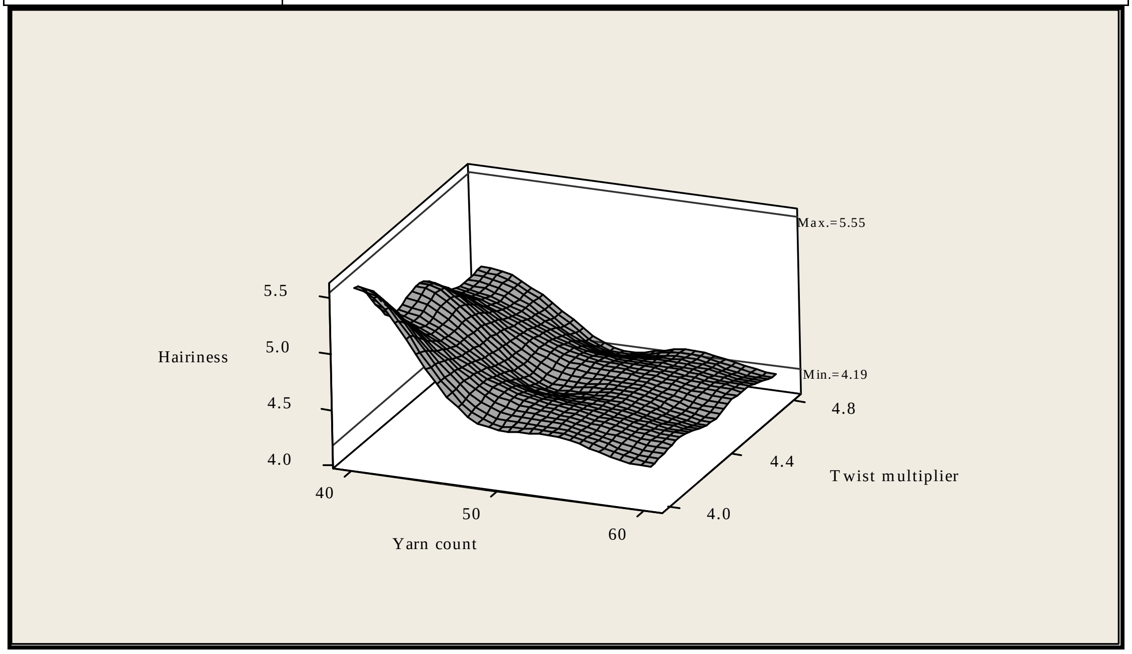


Fig. (10): Surface Plot of hairiness vs. yarn count and twist multiplier under jetring carded spinning system.

6- Jetring combed spinning system

Results shown in Table (6) and Figure (11) presented the mean values of hairiness as affected by yarn count and twist multiplier under carded spinning system. The effects of yarn English counts, twist multiplier and their interaction on hairiness were significant. Increasing yarn count from 40's to 50's and then 60's significantly decreased yarn hairiness by 21.0 and 30.83 % compared to yarn count 40's, respectively. In accordance, yarn hairiness was reduced by 9.83 % with increasing yarn count from 50's to 60's. When the twist multiplier increased from 4 to 4.4 and then 4.8, yarn hairiness was decreased by 5.11 and 8.44 % compared to twist multiplier 4, respectively meaning that yarn hairiness was only reduced by 3.33 % with increasing twist multiplier from 4.4 to 4.8.

Concerning the interaction effect, the yarn hairiness under the three yarn counts declined with increasing twist multiplier but the percentages of decrease were differed. The hairiness values were decreased by 4.14, 3.09 and 8.06 % using yarn counts (40's, 50's and 60's), respectively under twist multiplier 4.4 as compared to 4 while the corresponding percentages of decrease for twist multiplier 4.8 were 2.26, 4.75 and 20.40, respectively. **Skenderi *et al* (2018)** stated that the lowest hairiness was recorded by the jetring spun yarn while the highest hairiness was recorded by the ring spun yarn. They added that the hairiness of the rotor spun yarn lies between the jetring and the ring spun yarn.

Table (6): The average values of hairiness as affected by yarn count and twist multiplier under Jetring combed spinning system.

Yarn count (C)	**Twist multiplier (T)**			**Mean**
	4	**4.4**	**4.8**	
40's	5.31	5.09	5.19	5.19
50's	4.21	4.08	4.01	4.10
60's	3.97	3.65	3.16	3.59
Mean	4.50	4.27	4.12	4.30
LSD $_{0.05}$	C = 0.15 T = 0.15 C x T = 0.26			

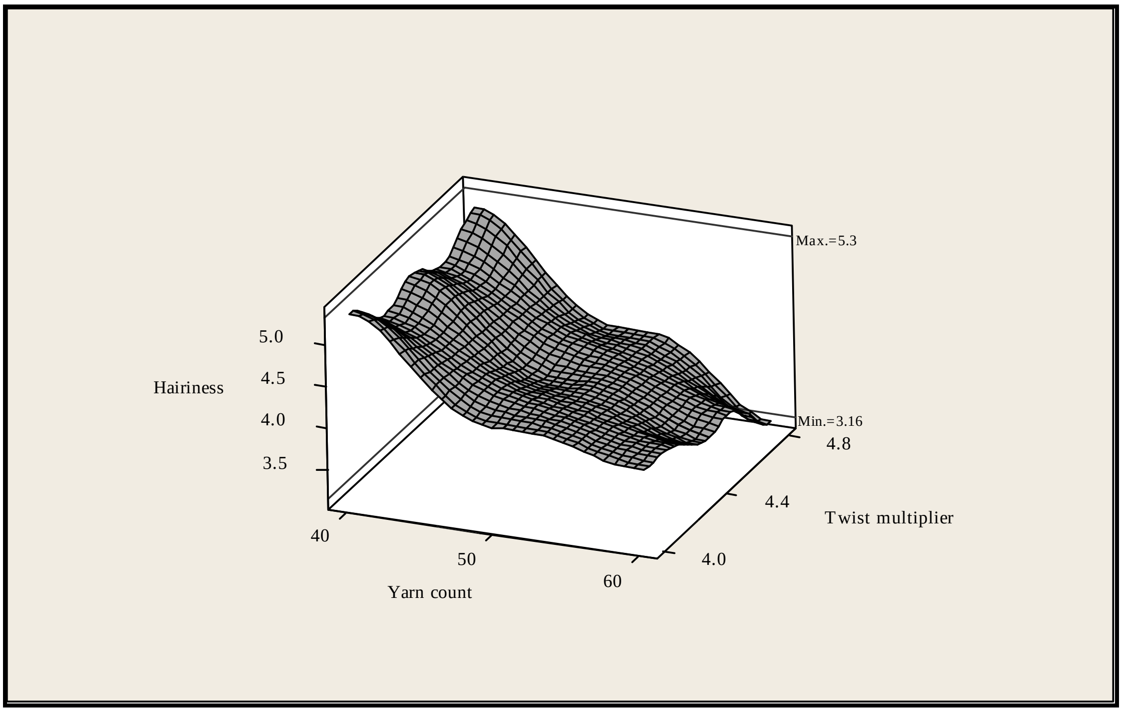


Fig. (11): Surface Plot of hairiness vs. yarn count and twist multiplier under Jetring combed spinning system.

- The relative contribution of yarn count and twist multiplier toward the hairiness under six spinning systems.

The relative contribution %, coefficient of determination R^2 and multiple correlation coefficient (R) of yarn count and twist multiplier toward the hairiness under six spinning systems were presented in Table (7) and graphically shown in Figure (12). Results exhibited that yarn count and twist multiplier explained the most variation of hairiness expressed as coefficient of determination (R^2 %) indicating that both yarn count and twist multiplier were already among the spinning parameters that effectively affecting the hairiness phenomenon. The coefficient of determination (R^2 %) of yarn count and twist multiplier toward hairiness values ranged from 68.42 for combed ring spun system to 92.40 for Jetring combed spun system. The residuals content (1- R^2 %) may be returned to some spinning parameters that affecting yarn hairiness but they were not take into account under the current study and/or also to unknown variation (random error).

On the other hand, the multiple correlation coefficients (R) between yarn count and twist multiplier of one side and yarn hairiness of the other side were greater than 0.8 for all spinning systems indicating strong associations between the two spun parameters and yarn hairiness. Results presented that the most yarn hairiness variation was effectively accounted for by yarn count compared to twist multiplier overall applied spun systems. The maximum relative contribution of yarn count toward yarn hairiness was obtained under Jetring combed spinning system (87.53 %) while the minimum relative contribution was observed by combed ring spun system (62.46 %). With respect to the effect of twist multiplier, the highest relative contribution was recorded by Jetring carded (11.62 %) and carded compact (11.33 %) spinning systems while the lowest relative contribution was observed by carded ring spun system. The current results are in harmony with those obtained by **Altaş and Kadoğlu (2006), Sanad *et al* (2011), Hager and Hassan (2016) and Abdel-Ghaffar *et al* (2019).**

Table (7): The relative contribution %, coefficient of determination R^2 and multiple correlation coefficient (R) of yarn count and twist multiplier toward the hairiness under six spinning systems.

Spinning system	Relative contribution %		Coefficient of determination R^2	Multiple correlation coefficient (R)
	Yarn Count	Twist multiplier		
Carded	70.51	3.44	73.95	0.86
Combed	62.46	5.97	68.42	0.83
Carded compact	66.90	11.33	78.23	0.88
Combed compact	70.00	9.74	79.74	0.89
Jetring carded	67.25	11.62	78.87	0.89
Jetring combed	87.53	4.84	92.40	0.96

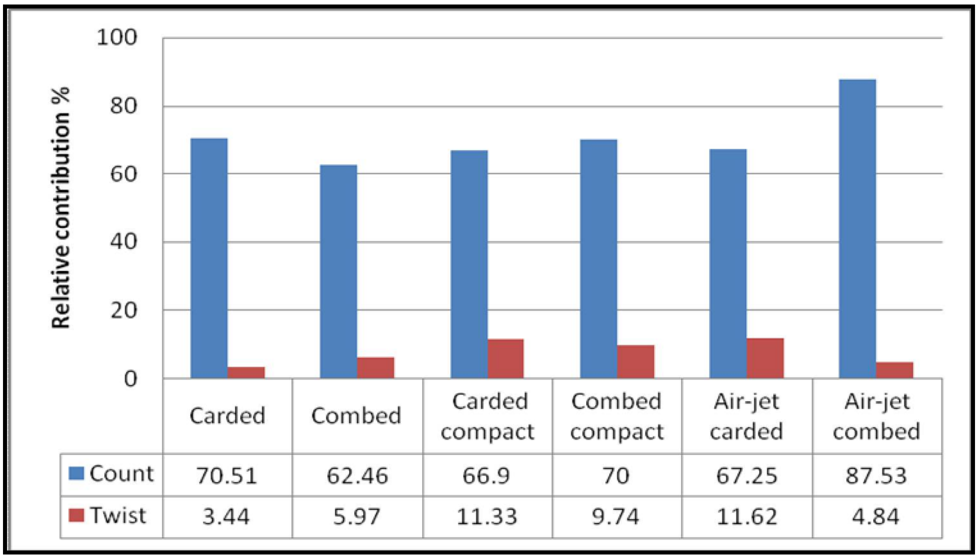


Fig. (12): The relative contribution % of yarn count and twist multiplier toward the hairiness under six spinning systems.

CONCLUSION

The present search aimed to reduce the yarn hairiness using the optimum yarn count and twist multiplier under six spun systems. Results indicated that the minimum yarn hairiness was obtained by Jetring combed ring spinning system with significant differences compared to the other spinning systems. Jetring carded ring and combed compact ring spinning systems located at the second order with significant differences than the others. Generally, it is indicated that the hairy yarns may be dramatically decreased with increasing yarn count to a certain extent and then slightly decreased while it was gradually decreased with increasing twist multiplier. Results showed that yarn count and twist multiplier reflected the most variation of hairiness expressed as coefficient of determination (R^2 %). But the most yarn hairiness variation was effectively accounted for by yarn count compared to twist multiplier under all applied spun systems.

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