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Research Paper

Performance evaluation of various natural agro fibres in carpet making and their costing

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■ **ABSTRACT :** The growing concerns for environment and health hazards associated with the use of synthetic dyes, particularly in western countries gave fillip for cultivation and use of naturally coloured cotton, other minor fibres like banana, sisal, hemp etc. The popular belief is that the industrial practices and particularly the chemical industry have altered the natural balance in the world. There is a perception that chemistry is fiddling with the nature. This in turn, leads to returning to traditional or so called more natural way of life. As a part of this trend, there is a lobby for using natural colouring matters today. The reasons for increasing popularity of naturally colorued cotton and other agro fibres include that, these fibres are ecological and economical. In processing of white cotton the chemicals and dyes used and their effluents cause pollution directly or indirectly, the chlorinated products and bleaching agents employed for bleaching cause skin irritation. Dyes containing traces of heavy elements such as arsenic, lead, cadmium, cobalt, zinc and chromium are found skin irritants. The cost of dyeing cotton and other agro fibres economically and environmentally can be very high especially in the counties with strict pollution standards. The cost of naturally coloured cotton is 31 per cent less than the conventionally grown and dyed yarn. Further, the demand for organically produced agricultural products is on the rise. Dyeing uses up to 85 per cent of all the energy used to produce textiles and produces more pollution than any other phase of textile manufacturing. Natural coloured cotton has high quality light and wash fastness, saves resources and prevents pollution. When most textile materials are subjected to continuous rubbing forces, the result is broken threads or holes that we usually associate with wear and abrasion. However, when carpets undergo similar forces, the most obvious results are loss of pile height, gradual flattening of yarns, fuzzing and matting of the pile. Aiming at developing environmentally friendly products, naturally coloured cotton and many other agro fibres were used for making carpets and subjected to some important functional parameters assessed for durability of the newly designed carpets. The results of the study showed that, among the five different types of carpets, compression recovery of naturally coloured cotton carpets was higher followed by cotton carpets. Compression recovery of all the carpets was far less and the carpets did not recover more than 50 per cent. Among the ten different carpets sisal carpets were the costliest followed by banana carpets. The cost of these carpets was high due to cost of raw material *i.e.* yarn and is not easily available. Naturally coloured carpets were the cheapest or economical among all types of carpets. The cost of production totally depended on the complexity of the design and number of colours used in the design.

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The concern for a life devoid of the use of extremely harmful chemicals, the need for an eco-friendly industrial and agricultural culture and an increasing awareness of depleting natural resources and the consequences therein, these are the factors, which are shaping the lifestyles of people worldwide (Kumar and Mishra, 2007). It is in this context that the relevance of natural fibers becomes important. Natural fibres are not only better for our bodies but also better for our environment. It makes a world of difference in the health and comfort of our people, especially those with allergies, asthma or multiple chemical sensitiveness.

In any textile mill, dyeing, printing and finishing are the most water intensive processes. Dyes containing traces of heavy elements such as arsenic, lead, cobalt, zinc and chromium are sometimes skin irritants to persons with sensitivities. Any effort to reduce or eliminate pollution caused due to dyeing and finishing is possible by utilizing naturally coloured genotypes that is not only economical but also ecologically sound. The use of naturally colour linted cotton being unique and attractive has tremendous potentiality to become a part of the cotton textile market.

"No dyes" quality of naturally coloured cotton means no dyes to fade and with each wash the garments give a new look. Being toxic free, protect the people with sensitive skin. The end uses of naturally coloured cotton include wide range of apparel, hosiery, and home textiles and can very well go as a fashion textile. Naturally coloured cotton can also be used in geo-textiles and sun protection fabrics due to its higher UPF values.

Any textile material produced either on handloom or on power loom or in mill sector need to perform the intended functions satisfactorily *i.e.* the money spent on textiles is worth when it serves the purpose and gives maximum satisfaction to the consumer. Of the several functional properties, durability is the most important one that depends on the constructional parameters of the textile material (Fashola and Ochegbudu, 2004). Following are the some important functional parameters assessed for durability of the newly designed carpets.

■ RESEARCH METHODS

The testing of the carpet samples was conducted at the ISO 9001:2000 certified institute, The Indian Institute of Carpet Technology, Bhadohi, Uttar Pradesh. The abrasion test (weight loss method) was carried out according to Woolmark TM 283 using WIRA carpet abrasion machine, WIRA instrument division, UK, BD12JL.Compression and recovery characteristics of the carpets were measured using WIRA carpet compression and recovery tester. Dimensional changes due to wetting were carried out according to IS: 2977-1964.

Cost analysis of the designed carpets :

The cost analysis of newly designed carpets using banana, sisal, cotton, jute and naturally coloured cotton was calculated considering various factors like cost of raw materials, labour charges for dyeing and weaving, cost of finishing etc.

■ RESEARCH FINDINGS AND DISCUSSION

It was observed from the Table 1 that, cotton x sisal carpets registered maximum weight loss of 22.32 mg followed by cotton x jute and cotton x banana carpets which showed weight loss of 18.16 mg. Cotton x cotton carpets reported weight loss of 9.20 mg whereas, very least weight loss of about 7.56 mg was seen in case of cotton x naturally coloured cotton carpets. As per the Wool Mark Company C1 1988 TM-283 (revised edition 2001) product specification "wall to wall carpets and tiles" abrasion maximum weight loss/1000 rubs is 70 mg.

The minimum weight loss in cotton x cotton and

Table 1 : Wear and abrasion of carpets

Sr. No.	Type of carpet	Wear and abrasion (average weight loss/1000 cycles) (Mg)
1.	Cotton x cotton	9.20
2.	Cotton x naturally coloured cotton	7.56
3.	Cotton x jute	18.16
4.	Cotton x banana	18.16
5.	Cotton x sisal	22.32

cotton x naturally coloured cotton carpets might be due to the reason that, cotton fibre contains some wax and naturally coloured cottons have higher wax content when compared to white cottons. Cotton has better cohesiveness than jute, banana and sisal due to convolutions in its structure. Therefore, there was difference between the loss in weight of carpet due to abrasion. The presence of wax seems to be responsible for all difference in weight loss. Jute, banana and sisal yarns undergo some scouring processes before being dyed which may result in weakening of the fibres. However, several processes involved in dyeing like pretreatments, dyeing and also post treatments may also cause weakening of these fibres. Hence, the weight loss may be higher when compared to cottons.

The processing of the naturally coloured cotton is done without using any bleach, dyes or any kind of chemicals, therefore, reducing pollution and conserving natural resources by not using water and energy that these steps normally require.

The test of analysis of variance for wear and abrasion showed that, highly significant difference was noticed between different types of yarns at 1 per cent level of significance. However, between the different treatments there was no significant difference at 1 per cent level of significance.

Compression recovery values are presented in Table 2. It is very clear from the results that, compression recovery was found to be 48.64 per cent in cotton x naturally coloured cotton carpets, and 47.73 per cent in cotton x cotton carpets. Cotton x jute carpets showed compression recovery of 38.35 per cent, followed by cotton x banana carpets which registered compression recovery of 37.31 per cent. Whereas, cotton x sisal carpets recovered 34.73 per cent. However, it was observed that, compression recovery of all the carpets was far less and the carpets did not recover more than 50 per cent. This might be due to the reason that, cotton, naturally coloured cotton, banana, jute and sisal fibres are all cellulosic fibres and the compression recovery of these fibres is less when compared to wool. Jute, banana and sisal fibres are considered hard cellulosic fibres because of their reasonably high tensile modulus and elongation at break. The amount of lignin present (as cementing material) in these fibres cannot be removed cent per cent which causes the harshness of fibres.

Table 2 : Compression recovery of carpets

Sr. No.	Type of carpet	Compression recovery (%)
1.	Cotton x cotton	47.73
2.	Cotton x natural coloured cotton	48.64
3.	Cotton x jute	38.35
4.	Cotton x banana	37.31
5.	Cotton x sisal	34.73

The test of analysis of variance for compression recovery showed that, highly significant difference was noticed between different types of yarns for at 1 per cent level of significance. However, between the different treatments there was no significant difference at 1 per cent level of significance.

The values for shrinkage are given in Table 3. Higher values for warp shrinkage (3.75 %) were noticed in cotton x banana and cotton x naturally coloured cotton carpets. Cotton x banana carpets reported warp shrinkage of 2.50 per cent and cotton x cotton carpets showed 2.25 per cent. Warp shrinkage was found to be less for cotton x sisal carpets.

Table 3 : Dimensional changes of carpets due to wetting

Sr. No.	Type of carpet	Warp shrinkage (%)	Weft shrinkage (%)
1.	Cotton x cotton	2.25	1.75
2.	Cotton x natural coloured cotton	3.75	1.00
3.	Cotton x jute	3.75	3.00
4.	Cotton x banana	2.50	1.25
5.	Cotton x sisal	1.50	1.00

In weft direction cotton x banana carpets reported higher shrinkage values (3.0 %) followed by cotton x cotton which showed shrinkage of 1.75 per cent. Lesser shrinkage values were observed for cotton x jute, cotton x naturally coloured cotton and cotton x sisal carpets. On the whole, maximum shrinkage in both the directions was seen in cotton x banana carpets and minimum shrinkage was observed in cotton x sisal carpets.

The test of analysis of variance for warp shrinkage and weft shrinkage showed that, highly significant difference was noticed between different types of yarns for at 1 per cent level of significance. However, between the different treatments also there was significant difference at 1 per cent.

Cost analysis of the designed and naturally dyed carpets :

For analyzing the cost of production of newly

designed carpets various factors like cost of raw material, wages for preparatory process and weaving, cost of dyeing materials and dyeing, cost of finishing were taken into account. Table 4 records the cost analysis of newly designed carpets of size 2'x3' each. The carpets were given the codes ex: for cotton carpets C_1 and C_2, for jute carpets J_1 and J_2 similarly for other carpets.

The raw materials *i.e.* cotton yarn was used as warp in all types of carpets as warp and as weft in cotton carpets. Cotton carpet yarn was procured at the rate of Rs. 80/kg. For cotton carpet C_2 the raw material for dyeing costed Rs. 43.20 whereas, the dyeing cost was Rs. 64.80 as it included many colours in the design. Weaving cost was also very high among all other carpets due to more number of colours and complexity of the design. Cost of weaving was calculated per sq.ft based on the design and the number of colours used in the design. C_2 carpet was woven @ Rs. 40/sq.ft and C_1 carpet @ Rs. 26/sq.ft. Hence the cost of weaving accounted to Rs. 240 and Rs. 156, respectively for C_2 and C_1. The cost of finishing with neem seed extract was Rs. 1.50 and with guar gum was Rs. 2.40 and was same for all types of carpets. The production cost of C_2 was relatively higher than C_1.

The undyed jute yarn was procured at the rate of Rs. 72/kg. For the jute carpets J_1 and J_2 undyed cotton yarn was used as warp yarn and dyed jute yarn was used as weft yarn. The cost of raw materials required for dyeing accounted to Rs. 30.20 for J_1 and Rs. 32.47 for J_2. Cost of dyeing incurred was Rs. 45.30 for J_1 and Rs. 48.71 for J_2. The cost of weaving accounted to Rs. 168.0 for J_1 and Rs. 138.0 for J_2. Hence, the production cost of jute carpets J_1 and J_2 was Rs. 290.60 and 266.20, respectively. Therefore production cost/sq.ft was found to be Rs. 48.50 and Rs. 43.33 for J_1 and J_2 carpets, respectively. The production cost of J_2 was relatively lesser than J_1 and production cost of jute carpets was relatively lesser than banana, sisal carpets.

Handspun and naturally dyed banana yarn was used as weft yarn in banana carpets. The banana fibre was procured @ 95/kg. The cost of raw materials required for dyeing accounted to Rs. 42.84 and Rs. 44.73 and cost of dyeing was Rs. 64.26 and Rs. 67.11 for B_1 and B_2, respectively. The cost of weaving was relatively less when compared to other carpets as the designs were simple. The production cost of banana carpets was relatively higher than cotton, jute and naturally coloured cotton carpets due to cost of fibre and additional spinning charges.

Sisal carpets were woven with undyed cotton yarn in warp and naturally dyed sisal yarn in weft direction. Machine spun sisal carpet yarn was procured @ Rs. 200/ kg. Sisal yarn was costly as it included many operations like fibre extraction, drying, machine spinning and bundling. Sisal yarn was dyed with many colours, hence the cost of raw materials for dyeing accounted to Rs. 54.80 and Rs. 57.01 and cost of dyeing Rs. 82.22 and Rs. 85.52 for $S_1$and S_2, respectively. Weaving charges

Table 4 : Cost analysis of designed and naturally dyed carpets

Sr. No.	Aspects	Cotton carpets		Jute carpets		Banana carpets		Sisal carpets		Naturally coloured cotton carpets	
		C_1 (Rs.)	C_2 (Rs.)	J_1 (Rs.)	J_2 (Rs.)	B_1 (Rs.)	B_2 (Rs.)	S_1 (Rs.)	S_2 (Rs.)	N_1 (Rs.)	N_2 (Rs.)
1.	**Raw material charges**										
	Undyed warp yarn	9.60	9.60	7.78	7.78	8.64	8.64	8.64	8.64	9.60	9.60
	Undyed weft yarn	38.40	38.40	35.42	35.42	58.14	58.14	122.40	122.40	93.60	93.60
2.	Yarn preparation/spinning charges	-	-	-	-	24.50	24.50	-	-	-	-
3.	Dyeing material cost	31.20	43.20	30.20	32.47	42.84	44.73	54.80	57.01	-	-
4.	Dyeing cost	46.80	64.80	45.30	48.71	64.26	67.11	82.22	85.52	-	-
5.	Weaving charges	156.0	240.0	168.0	138.0	120.0	168.0	132.0	156.0	150.0	168.0
6.	**Finishing cost**										
	With neem seed extract	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	With guar gum	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
7.	Total	285.90	399.0	290.60	266.28	322.28	375.02	403.96	433.47	275.10	275.10
8.	Cost of carpets/sq.ft	47.66	66.66	48.50	43.33	53.66	62.50	67.33	71.16	42.83	45.83

(Note: Dyeing charges include cost of extraction, fuel, labour, pre mordanting and after treatment charges. These are lab charges, the commercial production charges will differ.)

for S_2 were relatively higher as it included many colours in the design. Production cost of S_2 was more when compared to S_1.

Naturally coloured cotton carpets are a novel item. The naturally coloured cotton yarns were procured at the rate of Rs. 195/kg. Production cost of carpets included cost of raw material, cost of weaving and finishing. The cost of weaving incurred for N_1 carpet was Rs. 150.0 and for N_2 Rs. 168.0. The production cost of naturally coloured cotton carpets accounted to be Rs. 42.83 and Rs. 45.83 per square feet. The production cost of naturally coloured cotton carpets was relatively cheaper compared to other carpets due to the reason that dyeing of yarn was not involved in the process.

Conclusion:

Cotton x sisal carpets registered maximum weight loss of 22.32 mg followed by cotton x jute and cotton x banana carpets which showed weight loss of 18.16 mg. The presence of wax seems to be responsible for all difference in weight loss. Among the five different types of carpets, compression recovery of naturally coloured cotton carpets was higher followed by cotton carpets. Compression recovery of all the carpets was far less and the carpets did not recover more than 50 per cent. On the whole, maximum shrinkage in both the directions was seen in cotton x banana carpets and minimum shrinkage was observed in cotton x sisal carpets. Weaving cost of C_2 was high among all other carpets as the numbers of colours used were more and the design was complicated. Production cost of jute carpets was relatively lesser than banana and sisal carpets. In case of banana carpets, the cost of weaving was relatively less when compared to other carpets as the designs were simple and only few colours were used. The production cost of banana carpets was relatively higher than cotton, jute and naturally coloured cotton carpets due to cost of fibre and additional spinning charges. Among the ten different carpets sisal carpets were the costliest followed by banana carpets. The cost of these carpets was high due to cost of raw material *i.e.* yarn and is not easily available. Naturally coloured carpets were the cheapest or economical among all types of carpets. The cost of production totally depended on the complexity of the design and number of colours used in the design.

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