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PRELIMINARY INVESTIGATIONS ON SUN-HEMP TWINE AS A FISHING NET MATERIAL

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Introduction

The sun-hemp twine is an important net-making material in India next only to cotton and coconut fibre. Though the fishermen throughout the coast-line of India are using sun-hemp twines for gill-nets, boat-seines, beach-seines, bag-nets, stake-nets, etc., the characteristics of the twine as a fishing gear material have not yet been investigated. In these experiments, we have carried out a preliminary investigation on breaking strength, breaking stretch and rotting of the twines during continuous immersion in sea-water with a view to taking up further investigations on improving the twine as a gear material.

General Notes on Sun-hemp

Sunn, Sun or San-hemp (*Crotalaria juncea*) is an important fibre plant. It is not known in the wild state for it has been cultivated for centuries and in fact is the earliest fibre mentioned in Sanskrit literature. The plant is a shrubby annual from 6–10′ in height, with bright yellow flowers. It is extensively grown in India where about 543,000 acres are estimated to be planted every rainy season with an annual production of 95,000 tons of fibre. The plant yields a fibre that is stronger than jute, lighter in colour and more enduring. It is used for cordage, sacks, nets and coarse canvas. The United States, United Kingdom and France import a considerable quantity of coarse hemp twines.

The sun-hemp taken up for investigation in these experiments is grown as a rotation crop after the paddy harvest in the southern parts of Thiruthuraipoondy Taluk, Tanjore District, Madras State. The area so cultivated is about 3,000 acres. The well grown sun-hemp plants are cut and processed to yield fibres. The rest is ploughed back as a green manure. The seeds are sown during the end of January and the plant is ready for cutting by the end of February when they are about 8′ high. The thickness of the stem is roughly that of a pencil. The plants so cut are dried in the sun for 4 days, allowed to stand in water for one week, beaten with primitive implements and the long strands of fibre are separated without damage. The fibre is made into yarns, twines and nets by skilled labour, both men and women are engaged for this work. The fibre is classified into various grades and the first quality is used for making fishing nets. The rest is used for other domestic purposes. The total gross annual yield in this area is estimated to be 1,20,000 lb., first quality being 80,000 lb. The entire first quality production is used for fishing nets. They are at present exported to various places in India and Ceylon.

MATERIAL

Materials used for these experiments were purchased from a sun-hemp net manufacturer and wholesale dealer of point Calimere, Madras State. Sun-hemp twines (single ply, count 31,* made of 3 to 10 yarns) were tested. Locally hand-twisted Indian cotton 20's, 3 ply, 45 threads and Manila twine were also tested as control for the experiments. The twines which were used for these experiments were not of a good quality. Their thickness, twist of twine, etc., were not uniform.

RESULTS OF EXPERIMENTS AND DISCUSSION

The weight per unit length, diameter, average breaking strength and breaking stretch in both dry and wet condition of the twines which were under test are given in Table I, from which the following may be inferred:

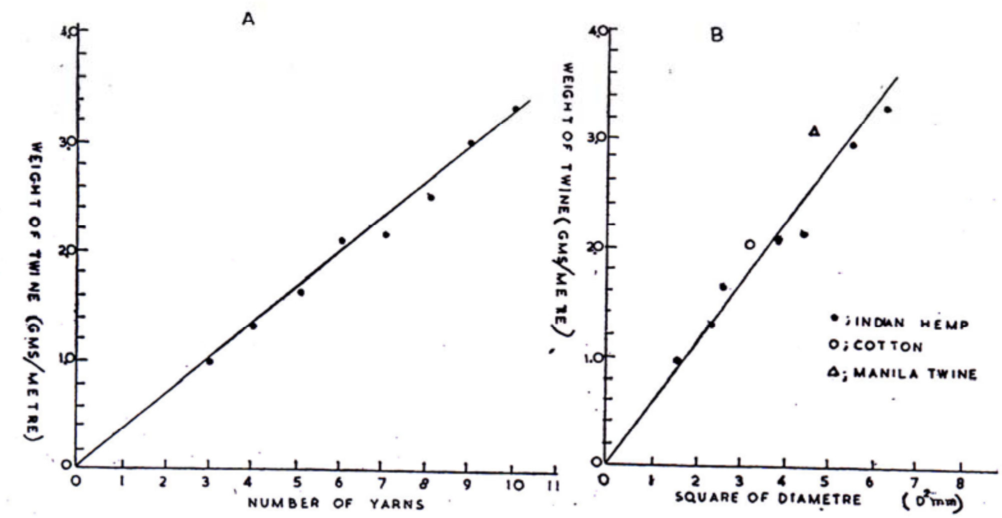

FIG. 1. Relation between number of yarns and weight of twine per unit length and relation between square of diameter of twine and weight per unit length.

(1) *Weight of sun-hemp twines.*—It is obvious that the weight of twine per unit length is proportional to the number of threads or number of yarns with which the twine is made up of, if the same threads or yarns are used in each twine. Figure 1 *A* shows the relation between the weight of sun-hemp

* This arbitrary numbering of yarns by the manufacturer is based on the thickness of the fibre used and the quality (determined by experience) of the fibre.

TABLE I

Breaking strength and breaking stretch of sun-hemp, Indian cotton and manila twine in dry and wet conditions

Materials	Sun-hemp twine, single ply, count 31 (in yarns)								Indian cotton 20s, 3 ply	Manila twine
	3	4	5	6	7	8	9	10	45 threads	3 yarns
Number of outer twist per feet	58	55	52	48	45	43	40	36	72	26
Weight of twine in gm./metre ..	0·967	1·315	1·626	2·102	2·142	2·556	2·981	3·318	2·045	2·867
Diameter (in mm.) ..	1·25	1·50	1·61	1·95	2·10	2·15	2·34	2·50	1·80	2·15
Average breaking strength (in kg.) in dry condition	11·3	18·2	19·0	20·2	19·5	27·1	39·6	32·8	13·8	44·7
Maximum breaking strength (in kg.) in dry condition	15·6	26·0	24·2	25·8	24·0	33·6	45·8	41·0	14·4	63·5
Minimum breaking strength (in kg.) in dry condition	6·8	12·0	14·6	14·2	16·6	19·0	33·6	27·4	13·3	32·5
Average breaking stretch (in %) in dry condition	6·8	6·7	6·7	6·7	6·7	5·5	6·8	7·0	31·1	..
Maximum breaking stretch (in %) in dry condition	10·0	8·3	8·3	7·8	8·3	8·4	11·1	8·9	39·0	..
Minimum breaking stretch (in %) in dry condition	5·0	5·0	4·5	5·6	6·1	3·9	6·1	5·6	23·2	..
Average breaking strength (in kg.) in wet condition	13·2	18·0	21·1	21·7	28·9	30·5	40·8	32·8	17·7	45·2
Maximum breaking strength (in kg.) in wet condition	20·2	20·0	25·4	25·0	34·0	35·4	46·8	37·5	19·2	59·5
Minimum breaking strength (in kg.) in wet condition	9·0	15·2	14·0	17·6	24·6	26·2	35·2	21·6	14·8	28·5
Average breaking stretch (in %) in wet condition	9·9	8·8	10·8	9·7	12·6	11·9	15·0	16·1	40·6	15·2
Maximum breaking stretch (in %) in wet condition	12·2	12·8	13·9	14·5	15·6	13·9	16·1	18·9	45·5	16·7
Minimum breaking stretch (in %) in wet condition	8·9	6·1	7·8	7·8	10·0	5·5	12·8	11·7	38·4	13·3

N.B. :

1. Results are an average of 10 tests in each case.
2. Average breaking strength in wet condition = twines dipped in water for about 24 hours before tests were made.

twine per unit length and the thickness of the twine which is expressed in terms of the number of yarns. Now, let W denote the weight of the twine in gm. per metre length of twine, and N the number of yarns which constitute one twine. Then the following formula will be obtained from the figure:

$$W = 0 \cdot 33\ N \tag{1}$$

Here, 0·33 represents the weight of count 31 single yarn per metre of twine. The weight of twine per unit length is also proportional to the square of the diameter of the twine, if the twine is made from the same material and has the same hardness of twist. Figure 1 *B* shows the relation between weight of twine per unit length and the square of the diameter of each twine. From the figure, the following formula can be obtained:

$$W = 0 \cdot 55\ D^2 \tag{2}$$

Here, W denote the weight of twines per metre in gm. and D the diamter of the twine in mm. From the figure, cotton and manila twines seem to be a little heavier than the sun-hemp twine. Cotton and manila twines are both hard twisted and the hemp twines are rather soft twisted. The difference in weight per unit length of hemp twine from the other two seems to depend mainly upon the number of twists per unit length.

(2) *Breaking strength of sun-hemp twine in dry and wet conditions.*— Breaking strength of twine is proportional to the number of yarns with which the twine is made up of, provided the same yarns are used in all the twines. From Table I the following formulæ can be obtained:

$$B = 3 \cdot 66\ N \text{ in dry condition} \tag{3}$$

$$B = 4 \cdot 10\ N \text{ in wet condition} \tag{4}$$

Here, B is the breaking strength in kg. and N the number of No. 31 yarns of sun-hemp, *i.e.*, Count 31 single yarn has 3·66 kg. of breaking strength in dry condition and 4·1 kg. in wet condition. Comparing (3) with (4), it may be said that the breaking strength of sun-hemp twine in wet condition is 1·12 times stronger than in dry condition. Breaking strength B is also approximately proportional to the square of diameter of twine, if the material and construction of twines are the same. Figure 2 *A* and *B* shows the above-mentioned relations.

Based on the above, the following formulæ can be deduced:

$$B = 6 \cdot 20\ D^2 \text{ in dry condition} \tag{5}$$

$$B = 6 \cdot 94\ D^2 \text{ in wet condition} \tag{6}$$

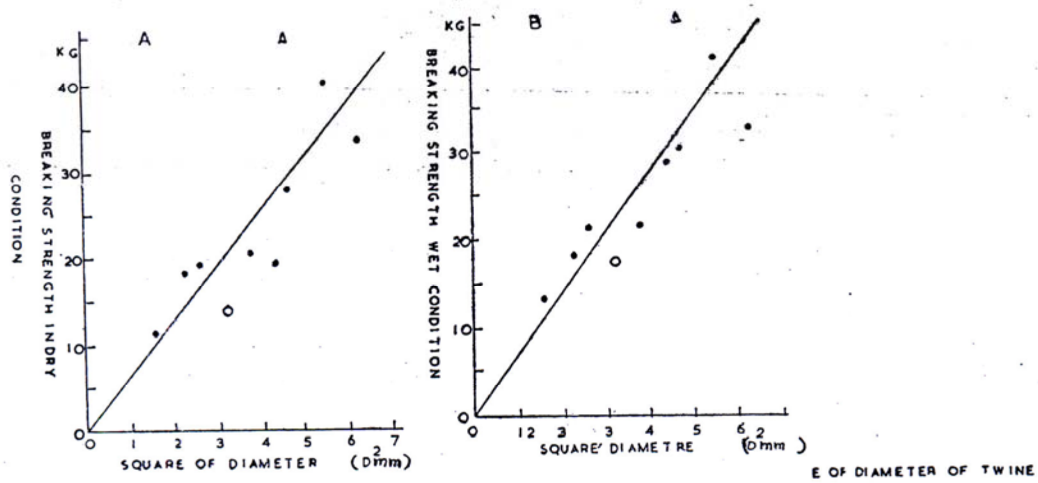

FIG. 2. Relation between breaking strength and square of diameter of twine.
(A) In dry condition.
(B) In wet condition.

Comparing (5) and (6), the breaking strength of the twine in wet condition is 1·12 times stronger than in dry condition as deduced from (3) and (4). Figure 3 shows the relation between weight of twine and breaking strength. From the figures, we can arrive at the following experimental formulæ:

$$B = 11{\cdot}25\ W \text{ in dry condition} \tag{7}$$

$$B = 12{\cdot}60\ W \text{ in wet condition} \tag{8}$$

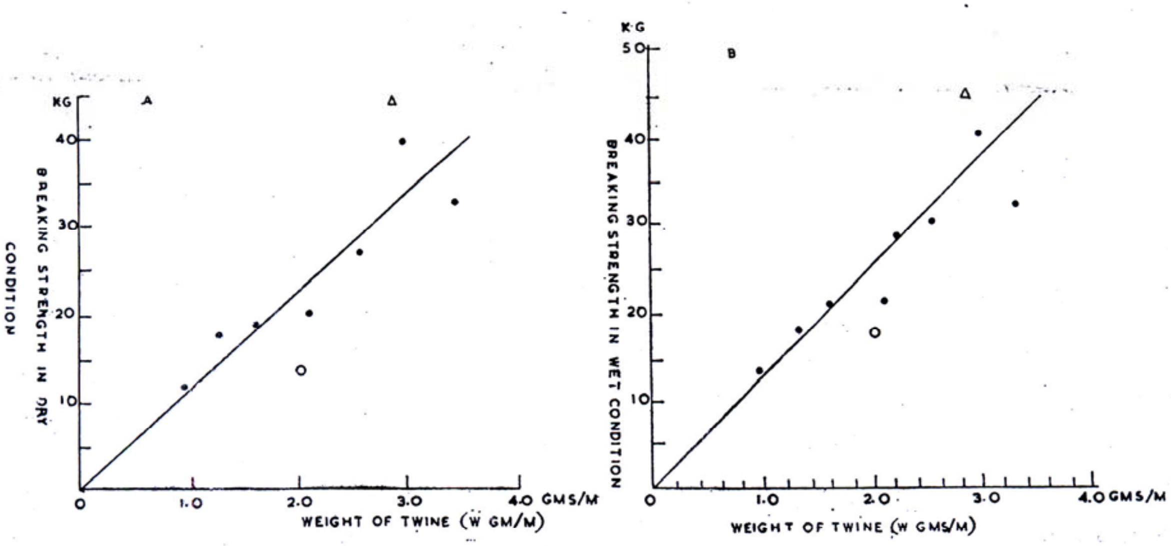

FIG. 3. Relation between weight of twine per unit length and breaking strength.
(A) In dry condition.
(B) In wet condition.

TABLE II

Relation between breaking strength and the number of days immersed

Number of days submerged in backwaters			Breaking strength in wet condition (kg.)						
			24 hrs.	Days 10	15	20	25	31	36
Hemp twines:									
3 yarns	Average	..	13·2	2·4	2·4	0·9	Rotten		
	Maximum	..	20·2	3·6	2·6	2·2			
	Minimum	..	9·0	1·4	0·2	0·2			
4 yarns	Average	..	18·0	5·0	3·7	1·9	1·7	0·51	Rotten
	Maximum	..	20·0	7·0	5·6	3·2	4·0	1·40	
	Minimum		15·2	3·0	1·6	0·8	0·8	0·00	
5 yarns	Average	..	21·1	8·3	5·4	4·1	1·8	0·7	Rotten
	Maximum	..	25·4	9·8	9·0	5·0	4·2	1·2	
	Minimum	..	14·0	6·6	3·2	3·2	0·2	0·0	
6 yarns	Average	..	21·7	11·6	7·5	5·0	2·7	1·6	Rotten
	Maximum	..	25·0	13·6	13·4	9·6	4·8	4·0	
	Minimum	..	17·6	10·2	5·2	3·0	1·2	0·6	
7 yarns	Average	..	28·9	14·0	10·9	7·0	3·4	2·4	0·80
	Maximum	..	34·0	16·6	15·8	8·0	6·6	3·6	1·20
	Minimum	..	24·6	7·8	7·2	3·6	0·6	1·6	0·40
8 yarns	Average	..	30·5	16·4	13·8	7·8	4·4	2·5	0·60
	Maximum	..	35·4	19·8	21·4	10·8	5·8	4·0	1·60
	Minimum	..	26·2	13·8	10·6	5·6	2·4	1·0	0·00
9 yarns	Average	..	40·8	18·6	11·2	9·8	5·2	3·1	1·20
	Maximum	..	46·8	21·8	15·4	16·4	6·8	6·4	2·80
	Minimum	..	35·2	14·4	6·6	5·6	2·6	1·0	0·00
10 yarns	Average	..	32·8	16·0	10·8	8·0	4·3	2·2	0·90
	Maximum	..	37·5	19·0	14·8	13·6	6·2	3·6	1·20
	Minimum	..	21·6	14·4	8·4	5·0	3·0	1·2	0·6
Cotton No. 20:									
45 threads	Average	..	17·7	9·8	6·5	5·0	3·2	3·0	Lost
	Maximum	..	19·2	11·6	7·6	5·8	4·2	3·6	
	Minimum	..	14·8	7·8	5·8	4·0	1·8	2·0	
Manila twine	Average	..	45·2	35·9	27·2	22·7	14·4	9·9	Lost
	Maximum	..	59·5	45·4	35·8	30·6	20·4	15·8	
	Minimum	..	28·5	32·4	18·8	16·8	10·8	5·2	

Here, B is the breaking strength in kg. and W is the weight of twine in gm./metre. From (7) and (8), the ratio of breaking strength in dry and wet condition is calculated to be $(12 \cdot 60/11 \cdot 25) = 1 \cdot 12$. As shown in Table I and Figs. 2 and 3, the breaking strength of sun-hemp twines has much variations and these variations may be caused by the absence of uniform thickness and difference in the qualities of hemp fibre.

(3) *Breaking stretch of the sun-hemp twines.*—Breaking stretches of the sun-hemp twines of different thickness are given in Table I. As shown in the table, the breaking stretches of the twines in dry condition do not vary corresponding to the variations in the thickness of twines. They are having a constant average breaking stretch of 7·6%. The breaking stretch in wet condition is much greater than in dry condition ranging from 8·8–16·1% and the percentage of stretch differs much due to changes in the thickness of twines, *i.e.*, the thicker the twine, the more will be breaking stretch. Generally, the breaking stretch of sun-hemp twine is lower than that of cotton twine and not substantially different from that of manila twine.

(4) *Rotting experiments on continuous immersion.*—Prior to carrying out the preservation experiments on sun-hemp twine, the continuous immersion tests were carried out to know the endurance of the hemp twine against rotting. Eight kinds of twines with different thickness were dipped in Cochin backwaters on 24th January 1958 together with the samples of cotton twines and manila twines. The results of the experiments obtained are shown in Table II. From the table, it is clear that the thin hemp twines rot quickly and the thick twines rot slowly, *i.e.*, the thicker the twine, the more slow is the rotting. From this fact, it may be difficult to compare the endurance against rotting between two twines made of different materials without considering the thickness of those two twines. But as an inference to the Table II and Fig. 1, it can be said that the sun-hemp twines rot more quickly than cotton and manila twine. If it can be assumed that the bacteria which destroy the fibres after attaching themselves to the surface of a twine are proportional to the area of the surface of the twine, then the decrease in breaking strength of twines after continuous immersion in water for a certain time should be proportional to the radius of the twines, if those twines were made of the same material. Now, let r, T_o and T_n denote radius of twine, the original breaking strength of twine and the breaking strength of the twine after continuous immersion in backwater for n days respectively. Then $T_o - T_n$ will be proportional to r. Here $T_o - T_n$ represents the decrease in breaking strength of twine after n days of continuous immersion.

From Tables I and II, the values of r, T_o and T_n and $T_o - T_n$ after 10 days and 15 days of immersion are tabulated as follows:

	Radius of twine 'r' in m.m.	Original breaking strength (T_o)	Decrease of breaking strength	
			After 10 days (T_o–T_{10})	After 15 days (T_o–T_{15})
Sun hemp:				
3 yarns ..	0·625	13·2	10·8	11·8
4 yarns ..	0·750	18·0	13·0	14·3
5 yarns ..	0·805	21·1	12·8	15·7
6 yarns ..	0·975	21·7	10·1	14·2
7 yarns ..	1·050	28·9	14·9	18·0
9 yarns ..	1·170	40·8	22·6	29·6
8 yarns ..	1·075	30·5	14·1	16·7
10 yarns ..	1·250	32·8	16·8	22·0
Cotton 20's 45/3 ..	0·900	17·7	7·9	11·2
Russian cotton 32's 18/3 ..	0·501	8·1	5·1	7·8
Manila ..	1·075	45·2	9·3	18·0

The relation between radius of the twines and the decrease of breaking strength of twines after 10 days and 15 days immersion in backwaters is shown in Fig. 4. In the Figure, 6 yarns and 9 yarns twines take extremely irregular positions; this can be explained by the fact that the value of the original breaking strength of the 6 yarn twines is extremely low and that of the 9 yarn twines just the reverse. If these two points are omitted, then the figure will show that decrease in breaking strength of twines, of the same material, is proportional to the radius of the twine. Basing the arguments on this theory, it can be concluded that cotton twine is the strongest of the three and manila twine is stronger than sun-hemp. From Table II, it may appear that manila twine is extremely resistant to rotting. But actually, the original breaking strength of manila twine is much higher than that of the other two, and there is not much difference in the rate of decline of its

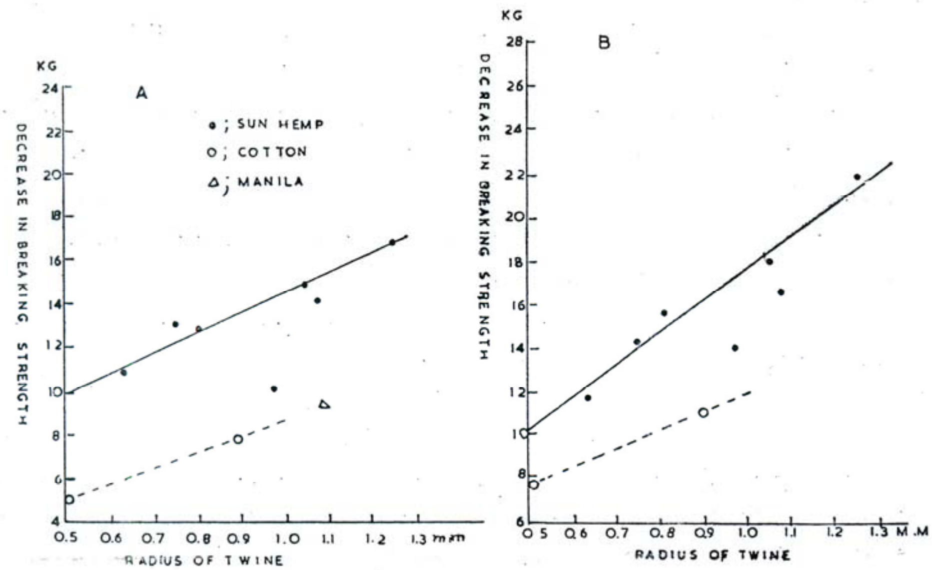

FIG. 4. Relation between radius of twine and decrease in breaking strength by continuous immersion.

(A) After 10 days immersion.

(B) After 15 days immersion.

breaking strength during periods of immersion, as compared to that of cotton or hemp.

SUMMARY

1. Preliminary investigations were carried out with sun-hemp net twines on the breaking strength, elongation in dry and wet conditions and on the rotting qualities during continuous submersion.

2. The results obtained are as follows:

(*a*) The approximate weight (in mg.) of sun-hemp twine per metre is given by $0 \cdot 33$ N. Here N represents the number of 31's yarn. The approximate weight (in mg.) of sun-hemp twine per metre is also given by $0 \cdot 55\ D^2$. Here D denotes the diameter of twine in mm.

(*b*) The approximate breaking strength of the twine in kg. is given by $3 \cdot 66$ N in dry and $4 \cdot 1$ N in wet condition; $11 \cdot 25$ W in dry and $12 \cdot 6$ W in wet condition; and $6 \cdot 2\ D^2$ in dry and $6 \cdot 94\ D^2$ in wet condition. Here W denotes the weight of twine in gm. per metre.

(*c*) The average breaking strength of sun-hemp twine in wet condition is $1 \cdot 12$ times more than in dry condition.

(*d*) The sun-hemp twine is stronger than Indian cotton twine twisted locally and weaker than manila twine.

(*e*) The breaking stretch of sun-hemp twine does not differ much with the thickness of the twine in dry condition, but in wet condition the breaking stretch increases with the thickness of the twine.

(*f*) The decrease in breaking strength of sun-hemp twine after continuous immersion in water for a certain time is proportional to the radius of the twine.

(*g*) The resistance of sun-hemp twine to rotting is considerably poorer than that of cotton twine and manila twine.

If fibre of select quality is made into twine of uniform thickness and twist, the sun-hemp twine can be improved considerably.

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