Fiber Flax and Flax Fiber

A Discussion of the Culture, Harvesting, and Working-up of Flax with Special Consideration of the Cost Factor as Compared with Cotton

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No other product of the soil has been so retarded by ancient traditions as fiber flax and flax fiber.

Possibly because food crops were of more vital importance than fine raiment, it was and still is put at the tail-end in crop rotations—some of the previous crops having been fertilized and flax getting only "the crumbs that fell from the table."

While I have no official data that give the relative effect of different fertilizers on flax, it might be well to compare what fertilizing has done with the more favored crops and reasonably expect somewhat similar results with flax.

Referring to United States Dept. of Agriculture's year book for 1930, pages 984, 986 and 987 show:

COTTON

Based on	25	reports	$3.84	spent	on	fertilizer	yielded	43	lbs.	per	acre
"	" 111	"	3.74	"	"	"	"	88	"	"	"
"	" 125	"	4.67	"	"	"	"	125			
"	" 186	"	4.72	"	"	"	"	162	"	"	"
"	" 154	"	4.95	"	"	"	"	200	"	"	"
"	" 208	"	5.91	"	"	"	"	246	"	"	"
"	" 122	"	6.61	"	"	"	"	291	"	"	"
"	" 35	"	6.38	"	"	"	"	328	"	"	"
"	" 45	"	7.46	"	"	"	"	360	"	"	"
"	" 45	"	8.37	"	"	"	"	402	"	"	"
"	" 20	"	7.16	"	"	"	"	447	"	"	"
"	" 30	"	9.75	"	"	"	"	497	"	"	"
"	" 13	"	8.08	"	"	"	"	647	"	"	"

OATS

Based on	159	reports	$.70	spent	on	fertilizer	yielded	11	bu.	per	acre
"	" 248	"	1.31	"	"	"	"	20	"	"	"
"	" 190	"	1.34	"	"	"	"	25			
"	" 445	"	1.13	"	"	"	"	30	"	"	"
"	" 283	"	1.40	"	"	"	"	35	"	"	"
"	" 531	"	1.44	"	"	"	"	40	"	"	"
"	" 168	"	1.20	"	"	"	"	45	"	"	"
"	" 312	"	1.55	"	"	"	"	50	"	"	"
"	" 78	"	1.31	"	"	"	"	55	"	"	"
"	" 123	"	1.83	"	"	"	"	60	"	"	"
"	" 84	"	1.85	"	"	"	"	71	"	"	"

CORN

Based on	7	reports	$2.25	spent	on	fertilizer	yielded	4	bu.	per	acre
"	" 17	"	1.89	"	"	"	"	13	"	"	"
"	" 27	"	2.79	"	"	"	"	22	"	"	"
"	" 37	"	2.95	"	"	"	"	32	"	"	"
"	" 47	"	3.56	"	"	"	"	41	"	"	"
"	" 57	"	4.80	"	"	"	"	50	"	"	"
"	" 58	"	6.88	"	"	"	"	67	"	"	"

an increase in production of from six to sixteen times, with from two to three times the expense on fertilizer.

Of course, the nature and knowledge of the soil had much to do with some of the increases shown, but undoubtedly fertilizer was a governing factor.

Russia, with poor cultivation and no fertilizer on its flax, gets 111 lbs. of fiber per acre.

Belgium, France and Ireland get 350 to 450 lbs. per acre. But from specially selected seeds over 1,000 lbs. of fiber per acre have been obtained in England and the United States.

The latter were from cultures developed in Ireland and known as JWS seed and Lirel seed.

Lirel seed grown in England yielded 1,120 lbs. of fiber and 784 lbs. of seed per acre.

JWS grown near Savannah, Georgia, yielded 6,251 lbs. of straw and 662½ lbs. of seed per acre and Oregon reports three to four tons per acre.

Savannah crop was given 500 lbs. of fertilizer to the acre, containing 9 per cent phosphoric acid, 3 per cent ammonia and 3 per cent potash.

A crop of 2 tons of flax takes from the soil 70 lbs. of nitrogen, 19 lbs. phosphoric acid and 44 lbs. of potash per acre.

Without knowing the nature of the soil and previous crops no one can prescribe the best composition of fertilizer to use.

Flax needs considerable moisture but should not be planted in wet soil, and should be sown as soon as safe from severe frosts so it will get the spring rains.

It would be well to plow in the fall, replow in the spring or thoroughly disk and harrow; then seed and harrow again and compact it with a heavy roller.

A stiff soil well rolled helps the flax to stand up against heavy rains and storms.

It should be harvested when the leaves fall off half way up the stems and the seed is well filled and turned brown; then stooked until dry enough to be stacked.

The customary method has been to pull it up by the roots to avoid moisture entering the ends of the stalks in the disagreeable process of water retting, also possibly because it was not easy to cut, but mowers are now made to harvest flax and machines of several types are now available for pulling it and cut ends do no harm in chemical retting.

Mowing costs $1.50 per acre, machine pulling $4.00 to $9.00 per acre and hand pulling $10.00 to $15.00 per acre.

Water retting takes from eight to twelve days according to temperature in rivers and ponds and three to five days in tanks with the water kept at a temperature of eighty to ninety degrees. In Russia flax is mostly dew retted and this takes several weeks according to the temperature and amount of moisture in the atmosphere.

Good judgment is required to know when it is best to stop the retting action. As a consequence there is an infinite variety of quality and color; the latter coming from soil water discolorations.

Fermenting vegetable matter is very unpleasant handling and the straw when saturated is very heavy.

The further process of spreading, drying and gathering again are tedious and expensive operations.

Chemical retting of the straw has also been tried but again the great bulk to be handled in and out of the tanks, drying, etc., is a heavy expense and in chemical retting the fibers are so minutely separated that it is exceedingly difficult, if indeed possible, to separate them from the shives.

For this reason a chemical degumming method has been devised and is now in practical use.

The straw is first decorticated and the fiber only passed automatically through the degumming liquid. In this way the decorticating of the straw is done at or near where it is grown and the fiber only shipped to a central point to be degummed.

Though not fully worked out, it is confidently believed that the gums and chemicals recovered in this process will more than cover the cost of degumming.

Another method tried is to bring the straw to a central point, pass it through a breaker and tow machine and chemically ret the tow. This has the disadvantage that only tow can be made.

Both of the latter, however, have the advantage that the green shives which have 7 per cent of protein and 3 per cent of fat, when mixed with a small amount of flaxseed make a fodder superior to most of the clovers.

Acids are not used as a rule in the degumming of flax. A moderate amount of alkalies does not attack or injure the fiber. In either case thorough washing is practised. None of the methods in use are near as drastic as those now used in bleaching linen.

A large percentage of the European crop, particularly that of Russia, is still cleaned by hand. It is first broken on V-shaped racks, then whipped with hard wood blades to remove the broken shives.

A great improvement (and the mechanical movement most in use) is the passing of the straw through a series of fluted rollers, then the broken straw is passed through a slot which is narrow enough so that the hand will not be pulled through it. The straw comes in contact with blades mounted on rapidly revolving wheels.

A later method is to pass the straw through fluted rollers, then place it on a carrying belt which conveys it between revolving horizontal intermeshing blades; the first set whipping one-half of the straw. Then its position is changed on the conveying belt so the other end may be whipped by the succeeding revolving intermeshing blades. This latter type is known as Turbine machines.

As it will be pointed out later, a considerable amount of the fibers do not run the whole length of the stalk but run out at many points between. Any device that beats from any intermediate point towards the root end will whip off these shorter branching fibers. It is in fact whipping against the grain.

Another type has a high speed revolving drum with blades mounted on it longitudinally. The straw is fed at right angles to the drum through rollers and over an adjustable edge parallel to the blades. When the straw is fed seed end first there is not the beating against the grain which happens in all the other methods. Therefore there is not so much tow.

The latest type, known as the Grant or Farmer's machine, weighs about five hundred pounds, occupies a space of four by five feet, and uses 3½ horsepower to turn out 300 to 350 lbs. of fiber per day and does equally good work on green or retted straw. It has the additional advantage that it de-seeds the straw and decorticates it at the same time.

Deseeding, threshing or rippling—each of which it is sometimes called—is usually a tedious hand operation.

With the Farmer's machine this is eliminated and is taken care of in feeding the straw to the reciprocating blades which do the decorticating.

This machine was designated the Farmer's machine because it is designed to operate on the farm with ordinary unskilled farm labor.

It saves the hauling of the bulky straw to a scutching mill and leaves the shives on the farm where they can be used for either fodder, or bedding cattle.

The machine is sufficiently inexpensive to come within the purchasing power of small communities or of farmers whose holdings are large enough to operate a tractor.

It cleans flax, hemp, jute and ramie perfectly. It does not make any tow and gets 28% of straight fiber from average flax.

The capacity of the semi-automatic machine is regulated by the speed with which the operator can withdraw a handful of flax from the sheaf and feed it into the machine.

The machine takes it instantly from his hand but the separation of the handfuls takes a little more time.

An average hand takes a bundle 7 to 9 inches in circumference. A bundle of flax of that size, thirty inches long, would weigh seven ounces and a medium operator should feed six per minute.

An assistant to separate the handfuls and pass them to the feeding operator would increase the speed one-third.

Fiber flax straw containing ten per cent of moisture yields twenty-eight per cent of decorticated (scutched) fiber. This fiber has about fifty per cent of extraneous matter holding together the ultimate staple of which its length is made up, and which it loses in the various processes of retting, decorticating, hackling, spinning, weaving and bleaching; until it becomes through these many handlings and laundryings beautifully soft linen.

This extraneous matter in present methods of water and dew retting and subsequent processes goes to waste; as does also the proteins and fats in the woody parts of the straw.

There are a number of leaf stems on the stalks—usually about twenty. At each of these leaf stems the fibers, starting at the root ends, run out so that only a portion of the fibers on the stalk runs its whole length. And these fibers again, when the extraneous matter is removed, resolve themselves into their ultimate lengths.

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A test on 27,880 lbs. of fiber flax straw water retted.

Weighed dry before being retted	27,880	lbs.
Weighed dry after being retted	15,060	lbs.
Showing a loss of 45.97 per cent in retting.		
When wheel scutched yielded in fiber 13¾% =	2,070¾	lbs.
When wheel scutched yielded in tow 4⅛% =	612	lbs.

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At the spinning mill.

The roughing took out tow weighing	92	lbs.
When roughed there remained of straight fiber	1,979	lbs.
This 1979 lbs. when hackled yielded in tipples	1,202	lbs.
This 1979 lbs. when hackled yielded in tow	707	lbs.
This 1979 lbs. when hackled yielded in lint & dust..	70	lbs.

Resulting in usable fiber.

1,202 lbs. Hackled Line
707 lbs. Tow from hackling
92 lbs. Roughing tow
612 lbs. Scutching mill tow
} Carded weighed 917 lbs. yarn

Yield of all fibers from dry straw weight	9.37 per cent
Yield of all hackled fiber from dry straw weight.	4.31 per cent
Yield of all tow yarn from dry straw weight...	5.06 per cent

The yarn from water and dew retted fiber loses from 30% to 35% in the boiling and bleaching process.

The ultimate fibers of flax are from ⅝ to 1¾ inches long and 1/10,000 inches in diameter.

They are brilliant white before spinning and a light creamy color when spun and of a cellulose composition held together by compounds of gum, waxes, sugars, etc.

In water and dew retting, through dilution and fermentation, these gums are partially removed, but enough remains to give the fiber the grey and brown hues familiar in commercial flax.

The beating of the wooden blades polishes this compound and the astute merchant puts a little grease on his hand giving it an additional luster and calls it "bringing out the nature of the flax."

The fact that over thirty per cent is taken off in the bleaching shows how much of the gums, etc., was left on in the customary method.

These gums, while they give cohesion to the fibers, do not add to the strength of the actual or ultimate fiber. In fact, they detract from the strength of the yarn as their presence keeps the fibers apart so they cannot be so easily or closely twisted together.

It is the number of fibers in each strand that gives it its strength.

Aside from the very marked improvement in the developing of new cultures of seed and the greater consideration given to the crop generally, the most material gain has been in the final perfecting of methods for chemical retting (degumming).

There are many known solvents for vegetable gums that will dissolve the gums without any injury whatever to the fiber.

This has been proven through the spinning of the fiber into very fine counts by several mills and the production of very superior linen. Efforts, therefore, have been concentrated on the economical handling of the fiber through the gum dissolving liquid, drying and the recovery of the gums, waxes and chemicals.

The speed of the fiber as it goes through the gum dissolving liquid regulates the amount of gum to be left on and this is under the control of the operator.

For spinning on flax mill machinery it has been found advisable to leave a much larger amount of gum on the fiber than is desirable for spinning on cotton mill machinery, but in order to get the fiber to the fineness and softness and color of cotton, it has been found necessary to remove practically all the gum. It has also been found necessary to remove absolutely all the shives and seed ends for there is no hackling of the fiber as in flax mills to do this.

It is also necessary to cut the fiber in defined uniform lengths to work it on cotton machinery. If it exceeds the distances between the centers of the drawing rollers, it will not draw regularly.

Therefore, it has been found necessary to keep the fibers straight and parallel in all its handlings until it is cut into the required lengths. If tangled, as in tow, there is no way of avoiding these greater lengths or of getting any uniformity whatever.

For flax spinning 33⅓% of gum is taken off and for cotton spinning 45%.

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Comparative test of 27,880 lbs. of dry straw scutched on the Grant Machine and chemically degummed for flax spinning machinery would yield

Weight of unretted dry straw	27,880 lbs.
Weight of scutched unretted fiber	6,970 lbs.
Weight of degummed fiber (35% loss)	4,531 lbs.

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Roughing not used	
When hackled yields in tipples	2,265 lbs.
When hackled yields in tow	2,209 lbs.
When hackled yields in dust & lint	57 lbs.

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Result in usable flax	
2,265 lbs. Hackled Line	= 8.11 per cent
2,209 lbs. Tow yarn—1,436 lbs.	= 5.11 per cent
	13.22 per cent

Chemically degummed flax loses from 10% to 12% in bleaching the yarns.

Comparative test of 27,880 lbs. of dry straw scutched on Grant Machine and chemically retted would yield

Weight of unretted dry straw	27,880 lbs.
Weight of unretted scutched fiber	6,970 lbs.
There is 45% loss of weight in degumming for spinning on cotton mill machinery	3,834 lbs.
1% loss in softening	3,796 lbs.
2% loss in carding	3,721 lbs.

Leaving of usable fiber—3721 lbs. or 13¾% from dry weight of the straw.
And 53.41 per cent from the scutched weight of the fiber.

The improvements in mechanism for harvesting, threshing and decorticating flax, in better yielding cultures and better treatment of the soil has brought flax in sharp competition with the best that can be done in cotton; and the spinning of it on cotton machinery at one-seventh the cost of flax spinning is going to entirely reverse the relative positions of these fabrics.

While three to four tons of straw and eight to fourteen bushels of seed are easily obtainable, I will base my figures on two tons of straw and eight bushels of seed per acre.

Rental of land	per	acre	$ 5.75
Preparing and planting	"	"	3.46
Fertilizing	"	"	1.87
Seed 1½ bu. JWS @ $3.27 per bu.	"	"	4.90
Extra harrowing	"	"	.50
Rolling	"	"	.50
Machine pulling	"	"	9.00
Stacking	"	"	1.00
Hauling, threshing & decorticating	"	"	15.00
			$41.98
Credit 8 bu. of seed @ $3.27			26.16
Cost of 2 tons of straw			$15.82
Pay farmer $25.00 per acre profit			25.00
Total cost of 2 tons of straw			$40.82

Degummed yields 667 lbs. fiber for flax mill = 6.01 cents per lb.
Degummed yields 550 lbs. fiber for cotton mill = 7.42 cents per lb.

Until the value of the recovered gums and waxes are fully demonstrated, two cents per pound should be added to these costs of degummed fiber, making them 8.01 cents per lb. for flax spinning and 9.42 cents per lb. for cotton mill spinning.

It costs 15 cents per lb. to produce water or dew retted flax fiber in Europe and Canada. In countries where labor is less expensive the production is proportionately lower so the costs remain about the same.

Harvesting by newly perfected mechanism reduces the cost from $15.00 per acre to half that amount.

The new method of scutching the straw from the stook or stack simplifies farm labor and skill to that of other crops.

The deseeding and scutching are done in one operation by farm labor and the shives which are good for fodder and fertilizer are left on the farm.

Mill scutching costs 5½ cents per pound. On the farm it costs 1½ cents per pound including the threshing.

Unretted straw yields 25% of unretted fiber and 65% of shives. The latter is good for fodder and fertilizer.

Retted straw yields 13¾% of fiber and the shives are only fit for burning.

There is from 40 to 50% shrinkage in water retting and it costs $30.00 per ton.

After the various mill operations there remains 9.37% (from straw weight) of spinning fiber and this loses 30 to 35% in bleaching the fabric.

The 25% of fiber obtained from green (unretted) straw loses from 30 to 40% in chemical degumming and yields of spinning fiber in the mill 13.22 to 13.75%. This in turn loses 5 to 10% in the final bleaching of the fabric.

The recovered waxes, gums, etc., are expected to cover the two cents per pound which chemical degumming costs.

Degummed flax is now being spun on cotton mill machinery without any change and without mixing with other fibers.

Spinning on flax mill machinery costs seven times as much as on cotton mill machinery.

It is generally estimated that the customary methods of producing flax based on European wages cost 15

cents per pound. New methods cost 9.42 cents per pound including a net profit of $25.00 per acre to the farmer.

Summary

The improvements in the mechanical harvesting, threshing and decortication of flax, together with the superior yielding seeds and better soil treatment will reduce the price to less than cotton. The spinning of flax on cotton machinery at the same costs as cotton as against the seven times higher price of flax spinning will enable the manufacturer to produce either staple at the same working costs. Linen being a more desirable fabric than cotton should reverse in time their present positions in the markets of the world.