J. Agril. Issues Vol. 9 (1&2): 01-08, 2004

AGRIHISTORICAL GENESIS OF FLAX (*LINUM USITATISSIMUM* LINN.)

D. SAHA and C.R. HAZRA*

Central Research Institute for Jute and Allied Fibre, Barrackpore 700 120 (WB) India
**Indira Gandhi Agricultural University, Raipur 492 006 (CG) India*

INTRODUCTION

Flax (*Linum usitatissimum* L) is a member of the plant family Linaceae. This family consists of about a dozen genera and nearly 150 species, widely distributed in the temperate and sub-tropical areas of the world. Flax is an annual herb with a slender, glabrous, grayish stem which grows up to a height of about 100-150 cm. and 0.15-0.35cm in diameter depending upon variety, soil conditions and length of growing season. The upper 10-12 per cent of the stem comprises of slender primary and secondary branches that bear the flowers and seed capsules. It has a distinct main stem and a short taproot. The varieties differ in their branching habits; those grown for fibre are almost unbalanced except near the top of the stem. The historical perspectives of this very important industrial crop bridging the oriental culture and western civilization are really very unique in its genesis.

MIGRATION

Flax (*Linum usitatissimum* L.) is not a new crop. There are six references to women and flax in the Bible, indicating that flax spinning and weaving were household industries in antiquity. The center of origin of flax is thought to be in the near East, but the exact area is still a topic of debate. A highly selected cultivars dating from 5500-5000 BC was found in Iran (Dempsey, 1975). Earlier flax types have been found both in Egypt and Switzerland. By 4000 BC the Egyptians had a highly developed flax industry. Other nations of the area also developed flax, and its domestication was well established in western Europe by the time of Charlemagne (742-814). China is also one of places where the flax was believed to be originated 5000 years ago. Common flax (*Linum usitatissimum* L.) was one of the first crops domesticated by man. Flax is thought to have originated in the Mediterranean region of Europe; the Swiss Lake Dweller People of the Stone Age apparently produced flax utilizing the fibre as well as the seed. Linen cloth made from flax was used to wrap the mummies in the early Egyptian tombs as well.

Flax has been used in food in Europe and Asia since 5000-8000BC, and the fibre of flax stem has been used for linen cloth, and many other uses. Approximately 200 species of *Linum* (flaxseed or linseed) are known (Carter, 1993). As a natural botanic fibre, its cultivation was practiced during ancient Egypt. The flax used to be planted in Nile River 10000-20000 years ago. Archaeologists found the linen fabric remains and stone flax sculpture in the tomb that existed before 5000-4000B.C. During the different periods of the human history, Egyptian, designed and unrivalled linen fabric delicately with high technology, During the Middle Ages of Europe, flax was planted in Switzerland, France, Britain, Belgium, Netherlands, Russian, Czechoslovakia, and Rome. In pace with wide-ranging planting of flax, the linen textile industry has occurred. In 1810, the French invented the linen loom. In the earlier nineteen century, the colonist took the flax to America. In the later 1900s, flax was delivered from Europe to Japan.

Flax was first brought to North America for its stem fibre to use in making of linen and paper. The stem fibre of flax makes a fine parchment paper. In the Northern Great Plains region of the United States and Canada, Flaxseed has been grown as a commercial oilseed crop for over 100 years. Linseed oil is pressed from flaxseed and further extracted with a petroleum solvent. Industrial linseed is not useable for food or feed, although the linseed meal remaining as a by-product after oil extraction is used for animal feed ration. Approximately 2,340,000 bu (60,000 tonnes) of flaxseed are used for food annually in Germany (Prentice,1990). Although cold-pressed flaxseed oil is not considered suitable for frying at high temperatures, flaxseed oil is used for low-temperature stir –flying in hundreds of villages in the flax-growing region of the People's Republic of China (Pan,1990). However, Flax has been with humankind long before Europeans' discovery of the Western Hemisphere. *Linum angostifilium*, the wild ancestor of flax, can be found from the Black Sea to the Canary Islands. *L. usitatissimum* (meaning "of greatest Use"), is the oldest cultivated fibre plant, with an evidence of its growth and use dating back to the fifth on millennium BC in both Mesopotamia and Egypt. While the former concentrated on wool production, the latter, employing the fertile fields of the Nile Delta, become experts at the creation of linen textiles that could not be rivaled in strength and fineness of weave today.

Egyptians turned the coarser, low-grade flax into rope and string; the finest quality was reserved for cloth making. Workmen's wives set up makeshift looms in the doorways of their dwellings to weave linen for household use, Female serfs and slaves worked endlessly in crews on large estates; in unlaundered tombs hundreds of sheets are commonly founds, stored up in anticipation of the departed's return. Linen fabric, millennia before coinage was invented, served as a medium of exchange and a measure of wealth.

L. angostifolium grows wild in Briton and was employed as early as 3000BC by the Swiss lake dwellers. Because these people centered their communities over swampy areas, many wooden and fibre artifacts have survived from their culture. Tools for flax preparation, hanks of spun thread and cloth of complex weave have all been found in the alkaline lake mud.

L. usitatissimum is believed by many historians to have been introduced into England by the Romans; by the 16th century, laws were enacted requiring that a quarter of and acre (one rood) of flax be planted for every sixty acres under cultivation. Linen and wool were the two most common fibres, often combined in linsey-woolsey, a fabric with warp threads of linen for strength and weft threads of wool providing bulk and warmth.

Some of the plants were left standing to ripen, and their seeds were collected for next years sowing as well as the preparation of linseed oil for medicinal use. The plants were uprooted, turned upside-down and the earth adhering to the roots shaken off. the seeds were cleared away. The stalks were cooked or dried in the sun, beaten and finally dressed with a hackle. The resulting fibres were spun by women into thread. Egyptian spinners often used two spindles simultaneously, with the flax lying on the ground or in a low container, which served as a sot of distaff, and sometimes the spinster stood on a foot-stool in order to have the greatest distance possible between the spindle and the flax.

AGRIHISTORY

Ancient Era: Flax has been used in the Middle East since the fifth millennium BCE. In Egypt its role was probably more important than in many other countries, as Egyptians rarely used wool, while cotton was unknown.A number of wall paintings in tombs (Petosiris, for instance, who had been a high priest of Thoth in Ptolemaic times) show flax being grown as a crop. The flax harvest usually preceded the wheat harvest. The flax plants were gathered in whole,

when they were in bloom, as better fibre could be produced from young plants. The Egyptians were well aware of this fact and attested in the documents.

Petrie (Kahun, Gurob and Hawara by W.M. Flinders) describes the spinning process thus, the size [of the 12th dynast spindles] braying from 7to15 inches long. The main difference from spindles of the XVIIIth dynasty is the greater depth of the whorl, and the long spiral groove for the thread at the top. There were used like the modern Arab spindles, most probably; the bunch of raw material after carding is loosely bound round the distaff, which is carried tucked under the left arm, the left hand controls the supply of fibre, dragging it out of the loose mass; the fibre as spun into thread is wound on the spindle below the whorl, and passes up the side of the whorl and through the groove at the top (a hook in the modern form) which prevents its unwinding. Then the right hand lays hold of the bottom of the spindle, and giving it a rapid spin between finger and thumb it is dropped, dangling by the thread from its top. While it continues spinning both hands are actively employed in dragging out the fibre (which comes off the distaff) into an equable thinness, which as it passes through the right fingers is immediately twisted into thread by the rotating spindle which hangs from it. As soon as the spindle has lost its spin, it is picked up by the right hand and reopened and more fibre is drawn out and supplied to lengthen the thread. When the spindle reaches too low to the ground it is supplied to lengthen the thread. When the spindle reaches low to ground it is taken in the right hand, the thread released from the top groove, and wound on the shank by tossing the spindle round in the hand; when wound up close to the loose fibre it is recaught in the groove and more spinning is continued. Woven linen has been known in Egypt since 5000BC. The oldest depiction of a loom was found at Badari on a pottery dish daring from the middle of the 5th millennium BCE.

The loom used to be horizontal with a wooden support for the warp beam and a cloth beam that could be rotated, to which the ends of the warp threads generally tied and onto which the woven clothe was wound. The warp yarns usually lifted with two little sticks (lease rods)in order to pull through the weft with the help of a shuttle, which according to a depiction already known in the old Kingdom. The weft used to be beaten in with a bent stick.

Two women generally used to work in the loom, in early times crouching as the looms used to be very low. But sometimes looms used to be made for three of even four weavers. The linen they generally produce could be exceedingly delicate. By 3000 BCE the Egyptian weavers were capable of weaving the finest of cloth with 64 warp threads and 48 weft threads per centimeter. About 6th dynasty (ca 2100BCE) cloth it was said, it was so fine it could be pulled through a signet ring. During the 11th dynasty the width of the cloth measured 160to 180cm. Vertical looms with heavy wooden frames came into use during the New Kingdom. A movable pole supported the warp beam. The lease rods lifting the warp yarns were worked with the help of a lever. The weft was beaten in with a comb and the cloth beam was at the foot of the loom. The weavers sat in front of it on little stools.The historical events as follows are very much promiscuous in terms of the usage of flax as an important ancient crop plants.

3,000 B.C. - Flax is cultivated in Babylon. Burial chambers depict flax cultivation and clothing from flax fibres.

650 B.C. - Hippocrates wrote about using flax for relief of abdominal, Theophrastus recommend the use of flax mucilage as a cough remedy.

1st Century A.D. - Tacitus praises the virtues of flax.

8th Century A.D - Chalemagne considered flax so important for the health of his subiects that be palled laws and regulations requiring its consumption.

15th Century A.D.- Hildegard von Bingen used flax meal in hot compresses for the treatment of both external and internal ailments

Modern era: Flax production was critical during both world Wars to make paint for military equipment, and as feed – flax cakes- for livestock overseas in WWI. Flax acreage dropped sharply WWII and again as synthetic fibres were developed, and almost disappeared by 1980 as latex paint displaced oil-based products. Today, flax is grown on limited acreage, but there is a renewed interest in the fibre for paper making and as healthy, edible oil.

The first mechanized method for spinning flax yarn was developed in France. Between 1810and 1820 Philippe de Girard was issued six patents relating to this new technology (Dempsey, 1975). To maintain maximum fibre length and quality, flax is pulled from the ground at harvest, rather than cut. Until World War II flax was mainly pulled by hand. Since then this extremely labor-intensive process has been mechanized, first by tractor drawn machines, and then by self-propelled pullers, These machines, along with specialized turners and dissevers, were mainly developed in western Europe in the 1959s and 1960 s, improving upon earlier U.S. developments during WWII and soon after, These technologies have greatly increased the speed and ease of harvest. They have also improved the utility of the inexpensive dew – retting process, whereby the pulled flax fibre is separated from cellulose and other stem parts by bacterial action in the presence of water (the dew) in the field. Field equipment and modern processing plant equipment have been further developed in western Europe during the 1980s and 1990s, allowing greater capture and separation of all classes of flax fibres while improving worker safety conditions. Thus, fibre recovery is currently about 25 per cent of total biomass yield, up from about 20 percent forty years ago. Flax breeding was very active in the United States during the 1930 and until the 1950s, but ceased by the early 1960s (Calvert and Mark, 1995). However, cultivars development has continued in Europe, especially in France, the Netherlands, and Belgium.

Ain-I-Akbari description about a linen that can be regarded as a matter of evidence that flax used to be cultivated in India during earlier times, but it has lost its ground since last two hundred years. It is the general conviction amongst the people that rapid strides in the development of jute crop cultivation and its associated industry. The historical existence of flax in India can be narrated as follows;

(i) The earliest evidence of commercial flax production in India exists at the beginning of the nineteenth century till 1850s. Experiments were conducted at Sahabad in the year 1837, Bullea in the year 1841, Monghyr in the year 1839, Punjab in the year 1854. Sargur and Nebuddah areas are best suited for the flax production.

(ii) It can be inferred that flax of marketable quality can be grown in Bihar, The North Western States, The Punjab and the Central States as well.

FLAX FOLKLORE AND CUSTOMS

Flaxseed as a Plug for Drains: Old- timers suggested making a temporary block for drains by partially filling a sock or pantihose with flaxseed and dampening it with water. A string used to be tied up to the end of the sock or pantihose makes future removal easy. The water-soaked parcel expends, effectively seal the opening into which it usually placed. It generally removed after the treat of sewer back up is over.

Linseed oil as a Rust Preservative: A practise common among farmers is to coat shovels, axes and other implements with linseed oil as a rust preservative. Linseed oil seems to dry and seal the surface without running off or evaporating.

Flaxseed as a poultice for Boils and Skin Abscesses: Roll about 3 tbsp of flaxseed in a 6-inch square of clean, white cloth. Twist either end tightly to contain the flaxseed. Holding the flax parcel by each of its two ends, dip the middle portion into a small bowl of boiling water. Wring it out, and place the poultice on the infected area. Cover it with a dry cloth. The

flaxseed retains the heat, providing relief to the infected area. Remove the poultice when it has cooled.

Flax as a gel for hair: Older women say that when they were young, women used to boil flaxseed in water and then, use the liquid as a setting gel for their hair. It apparently worked very well.

Agro-industrial Uses: Flax, *Linum usitatissimum* is one of the best fibres grown in temperate regions. Flax has two general markets, one group grown for its textile, and a second type grown for its seed, which is converted to linseed oil for paints and other industrial products, with a smaller but growing portion converted into linseed meal and oil as a health supplement. Flax plants range in height from 12 to 40 inches, and have shallow taproots. The same species is used for both fibre and seed, with breeding of specialized cultivars for the two different products. The seed-producing varieties have shorter stems and are heavily branched. The fibre varieties pursue stem development resulting in a taller plant more sparsely branched.

Flax has been cultivated for nearly 10,000 years, and was grown in North America as early as 1626. With the invention of the cotton gin in 1793, cotton became an inexpensive substitute, and largely displaced flax as a fibre source in the United States and Canada. Subsequently, flax has been cultivated in North America primarily for its seed (Mo, 1969). An estimated 12 million hectares grow textile flax, while 500,000 hectares are cultivated for the oil-seed variety (Wong, 1990). This crop has a specific gravity of 0.32-0.68, somewhat greater than jute and hemp, but comparable to bagasse. In light of nutrient requirement, flax can only be grown once every five years on a particular acreage (West, 1995). Flax and oil flax usually cultivated mainly for food and medicine, a little for fibre. In 1906, the fengtian Agricultural Experimental farm introduced some varieties of flax from Japan and planted them in the northeast of Chine successfully. After one century, it formed flax Industry in a certain scale in Chine where more than 140 flax material companies and more than 30 linen textile companies exist. There are more than 20 countries where the fibre flax is planted internationally, almost in Europe and Asia, especially in E.U. countries. The straw yield is 7500kg/hm^2, fibre yield is 1200-1800kg/hm, fibre content is 33 per cent in France, Netherlands, and Belgium, flax quality is in lead all over the world. There have been some flax groups, which united the flax planting, material processing and marketing together and they had remarkable benefit. Although all flax cultivars produce fibre in the stems and oil (linseed) in the seeds, fibre flax cultivars have been bred and selected specifically to produce large quantities of very long, high quality fibre with oil production only a secondary consideration. Flax produces fibres of varying length. The longest fibres can be used in making fine linens for clothing, draperies, and furniture, medium fibres have been used for canvas and geo-textiles, while short fibres have been used for paper and sacking.

Flax is a history lesson in itself. It was brought by colonists and planted for fibre to weave into heavy linen clothing. Linseed oil was extracted from the seed and used as a preservative and paint. As America moved west and urbanized, demand for paint jumped and flax production soared. A huge linseed oil and paint industry developed alongside the US's major flax growing areas of Minnesota and the Dakotas. The first manufacturer of prepared paints in the U.S. was in the Twin Cities, and over half of the major paint companies operated here. By the 1940s Minnesota produced half of the country's flax.

FLAX FOR A NEW CENTURY

As we head into the 21st Century, new markets for flax worldwide are soaring. These are partly fuelled by a movement, which distinguishes flaxseed as a nutritious food.

Naturally nutritious flax: Following the long-established eating patterns of others, North Americans are enjoying more flaxseed breads and baked goods. The use of flaxseed in

breads, bagels and other baked goods has tripled demand for flax in the food industry in North America this decade. Omega-3 enriched eggs from laying hens fed a special flaxseed diet are also gaining in popularity amongst consumers on the North American continents and abroad.

Environmentally friendly flax products: The flax industry is also springing forward with other flax products for a new century. Environmentally friendly flax products suit not only the world of today, but also that of the future. In manufacturing, new linseed oil products like Archer #1™ and Dilulin ™ have been formulated for modern products. These linseed oil products help manufacturers make their goods with less pollution.

In paints, stains and other coatings: Dilulin, manufactured by Cargill Limited, substitutes for petroleum-based solvents in a wide range of paints, stains and other coatings. It provides good coverage and protection, while reducing solvents, which are contributors to much pollution and smug. Solvent reduction is mandatory in many jurisdictions throughout the world. By adopting Dilulin, manufactures reduce solvent use and meet environmental regulations.

In particleboard manufacturing: Archer #1, produced by Archer Daniels Midland Co. (ADM), also satisfies environmental concerns. Archer#1 acts as a co-adhesive in particleboard and hardboard manufacturing. It replaces some petro-chemicals in these wood products, thereby reducing the discharge of pollution-causing compounds during the manufacturing process. The composite wood products' industry has experienced enormous growth recently, and is projected to produce about 33 billion square feet of oriented strand board in North America by the year 2,000, according to ADM.

In flooring products: Linoleum, flooring made of all-natural ingredients, also helps reduce pollution. Biodegradable linoleum decomposes completely when discarded, unlike petroleum-based vinyl floorings, which remain solid much longer.

THE FACTS ABOUT FLAX

Flax's high nutritional value makes it a popular choice among people demanding healthful and delicious foods. That's because flaxseed has a pleasant nutty flavour. Flaxseed is also rich in dietary fibre and lignans, plentiful in vitamins and minerals, and very high in essential fatty acid-a natural fit for better-health diets. The essential omegra-3 poly unsaturated fatty acid alpha-linolenic acid (ALA or LNA), found in flaxseed must be eaten as part of the diet. The body then converts it into two others: eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). They each play an important role in good nutrition. Evidence from dietary surveys and animal studies shows that omega-3s may reduce the rate of blood clotting and therefore the likelihood of heart disease. Nutritionists know that these fatty acids aid the proper development of the brain and vision in babies. Scientists also think that they have a beneficial role in other disease prevention, including hypertension, cancer, and inflammatory and immune disorders such as rheumatoid arthritis.

MODERNIZATION OF PRODUCTION TECHNOLOGY

When Sir George Yeardley returned to Jamestown in 1619, one of his instructions from the Virginia Company of London was to promote flax harvesting. The stockholders hoped that, as with silkworm cultivation, viticulture and glass production, the colonists would use this ancient crop to both realize a profit and diversify their labors.

Ultimately, none of these ventures was commercial success. The labor involved was either too intensive or required too much skill, the climate and soil of the Chesapeake region did not cooperate, or plain bad luck attended the operations That did not mean, however, that wine, silk or linen were never produced in Virginia. Although flax, the plant from which linen is

derived, never rivaled tobacco, as a cash crop in the Chesapeake, most farmers and plantation owners grew small amounts will into the 1800's for their own use.

The plant that provides the raw material from which linen is made is an annual, which grows two to three feet high on a slim, little-branching stem. It is this woody stalk, hollow when dried, which is harvested and ultimately manufactured into linen.

Spinning flax into thread is facilitated by properties inherent to the fibre, including its length (two to three feet when will prepared), its high pectin content (when wet, the pectin acts as a glue to further bind fibres together) and the nodes which appear along the length of the fibres (similar to those found on bamboo) which incline them to join even more readily.

Additional properties of flax make it a desirable finished product. Other than ramie, it has the greatest tensile strength of any natural fibre, and is 20 per cent stronger when wet, It is highly absorbent and dries quickly, and its high wax content gives it linen's characteristic luster. It is also long lasting. If not exposed to synthetic bleaches or mechanical drying, a regularly used linen sheet can survive for a century or more.

Making flax an even more valuable crop, the seeds can be harvested and linseed oil (used in wood treatments, paint and animal fodder) extracted. Although flax has many advantages as a fibre crop, its overwhelming disadvantage is the amount of labor, skilled and otherwise, required from sowing to harvest. Flax needs a deep, rich soil, and, like tobacco, quickly depletes the nutrients from the land where it is planted, In early settlement days in Virginia that meant it could only be raised on newly cleared ground, After two or three years of a flax crop, a farmer needed to sow a less nutritionally demanding crop, such as wheat Later in the colonial period, farmers could incorporate flax into a rotation process that included heavy dunging or the sowing of cowpeas a year or two before the next flax crop was to be planted. After ploughing in November, February and March, the ground generally harrowed and raked fine. The small, oily flaxseeds were sown broadcast in April and a final harrowing took place, The closer the seeds were spaced, the less branching took place in the resultant plants and the higher the quality of the crop. If flax is sown properly, weeding is unnecessary because there is no space for unwanted plants. Flax takes about a hundred days to mature. When the leaves become yellow and the seed turn brown, the flax is pulled from the ground by the roots, spread to dry for a few days, and, if time was not a factor, stored until the next year to age. Processing flax is an extremely labor – intensive process, providing skilled and unskilled employment for both adults and children. First, the upper parts of the flax bundles are drawn through coarse combs to remove seed in process called ripping. After the seeds are removed, it is necessary to separate the long, silky inner fibres which constitute the end product from the straw and inner pitch. Retting, in which the unwanted fibres are loosened and decomposed, can be achieved in several ways. The flax can be left out in the field, where the exposure to the elements, particularly the moisture in the air, can do the work. A pond or through can be used to achieve the same effect in much less time, but with a prodigious odor, The ideal way to ret flax is to expose it to constantly running water, such as a stream. The amount to time this step requires depends on the quality of the flax, the temperature and numerous other variables.

When the straw comes away easily from the few bent fibres, it is time to grass the flax. The bundles are untied and laid in a field for a few days until they are dried on one side, then turned so the other side can be dried. When the crop is thoroughly moisture free, it is stacked inside to age for few more weeks. Next, a series of steps free the linen fibre from the boon (unwanted plant material). The brake, a large wooden machine, is used to break down the trash material and loosen it further from the end product. Then the flax is scotched (beaten against a board with a blunt wooden knife). The final process is hackling, in which the fibre is drawn through a series of metal combs to remove the last of the boon and shorter fibres. The end result is a strick, a half-pound bundle of long, light grey fibres, which

resembles human hair. Over 85% of the plant has been removed before the strick is produced. Some of the shorter fibres removed during hackling can be used as tow for sacking or inferior cloth.

Since flax is such a long fibre, special care must be given before spinning to keep it from tangling. A distaff is a tool, which keeps the fibres separated and properly aligned during spinning. Thread is produced using the small wheel often called a flax wheel. An experienced spinner has little difficulty creating a fine, strong thread with flax. In order to produce a smooth yarn, however, she must also be able to moisten the flax continuously as she is spinning. After the thread is spun, it must be stretched and boiled to set the twist put into it by spinning. Bleaching can be done before or after weaving, by exposing the fibre to sunlight for prolonged periods or using such chemical treatments as chloride of lime, soap and soda or lye water.

Today, Eastern Europe produces 80 percent of the world's flax crop. France, China, Egypt, Holland and Belgium provide flax as well. Due to increasingly efficient mechanical harvest and processing, this ancient fibre is becoming more popular than a generation ago. Although it is mostly a crop of temperate region of the world, it is grown in India as well in a limited area of Himachal Pradesh, Hills of Western Uttar Pradesh and down hills of North Bengal requiring a low temperature ranging between 10^0c-25^0c during its growth phase from November through February. The relative humidity requirement is ranged between 60-70percent with a rainfall of 120-250 mm. Indian required around 1200 tons of flax fibre annually and its requirement is mostly fulfilled by import of raw fibre from Belgium and Holland at the cost of nearly 300-400million rupees every year for import of this fibre. Our national effort is on the way in developing high yielding varieties of flax through the selection from the germplasm collected from Holland and Belgium. Areas of flax cultivation in India has also been identified. Some of the available germplasm of the country could be characterized and evaluated. Targeting towards the augmentation of genetic variability in gene pool along side the necessary importance towards the propagation of dual purpose flax types for its multipurpose commercial exploitation at the global market for making this crop an important industrial crop of India as well will be the crux of newer paradigm shift in flax based agricultural, industrial and developmental research for sustainable flax based agro-economy.

REFERENCES

Calvert, L.J. and Marks, J. 1995. Is flax back? Oregon's *Agr. Progr.* 41(4)-42(2), 16-21.

Carter, J.F. 1993. *Omega 3!!* Report for the North Dakuta Legislature.

Dempsey, J.M. 1975. *Fibre crops.* Univ. Florida Press, Gainesville.

Mo, A.H. 1969. Flax article, Funk and Wagnalls New Enclycopedia, Vol. 10.

Pan, Q. 1990. Flax production, utilization and research in China. Proc. 53rd Flax Inst. p.59-63.

Prentice, B. 1990. Whither the end-product markets for flax? The emerging picture. Proc. 53rd Flax Inst. P 46-54.

West, D.P. 1995. Telephone Discussions and hemp slides to Erwin Lloyd and David Seber. Ga*me*tec. Prescott, Wisconsin.

Wong, A.I. 1990. *Bleached Flax Pulp Mill Prospectus.* Arboken, Vancouver, British Columbia.