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on

SOYBEAN PROCESSING AND UTILIZATION

SUBPROJECT 1

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SUMMARY

It begins to appear that the production of soybeans in India may be falling short of the country's demand for soya based products. Contributing factors include: 1) farmers tending to grow soybeans on marginal productive land, 2) new processing plants being constructed, 3) existing plants increasing their capacities, and 4) the development of new soya based foods. A successful Soybean Processing and Utilization Project is likely to create a need for additional production activity.

Research related to the handling, storage and aeration of bulk soybeans needs to be initiated as soon as possible since bulk storage and handling facilities are rapidly being constructed by grain buyers and processors. A demonstration and evaluation of the potential benefit of bulk storage of grain at the village level should be included as a part of this effort.

Construction of laboratory/office space, procurement of equipment, and the filling of sanctioned posts for the SPU Project need to be kept on schedule. Shortages of facilities and scientists are delaying an aggressive advancement toward meeting the objectives of the project.

Educational and technology transfer activity needs to be intensified by making use of the existing information and technology related to utilizing soybeans to enhance the protein level of the Indian diet. A coordinated cooperative effort between governmental agencies, educational and research institutions, and the private sector will be necessary if India is to achieve its timely goal of improving the growth and health of its people by the domestic use of soybeans.

Specific recommendations include:

1. Fill the sanctioned post, preferable an agricultural engineer, to investigate and monitor the handling and storage of bulk soybeans.

2. Investigate the potential of aeration cooling of soybean seed and bulk stored soybeans.

3. Initiate a research project on the development of technology for evaluation of soybean quality.

4. Review reported research, identify and prioritize future research endeavors.

5. Assign at least two extension specialists on a 100% time basis to disseminate information and technology.

OBSERVATIONS OF THE HARVESTING, DRYING, HANDLING, STORAGE, MARKETING AND PROCESSING OF SOYBEANS IN MADHYA PRADESH STATE, INDIA

Approximately 80% of the annual soybean production of India is produced in the Central India State of Madhya Pradesh. The flat valleys and other relatively level land areas and climatic conditions of the region are well suited to the growing of soybeans. Soybeans also fit into the double cropping pattern, fall harvest allowing the sowing of another crop, such as wheat, for spring harvest.

On November 11 and 12, 1986, discussions with Central Institute of Agricultural Engineering Scientists, visits to village farmers (cultivators), seed development corporations, and grain markets, all near Bhopal, were held to obtain information related to the production and marketing of soybeans. On November 19 and 20, soybean processing facilities were visited at Dewas, Ujjain and Indore.

Village Farmers

Soybeans planted in June and July, often on land not suitable for other grains, are generally harvested by sickle in October and November. The moisture content of the soybeans is critical to prevent excessive shatter losses. Farmers determine the time to harvest by observing the maturity of the plants and biting the seed with their teeth. To keep shatter losses to a minimum, soybeans must be harvested at a moisture content not less than 12%. Since the moisture content may drop several percentage points even in one day during the dry weather harvest season, a day or two delay in harvesting can result in a drastic increase in shatter losses. The sickle cut plants are transported to the threshing location by carts. Additional moisture loss while awaiting threshing and cleaning will result in soybeans placed in bags at approximately 10% moisture content.

Farmers produce both black and yellow soybeans. Yellow soybeans mature in 100 to 105 days, while black maturity requires 10 to 15 days less time. The earlier maturity of black soybeans allows the planting of some other crop which may not be possible following the harvest of yellow soybeans. The oil content of black soybeans is about 14%, as compared to 16% or more for the yellow, resulting in a market value approximately 5% less than for the yellow. This lower market value of the black is compensated for by an increased yield over the yellow providing farmers with about the same income from either variety.

Soybean yields in the Bhopal area are in the range of 8 to 10 quintals per hectare (704 to 880 lbs/acre) and it requires approximately 100 man-hours per hectare (2.5 acres) to cut with the sickle. Since delays of harvest must be avoided, several labourers will be employed for harvesting and threshing. All purpose mechanical threshers, rotating hammers against a slotted screen, powered by 220/440 volt, 5 to 10 hp electric motors are used to thresh 40 to 60 quintals (8800 to 13200 lbs) per day. The threshing causes a minimum of damage but discharges considerable amounts of broken plant parts, thus additional cleaning is required prior to bagging. Soybean damage is minimized by operating the thresher at a relatively slow speed, only about 500 rpm as compared to 750 rpm for wheat.

Another common method of threshing is treading by bullock. A thick mat of plants and the slow movement of the bullocks also causes very little damage to the soybeans. Two men and four pairs of bullocks can thresh about 20 quintals (440 lbs) in three days. Tractors with rubber tires are also used to tread thick mats of dry soybean plants. Treading is also done prior to mechanical threshing to decrease the amount of material put through the thresher.

Cleaning is accomplished by winnowing (allowing wind to separate the trash from the soybeans) or by mechanical cleaner (powered blower and agitated screens). During soybean harvest natural winds are light; therefore, powered fans must be used to create air movement through which the threshed materials is passed. Labourers dump material from small baskets into the air stream. A man powered cleaner is capable of cleaning about 8 to 9 quintals (1760 to 1980 lbs) per day. Air movement and two oscillating screens clean the grain very well. Man-powering the cleaner is not overly strenuous as a man can operate the cleaner continuously for one hour without rest. Electric motors are also used to power wind machines and mechanical cleaners. Other labourers, men and women, are required to feed the cleaner and bag the cleaned grain in a quantity of 80 to 85 kg (176 to 187 lbs) per bag. Sweepers, labourers with brooms, continually sift the discharged material and sweep the threshing floor to reclaim spilled grain. Unskilled labour is inexpensive, Rs.8 to Rs.12 ($1.00 to 1.50) per man or woman-day; therefore, labourers are often employed instead of investing rupees in mechanical equipment.

Mechanical equipment is available, some made in shops in Bhopal, and electrical energy for operating the motors not very costly. A 50% subsidy for agricultural use results in a net agricultural energy cost of only about Rs. 0.25 per kilowatt-hour. The larger farmers are purchasing mechanical equipment and sometimes a group of smaller farmers will cooperatively purchase a thresher and/or cleaner.

Farmers, particularly the smaller farmers cultivating from less than one to only several hectares, generally store only enough grain for their own use as food, feed or seed. Soybeans for food use or seed for the next planting are stored in gunny (jute) bags and/or metal and mud bins up to a tonne or more capacity placed in the living quarters. This provides a cooler and safer environment as compared to open sheds, but even so, high temperatures prior to June or July planting reduces the germination of the soybean seed.

Farmers do not perform any separate drying procedure to reduce the moisture content of harvested soybeans. As previously indicated, the natural moisture loss occurring during harvesting, threshing, and cleaning results in a soybean moisture content of about 10%. However, if more drying is required it would be accomplished by exposing the soybeans to the sun for an additional period of time.

Marketing

Farmers transport their bagged soybeans to the market place by bullock cart, tractor trailers or hired trucks. The market operates on the basis of open bidding 1/. Buyers representing processors or grain traders make their bids based on their judgment (visual observation) of the grain's quality. On November 12, 1986, at Bhopal, black soybeans were selling in a range of Rs.325 to 330 per quintal ($26.00 to 26.40 per 220 lbs) and yellow soybeans in a range of Rs.340 to 345 ($27.20 to 26.70). During the following two weeks the price increased to around Rs.400. A charge of Rs.1.50 is levied against the farmer for handling and selling. The selling lots range from only a quintal or two up to perhaps 17 to 20 quintals. After the bidding is closed the grain is weighed, often by beam balance scales, and bagged at 85 kg per bag. The farmer receives cash immediately, having been at the market no longer than perhaps about three hours. He does have the option of leaving his grain at the market place for a few days, at no storage charge, if he chooses to sell later hoping for a better price. The cooperative societies buy from their member farmers at fixed price.

The purchased, weighed, and bagged grain is loaded directly, or within a day or two, onto 20 tonne capacity trucks for transport to the processors, Bagged grain at the market place not under roofed, open cubicals is covered with tarps in the event of rain. Since the bags are stacked directly on the ground it may be necessary to construct mud diversion dams around the stacks. Some market places have or are in the process of constructing metal bins and silos for bulk storage of soybeans.

1/ In early December, 1986, some foodgrains changed hands under the kachchi adat system in which farmers receive payment from a middle man and deliver their grain to a third party.

Farmers rarely deliver soybeans containing a moisture content exceeding the allowable limit of 10%. If they do, a lower bid price is reflected because additional drying may be necessary. This lower bid price discourages sellers from marketing any overly moist soybeans. Likewise, the allowable limit of 2% mud (dirt) is rarely exceeded. However, if necessary, unclean grain can be cleaned at the market place with an electric powered mechanical cleaner.

A governmental agency also establishes support prices for grain. In November, 1986, the support prices for soybeans were Rs.255 and Rs.290 per quintal for black and yellow soybeans, respectively. In general, supply and demand keeps the price of soybeans above the support prices.

Farmers are satisfied with the marketing procedure, receiving a fair price for the quality delivered. Experienced buyers are able to visually access the quality of the grain purchased without the aid of instrumentation or mechanical devices to measure quality factors.

PROCESSING

Processors receive soybeans in bags delivered by truck. The bagged grain is stored in open piles (covered with tarps in the unlikely event of rain, except during the June to September rainy season) or in warehouses. Most processors store only enough soybeans to operate their plants for two or three months. A replenishing supply moves from the market storages almost on a continual basis except for the rainy months. Some processors have or are constructing large bulk soybean storage facilities. The capacity of these warehouses or concrete and metal silos will be in the range of 5,000 to 15,000 tonnes (183,333 to 550,000 bushels, based on 60 lbs/bu). The storage period in these bulk storage facilities will be extended to five or six months. Mechanical conveyors will be installed for loading and unloading. Some units will be equipped with temperature sensors and provision made for aerating the grain.

Most of the soybeans are processed for oil extraction by hydraulic expellors or with solvents like hexane. The extracted oil is refined and marketed in India. Soybean meal is obtained from the deoiled cake by grinding the soycakes, flakes or chips, which are the by-products of the oil extraction process. Most of the meal is exported to other countries for use as animal and poultry feed. However, soybean meal contains 45 to 50% protein and is a source of lysine and other amino acids. Some processors are producing lysine and/or food products such as soya flour or soy milk. Other processors express concern about the strict micro-organism limitation placed on soybean meal used for food products and are reluctant to invest in food product preparation equipment.

Summary

The production and marketing procedures for producing soybeans appear to be relatively efficient with total losses during harvesting, handling, marketing, and storage in the range of 8 to 10%. The system is, however, very labour intensive and opportunity does exist for decreasing losses at most all points throughout the total chain of events. Mechanical drying is used on a very limited basis, as well as is bulk storage. As soybean production increases, buyers and processors construct bulk storage facilities, and processors demand high quality soybeans for food products production, a need will undoubtedly develop for increased activity in mechanical drying and aeration of stored soybeans.

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SOYBEAN PRODUCTION IN ILLINOIS

Soybeans are a major crop in Illinois, second only to corn (maize). The combined production of corn, soybeans, and some other grains such as sorghum and wheat makes Illinois an important grain production area of North America. Illinois, which lies approximately 3 degrees on either side of the 40 degree north latitude, has deep, black, fertile, wind blown soil. Annual precipitation received in the form of rain and snow is adequate in most of Illinois for growing grain without the need for irrigation.

Illinois farms range in size from a few hundred acres to several thousand acres. Most farmers produce corn and soybeans, both often serving as cash crops only. Corn is utilized as animal and poultry feed and processed for food products. In recent years some corn has been used for the manufacture of ethanol. Soybeans are mainly processed for their oil content. Illinois also exports large quantities of corn and soybeans. The general flow of soybeans from the point of production to final use is illustrated in Fig. 1, page 13.

Soybean Harvesting

In Illinois, soybeans in most years dry in the field to at least 13% moisture content, but seldom to below about 10%. Some farmers harvest at moisture contents above 13% to decrease field shatter losses, to continue harvest when soybeans regain moisture during wet weather, and to complete harvest earlier so they can commence the harvesting of corn. The wet soybeans will be dried to at least 13% moisture content in bin dryers using no or moderate amounts of heat or in heated air dryers with air temperatures not exceeding 40°C (104°F).

The weather conditions in Illinois during the soybean harvesting months of September and October consists of daily high temperatures in the range of 21 to 26°C (70 to 80°F) and minimum night temperatures of 1 to 4°C (30 to 40°F). The daily mean wet bulb temperature depression during these months is 3.3 to 4.4°C (6 to 8°F) creating mean daily relative humidities of 60 to 70%. During the night, relative humidity often increases to the point of saturation and heavy early morning dews often occur. These moist conditions cause the soybeans to absorb some moisture, which is desirable if the soybeans have previously dried to a moisture content less than 13%. Farmers often combine during the morning hours when shatter losses will be less as compared to late afternoon harvest when the soybeans will have again lost this reabsorbed moisture. Also operating combines during the night hours when conditions are less dry is not unusual.

The combine is the same machine used for harvesting corn with the corn row head replaced by a small grain sickle bar header. Even though changing the headers may require an hour or two of time the change is sometimes made to allow morning harvest of soybeans followed by afternoon harvesting of corn.

The grain is transported from the field in tractor-drawn side draw off wagons or in trucks equipped with hydraulic lift beds. Screw conveyors (rotating augers in tubes) are the common conveying devices for loading and unloading farm bins. Many farmers store soybeans on their farms at harvest and market later when they hope to obtain a better price. Other farmers, lacking sufficient storage facilities, will transport the grain to market (a local country grain elevator) at the time of harvest.

Soybean yields are measured in 60 pounds (27.3 kg) units at 13% moisture content, referred to as a bushel. The volume occupied by this quantity is approximately 1.25 cu.ft. (0.0354 m^3). Rain-grown yields in Illinois are in the range of 35 to 55 bushels per acre (23.9 to 37.5 quintals/hectare). The main harvest losses are due to improper combine adjustments, including the cutter bar height. A careful operator can keep harvest losses to less than 2%, unless overly dry conditions make it nearly impossible to avoid shatter losses.

Soybean Drying

Although mechanical drying of soybeans is not a common practice by Illinois farmers, harvesting soybeans at moisture contents of 14 to 18% can reduce shatter losses and make the time of harvest less dependent on favorable weather conditions for field drying. Mechanical drying of soybeans is accomplished with the same equipment and procedures that are used for the drying of corn.

Mechanical drying includes two general methods, i.e., drying with unheated air or with air which has heat added to increase its temperature. Unheated air drying is performed by placing relatively deep beds (2 to 7m) in bins equipped with perforated floors and electric motor driven fans. Drying will require a day or two up to several days depending on the moisture content of the grain and the quantity of air supplied. During the drying of corn, stirring machines are often installed in the bins to stir and mix the deep beds for more uniform moisture removal. Since soybeans are required to be dried only three to five percentage points they are not usually stirred while being dried.

Heated air drying is also performed in bins by heating the air with liquidified petroleum (L.P. Gas), electrical resistance heaters, biomass combustion units, or solar energy. Small amounts of heat added to increase the air temperature less than about 5.5°C (10°F) will not require stirring of the grain. Greater temperature increases will require the grain to be stirred to avoid excessive over-drying of the grain in the lower portions of the bin.

Batch and continuous flow heated air dryers are also used to dry soybeans. The fans on these farm dryers are usually driven with a tractor power-take-off, although increased distribution of three phase electric power to rural areas or the installation of phase converters has resulted in the use of large electric motors on some farm dryers. L.P. Gas is burned in direct fired burners, i.e., the products of combustion pass through the grain being dried. Excessive splitting of the soybeans will likely occur if the relative humidity of the air is decreased much below 40%; therefore, it is recommended that the drying air not be heated above 32 to 38°C (90 to 100°F). Even at these temperatures some splits will be generated.

The amount of moisture removed in drying soybeans and the moisture content to which soybeans will equilibrate for various air conditions are given in Appendix B.

Soybean Aeration and Storage

Since the price of soybeans in the U.S. markets is based on a moisture content of 13%, Illinois farmers attempt to store and deliver soybeans with a moisture content as close to 13% as possible. During the months of November through March in Illinois the ambient temperatures are low enough to allow the storage of 13% soybeans without difficulty. A lower moisture content of 11 to 12% is more appropriate for storage during April through September.

Soybeans stored on the farm are placed in large capacity metal bins often equipped with perforated floors. Although some bins have air ducts on the floor or embedded in the floor, perforated floors provide a more uniform distribution of the drying air or the cooling air. Aeration to cool the grain is recommended and is employed by the majority of the farmers. If the bin is equipped with a large drying fan it will be operated periodically for short periods of time. Smaller aeration fans are often operated continuously or sometimes controlled by an automatic controller to decrease the energy consumption.

Because of the relatively low temperatures existing during the majority of the storage period insects are rarely a problem; therefore, soybeans seldom require fumigation. The low winter temperatures allow the soybeans to be cooled to -3 to 3°C. Some farmers even cool their grain to lower temperatures which requires additional fan energy and such low temperatures are not necessary to control fungi growth and insect activity. Cooling the grain to a very low temperature can also cause condensation of moisture to occur on the grain when it is removed from storage during warm temperatures in the summer. This can be prevented by gradually warming the grain by operating the aeration fans during the spring and early summer months. Of course, this practice also increases the energy consumption; therefore, cooling to below about 0°C is not generally recommended. The approximate time required to produce a 5 to 10°C temperature change, cooling or warming, of grain is given in Table 1.

Table 1. Approximate Grain Cooling or Warming Times

Air Flow Rate M^3/min-tonne or cfm/bu	Cooling or Warming Time hours
1/20	300
1/10	150
1/5	80
1/2	30
3/4	20
1	15

An aeration cooling cycle is started whenever the average day-night air temperature is 5 to 10°C cooler than the grain. A lower grain temperature can be achieved earlier in the season by aerating only during the cooler night hours. However, because of less hours of operating time per day, the airflow rate should be greater than that provided for continuous aeration. Normally, cooling air is drawn downward through stored grain, counteracting the tendency of warm air in the grain to rise. However, when a large drying fan is used intermittently for aeration it is not necessary to reverse the direction of airflow. The high air volume of the drying fan changes the grain temperature in a few hours; therefore, upward airflow is satisfactory. Upward airflow may result in some condensation as warm, moist air is exhausted from the surface of the grain; however, the air high airflow of a large fan will evaporate any condensation rather quickly.

Measuring the temperature of the air exhausting from the grain gives an average grain temperature. If "hot spots" are suspected, a grain temperature probe or a thermometer lowered down a pipe thrust into the grain is used to check the temperature at several points. Normal aeration procedures may correct small hot spots. Large hot spots may require that grain be removed from the storage. Unusual odors, particularly moldy or musty odors, are an indication that immediate action be taken to determine and correct the problem.

If any change in the moisture content of the stored grain is undesirable, the grain will be aerated with air in moisture equilibrium with the grain. This is considerably more critical with the high airflow generated by a drying fan. Aeration airflows of 1/10 m^3/min-tonne or less cause very slow and small exchanges of moisture between the air and the grain. If the average condition of the ambient air over a period of weeks, or even months, is nearly in equilibrium with the stored grain moisture content the aeration fans can be operated continuously with little, if any, change in the moisture content of the grain.

Automatic aeration controls, including the availability of programmed micro-computer controllers, take advantage of favourable weather conditions for more precise aeration and perhaps reduce the fan energy consumption for large amounts of stored grain. Manual operation is more practical for relatively small amounts of grain.

The electrical power requirement of the aeration fans will be influenced by airflow rate, kind and depth of grain, and the aeration cycles (operating time) required during a storage season. However, aeration of grain to control its temperature and to keep it cooler than non-aerated grain is good insurance towards maintaining the quality of grain during storage. Annual electrical energy costs for properly designed, installed, and managed grain aeration systems in the U.S. will usually be less than one cent per bushel (less than Rs.5/tonne).

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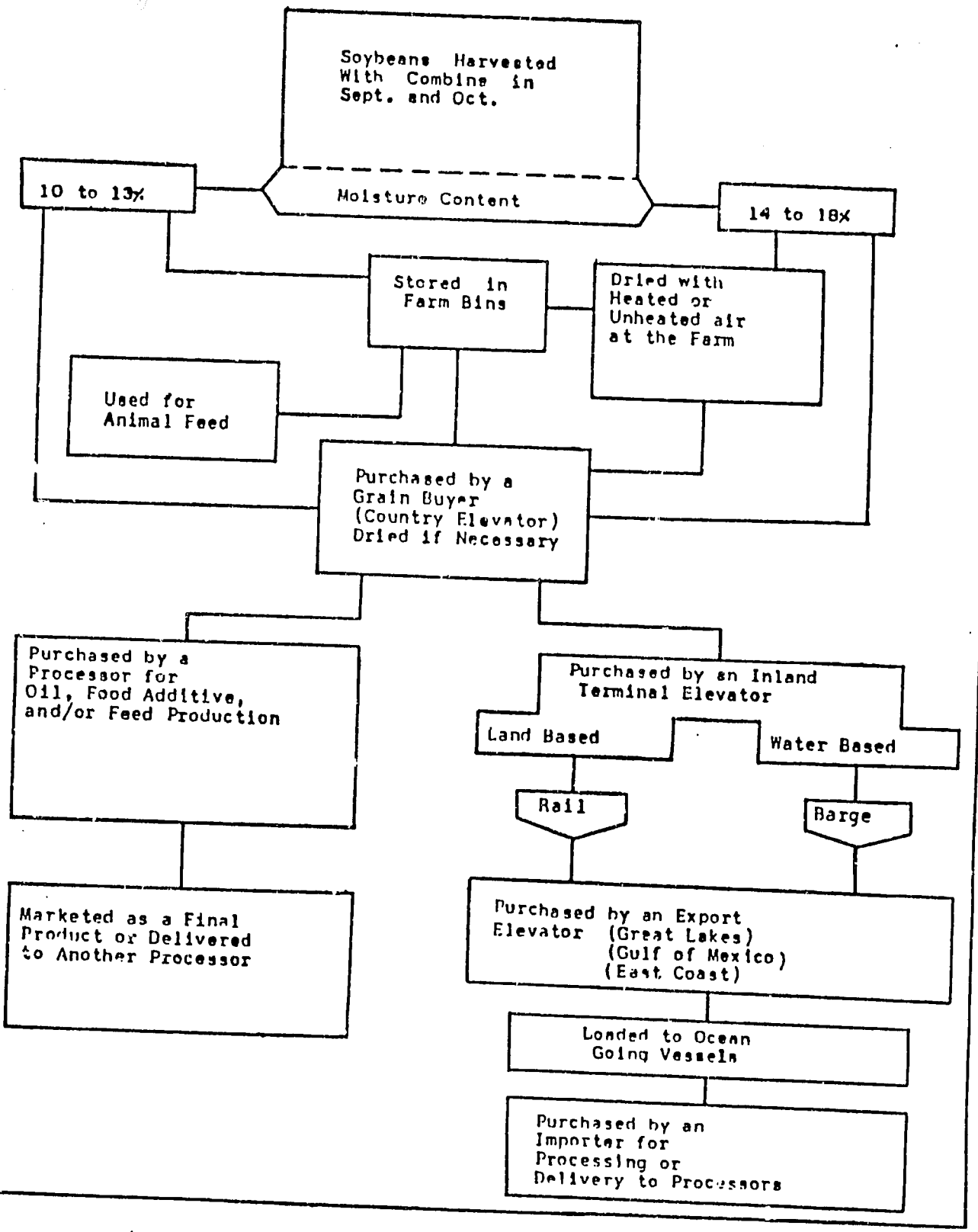
Fig. 1 General Flow of Soybeans from the Point of Production in Illinois to Final Use



SEED PROCESSING IN MADHYA PRADESH STATE, INDIA

Seed production and processing were discussed with Mr. Ajit Singh, Deputy Manager and Mr. Ramraj Karsoliya, Chief Engineer, Madhya Pradesh State Seeds and Farms Development Corporation, Bhopal on November 12, 1986. Seed production was also discussed with Dr. M.D. Tedia, Director and Mr. Anil Sharma, Amalah Farm, Sehore District, M.P. State Cooperative Oilseed Growers' Federation Limited on November 20.

The M.P. State Seeds and Development Corporation has the responsibility to produce, process and distribute seeds of different varieties of various crops to farmers. This program, begun in 1983, calls for the production of certified quality seeds of different crops on Corporation Farms, Government Farms, and farmer's fields in different areas of Madhya Pradesh.

The M.P. State Seeds and Farms Development Corporation has 64 farms throughout the State where seeds are produced and also obtains seed from Government Farms and from cultivators (farmers). Harvesting soybeans for seed is not unlike harvesting soybeans for processing. Soybean plants are harvested by sickle (10 men/acre/day) and transported to a threshing floor. The seed moisture content at harvest is in the range of 12 to 14% and yields are 6 to 9 quintals per acre. Threshing is accomplished by bullock treading with minimal damage. Two men and four pairs of bullocks can thresh about 20 quintals in three days. By the time threshing and cleaning is completed the soybean seed will have dried to a moisture content of 8 to 10%.

The Corporation processes seed in 26 processing plants where contaminants are removed, seeds cleaned, sized and graded. Three samples are taken from 200 quintal lots. Two of the samples are sent to the laboratory for germination tests. The third sample is retained as a file sample for one growing season. Germination must be at least 70%. The seed is bagged at a moisture content of 10% or less. Chemical protectants may be added directly to the seed or sometimes are placed in the bags in sealed containers if there is a possibility the seed might not be planted. This allows unplanted seed to be used for other purposes. The bagged seed is tagged as to variety and germination and placed in warehouses for storage from November to June.

The processed and certified seed is sold for cash to the Corporation's 64 farms and to registered and licensed private dealers. Some seed is consigned to government agencies. The major portion of the certified seed is distributed to farmers through cooperative societies. Payment to the Corporation for this seed by the cooperative societies can be kept in abeyance for 45 days which lessens the societies' distribution risk. The price for sale of seed to farmers is established by the Corporation. The cooperative societies and the private dealers receive a 10% commission for handling and selling. It is estimated that 75% of the farmers are members of cooperative societies and that about 20% of the seed sown annually in Madhya Pradesh is certified seed.

The Cooperative Oilseed Growers' Federation also develops and grows soybean seed for farmer members of Oilseed Cooperative Societies. Land for growing seed and laboratory facilities for analyzing seed are available at the Amalah Farm, Sehore District. Not only is OILFED involved in development and multiplication of high yielding varieties of soybean seed, they have taken an integrated approach to production, marketing, processing and utilization. Their objective is to increase soybean production by organizing producers cooperatives to ensure procurement of soybeans for their processing plants, while at the same time paying a premium price to the farmer members. At district farms they expect to evolve new techniques and cultural practices and to train and assist farmers in adopting these practices through intensive extension programs.

Concern about the soybean seed germination was expressed by the Corporation and by others. Although the 70% minimum is being achieved they believe it should and can be increased. They are also very much aware of the damaging effects of high temperature during storage on seed germination. Bagged seed stored in warehouses is not being aerated. The potential exists for achieving some temperature modification of stored soybean seed by controlled operation of properly designed and installed aeration equipment.

SOYBEAN SEED HARVESTING, DRYING AND STORAGE

Quality soybean seed production begins with the harvest of fungi free, undamaged seeds grown as near optimum conditions as possible. Proper growing conditions include weed free fields with sufficient moisture throughout the growing season to insure the maturity of viable seeds. Methods of harvesting soybeans for seed varies from direct field combining in mechanized countries, such as the United States, to hand sickle cutting followed by bullock treading as a means of threshing in less developed countries.

Soybeans are susceptible to damage, particularly splitting of the seeds, at moisture contents below about 12%, wet basis; therefore, it is preferable to harvest seeds having moisture contents above 12%, even as high as 14 to 16%. One problem of harvesting at higher moistures is that all seeds may not have uniform maturity. Immature seeds will increase grading requirements and may reduce the germination level of a final seed lot.

Threshed seed having a moisture content in excess of 12% will require drying to least 12%. Successful drying methods vary from the use of highly mechanized heated air dryers to sun exposure on drying floors. Soybean drying studies have indicated that when the relative humidity of the drying air is below 40%, stress cracks and splitting can be induced in the seeds. Since a temperature rise of 10°C will reduce the relative humidity of air to about one-half of its value prior to heating, both selection and management of soybean seed drying equipment is critical. Unheated air or very low heat input bin dryers are ideal for drying seed. The rate of drying will depend on the volume of air supplied, generally limited only by the investment which can be economically justified for purchasing fan power and energy. Controlled temperature and relative humidity drying is possible; however, the cost of equipment to precisely control relative humidity usually discourages using this method, even to dry relatively high valued seed.

Once high quality seeds have been produced, properly dried, cleaned, sized, graded, treated, labelled and bagged they must be stored up to nine months before being planted. Seed moisture content and storage temperature are the critical factors in maintaining germination during long term storage. Mechanical dehumidification and refrigeration equipment is used to maintain optimum seed storage environments in industrialized and mechanized nations; however, a lower level technology must often be employed in lesser developed countries. The storage problem is magnified by the fact that the climatic conditions in these countries is most often hot and dry or hot and humid.

Soybean seed storage investigations conducted in the U.S., Puerto Rico, and India are examples of studies with the primary objective of developing simple and inexpensive methods for maintaining seed quality during storage. Drying the seed to a moisture content of at least 10% and maintaining this moisture by placing the seed in sealed containers has proven effective in reducing loss of seed germination. Further germination loss can be achieved if storage temperatures can be lowered.

In areas of hot and dry climatic conditions there is a potential of utilizing evaporative cooling to lower the temperature of sealed seed storage containers. Effective methods of taking advantage of the evaporative cooling principle merit some additional investigation.

Cooling of stored grain is a well developed procedure in regions of cool or cold climatic conditions. Aeration equipment, consisting of electric motor powered fans, air distribution ducts or perforated floors, is installed to move relatively small amounts of naturally cool air through stored grain. Nearly all regions, including hot and humid areas, experience a daily variation in temperature. Effective methods and management procedures to take advantage of lower night time temperatures to modify seed storage environments also warrants further investigation.

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TOUR OF SOLVENT EXTRACTION PLANTS

A brief tour report of Dr. Nawab Ali, Project Director, SPU Project along with Dr. Gene C. Shove, SPU Project Consultant and Dr. M.D. Tedia, Director (P&E), MPOILFED during November 19-20, 1986

(Prepared by Dr. Nawab Ali)

The team visited three solvent extraction plants located at Dewas, Ujjain and Indore. Two plants are in private sector and one in public sector, i.e., owned by MP Oil Federation.

1) Prestige Foods Limited, 6-B Industrial Area II, Dewas 455 001.

This plant is running about 250 days in a year and having a capacity of 200t of soybean per day. In oil extraction, it consumes 8 to 10 litres of Hexane per tonne of soybean crushed. 17.5% oil is recovered. Oil content in DOC is in the range of 1.2 to 1.5%. The Prestige Foods are expanding their capacity of crushing by installing another plant in the nearby area having 350t per day crushing capacity. It is under construction and they hope that by January/February, 1987, they will put it in operation.

They purchase soybean of yellow variety @ Rs.400/q and black variety @ Rs.375/q. This price was existing in the market in the 3rd week of November, 1986. The DOC/soybean meal is exported by this plant to some of the countries located in middle east. The export price ranges between Rs.2,000 to 2,500/t.

The company markets the oil produced in this plant after refining under the trade name of Prestige Soy Oil. Mostly it is placed in 15 kg tin containers.

The soybeans purchased by the firm are stored in gunny bags over a dunnage in flat godowns. They are also constructing three bunkers having a total storage up to 42,000 tonnes (14,000 tonnes in each bunker). This will last the firm for about six months of crushing. The company has plans to purchase 80,000 tonnes of soybean in 1986 and increase its purchase in 1987 to 1,15,000 tonnes.

The Prestige Foods also have a small laboratory for analysing the oil content in soybean and in DOC. Facilities for analysing the quality of oil in their small laboratory. This firm also has a cattle feed plant where they use some of the soybean from the plant to manufacture cattle feed.

2) Soybean Oil Extraction Plant of MP Oil Federation, Govt. of MP located at Ujjain.

This soybean solvent extraction plant is under the regional Soybean Processors Cooperative Union Ltd. as a part of MP State Cooperative Oilseeds Growers' Federation Ltd. and technical/financial support by National Dairy Development Board. The plant capacity is about 400t per day. It is built over an area of about 40 hectares including the plant office and some residences for essential staff with a provision for future expansion to double the capacity of the existing plant. The total estimated cost of the complex is 200 million rupees.

The plant has been laid out very nicely. It has a raw material receiving section with storage facilities, pre-processing unit, oil extraction unit, oil refining unit, use of by-product such as gum, etc. for making lecithin. The storage facilities for finished products such as oil, soy-meal, etc. are also there. The plant has two boilers. The bigger one has a capacity of 15 t/hr steam and the smaller one has a capacity of 5 t/hr of steam. The bigger boiler serves the purpose of oil extraction and the refining section. However, when only the refining section is run, the 5t boiler is used for steam generation.

Raw Material Storage: The plant has raw material storage capacity of 35,000t in 5 circular shape concrete silos of 7,000t each. This storage capacity serves the plants for three months. The facilities to the silos and measurement of temperature at 36 points are connected with a computer programming system. Some of the soybean are also stored in bins and in bags over a dunnage covered with tarpaulin. This storage is generally for a period from December to March.

Preparatory Unit: This unit has a storage capacity of 800t in two bins of 400t each, known as day bins. This serves the plant for day to day requirement. It also has a storage facility of 400t in two bins of 200t each. Besides this unit, the preparatory section of the plant has machines like cleaner and grader, destoner, cracker, dehuller and flaker.

Extraction Unit: This has suitable extraction unit using hexane, installed by M/s De Smet. The provisions are there for desolventization of soymeal, to produce edible grade soymeal of 40 t/day capacity. It is possible by using low temperature to desolventize hexane under vacuum.

Refining Unit: Various machines needed for this have been installed and the Oil Federation is producing soybean oil under the trade name "Soyagold". Packing is done in 15 kg tins. They are also likely to start packing of this oil in 1 and 5 kg containers. The present cost of Soyagold is about Rs. 300 per 15 kg tin.

Storage Facilities: The storage facilities of crude oil up to 6,000t and refined oil upto 600t are there. Bagged storage facilities are provided to store 7 to 8 thousand tonnes of soymeal in gunny bags under godown. Storage of edible flour will be made in plastic-lined gunny bags. The storage facility provided is about 1,000t.

The Federation receives soybean from growers through 600 soybean growers societies located in 13 districts of Madhya Pradesh. The moisture content of beans at the time of procurement is 7 to 8% with 5 to 6% damaged grain having an average oil content of 18%. Black and yellow soybeans are procured and stored separately. At Ujjain only yellow soybeans are crushed. The black soybean procured by the Federation is sent for crushing to its Sehore plant.

3) General Foods Private Limited.

This solvent extraction plant is of 250t per day capacity. They produce soy-oil under brand name of "Soyum Oil" in 1 kg and 5 kg containers and in the trade name of Tulsi Soy-Oil in 15 kg containers. The deoiled soymeal is exported to other countries.

Visit to M.P. Scate Cooperative Oilseed Growers' Federation Ltd. (OILFED) Soybean Extraction Facility near Sehore, December 6, 1986, accompanied by Dr. Nawab Ali, CIAE and Mr. Soni, Agricultural Engineer, OILFED

Mr. Pradeep Sharma, Production manager, explained the flow of soybeans through this modern oil extraction plant, which started operating April, 1986, and by December had processed over 200,000 tonnes. The facility has a capacity of 200 t/day. Soybeans with moisture contents of 7 to 9% are received in 90 kg bags on trucks from OILFED Cooperative Societies. After weighing the soybeans are unloaded into two 7,500 tonne godowns. Yellow and black soybeans are kept separated and are processed separately. Bags are opened and dumped manually onto a 40 t/hr conveyor to begin their journey through the automated plant. The soybeans are elevated into a 300t day bin from which beans for processing flow by gravity. The beans flow in order through a Buhler cleaner, destoner, cracker and de-huller. Magnetic particles are also removed. A Vetter conditioner adds moisture to increase moisture content to 9% prior to flaking. The large flaking rollers rotating at 220 rpm are powered by two 60 hp (45kw) 960 rpm electric motors. The flakes then enter into the oil extractor where hexane is added to extract the oil. The hexane is boiled off in distillers to separate it from the oil. Five or six kg of hexane per tonne of soybeans are not recovered. Crude oil is stored in four 100t, four 200t, and two 50t steel tanks. Crude oil is transported by tanker truck to other OILFED plants for refining. The de-oiled cake is conditioned, ground, and dried to 10% moisture prior to bagging in 65 kg jute bags (plastic bags if specified by the buyer) and stored temporarily in a 5,000t godown for almost daily load out to trucks.

The investment in this automated plant is approximately Rs.100 million. Under construction at the present time is a large solar collector for heating water to approximately 85°C to decrease the fuel consumption of the boilers. OILFED is providing the solar collector foundation. The solar collector itself is subsidized by the Indian Government.

Future plans call for the construction of an oil refinery and an edible grade soya flour facility to be funded by the World Bank and to increase the plants' daily capacity from 200t to 400t. Already existing at the plant is a 300t steel bin for soybean splits if it becomes necessary to separate out the split beans. This is necessary sometimes, depending on the use of the beans, because split soybeans are more susceptible to microorganisms than are whole beans. Another 300t bin is available for tempering.

In further discussion with Mr. Dutla, General Manager, he indicated that as the price of soybeans started rising during the latter part of November, farmers began holding back their stock of soybeans. As an incentive to keep soybeans flowing into the processing plants OILFED initiated a future selling plan. Farmers could deliver their soybeans to the cooperative society and have the option of actually selling on any day they chose, up to December 31, 1986. Mr. Dutla also made some remarks on the potential of an increase in the price of soybean oil. He said there are many factors affecting the price of oil and that a sharp increase in the price of raw soybeans, as occurred in late November and early December, would not be significant factor. The processing plants purchased soybeans at a much lower price the prior year or two so they would merely accept a lesser margin of profit this year. However, it was interesting to note that the price of refined soybean oil at Indore was increased by Rs.5 to 10 per kg, the latter part of the first week of December.

TOUR OF FOOD MANUFACTURE PLANT AND FOOD RESEARCH INSTITUTE

Visits in Karnataka State, India related to Soybean Processing, Research, and Utilization - December 1 & 2, 1986
Accompanied by Mr. M.A. Nair, Winrock International, New Delhi

Mr. M.R. Chandrasekhara, Head of Research & Development, Mysore Snackfoods, Ltd., 19 Platform Road, Bangalore 560 023, conducted a tour of their food production facilities and wheat flour milling equipment. De-oiled soybean cake is purchased, under Snackfoods' specifications, from oil extraction processors. Snackfoods makes the quality evaluations in their laboratory at the time the bagged cake is delivered to their plant. They seldom refuse to accept cake, but immediately inform the oil processor if his cake is falling below Snackfoods' specifications.

Two extruders process the cake under high temperature and pressure into bite size nuggets, which are dried, cooled and sorted by size prior to bagging. The bagged nuggets are sold to food outlets which generally sell the product in small bulk quantities without packaging. Only a very limited amount of the de-oiled cake is stored at the plant as a daily source of cake is available. Smaller extruders are used to make pasta like products from other raw materials. In the past, Snackfoods has not directly marketed the several different foods they have developed, but chose to have marketing firms perform that function. More recently they have become involved in some direct selling and indicated they may do more in the future.

Wheat flour is milled when there is a demand; however, the mill was not operating on December 1. Snackfoods has a baking and analysis laboratory for evlauating baked products.

An additional discussion about Snackfoods and its sister companies was held with Mr. M.K. Dattaraj, Technical Director, Mysore Feeds Pvt. Ltd., who also serves as a director for Krishna Flour Mills Ltd., Krishna Plastic Industries Pvt. Ltd., Mysore Vegetable Oil Products Ltd., Krishna Industries Pvt. Ltd., Krishna Plasto Fibre Ltd., as well as Mysore Snackfoods Ltd. These companies are producing a variety of products varying from nutritional infant foods to animal feeds. Mysore Snackfoods Ltd. appears to be an aggressive firm with the facilities, personnel and interest to develop and market new foods, including soya based foods.

At the Central Food Technological Research Institute (CFTRI) in Mysore, Mr. S.K. Majumder, Deputy Director, introduced scientists who explained projects related to the storage, processing, and utilization of soybeans and other grains. Scientists in over 30 disciplines at the Institute are involved in research, development, and fabrication of equipment. Many of the technologies and equipment evolved at CFTRI have been accepted by manufacturers and grain and food processors.

Research related to soybean processing and utilization is receiving attention, i.e., fumigation and rodent proofing of stored grain, sealed storage bins, drying of grains, use of solar energy, and use of soybeans for snacks and other food products. Although one scientist expressed some concern about the "beany" flavor of soya based foods and lack of acceptance of these foods by village people, many new foods and food additives to fortify existing foods have been developed at CFTRI. This large multi-discipline Institute should continue to play an important role in meeting India's objective of improving the nutritional value of its foods and food ingredients.

POTENTIAL RESEARCH PROJECTS PREPARED AND DISCUSSED WITH CIAE SCIENTISTS

Four research proposals were prepared and discussed in detail with CIAE scientists, particularly those scientists associated with the SPU Project and the PHT division at CIAE. The scientists, the SPU project director, and the CIAE director generally agreed that these four proposals were viable and appropriate areas of research to pursue. As positions on the SPU Project are filled and time allows these proposals will be completed in the proper format and submitted for review and possible approval. Another research area discussed but not presented in draft form relates to additional work in the drying of grain. Since considerable grain drying research has already been conducted in India and reported in various publications and present methods and immediate future methods of handling soybeans indicate that excess moisture in soybeans is not and will not likely be a problem, additional grain drying research appears not to be of a high priority at the present time. Admittedly, as buyers and processors of grain begin to store larger quantities of bulk grain for longer periods of time, a need for some drying may develop. Monitoring of these large bulk grain storage facilities will help identify such a need. If at that time adequate grain drying information on the drying of grain, particularly soybeans under Indian conditions, is not available a soybean drying project should be initiated.

Drafts of the proposals deemed to be of a higher priority follow:

RESEARCH PROJECT FOR CONSIDERATION AS A PART OF PROJECT NO. 386-0470 (AGRICULTURAL RESEARCH UMBRELLA)

SUBPROJECT 1 : (Soybean Processing and Utilization) ICAR/USAID/CIAE.

Prepared by : Dr. Gene C. Shove, Professor of Agricultural Engineering, University of Illinois at Urbana - Champaign.

Title : Establishment of Appropriate Systems Technology for the Evaluation of Soybean Quality.

Objective : To determine the condition and quality of whole soybeans prior to storage and to evaluate changes during storage.

Justification: As larger quantities of soybeans are directed to food use, the quality of the food grade soybeans will be more important as contrasted to soybeans destined for oil extraction. A systematic procedure will be required for evaluating the condition and quality of the soybeans along the route of movement from the point of production to the point of final use. This investigation will identify existing procedures and develop new procedures that will be appropriate for soybean quality evaluation in Madhya Pradesh.

Plan of work: Methods and equipment available in Madhya Pradesh for measuring characteristic quality factors of soybeans will be identified and a survey conducted to determine what, if any, of these methods and equipment are used throughout the flow of soybeans from farm to final use.

Factors to be considered include: moisture content, splits, mechanical and other damage, color, presence of micro-organisms, test weight, foreign material and breakage susceptibility. Other quality factors include: oil and protein content, hardness, free fatty acid, germination, and typsin inhibition. The measurement procedures for these factors in use or available in Madhya Pradesh will be compared with those of other countries, particularly the US, to determine if there are deficiencies in the Madhya Pradesh techniques.

Results: The benefits to be derived from making soybean quality measurements will be presented to all appropriate firms and organizations.

Duration: One year

Personnel: To be determined.

RESEARCH PROJECT FOR CONSIDERATION AS A PART OF PROJECT NO. 386-0470 (AGRICULTURAL RESEARCH UMBRELLA)

SUBPROJECT 1 : (Soybean Processing and Utilization) ICAR/USAID/CIAE.

Prepared by : Dr. Gene C. Shove, Professor of Agricultural Engineering, University of Illinois at Urbana - Champaign.

Title : Evaluation of Bulk Soybean Storage Facilities.

Objective : To determine the effectiveness of large bulk soybean storage facilities in maintaining the quality of soybeans prior to processing.

Justification: The increasing production of soybean in Madhya Pradesh has generated the construction of new soybean processing plants and the modification of existing facilities to increase their volume. The large quantities of soybeans processed by these processors requires that relatively large quantities be stored at the processing plant sites. The handling of such large quantities of soybeans in bags also becomes more difficult and less efficient; therefore, an investigation of bulk storage and handling facilities to identify optimum equipment and management procedures is needed.

Plan of work: Large bulk soybean storage facilities are under construction at Prestige Soya Industries, Dewas and at Regional Soyabean Producer's Co-operative Union Limited, Ujjain. The units at Dewas will be rectangular having a capacity of 14,000 tonnes each. Those at Ujjain are circular having a capacity of 7,000 tonnes each. Each will be equipped with different inloading and outloading conveyors. The units at Ujjain will have grain temperature sensing cables and a portable fan for aeration, if needed, will be available to force air into a floor air duct system. The quality of the soybeans in and out of these bulk storages will be determined and objectionable breakage or other damage created by the conveyors determined. Ambient air conditions will be monitored and the recorded stored soybean temperatures at Ujjain will be studied and particularly analysed if hot spots should develop. Observations of the day-to-day operation and management of these bulk storages will be made to help identify unforeseen problems and to aid in their solution.

Results: Day-to-day observation of the operation and management of these large bulk soybean storage facilities should help to identify unforeseen problems and provide a basis for finding solutions to any handling and storage difficulties. Appropriate findings and information will be prepared and distributed.

Duration: Three years Personnel/Budget: To be determined.

RESEARCH PROJECT FOR CONSIDERATION AS A PART OF PROJECT NO. 386-0470 (AGRICULTURAL RESEARCH UMBRELLA)

SUBPROJECT 1 : (Soybean Processing and Utilization) ICAR/USAID/CIAE.

Prepared by : Dr. Gene C. Shove, Professor of Agricultural Engineering, University of Illinois at Urbana - Champaign.

Title : Investigation of the Potential of Aeration Cooling of Soybean Seed and Food Grade Soybeans.

Objective : To determine the reduction in storage temperature of soybeans that could be achieved by controlled operation of aeration equipment.

Justification: Uniform maturity of soybeans depends in part on obtaining a good plant population with the first planting; therefore, a high and known germination of the seeds planted is desirable. The high temperatures encountered in Madhya Pradesh during the six to nine months storage of soybean seed from fall harvest to summer planting often reduces the germination. In addition, as the need for a supply of food grade soybeans develops it may also become important to modify the storage temperature of these soybeans. The cost of mechanical refrigeration equipment, maintenance problems, etc., does not make mechanical cooling a viable alternative. However, some temperature reduction of stored grain temperature can be achieved by the use of aeration equipment (electric powered fans) and taking proper advantage of the lower temperatures existing during the usual daily fluctuation in air temperature.

Plan of work: The investigation will be conducted at three locations including: the CIAE at Bhopal, the GBPUAT at Pantnagar and or the University of Illinois, and a seed storage warehouse near Bhopal.

At the CIAE an aeration fan will be installed on an insulated room loaded with a product, preferably bagged soybeans. A differential thermostat will cause the fan to force air through the room when the ambient air temperature is one or two degrees below the product temperature. One sensing element of the differential thermostat will be placed in the product and the other sensor will be subjected to ambient air to effect this desired aeration fan control. Because of the dry climatic conditions existing in Madhya Pradesh during the storage of soybean seed it is not likely seed moisture content will increase because of high relative humidities. However, if it is determined that the seed moisture content increases, a humidistat set at the seed's equilibrium relative humidity will be placed in series with the differential thermostat.

The following data will be recorded:

Ambient air temperature and relative humidity, continuously

Product temperature at various locations, twice daily

Product moisture content, weekly

Hours of fan operation

An analysis of the data from this laboratory experiment will determine the potential cooling of a product that can be achieved by controlled operation of an aeration fan.

At a seed storage warehouse near Bhopal where the warehouse manager is willing to cooperate a similar experiment will be conducted. This experiment will help identify the difficulties of applying such an aeration scheme to a large storage facility and perhaps indicate modifications necessary to make aeration cooling successful.

At the GBPUAT or at the University of Illinois an investigation of historical weather information will be initiated to study ambient air temperature and relative humidity as related to aeration cooling. Computer programs are available by which the number of hours of fan operation can be determined for various limits placed on ambient air temperature and relative humidity. Weather data from individual years can be studied, as well as combining several years of data to provide predictions of average hours available. The investigation should be suitable for a M.S. degree in agricultural engineering at the GBPUAT or the University of Illinois. It would also be a suitable assignment for a CIAE scientist participating in a short term training program at a university in the U.S.

Results: If aeration cooling of soybean seed and food grade soybeans is proven successful a manual "Aeration Cooling of Soybeans in Madhya Pradesh" will be prepared for distribution.

Duration: Two years

Personnel: To be determined.

Budget: To be determined.

RESEARCH PROJECT FOR CONSIDERATION AS A PART OF PROJECT NO. 386-0470 (AGRICULTURAL RESEARCH UMBRELLA)

SUBPROJECT 1 : (Soybean Processing and Utilization) ICAR/USAID/CIAE.

Prepared by : Dr. Gene C. Shove, Professor of Agricultural Engineering, University of Illinois at Urbana - Champaign.

Title : Investigation of the Potential of Applying Evaporative Cooling to Lower the Temperature of Stored Soybean Seed.

Objective : To develop an inexpensive, suitable procedure to lower the temperature of soybean seed stored in small quantities by village farmers.

Justification: Many Madhya Pradesh village farmers, particularly those with very small land areas under cultivation, save some of their harvested soybeans as seed for the next planting. If these seeds are stored in gunny bags, high temperatures and possible increase in seed moisture content can seriously decrease germination. CIAE scientists have shown that the loss of seed viability can be reduced by placing the seeds in sealed containers. Metal bins and plastic bags have been utilized. It has also been shown that temperatures of 30°C and above have detrimental effects on seed germination. Any method of reducing the temperature of the stored seed must be inexpensive if it is to be suitable for the village farmers. The dry climatic conditions during the storage period from fall harvest to summer planting creates a relatively large wet bulk depression; therefore, the principle of evaporative cooling may have merit for lowering the temperature of stored seed.

Plan of work: An evaporative cooling apparatus and procedure will be designed that can be easily applied to sealed, metal seed storage bins. A bin under laboratory conditions at the CIAE will be monitored to determine the cooling of seed that can be obtained with evaporative cooling. Similar bins of village farmers will also be equipped with evaporative cooling apparatus and the farmers instructed on how to manage the coolers. The temperature of the seed in the evaporative cooled bins will be measured periodically and compared with the temperature of seeds in similar bins not equipped with evaporative coolers. The farmers and family members will be asked to comment on their involvement in maintaining a water supply to the evaporative coolers.

Results: If benefits of using evaporative cooling to maintain a lower temperature of stored seed can be established and the cost of the cooler justified, the use of evaporative cooling will be introduced and demonstrated in other villages throughout the soybean producing areas of Madhya Pradesh and other states of India.

Duration: Two years Personnel/Budget: To be determined.

SUGGESTIONS FOR INCREASED RESEARCH ACTIVITY ON SOYBEAN PROCESSING AND UTILIZATION

Considerable research has been accomplished on soybean processing and utilization during the past few years as documented in the Proceedings of the National Seminar on Soybean Processing and Utilization held at the Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh on 22-23 November, 1986. However, much of this research accomplishment was not a direct result of the Indian Council of Agricultural Research (ICAR) and the United States Agency for International Development (USAID) Subproject 1 Soybean Processing and Utilization (SPU) under Project No. 386-0470 Agricultural Research Umbrella. The research was reported mainly by researchers from institutes, universities, corporations, and other All India Coordinated ICAR Schemes, i.e., Post Harvest Technology (PHT). Although CIAE has been designated as the focal point for SPU research, a building providing scientists with laboratories and office space is not to be completed until sometime in 1987. Only recently was Dr. Nawab Ali officially designated as Director of the SPU Project and he lacks sufficient scientists to mount an aggressive program. Nine of the 15 sanctioned posts for the project remain vacant. There is however, a good working relationship with PHT scientists at CIAE which has helped keep the SPU Project alive during the past year or so.

The vacant position in the area of drying, handling, storage and aeration should be filled as soon as possible. There is interest in providing proper storage for larger quantities of soybeans at the village level, some soybeans are beginning to be handled in bulk, and soybean buyers and processors are installing large bulk storage facilities. The necessity of having an agricultural engineer to pursue and monitor these new avenues in soybean production and storage is readily apparent.

The completion of the SPU Project laboratory and office building on the CIAE Campus at Bhopal and the addition of scientists will provide a needed cohesiveness for the project. Some laboratory equipment is on order. Suggestions for other equipment appropriate for the new building include:

1. Microcomputer for running computer programs that will be helpful to the project and for analyzing research data, i.e. IBM PC AT or Hewlett Packard Vectra PC.
2. Grain Analyzer for determining moisture, oil and protein content, i.e. Dickey-john, Auburn, Illinois.
3. Letter quality printer to interface with the microcomputer having the capability of single sheet feed as well as continuous sheet feed.

In a more general sense, it would seem appropriate to make a critical review of reported research related to soybean processing and utilization. The Proceedings of the National Seminar held at CIAE on 22-23 November, 1986, would provide a good basis for such a review. The review would help to: (1) identify where good research related to SPU is being conducted and should be continued, (2) identify areas that are receiving less than adequate attention, (3) identify the areas that should receive concentrated effort at CIAE, and (4) identify technologies that are ready for implementation, but for various reasons are not being adopted. The review team should include at least Dr. Nawab Ali, Director SPU Project; Dr. P.S. Bhatnagar, Coordinator, All India Coordinated Research Project on Soybeans Project; Dr. Anwar Alam, Asst. Director General for Engineering, ICAR; Dr. B.L. Amla, Director, Central Food Technological Research Institute, and appropriate USAID personnel.

EXTENSION ACTIVITIES RELATED TO SOYBEAN PROCESSING AND UTILIZATION

Although I understand there are extension personnel working at the village level to educate farmers and housewives on the use of new technology related to soybeans and that cooperative societies have a similar undertaking, I sense the lack of an over-all coordinated effort. I believe that a successful attainment of the SPU project objective of getting more protein in the Indian diet, via the use of soybeans, will only be accomplished by a coordinated effort. This entails a group of people dedicated to the effort and motivated to apply their energy to make things happen.

Success does not come without effort applied to a set of guidelines and the guidelines need to be sanctioned by the administrators, conveyed to and accepted by the extension workers. In describing the success of the Hindustan Lever Limited milk processing operation during the mid to late 1970's in Uttar Pradesh, Ruth Karen (Williams & Karen, 1985) listed the general manager's "Ten Commandments for Rural Development" as:

1. Establish credibility through honesty and integrity;
2. Assure that plans are generated at the grass roots by the farmers themselves;
3. Set up an effective organizational structure for follow through;
4. Provide or organize financial support;
5. Build a viable communication system, both physical and people-to-people;
6. Upgrade agricultural practices;
7. Introduce animal husbandry, not as a replacement for existing cultivation of food or cash crops, but as a viable secondary occupation for the farm family;
8. Promote appropriate alternative energy sources, such as bio-gas fueled by cow dung;
9. Aid village industries, particularly those relevant to women;
10. Help to build health and education infrastructure.

These "Commandments" appear to be well thought out and could provide the basis for the organization of an over-all coordinated effort to "make things happen" in the processing and utilization of soybeans.

During the closing session of the National Semir .r on Soybean Processing and Utilization in India held at CIAE, Bhopal, 22-23 November, 1986, Dr. N.S. Randhawa, Director General and Dr. Anwar Alam, Assistant Director General (Engineering), ICAR expressed a concern about the need for more emphasis on educational and technology transfer activities. I believe the concern has been noted and that an aggressive effect should be organized to complete the task.

A more extensive effort could be initiated immediately utilizing technological information already available on some aspects of utilization of soybeans as a source of protein in the Indian diet. I suggest at least two persons, one female and one male, be assigned to the SPU Project as 100% time educational and technology transfer specialists. Research scientists should also be encouraged to participate in extension activities as time permits. Selective demonstrations of the more simpler new technologies will help gain the confidence of the village people. These demonstrations can pave the way for more sophisticated technologies to follow later.

During discussions with top management of corporation and processors in November and early December they expressed a willingness to cooperate in extension activities. Often they are not sure where they can best contribute. Extension specialists can provide the needed liaision to implement cooperative activity between governmental agencies, educational and research institutions, and private corporations.

APPENDIX A

ACTIVITIES OF DR. GENE C. SHOVE IN INDIA
2 November - 13 December, 1986

Places of duty and/or visited:

- USAID and Winrock Offices, Ashok Hotel, New Delhi
- Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh
- Three villages and surrounding farms near Bhopal
- Grain market in Bhopal
- Madhya Pradesh State Seeds & Farm Development Corporation, Bhopal
- Prestige Soya Industries, Dewas and Indore
- General Food Private Limited, Indore
- Regional Soyabean Producers' Corporative Union Limited, Ujjain
- M.P. State Co-operative Oilseed Growers' Federation Limited, Amalah Farm, Sehore District
- Dr. A. Alam, Indian Council of Agricultural Research, New Delhi
- Indian Agricultural Research Institute, Divn. of Agricultural Engineering, New Delhi
- Mysore Snack Foods Ltd., Bangalore, Karnataka
- Central Food Technological Research Institute, Mysore, Karnataka
- M.P. State Cooperative Oilseed Growers' Federation Ltd., Sehore

Extended discussions with:

- Dr. Anwar Alam, ICAR
- Dr. Surjan Singh, USAID
- Dr. Mark A. Smith, USAID
- Dr. T.P. Ojha, Director, CIAE
- Dr. Nawab Ali, CIAE, Head, SPU
- P.C. Bargale, S.D. Deshpande, R.S. Devnani, A.P. Gandhi, R.P. Kachru, R.C. Maheshwari, K.M. Sahay; CIAE Scientists
- Prof. A.C. Pandya, Former Director, CIAE
- Dr. M.D. Tedia, Director, OILFED
- Dr. Hari R. Tyagi, JNKVV
- Dr. David R. Mears, USAID
- Dr. Guy B. Baird, Winrock International
- Mr. M.A. Nair, Winrock International

Seminars presented:

- Soybean Harvesting and Drying, CIAE	15 Nov.
- Soybean Aeration and Storage, CIAE	17 Nov.

Presentation:

- Soybean Harvesting and Drying, National Seminal SPU, CIAE	22-23 Nov.

ITINERARY OF DR. GENE C. SHOVE

NOV. 2	0500 Hrs.	Arrive Delhi Stay at Hotel Samrat	BA-147
NOV. 3-5		Discussions with ICAR and USAID/Winrock	
NOV 6	0635 Hrs. 0830 Hrs.	Depart Delhi Arrive Bhopal	IC-433
NOV. 6-23		In Bhopal with Central Institute of Agricultural Engineering (CIAE) - (Contact person - Dr. Nawab Ali, Project Director Stay at Taj	
NOV. 24	1530 Hrs. 1725 Hrs.	Depart Bhopal Arrive Delhi Stay at Hotel Samrat	IC-434
NOV. 25	0730 Hrs. 1300 Hrs.	Depart Delhi Arrive Pantnagar *	By Car
NOV. 25-29		At Pantnagar - G.B. Pant University of Agriculture & Technology - (Contact person - Dr. B.P.N. Singh Stay at Lambert Square Guest House	
NOV. 29	1430 Hrs. 2000 Hrs.	Depart Pantnagar Arrive Delhi Stay at Hotel Samrat	By Car
NOV. 30	1210 Hrs. 1445 Hrs.	Depart Delhi Arrive Bangalore Stay at Taj Residency	IC-403
NOV. 30-2		In Bangalore	
DEC. 1		Visit Private Sector Processing Plant in Bangalore	
DEC. 2	0800 Hrs. 1030 Hrs.	Depart Bangalore Arrive Mysore Visit the Central Food Technology Research Institute	By Car

* Circumstances prevented the visit to Pantnagar and the trip was cancelled.

	1630 Hrs. 1900 Hrs.	Depart Mysore Arrive Bangalore	By Car
DEC. 3	1535 Hrs. 1810 Hrs.	Depart Bangalore Arrive Delhi Stay at Hotel Samrat	IC-404
DEC. 4	0635 Hrs. 0830 Hrs.	Depart Delhi Arrive Bhopal	IC-433
DEC. 4-8		In Bhopal with CIAE. Visit Private Processing Plants probably in Indore Stay at Jehanuma Palace Hotel	
DEC. 8	1530 Hrs. 1725 Hrs.	Depart Bhopal Arrive Delhi Stay at Hotel Samrat	IC-434
DEC. 8-13		In Delhi - Wrap-up meeting with ICAR and USAID/Winrock and preparation of report	
DEC. 14		Depart for U.S.	

Programme of Visit of Dr. Gene C. Shove, Consultant, SPU Project at CIAE, Bhopal 462 003 during 6 - 24 November, 1986

Place of work	Room No. 211, CPE Building, CIAE, Nabi Bagh, Bhopal 462 018
His (Dr. Shove) counterpart and contact person	Dr. Nawab Ali, Project Director Incharge, SPU Project, CIAE, Bhopal 462 018.

Visit Period: 6 - 24 November, 1986

November 6, 1986 (Thursday)

0830 hrs	Arrival Bhopal Airport stay at Taj Hotel, Hamidia Road
1100-1200 hrs	Preliminary discussion with Dr. T.P. Ojha, Director, CIAE and Dr. Nawab Ali, Project Director Incharge
1400-1700 hrs	Visit to SPU Project and its Laboratories and the facilities of CIAE in general - Dr. Nawab Ali

November 7, 1986 (Friday)

1000-1300 hrs	Discussions with the scientists working on Soybean Processing and Utilization Dr. A.P. Gandhi Mr. S.D. Deshpande Mr. K.M. Sahay
1400-1700 hrs	Discussion continued. Meeting Dr. Nawab Ali for any additional information or otherwise

November 8, 1986 (Saturday) (Holiday)

Aternoon	Local visit with Dr. Nawab Ali
November 9, 1986 (Sunday)	Rest day
November 10, 1986 (Monday)	Review of work done by CIAE in the area of soybean handling and storage - Dr. Nawab Ali

November 11, 1986 (Tuesday)	
1000-1700 hrs	Visit to neaby villages to get familiar with post production practices of soybean such as handling, threshing, storage, transport, etc. Action - Mr. S.D. Deshpande - Dr. Nawab Ali/Mr. S.D. Deshpande
November 12, 1986 (Wednesday)	
1000-1700 hrs	Visit to grain market and study the handling, weighing, bagging, storage, etc. of foodgrains specially soybean - Dr. Nawab Ali/Mr. S.D. Deshpande
November 13, 1986 (Thursday)	
1000-1700 hrs	Analysis of the information collected on handling, conditioning, transportation, storage, etc. on soybean and design of a proposal to help in improving the overall effectiveness of the present post-production system
November 14, 1986 (Friday)	
1000-1700 hrs	-do-
November 15, 1986 (Saturday)	
1000-1300 hrs	Analysis of information collected.
1400-1700 hrs	Special talk on Harvesting and Drying of Soybean to the scientists of CIAE in Seminar room of CPE building
November 16, 1986 (Sunday)	Rest day
November 17, 1986 (Monday)	
1000-1300 hrs	Working on report concerning minimisation of soybean seed viability at farm level storage

1400-1700 hrs	Special talk on Aeration/Cooling and Storage of soybean to the CIAE scientists in Seminar Room CPE Building
November 18, 1986 (Tuesday)	
1000-1700 hrs	Further discussion with Dr. Nawab Ali and working on proposal for effective handling and storage of soybean
November 19, 1986 (Wednesday) November 20, 1986 (Thursday)	Visit to three Soybean Processing Plants located at Dewas, Ujjain and Indore - Dr. Nawab Ali (i) Prestige Foods Ltd., Dewas (ii) M.P. Oil Fed. Solvent Plant, Ujjain (iii) General Food Pvt. Ltd., Indore
November 21, 1986 (Friday)	Analysis of information collected from various solvent extraction plants and necessary follow-up actions
November 22-23, 1986 (Saturday and Sunday)	Participation in the National Seminar on Soybean Processing and Utilization at CIAE, Nabi Bagh, Bhopal 462 018
November 24, 1986 (Monday)	
1100-1200 hrs	Discussion with Dr. T.P. Ojha, Director and Dr. Nawab Ali, at CIAE, Nabi Bagh
1530 hrs	Departure for New Delhi.

Programme of Visit of Dr. Gene C. Shove, Consultant, SPU Project at CIAE, Bhopal 462 003 during 4 - 8 December, 1986

Place of work	Room No. 211, CPE Building, CIAE, Nabi Bagh, Bhopal 462 018
His (Dr. Shove) counterpart and contact person	Dr. Nawab Ali, Project Director Incharge, SPU Project, CIAE, Bhopal 462 018.

Visit Period: 4 - 8 December, 1986

December 4, 1986 (Thursday)

0830 hrs	Arrival at Bhopal Airport Stay at Jahanuma Palace Hotel, Shamla Hills, Bhopal 462 002
1100-12000 hrs	Discussion with Dr. Nawab Ali, Project Director, SPU Project at CIAE, Nabi Bagh
1200-1700 hrs	Analysis of data collected during his visit to CFTRI Mysore and other places and report preparation

December 5, 1986 (Friday)

1030-1330 hrs	Discussions on Research Proposals on handling, storage and transportation of soybean with Project Director, SPU and other scientists of PHT group. * Establishment of appropriate systems technology for the evaluation of soybean quality * Evaluation of bulk soybean storage facilities
1430-1700 hrs	Discussions continued * Investigation of the potential of aeration cooling of soybean seed and food grade soybean

	* Investigation of the potential of applying evaporative cooling to lower the temperature of stored soybean seed
November 6, 1986 (Saturday)	
1015-1500 hrs	Visit to Soybean Solvent Extraction Plant (Black Soybeans) and Cattle Feed Plant of M.P. Oil Federation located at Sehore
November 7, 1986 (Sunday)	Rest day
November 8, 1986 (Monday)	
1030-1130 hrs	Meeting with SPU scientists and visit to Soybean Building and Laboratory
1130-1300 hrs	Final discussion with Dr. T.P. Ojha and Dr. Nawab Ali
1400-1500 hrs	Departure to Bhopal Airport for New Delhi.

APPENDIX B

MOISTURE REMOVAL AND EQUILIBRIUM MOISTURE

Table 1. Required moisture removal to produce one kilogram of Soybeans containing various final moisture contents

Initial Moisture Content, % w.b.	Final Moisture Content, % w.b. 13	12	11	10
		grams water removed		
18	61.0	73.2	85.4	97.6
16	35.7	47.6	59.5	71.4
14	11.6	23.3	34.9	46.5
12	-	0	11.4	22.7

Table 2. Approximate equilibrium moisture content of soybeans at various temperatures and humidities

Air Temp.		Relative Humidity, Percent						
°C	(°F)	30	40	50	60	70	80	90
0	(32)	7.1	7.9	8.8	11.5	13.2	17.2	22.6
5	(41)	6.9	7.7	8.6	10.4	12.9	16.9	22.4
10	(50)	6.7	7.3	8.3	10.3	12.6	16.5	22.1
15	(59)	6.5	7.2	8.1	10.1	12.4	16.1	21.9
20	(68)	6.3	7.1	8.0	9.9	12.2	16.0	21.6
25	(77)	6.1	6.9	7.8	9.7	12.1	15.8	21.3
30	(86)	5.9	6.6	7.7	9.5	11.9	15.6	20.9
35	(95)	5.7	6.4	7.6	9.3	11.7	15.4	20.6

APPENDIX C

MEMORANDUM

To : Dr. Nawab Ali/Dr. T.P. Ojha
From : Gene Shove

RE : Oral Presentation of Research Results

Having heard most of the presentation given by scientists at the National Seminar on Soybean Processing and Utilization in India held at CIAE, 22-23 November, 1986, I would like to comment on the quality of the presentation at such a seminar. By training, scientists are accurate, detailed and precise in their work, writings, and oral presentations. In manuscript writing and presentations before peers these traits are all appropriate; however, oral presentations before a varied audience such as the audience at the National Seminar on SPU, should be tempered, particularly in relation to presenting details. At well organized seminars, meetings, conferences, etc., written proceedings or papers are usually available. Therefore, I believe the challenge facing a speaker is to briefly present his/her work and results in a way that will generate sufficient interest by the listeners, especially the less interested, that they will read the scientist's written paper for further details and information. Preparation of such a presentation is not unlike trying to write one's life history in 25 words or less. It may be easier to write a book. Information on visuals should be kept to a minimum with large lettering that is readily read even in the back of the room. High-lighting the most important part of even the simplest visual is helpful to the viewer.

I recommend that a seminar or workshop on how to give good oral presentations be organized for CIAE Scientists. A knowledgeable professional qualified to discuss scientific paper presentations should be brought in to lead such a seminar. Perhaps at some other seminar CIAE Scientists can be leaders in giving concise, interesting presentations.

A second suggestion concerns the execution of ground rules established for a session. Speakers should be informed of such ground rules at the time they are notified of their acceptance as a speaker. These ground rules should be given at the beginning of the session as a reminder to speakers and to inform the audience of the ground rules. A mechanical device, i.e., a bell, buzzer, flashing light, etc., to give a warning and a stop speaking signal is helpful to the session moderator. However, the device does not relieve the moderator from the responsibility of keeping the session moving ahead on an established time schedule.

APPENDIX D

COMPUTER PROGRAMS

The following IBM BASIC microprocessor computer programs may be useful to some aspects of the SPU Project. These programs are not copy protected and may be copied and/or modified to make them more useful to Indian conditions and situations.

Agricultural Engineering Tool Kit. File Name: MENU.BAS
Compiled by Prof. William H. Peterson, Extension Agricultural Engineer, University of Illinois, four groups of programs are available:

1. Energy series
2. Grain conditioning and psychrometric chart
3. Bean strength, storage volume calculations, and finance
4. Manure structure design

Controlled Aeration Analysis. File Name: AERATE2.BAS
This program counts the number of hours an aeration fan would run with the temperature and humidity ranges for control settings that you specify. Springfield, Illinois weather data from 1967 through 1977 is included. The program is written to use this three-hour interval data.

Controlled Aeration Analysis. File Name: AERATE2.EXE
Same as above but compiled for faster operation and is executed from DOS.

Note: A different weather data file, even using a different time interval, could be prepared. It would then be necessary to rewrite some of the program statements so that this new file could be used.

Each of the above three files resides on a separate diskette. Diskettes containing these files have been distributed to:

Dr. Anwar Alam, Asst. Dir. General (Engineering), ICAR, Krishi Bhavan, New Delhi 110 001
and
Dr. Nawab Ali, SPU Project Dir., CIAE, Berasia Road, Bhopal 462 018