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SOYBEAN PRODUCTION

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Soybeans have become an important cash crop in the eastern third of North Dakota. The crop reporting service showed only 6,000 acres harvested in 1946. In more recent years, however, acreage more than doubled from 1976 to a record 540,000 acres planted in 1983 and over 800,000 acres in 1984. As with other crops, acreage will fluctuate in response to the anticipated price-yield return ratio.

The cash value return for soybeans in North Dakota has been higher than other oil crops and most cereals for the last six years (Table 1). This relatively high gross cash value combined with the low production costs (including minimal disease and insect costs) has contributed to the increased acreage. The state yield average for 1983 was 28.0 bu/acre, giving a 1978-83 average of 24.8 bu/acre.

Table 1. Average Gross Values of North Dakota Crops for 1978-83.*

Crop	Gross Value of Production per acre**	Price per Unit
Dry edible beans	$ 209.74	$ 18.70/cwt
Corn, grain	178.19	2.51/bu
Soybeans	158.23	6.38/bu
Sunflower, non-oil	145.06	12.45/cwt
Sunflower, oil	118.99	10.19/cwt
Wheat, durum	104.09	3.90/bu
Barley	94.19	2.12/bu
Wheat, spring	93.25	3.54/bu
Flax	74.64	6.24/bu
Rye	61.65	2.09/bu
Oats	60.98	1.35/bu

* North Dakota Agricultural Statistics No. 53, June, 1984.

** Production costs will vary with the crop and management system.

Soybeans are a full season crop. They are primarily grown in southeastern North Dakota. However, increased acreage in Grand Forks, Walsh, Barnes, Griggs, Foster, Wells, Eddy, Stutsman, Pembina and LaMoure Counties show economic feasibility in those areas. The need for a long growing season and satisfactory soil moisture during pod filling may limit the westward expansion in the state with present varieties. However, soybeans should be one of the crops in the rotation when irrigation water is available.

SOIL PREFERENCE

Soybeans do best when grown under soil conditions favorable to corn. A fertile, mellow, medium-textured loam soil usually is best, but soybeans can be produced on a wide range of soil types. Heavier soils should have good drainage. Sandy loam soils warm up faster, allowing soybeans to emerge sooner and develop rapidly in a cool or short growing season. Soybeans planted in soils with a pH greater than 7.5 or in high lime soils may have leaf yellowing due to iron chlorosis and other nutrient problems. Some varieties of soybeans are more tolerant to high lime soils.

ROTATIONS

Soybeans fit well into most southeastern North Dakota crop rotations. Wheat yields at Fargo were 35 percent greater when planted on soybean land than when following wheat, surpassing other tested crops as a contributor to next year's wheat crop yields (Table 2). Also, no-till wheat yields following soybeans were higher than following other previous crops. Studies from neighboring states have shown corn to yield better following soybeans than when in continuous corn. Soybeans, a legume, provide a break in the biological disease cycle of various cereal pathogens and account for part of the recorded yield increases.

Table 2. Effect of previous crop on wheat yields under no-till and conventional tillage systems at Fargo, ND, 1977-83*

	Conventional Wheat Yield		No-till Wheat Yield	
Previous crop	Wheat yield (bu/A)	Wheat on wheat (%)	Wheat yield (bu/A)	Wheat on wheat (%)
Wheat	33.8	100	33.3	100
Soybean	45.3	134	44.9	135
Sugarbeet	40.8	121	38.8	117
Sunflower	39.3	116	39.1	117
Corn	38.6	114	37.3	112
Flax	38.0	112	37.5	113
Barley	37.0	109	36.0	108

* Unpublished data from Agronomy Dept. at North Dakota State University

Soybeans should follow corn, wheat, barley or other grass crops in a rotation. Soybeans should not follow alfalfa, drybeans or sunflower where white mold disease (Sclerotinia sclerotiorum) has been detected. Soybeans in North Dakota have not shown a yield reduction due to white mold, but the organism uses soybeans as a host carry-over to other susceptible crops. Broadleaf crops such as dry beans and sunflowers should not follow soybeans where white mold disease was present.

Soybeans often mellow the soil sufficiently so that deep tillage in preparation for next year's crop is not necessary except when weed infestation is serious. With certain soil types, this mellowing may predispose the soil to additional erosion.

SOYBEAN VARIETY SELECTION

Soybean variety selection should be based on maturity, yield, lodging and disease reaction. Com-

parative maturity and yield of public and some private soybean varieties can be obtained from a current copy of Extension Circular A-654, "North Dakota Dry Bean and Soybean Variety Trials."

Generalized areas of adaptation are indicated by zones in Figure 1. In general, seed maturity group 1 in Zone 1, maturity group 0 in Zone 2, maturity group 00 in Zone 3 and as early a group 00 as possible for Zone 4. When evaluating private company data and descriptions, make comparisons with public varieties grown for several years in your local area. Suggested public varieties are listed in Table 3.

Table 3. Agronomic characteristics on public soybean varieties suitable for North Dakota production.

Variety*	Fargo relative maturity	Height	Resistance to lodging	Hilum color	Zone**	Remarks***
Maple Presto	v. early	v. short	good	gray	3-4	1, 2
Maple Amber	v. early	v. short	good	brown	3-4	1, 3
McCall	early med.	short	good	yellow	2-3-4	
Clay	med. early	short	good	yellow	2-3	
Ozzie	medium	medium	good	yellow	2	
Evans	medium	medium	good	yellow	2	
Dawson	medium	medium	good	yellow	2	
Simpson	medium	medium	good	buff	2	3
Swift	medium	medium	good	buff	1-2	
Hodgson 78	med. late	medium	good	buff	1	4
Lakota	late	med. tall	fair	black	1	5

* Listed in order of maturity, earliest at top. Refer to Ext. Cir. A-654 for yield performance.

** See map - Fig. 1 for soybean maturity zones.

*** 1-Sensitive to Sencor/Lexone. 2-Frequently has seed quality problems and shatters. 3-Sensitive to lime induced iron-chlorosis on high pH soils. 4-Plant early. 5-Plant very early.

Soybean lodging characteristics are an important consideration when conditions favor high yields. Lodging reduces yield and creates harvesting problems. Where higher yields are obtained under irrigation, lodging is a major factor to consider in variety selection, water management, and planting density. Most Corn Belt soybean diseases have not been a serious problem in North Dakota, but we can expect to see increased incidence of disease as soybean acreage increases. Research workers will develop information on disease reaction as disease pressure increases.

SEED QUALITY

The selection and use of high quality seed is one of the basic keys to satisfactory soybean yields. Hot, dry conditions during development and maturation may reduce seed size, increase seed injury, and contribute to lowered germination.

Mechanical injury may be the greatest single cause of poor germination and seedling vigor in soybeans. Injury can occur at any point during harvesting, handling or seed processing. Least mechanical injury occurs at 12 to 14 percent moisture. Severe bruising and seed coat breakage may occur at higher or lower moisture content. Harvesting at a low moisture content (8-10 percent) following intermittent wet and dry periods can increase the amount of seed coat cracking. Frequent combine adjustments can compensate for changes in seed moisture during the day. Care must be taken during seed cleaning and conditioning to prevent seed damage. Use belt conveyors when possible,

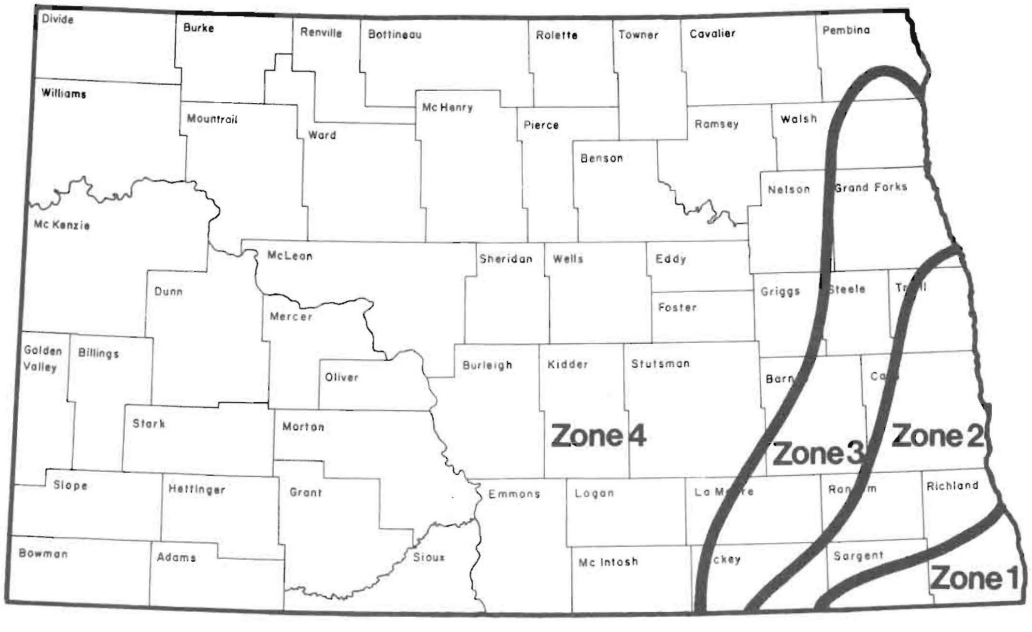

Figure 1. General maturity zones for soybean varities.

and if augers are used, keep them fully loaded. Seed should not be dropped onto floors. Damaged potential increases as temperature goes down.

The influence of soybean seed size on germination potential, early seedling vigor and crop yield is not always predictable. Seed of fairly uniform size with few very small or extremely large seed will reduce problems in precision planting.

Select soybean seed that is free of disease, seed coat cracking, splits and green immature seed. Use seed produced the previous crop year. Seed two years old or older usually has lower germination and less seedling vigor. Seedling vigor declines first when soybean seed deterioration occurs, then ability to establish a stand in the field declines and finally germination percentage declines. Therefore, when soybean germination percentage is low, the seedlot should be discarded because of probable lower seedling vigor and reduced yield.

SEED TREATMENT

Treating soybean seed with a fungicide or fungicide plus insecticide generally does not increase yield when high quality seed is planted under North Dakota conditions. Seed treatment benefits seedlots that are damaged by disease, frost, excessive seed coat breakage and age. In most cases, lots that do not meet certification standards should not be planted. Fungicides commonly used alone or in combination with insecticides are Thiram, Carboxin, Captan, Maneb and Terrachlor. Be sure to read the label regarding restrictions on all seed treatment material. Treated soybean seed can only be used for planting purposes.

INOCULATION

Inoculate soybean seed with soybean rhizobia bacteria before planting. This places the bacteria in the new plant root zone and allows the soybean plant to function as a legume, utilizing and fixing nitrogen from the air. The soybean inoculum strain is specific for soybeans and different from other legumes such as alfalfa, clover or peas. Fields with no soybean history must always have the seed inoculated. Inoculation of seed for fields having prior soybean history is also recommended because new improved strains of bacteria are being developed which are more efficient convertors of atmospheric nitrogen.

Several companies market inoculum, and their products fall into four general classes: peat-based and clay-based products for seed surface application, granular material to be placed in the seed furrow, and liquid mixtures to apply in the planter box at planting time. All of these types do a good job when used properly. Likewise, all can fail if directions are not followed. The important factor to remember is that live bacteria must be in contact with the new root hairs when the soybean seed germinates.

Bacteria do not move in the soil and must be placed in the area of the seed to be effective. The granular material is good for new soybean fields as the bacteria are placed in the seed furrow. However, granular inoculums are the most expensive class of inoculums. Seed surface applied inoculants may require the addition of stickers to help hold the bacteria on the seed. Commercial stickers are available and dry milk powder and sugar solutions will do the job. When using seed treatment and a seed surface inoculant, apply the seed treatment first and then apply the inoculant prior to planting.

Applying inoculum is cheap insurance. Good nodulation benefits the growing soybean crop with its required nitrogen and will also benefit the following crops. Remember inoculum is a living bacteria and treat it like you would other living products. Store inoculum at its proper temperature and in the dark. Inoculated seed should also be stored in the dark. If weather causes a delay in planting of more than a day, reinoculate when planting resumes.

SEEDBED PREPARATION

Soybeans can be grown on a wide range of soil types under various cultural practices. Because of seed size and physiology, soybean seeds require more moisture imbibition than the cereals for germination. Also, soybeans are seeded only 1.5 to 2.0 inches deep. These factors explain why preparation of a firm, uniform seedbed is important for optimum stand establishment. Shallow spring tillage to kill weeds before planting is effective on fall tilled fields. Spring plowing is usually done just before planting. Several reduced tillage programs can be followed and many farmers are growing soybeans with a no-till program. Special planters may be required to handle surface residue in no-till and some reduced tillage systems. Soybeans, like other legume crops, have difficulty emerging through compacted layers and surface crusts.

FERTILIZING

Soybeans do best in fertile soil and make good use of carryover fertilizer. Response to application of commercial fertilizer has been inconsistent under North Dakota growing conditions. If a soil test of the field or response in other crops indicates distinctly low phosphate availability, a row application by planter attachment of 10 to 30 pounds of phosphate per acre may be beneficial.

Fields that have no prior soybean history may benefit from additional nitrogen fertilizer if the soil test shows less than 60 pounds per acre available in the top 24 inches at planting time. High nitrogen fertility circumvents the benefits of rhizobium bacteria as the bacteria will not convert atmospheric nitrogen when soil nitrogen is readily available to the plant, so don't over-fertilize with nitrogen.

Starter fertilizer is best placed in a band 2 inches to the side and 2 inches below the seed. "Pop-up" fertilizer, a small amount of nitrogen or potassium fertilizer placed in direct contact with the seed, should not be used on soybeans because severe fertilizer salt injury can result.

Micronutrient deficiency symptoms can be a problem on high pH (alkaline) soils. Iron deficiency is the most commonly reported trace element problem in North Dakota. Iron deficiency (chlorosis), which is evident by leaf yellowing, occurs on high-lime (calcarious) soils. It is best corrected by foliar application of 0.10-0.15 pounds per acre of iron in the form of iron chlelate at the second trifoliate leaf stage.

Fertilizer results have varied considerably. Experience on your farm is your best guide. Leave an unfertilized check strip for comparison. The use of foliar fertilization is not a substitute for a good soil fertility program of soil applied fertilizers and micronutrients. Consult Ext. Circular SF-719 for additional information.

PLANTING

Soybeans are susceptible to frost and prolonged exposure to near freezing conditions in spring and fall. Plant soybeans after the soil has warmed and air temperatures are favorable. Soybean planting generally should not be prior to five days before the average last killing frost. This provides less than a 50 percent chance of frost killing the soybeans. Delayed seeding until after the average last frost date allows time to kill early germinating weeds with tillage. Earlier planting in cool, wet soil may result in low germination, increased incidence of seedling diseases and poor stands.

Planting dates between May 10 and 25 appear to be favorable for higher yields yet have a reduced risk of frost injury. Plant as early as the frost date permits on fields where weeds are not a serious problem so the beans can take full advantage of the entire growing season and produce top yields. Four years' data from date-of-planting studies at the NDSU Fargo Experiment Station show that late plantings had lower seed yield, poorer seed quality, lower oil content, shorter plant height, and pods set closer to the ground. However, late planting may be justified where weed control is of primary importance. Some early maturing varieties have had acceptable yields when weather factors like hail, late spring frost, floods, etc., necessitate very late planting.

Planting in rows is the most common method used and permits cultivation for weed control. Seeding can be done with a row crop planter with the proper plates, air planters, grain drills, and air seeders. The seed metering system of grain drills must be adjusted carefully to avoid seed damage. Plugging every other spout may be necessary with some drills to obtain a uniform seeding of undamaged seeds. Plant to cover seed 1½ to 2 inches deep and place the seed in moist soil. Planting deeper than two inches or in a soil that crusts, may result in poor emergence.

ROW SPACING

North Dakota State University Experiment Station results at Fargo, Casselton and Oakes indicate that 12-inch row spacings give higher yields than wider row spacings (Figure 2). A 2.7 bushel per acre increase was reported at Fargo when row spacing was reduced from 30 inches to either 6 or 12 inches. At Casselton, yields increased approximately 5 bushels per acre when row spacings were reduced from 36 inches to 12 or 6 inches. Research on irrigated soybeans at Oakes indicated yields from narrow spaced rows were significantly higher than from wider spaced rows. Early planted soybeans in 12-inch rows yielded 25 percent and 40 percent more than 24 and 30-inch row spacings, respectively. The yield response to narrow spacing was considerably less with late planting.

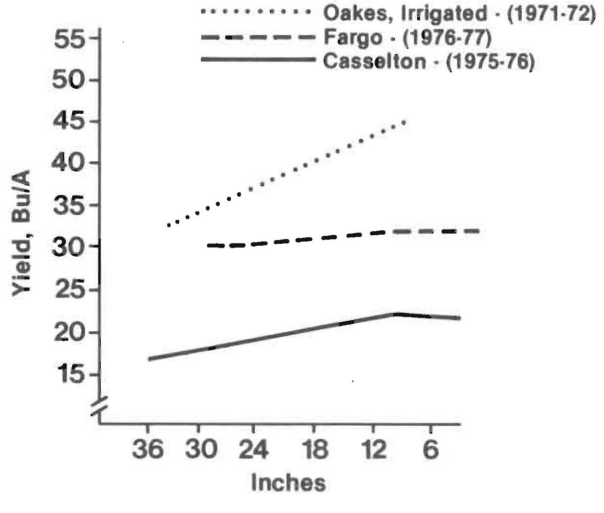

Figure 2. The effect of row spacing on soybean yields at Casselton, Fargo and Oakes, North Dakota.

Close drilled or solid seeded soybeans will produce satisfactory yields only if the land is relatively free of weeds, has good fertility and has adequate soil moisture during the pod filling portion of the growing season. Some weed control early in the season can be obtained with a harrow or rotary hoe, but mechanical weed control often is not satisfactory and chemical control is necessary if the field is very weedy. Herbicide combinations can be very useful for weed control in solid-seeded soybeans. (See Weed Control section).

RATE OF PLANTING

Soybean yields at Fargo have not varied significantly over a wide range of plant populations. A plant population of approximately 150,000 plants per acre is desirable regardless of row spacing. One pound of medium sized soybeans will contain about 2800 seeds. A bushel of soybeans will produce about 150,000 plants per acre assuming 90 percent germination. This would give plants 1.5 inches apart within the row at a 24-inch row spacing. Seed per pound in currently available varieties ranges from 2200 to 3400. Seeding rates should be based on the number of viable seeds planted and not pounds per acre (Table 4).

Table 4. Number of viable seed per foot of row which will result in 150,000 plants per acre.

Row spacing	Seed/ft of row
40"	10
36"	9
30"	8
24"	7
12"	3
6"	2

High planting rates may cause yields to decrease in low rainfall years because of drought stress, and in good rainfall years high planting rates may have more lodging problems. Low plant populations reduce lodging problems but contribute to low pod set and excessive branching. Extreme low seed number per foot of row may result in erratic stands due to a lack of seedling energy necessary to break the soil surface. This may be critical in solid seeded stands.

Seeding rates should be increased to compensate for unavoidable plant thinning such as with rotary hoeing for early season weed control. Slightly higher seeding rates may be advantageous with June plantings or with no-till plantings, where soil temperatures are lower.

WEED CONTROL

Fields relatively free of weeds are desirable to avoid yield loss from weed competition. Effective weed control is important for profitable soybean production.

Start weed control early. Soybeans are poor weed competitors when cool temperatures slow germination and growth. Prepare seedbeds immediately prior to planting to kill germinating weeds. A rotary hoe, harrow or weeder can be used after planting and before the soybeans emerge. However, do not use mechanical weeding when soybeans are just emerging as the tender hypocotyl arch will be injured. For best results use these mechanical methods when the ground is not covered with trash, not cloddy or wet and when the weed seedlings are just emerging and not more than ¼ inch tall.

Preemergence or preplant incorporated herbicides offer the best opportunity for selective weed control in soybeans. The following herbicides are suggested: Trifluralin (Treflan), ethalfluralin (Sonalan), fluchloralin (Basalin), and pendimethalin (Prowl) are dinitroaniline herbicides applied preplant incorporated for the control of annual grasses and broadleaf weeds. These herbicides will not control wild mustard, common cocklebur and volunteer sunflower. Proper timing and depth of incorporation is essential for each herbicide. Prowl can be used preemergence or preplant incorporated, but weed control generally is superior with incorporation.

Herbicides such as alachlor (Lasso), chloramben (Amiben), metribuzin (Sencor, Lexone) and metolachlor (Dual) applied preplant incorporated or preemergence immediately following planting have given good to excellent broadleaf and grassy weed control depending on weed species. Preemergence herbicide weed control is enhanced by ⅓-½ inch of rainfall following application. Tank mixing metribuzin or chloramben with other herbicides improves control of many broadleaf weeds, especially wild mustard. Observe label precautions when using metribuzin on sandy soils and on soils above pH 7.5 as soybean injury may occur. Injury can be reduced by using herbicide combinations including lower rates of metribuzin.

Postemergence applications of bentazon (Basagran), acifluorfen (Blazer), dinoseb (Premerge) and dinoseb plus naptalam (Dyanap) can be used in soybeans for broadleaf weed control. Dyanap should be applied at the cracking to crook stage of soybean growth to avoid crop injury. Emerging weeds will be killed and Dyanap may provide some residual control of wild mustard. Both bentazon and acifluorfen have given consistent wild mustard control and good control of certain other broadleaf weeds. Bentazon is good on cocklebur and volunteer sunflower control, whereas acifluorfen is the best choice for redroot pigweed and eastern black nightshade control.

Herbicide applications of preplant incorporated diallate (Avadex) and postapplied barban (Carbyne), diclofop (Hoelon), sethoxydim (Poast) and fluazifop (Fusilade) control wild oats in soybeans. Diclofop, sethoxydim and fluazifop will also give good control of annual grasses, including green and yellow foxtail and volunteer corn. Oil concentrate should be added to these grassy herbicides for optimum control. Quackgrass can be controlled in soybeans using higher rates of sethoxydim or fluazifop postemergence or by using glyphosate (Roundup) preplant or anytime prior to crop emergence. Glyphosate or paraquat (Paraquat CL/Gramoxone) can also be used as a preplant or preemergence burndown herbicide treatment in no-till soybeans. Soybeans will not tolerate residues from previous applied herbicides such as atrazine, picloram (Tordon 22K) and chlorsulfuron (Glean). Avoid planting on suspect residue land areas or have an assay of the soil to determine crop safety.

Soybeans are susceptible to injury from 2,4-D, MCPA or dicamba (Banvel) and drift into soybean fields should be avoided. (Refer to Ext. Circular W-253 for further information on herbicide rates, mixtures and use). Always read and follow the label directions when using pesticides.

HARVESTING

Timely, careful harvesting means extra bushels of soybeans. Soybeans are easy to thresh, but the challenge is to get all the soybeans into the combine. Straight combining is the most satisfactory and commonly used method of harvest. Swathing soybeans can result in excessive field losses due to shattering. Use of floating headers, pickup reels, love bars and all row crop headers are necessary to reduce harvest losses. Keep your combine in good repair. A cutterbar in poor condition will increase gathering losses. Be sure knife sections and ledger plates are sharp, and that wear plates, hold-down clips and guards are properly adjusted. Proper reel speed in relation to ground speed will reduce gathering losses. Use a reel speed about 25 percent faster than ground speed. Operate the cutterbar as close to the ground as possible at all times. Keep forward speeds at or below 3 miles per hour. Slow down if stubble is high and ragged, or if separating losses are high. About four beans or one to two pods per square foot represent a loss of 1 bushel per acre.

Harvest soybeans when the plants are mature and the beans have approximately 14 percent moisture. Harvest may be started at 17 to 18 percent moisture when drying is available. Harvest as much of the crop as possible at 12 percent moisture or above to avoid cracking seed coats and "splits." When beans are extremely dry, 8 to 10 percent moisture, harvesting will cause more shattering and seed injury. Under these conditions, combine during morning or evening hours when relative humidity is higher and adjust the combine accordingly. Adjust cylinder-concave clearance according to the operator's manual. When beans are tough, cylinder speed may have to be increased. Decrease cylinder speed as beans dry during midday to reduce breakage. Paraquat can be applied as a dessicant to aid harvesting if green weed growth delays harvest. Do not apply a dessicant until soybean moisture is under 30 percent.

STORING

Soybeans may be stored safely for short periods during cold weather with a moisture content as high as 14 percent. For safe storage during the spring or summer, soybeans should not contain more than 12 percent moisture. An air screen cleaner to scalp off foreign material, weed seeds and fines should be used before applying air and heat to soybeans. Sound beans, free of foreign material and splits, store better and stay in condition longer. The maximum drying temperature for soybeans is about 140 F. When soybeans are to be used for seed, the temperature should not exceed 105 F. In drying soybeans, a grower is seldom confronted with removing more than 2 or 3 points of moisture.

UTILIZATION

The soybean seed contains about 20 percent oil and 40 percent protein. These two components determine the economic worth of the soybean seed. Soybeans have been called the "Cinderella Crop" in the U.S. because of its rapid expansion the past 25 years. For over a hundred years soybeans have been called "The Meat of The Fields" in the Orient.

Farmers and animal feeders worldwide have benefited from the expansion of soybean production, as people around the world strive to improve their diets. This is being accomplished both through increased animal productivity and use of soy protein directly in human consumption. Availability of large supplies of soy oil helped the food industry develop and market many new food products.

While acreage expansion in North Dakota has lagged behind the Corn Belt, the increased production the past few years indicate soybeans are here and North Dakota farmers are aware of this "Cinderella Crop."

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