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THE EXPERIMENT STATION OF THE UNIVERSITY OF NEBRASKA
COLLEGE OF AGRICULTURE W. V. Lambert, Director; E. F. Frolik, Associate Director

CONTENTS

FOREWORD

The purpose of this bulletin is to bring together the latest information available on the production of dry edible beans under irrigation in Nebraska. Cultural practices and disease control are stressed, but included are items on marketing, cleaning, and the use of by-products—straw and cull beans.

The information was assembled from results obtained by Nebraska Agricultural Experiment Station and published information in Farmer's Bulletin 1996, "Growing Dry Beans in the Western States," Farmer's Bulletin 2003, "Legume Inoculation," and the Yearbook of Agriculture, 1952, "Insects."

The author wishes to give recognition to the following who aided in sections printed here: R. E. Hill, Bean Insects; J. L. Weihing, Bean Diseases; and F. B. Morrison, Cull Beans for Livestock Feed.

Cover Picture: Examining a good field of nearly mature beans.

FIELD BEAN PRODUCTION UNDER IRRIGATION IN NEBRASKA

BY F. V. PUMPHREY[1]

PRIOR to 1935 the acreage of field beans grown under irrigation in Nebraska was about the same as the acreage of beans grown on dry land. During World War II, when labor was scarce and food requirements were great, the field bean acreage under irrigation was greatly increased. The value per 100 pounds of dry edible beans increased each year from 1940 through 1947 (Table I) making beans a profitable irrigated crop. Also, irrigation farmers in western Nebraska possessed most of the machinery necessary for field bean production. The dry land acreage of field beans during and following the war decreased mainly because of the favorable price of wheat.

The average acreage of field beans in Nebraska during 1936-40 was 16,500 acres from which were obtained 158,000 bags annually valued at $3.36 per bag. During the period 1946-50, the average acreage was 72,000 from which were obtained 1,102,000 bags yearly valued at $7.45 per bag. Table 1 shows that since 1950 the bean acreage and prices have not been as high as during the period 1946-50. During the period 1946-50 more than 98 per cent of Nebraska's field bean acreage was irrigated.

Bean Types

There are many types of dry edible beans. They vary in size, color, shape, mottling, and culinary characteristics. The major types grown in the United States and the States in which their production is of greatest importance are given in Table 2.

During 1946-50 seven states produced over 93 per cent of the dry bean crop. The remainder of the production was scattered through more than a dozen states. California was the leading state with nearly 25 per cent of the total. Michigan closely followed California in production of dry beans. Other major dry bean producing states were Idaho, Colorado, New York, Wyoming and Nebraska.

Nebraska's entire bean production consists of two types – Great Northern and Pinto. Each type is marketed throughout the United States in the dry packaging trade. The Great Northern and Pinto are preferred by the housewife over the Pea bean because of their greater

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Table 1. Dry Bean Production in Nebraska. Acres Harvested, Average Price Received by Farmers, Production of Cleaned Beans, and Yield per Acre of Uncleaned Beans. U.S.D.A. Agricultural Statistics.[1]

Year	Thousand Acres	Price[2]	Bags Cleaned 1,000	Acre Yield (pounds)
1934	12	4.30	.....	570
1935	16	3.35	.....	650
1936	12	4.10	.....	940
1937	22	3.20	.....	1,050
1938	19	2.70	.....	1,000
1939	14	3.35	.....	1,100
1940	21	2.65	.....	1,520
1941	27	3.80	406	1,600
1942	35	4.80	521	1,600
1943	80	5.70	874	1,150
1944	47	5.90	548	1,250
1945	48	6.10	694	1,520
1946	62	8.70	1,022	1,700
1947	73	9.30	1,005	1,450
1948	83	7.00	1,419	1,800
1949	82	5.80	1,200	1,600
1950	62	6.40	862	1,575
1951	67	7.30	724	1,250
1952	56	7.70	1,063	2,000
1953	68	7.60	1,150	1,850
1954	77	7.10	1,200	1,700

[1] Agricultural Statistics. USDA Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

[2] Price of 100 pounds of cleaned beans.

size and quicker cooking time. Pinto beans are preferred by many people in Southwestern United States and are exported to Mexico some years. The Great Northern and Pinto are not used by the canning trade for they do not retain their shape after processing and canning.

Field Bean Area in Nebraska

Climatic conditions — temperature and rainfall — are the main factors determining the field bean growing area in Nebraska. Farmer's Bulletin No. 1996 states, "Though a warm-season crop, beans do not thrive where temperatures go extremely high. A few hot dry days at blossom time may mean severe damage from blossom drop. Cool, humid or rainy weather is also unfavorable to beans but they are adapted to a fairly wide range of temperature. Preferably they should have monthly means of 65° to 75° F., but they are not tolerant to frost or to prolonged exposure to weather that is near freezing. The frost-free growing season must be about 120 to 130 days, depending on the variety." [2]

Most varieties grown in Nebraska will mature within 90 to 105 days after planting. An additional length of growing season is needed to insure a warm soil at planting time and to have the crop mature during years when early frosts occur in the fall.

At planting time, germination and seedling vigor are retarded by cool rainy weather. Such weather

[2] Mimms, O. L. and Zaumeyer, W. J. Growing Dry Beans in the Western States. U.S.D.A. Farmer's Bulletin No. 1996, 1947.

during the late summer and early fall promotes bean diseases. Late August, September, and early October should be dry to facilitate harvest without damage to the quality of the crop. Great Northern beans, especially in the wind-row, are seriously discolored by long periods of rainy weather. In some years this deterioration of quality costs the bean growers thousands of dollars.

Temperature and moisture requirements of beans limit Nebraska's bean growing area to the Panhandle counties. Of the eleven counties in the Panhandle, seven counties produce 99 per cent of the bean crop. In these seven counties over 98 per cent of the bean acreage is irrigated. Figure 1 shows the distribution of the irrigated bean acreage in Nebraska between 1949-53.

Selection of Land

Field beans can be grown on a wide range of soils if the soil is reasonably fertile, well drained, and aerated. Extremely sandy soil is not suited to bean production because of the hazards of wind erosion and the low moisture-holding capacity of such soil. Beans are sensitive to alkali and water-logged conditions and can not be successfully grown where such conditions exist.

Fields planted to beans should be well adapted to irrigation. Fields should have a uniform slope which is not too steep, and no areas in which irrigation water will pond. Standing water will cause serious damage to bean plants in a very short time.

Cropping System

Beans must be rotated with the other crops usually grown under irrigation in western Nebraska. *The growing of beans after beans, sometimes successfully practiced, is very hazardous because of the intensification of diseases as a result of bean refuse left in the soil. The practice of following beans after beans is not a good one where stable and permanent bean production is desired.* Also, from the stand-

Table 2. Dry Edible Beans, Average Production by Classes, 100 pound Bags, United States, 1946-50, with Leading States.[1]

Class	1,000 Bags	Leading States
White Pea (Navy)	4,013	Michigan, New York
Great Northern	3,192	Nebraska, Idaho, Wyoming
Pinto	2,465	Colorado, Idaho, Nebraska
Red Kidney, light and dark	1,320	New York, Michigan, Calif.
Baby Lima	1,100	California
Standard Lima	1,076	California
Blackeye	609	California
Small White	540	California
Small Red	483	Idaho, Washington
Pink	462	California
Cranberry	157	Michigan, California
Yelloweye	119	Michigan, New York
White Morrow	83	New York
White Kidney	11	New York
Other beans and seed	617	
TOTAL	16,257	

[1] Agricultural Statistics, U.S.D.A., Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

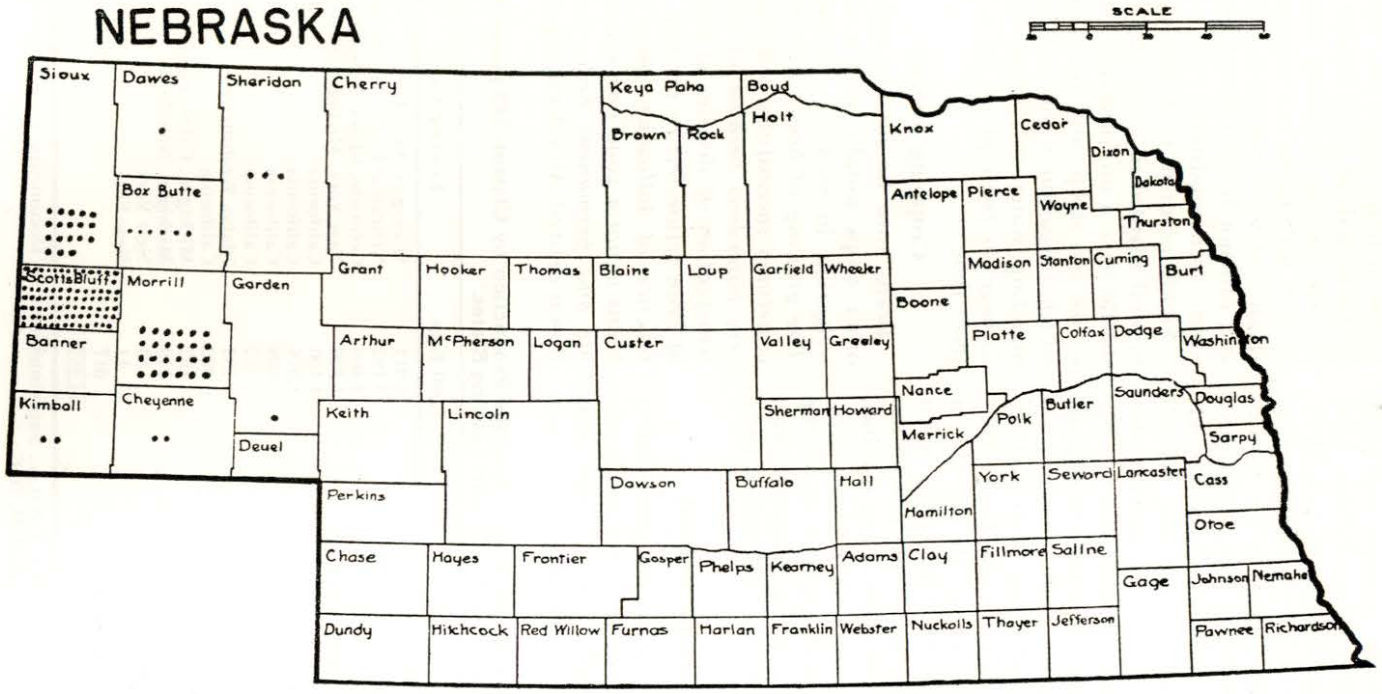


Figure I. Distribution of irrigated bean acreage in Nebraska between 1949-1953. One dot equals 500 acres.

point of disease control, it is hazardous to spread bean straw or manure containing bean straw on land that is to be planted to beans (see Diseases and Their Control).

Rotations which include beans can be flexible. Field beans can be grown either ahead of or after most other crops. They do not demand a favorable position in the rotation but respond well when in a favorable position. The bean crop may be grown advantageously after alfalfa or sweet clover. Sweet clover, when followed by beans, has an excellent opportunity to make a good spring growth prior to plowing, since the beans should not be planted prior to June 5 or 10. Sweet clover plowed under as green manure may contain 125 pounds or more of nitrogen per acre. The sweet clover not only greatly benefits the beans but is also beneficial to the next crop that follows in the rotation.

Beans usually follow potatoes in rotations including potatoes. Potatoes are planted in the most favored position—following alfalfa or sweet clover. Beans can be grown either before or after sugar beets. On soils high in lime (calcareous) at the surface, beans following sugar beets may become more yellow and chlorotic than nearby beans which do not follow sugar beets. Usually the yellowing of the bean plants is associated with cool, rainy weather; with the return of warm dry weather the yellowing disappears. At the present time research workers have been unable to determine the cause of this chlorosis, why the chlorosis is more severe following sugar beets, or if the chlorosis reduces the yield of beans.

Corn stalks bother slightly during the first cultivation when beans follow corn.

Crop rotations which have proved successful for bean production under irrigation in the Nebraska Panhandle follow:

Alfalfa or sweet clover

Plowing under sweet clover. Such a growth will contain as much as 125 pounds of nitrogen per acre.

Beans
Sugar beets
Corn
Beans

Alfalfa or sweet clover
Beans
Sugar beets
Corn

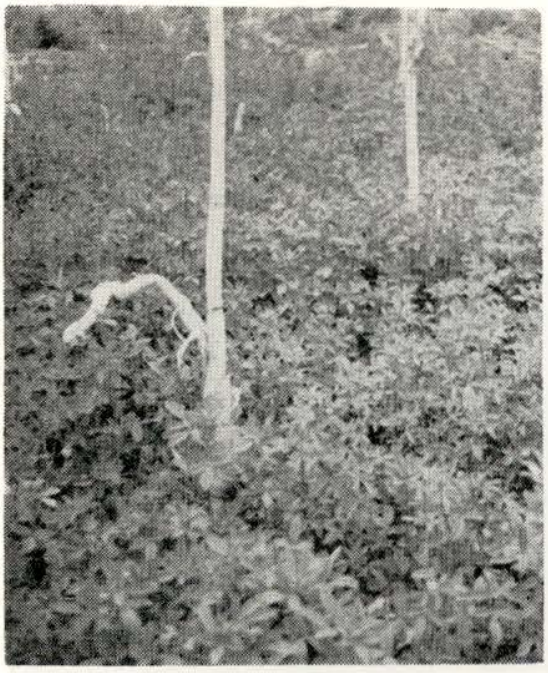
Alfalfa or sweet clover
Potatoes
Beans
Sugar beets

Alfalfa
Beans
Sugar beets
Corn
Barley and sweet clover
Beans
Sugar beets

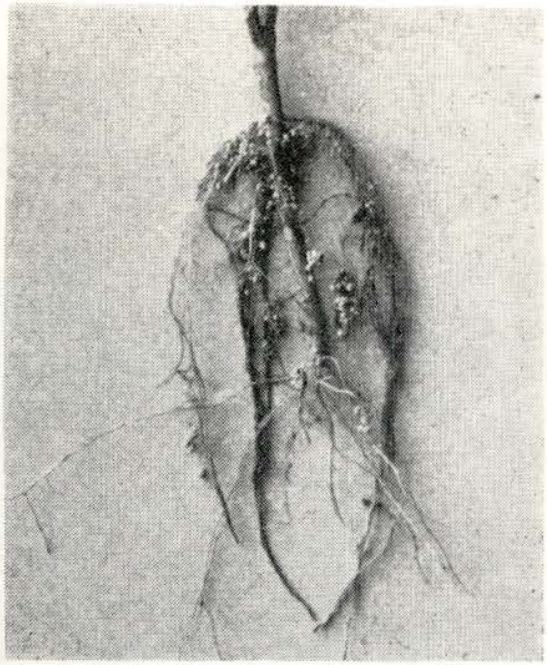
Many farmers are including sweet clover in their rotation by seeding the sweet clover in their corn field prior to or during the last cultivation or ditching. Fifteen pounds of seed is broadcast per acre. The sweet clover makes little growth the year it is seeded. The following spring the sweet clover will make a good growth, sometimes as much as two feet, if plowing is delayed until nearly June 1. It is essential that plowing be delayed so that the sweet clover can produce a large amount of organic matter and nitrogen. Success of this practice depends on having a fertile soil, a clean field, a minimum of slope for irrigation, and not an excessively thick stand of corn.

Nitrogen Fixation by Field Beans

Field beans are a legume and are able to obtain nitrogen from the atmosphere (air) through a process known as symbiotic nitrogen fixation. By this process, bacteria, which live in the nodules on the bean roots, change atmospheric nitrogen to a form useable by the bean plant. Within a few weeks after the bean plant begins to grow,



Sweet clover seeded in corn proves very useful in irrigated rotation.



A well nodulated field bean root.

nitrogen fixing bacteria enter the root hairs. They multiply rapidly and cause the formation of nodules on the roots. The bacteria obtain the food they need from the bean plant, use this food to fix or change nitrogen of the air to a form which can be used by the bean plant.

Nitrogen fixation is usually greatest on soils low in nitrogen or organic matter, yet well supplied with mineral nutrients such as phosphorus, calcium, potassium, and magnesium. This explains why good yields of field beans are often produced on sandy soils low in nitrogen and organic matter.

Field beans fix an average of 40 pounds of nitrogen per acre. This quantity or more of nitrogen is removed per acre in the beans and straw. Thus, even though field beans are a legume they can not be considered a soil improving crop.

Additional information on nitrogen fixation can be found in U.S.-D.A. Farmer's Bulletin No. 2003, "Legume Inoculation."

Fertilization

The larger bean yields are consistently produced on the more fertile soil; thus, beans do respond to soil fertility. However, applications of commercial fertilizers containing nitrogen and phosphorus for beans have not consistently produced increased yields. A high level of fertility can best be maintained by properly fertilizing each crop other than beans in the rotation. The use of manure and commercial fertilizer for sugar beets, corn, and potatoes, and a liberal use of alfalfa and sweet clover in the rotation will usually keep the soil fertile.

Usually the application of nitrogen fertilizer for beans will increase vine growth and delay maturity slightly without increasing yields. Barnyard manure has proved to be a much better fertilizer for field beans than commercial fertilizer.

Soils low in available phosphorus, such as Mitchell and Minatare silt loam, if properly fertilized with phosphorus to produce good yields of alfalfa and sugar beets, will probably contain sufficient available phosphorus to produce good yields of beans. If these soils have not been fertilized with phosphorus, an application of 30 to 50 pounds of available phosphate is recommended.

Land Preparation

A well prepared seed bed is essential to successful bean production. Poor seed beds result in uneven germination, poor stands, weedy fields, and consequently a great loss in yield. Spring plowing and land preparation is recommended in Nebraska. Except on the fine-textured soils, wind erosion is so severe on fall plowed land that fall plowing is not recommended.

Alfalfa and sweet clover should be plowed in mid-May. At this time growth will be sufficient to add considerable organic matter, and soil moisture will not have been seriously depleted. Rainfall, in most years, is sufficient to replenish the soil moisture and provide moisture for germination. Often, when the plowing of alfalfa and sweet clover is delayed until June 1 or later, moisture for both plowing and germination becomes a prob-

Planting field beans in a well-prepared seed bed. Note small clods which help prevent wind erosion.

lem. This may be overcome by irrigating before plowing.

After plowing, the land should be packed and harrowed to insure a firm seed bed, conserve moisture, and kill weeds. If the land is well tilled just prior to seeding and all weeds killed, the labor of keeping the crop clean will be greatly reduced. Land that is slightly uneven after plowing may need to be floated once or twice before planting to prepare the land for irrigation. Floating will aid in packing the seed bed and killing weeds but will increase the hazard of wind erosion.

Seed Selection and Varieties

Only good quality, disease free seed should be planted. Disease free seed usually is insured by buying certified seeds produced in Idaho or similar areas which are relatively free from common blight. *Nebraska is unable to produce beans sufficiently free of disease that can be used for seed purposes.* Any farmer who plants locally grown seed hoping to save money in seed cost is not saving money. His loss in yield will be more than his savings in seed cost.

Testing of various bean types at the Scotts Bluff Experiment Station indicates that the Great Northern and Pinto are best suited to growing in Nebraska (Table 3). Other types, Red Mexican and Small White, can be grown successfully in Nebraska some years. In years of adverse growing conditions, these types produce poorly and would have to command a premium in price to compete with Great Northern or Pinto. Also, local marketing outlets might need to be established for types other than these two now commonly grown.

Yields reported in Table 3 indicate that the commonly grown varieties of Great Northern and Pinto produce approximately the same. Other characteristics of these

varieties, maturity, vine type, bean size, and quality, are similar. Varieties of Great Northern now grown in Nebraska are U.I. 16, 31, 59, and 123. Pinto varieties are U.I. 78 and 111. Farmers unfamiliar with bean varieties are advised to consult with locally experienced growers, local marketing organizations, the county agricultural agent, and State Experiment Stations for the latest recommendations regarding varieties and best sources of seed. Varieties are continually being improved. The best variety today may be second-best tomorrow.

Inoculation

The inoculation of the bean seed with nitrogen fixing bacteria is generally unnecessary. The soil of bean growing areas of Nebraska appears to be well supplied with nitrogen-fixing bacteria. For areas which have not been previously cropped to beans, inoculation with the proper type of symbiotic bacteria is recommended.

Planting

Date of Planting: For best results field beans should not be planted until the soil is thoroughly warm. Usually this is near June 10 and definitely after June 1. Plantings in late May are likely to encounter cool rainy weather delaying germination, causing seed rot, and increasing maggot injury to the seedlings. Late June plantings (June 20) often escape damage from hail storms. Sometimes replanting is necessary because of damage by wind or hail. Beans planted as late as July will mature if weather conditions are favorable. Beans planted this late often produce very good yields of high quality if there is no rust epidemic. Observations over many years indicate that early planted beans are more seriously damaged by bacterial blight than late planted beans.

Rate of Planting: For maximum yields Great Northern and Pinto beans should be planted two to

Table 3. Yield of Dry Edible Beans Produced by Different Types and Varieties. Scotts Bluff Experiment Station, Mitchell, Nebraska. 1950-1953.

Type and Variety		Pounds per Acre	
		Mean, 1950, 1952[1]	Mean, 1951, 1953[2]
Great Northern:	U.I 16	3190	1240
	U.I. 31	3115	875[4]
	U.I. 123	3160	1025[4]
	Mont. 5	3070	1460
Pinto:	U.I. 78	3060	770[4]
	U.I. 111	3240	1100
Red Mexican:	U.I. 3	2860	207[4]
Small White:	U.I. 1	2885[3]	765

[1] 1950 and 1952 were favorable years for field bean production at the Scotts Bluff Experiment Station.

[2] 1951 and 1953 were unfavorable years for field bean production because of disease—common blight and rust.

[3] Grown only in 1950.

[4] Grown only in 1951.

four inches apart in rows spaced 20 or 22 inches apart. This requires a seeding rate of 60-70 pounds per acre and seed with germination of 95 per cent or more. Farmers who plan to harrow or rotary hoe their beans for weed control should plant slightly heavier rates.

Thin stands of beans (plants 6 to 8 inches apart) will produce yields almost as high as stands with plants 3 to 6 inches apart. Replanting is not recommended until stands are thinner than one good plant every 8 to 10 inches.

If beans are seeded at too low a rate the crop can not utilize the full productive capacity of the soil. If more than the optimum rate of seeding is used, the yield is not significantly increased and the additional seed is wasted; also, more disease problems may be encountered under certain conditions.

Depth of Planting: Preferably, beans should be planted 1½ to 2½ inches deep and in moist soil. The depth of planting may vary with soil moisture and soil texture. In sandy soil beans can be planted as deep as 3 inches if necessary. Sometimes farmers throw a ridge cover over the row and harrow the ridge cover off after the seeds have sprouted. The ridge aids germination by preventing the drying out of the soil around the seed and the harrowing helps to control weeds and breaks any crust that may have formed. If a period of rainy weather occurs so that the ridges can not be harrowed at the proper time, serious difficulties are encountered.

Method of Planting: Beans are surface planted in rows with various types of planters. The principal ones used are four or six row bean and beet planters. Farmers who raise both beans and sugar beets plant these crops in the same row width—20 or 22 inches. Thus, the same cultivator can be used for each crop. Some farmers prefer to use alternate wide and narrow

Careful cultivation is essential for weed control. The soil is carefully pushed around the bean plants so that small weeds are smothered.

The second cultivation. One additional operation of cultivating and ditching will be necessary.

rows such as 16 and 24 inches to facilitate the use of large tractors. Also, these farmers may irrigate only in the wide row.

Cultivation

Cultivation is done primarily to control weeds, to prevent crusts from forming, and to make furrows for irrigation. The number of cultivations necessary during the season depends on the condition of the soil, amount of weed seed in the soil, variations in amounts and time of rainfall, and the kind of machinery used. Usually three cultivations are necessary.

The common practice is to cultivate immediately after the beans have emerged and are fully erect. During this first cultivation soil is carefully pushed around the beans so that the small weeds are smothered. If this is successfully accomplished, the field can be kept free of weeds relatively easily the rest of the season. The last cultivation and ditching should be given the beans just as the first flowers appear. At this time the plants are growing rapidly and soon fill 20 or 22 inch rows full of vines; within a few days it becomes impossible to use a tractor in the field.

A variety of duckfeet, shovels, disks, sweeps, and shields are available. Good judgment and experience with these tools is necessary to determine which is best suited to the cultivating job. Cultivations and ditching for irrigation should be as shallow as possible but still deep enough to do the job adequately. Beans are shallow rooted and can easily be root pruned.

One hoeing may be necessary to clean the weeds left by machine tillage.

Irrigation

Field beans obtain most of their moisture from the upper two feet of the soil. Light irrigations will

Irrigating field beans by using syphon tubes and surveyed field ditch.

usually replenish the moisture in the root zone to field capacity. The number of irrigations needed during the growing season and the amount of water per irrigation depends on seasonal weather conditions such as temperature, rainfall, and humidity, and vine growth. During cool, rainy periods beans grow slowly and use little water. Irrigation during such periods may only increase the unfavorable effects of cool, rainy weather.

In the early stages of growth bean plants do not have deep roots. They may suffer from insufficient moisture even though the soil may be very moist below the first foot. For this reason the first irrigation should not be delayed beyond the time when the first few inches of soil become dry. If the root zone was well filled with moisture at planting time, the first irrigation may come near the time that buds and runners start to appear on the bean plant. At this time the bean plant is growing rapidly and an irrigation is desirable to get many blooms and a good set of pods.

A moderate application of water when early pods begin to fill and another to help the late pods fill are recommended. This last irrigation may occur immediately before the first pods begin to change color. Heavy late irrigation in fields of high fertility will cause excessive vine growth, delay maturity, and increase losses from disease.

Sandy soils will require a larger number of irrigations than soils of finer texture and greater water holding capacity. In all cases the water should be allowed to run only as long as is necessary to wet the soil to field carrying capacity in the root zone (the top three feet with field beans).

In experiments conducted at the Scotts Bluff Experiment Station from 1942 to 1944, field beans irrigated three times each year produced an average yield of 34.5 bushels per acre. The average yearly use of irrigation water by each bean crop was 12.9 inches.[3]

Harvesting

Farmers need to exercise good judgment during bean harvest to keep field losses low and bean quality high. Experience is a valuable asset. Improper timing of harvest operations and improper use of machinery may cause large field losses.

[3] Scofield, C. S., and Howe, O. W. Water Imput Used for Field Crops at the United States Scotts Bluff (Nebr.) Field Station, 1941-44. U.S.D.A. Circular No. 777, 1948.

Field beans set their pods over a period of two or three weeks, and consequently all pods do not ripen at the same time. This complicates harvesting because some pods are ripe enough to shatter while other pods are immature. Fully developed beans in pods which have just begun to change color will usually mature satisfactorily after the vines are cut.

Bean cutting should begin when most of the pods have turned yellow and before they have dried. If the pods are allowed to become too dry they will shatter. If the vines are cut too early, the immature beans will shrivel and the vines will require a longer time in the windrow before they become dry enough to thresh.

Usually four-row cutters are used which put two bean rows in one windrow. Side-delivery rakes are used to place two or more of these

Cutting and windrowing field beans.

Slow, careful combining is essential for high quality beans, and low field losses.

double rows into one windrow. Special rakes and windrow machines which handle the beans more gently are available for this job. Raking must be done before the vines and pods are dry or while they are damp from dew in order to keep shattering at a minimum. If a combine is to be used, attention should be given to the size of the windrow. Usually four bean rows will make an adequate windrow for a combine.

Beans in the windrow can readily be blown about by high winds. Thus, farmers desire to keep the time the beans are in the windrow to a minimum. This is usually accomplished by delaying cutting until the beans are fully ripe—a practice which usually increases shattering even though cutting and raking are done while there is dew. While in the windrow Great Northern beans can become discolored if heavy and continuous rains occur.

Combines with pick-up attachments are used almost entirely to harvest field beans. In 1950 over 80 per cent of Nebraska's bean crop

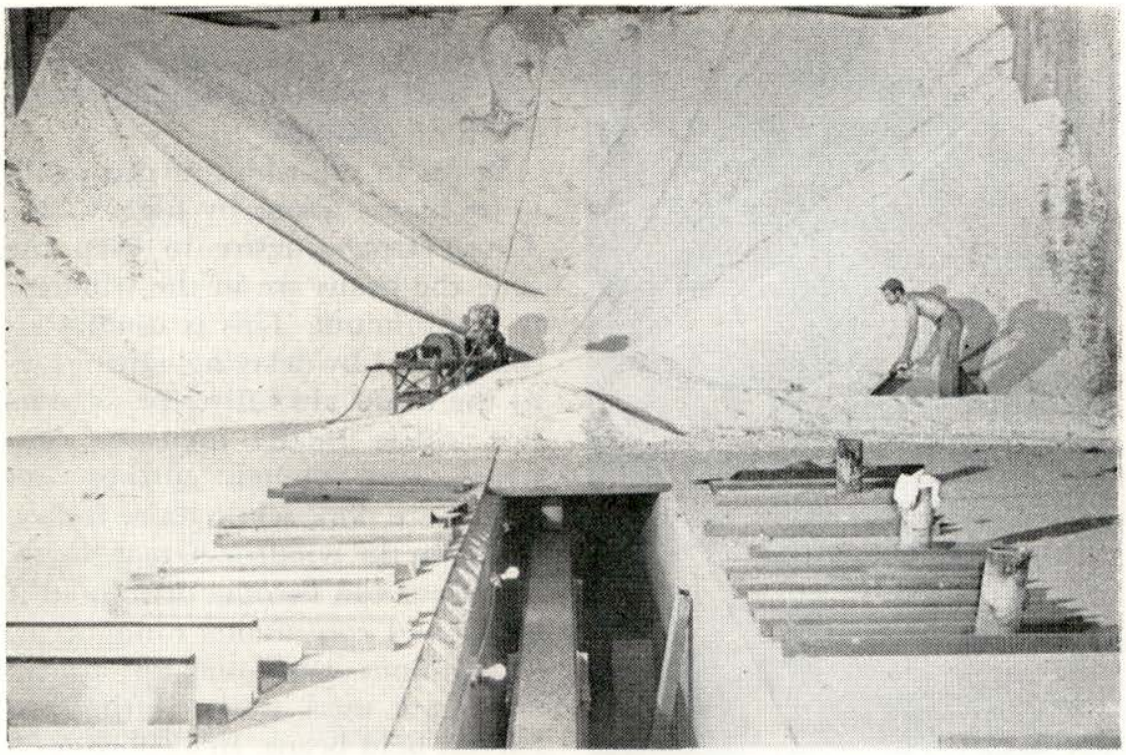
was combined; in 1953 over 90 per cent of the crop was combined. In general small machines, 6 foot, are used, but a trend exists for more custom combining and the use of larger machines. Present equipment necessitates combining from the windrow since suitable equipment is not available for direct combining.

Beans require slow and careful threshing. The beans are readily cracked or split if not handled properly. Most combines can be adjusted so they will handle beans satisfactorily. A slower cylinder speed is the main operating difference between threshing beans and small grain.

Farmers are well rewarded for the time spent in properly adjusting their combines. They save beans from going over the sieves, reduce cracking, and have cleaner beans which grade higher and bring more money when sold.

A survey conducted in 1953 showed that Nebraska field bean growers lost in harvesting operations an average of over three and one-half bushels of beans per acre, worth a total of $17.00 per acre. Improperly adjusted machines, combines over-loaded, and operations poorly timed contributed to beans lost during harvesting. In 1954 and 1955 dew conditions were much more favorable during the harvesting period. A survey of bean fields each of these years indicated losses were only half those of 1953.

If it is uncertain when a combine will be available, it may be well to stack the beans. This prevents the blowing away of the windrow of beans during severe wind storms, reduces shattering and losses from rain. Stacking beans for threshing



Bulk warehouse storage of beans direct from combines. These beans are going to cleaners and to sorters.

at a later date once was the common method of harvesting beans, but now few are harvested in this manner.

Marketing, Cleaning, and Grading

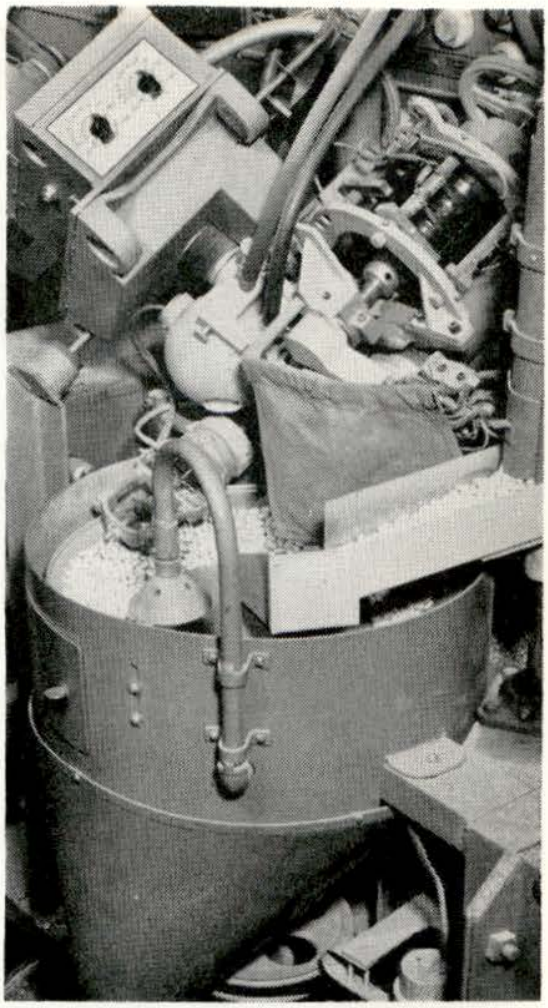
In Nebraska the crop is trucked in bulk directly from the combine to the local warehouse or elevator. These beans direct from combines may contain trash, broken and discolored beans, small clods, and stones. The beans are given a tare and grade by the operator of the warehouse. The warehouse operator may buy them at this time. However, warehouse charges are low enough to permit growers to store their beans to sell at a later date.

Proper cleaning requires special costly equipment and is justified only if large quantities of beans are to be cleaned. Air cleaners, gravity separators, electric-eye sorting machines and polishers have replaced hand labor once used. Modern processing plants market beans of 99 per cent purity or better without being touched by human hands. These plants are mechanically equipped to package beans in a great array of consumer-size packages or in 100 pound bags for canning and wholesale trade.

The United States Standards for Beans, published by the Department of Agriculture, defines grades for beans.

Cull Beans as Livestock Feed

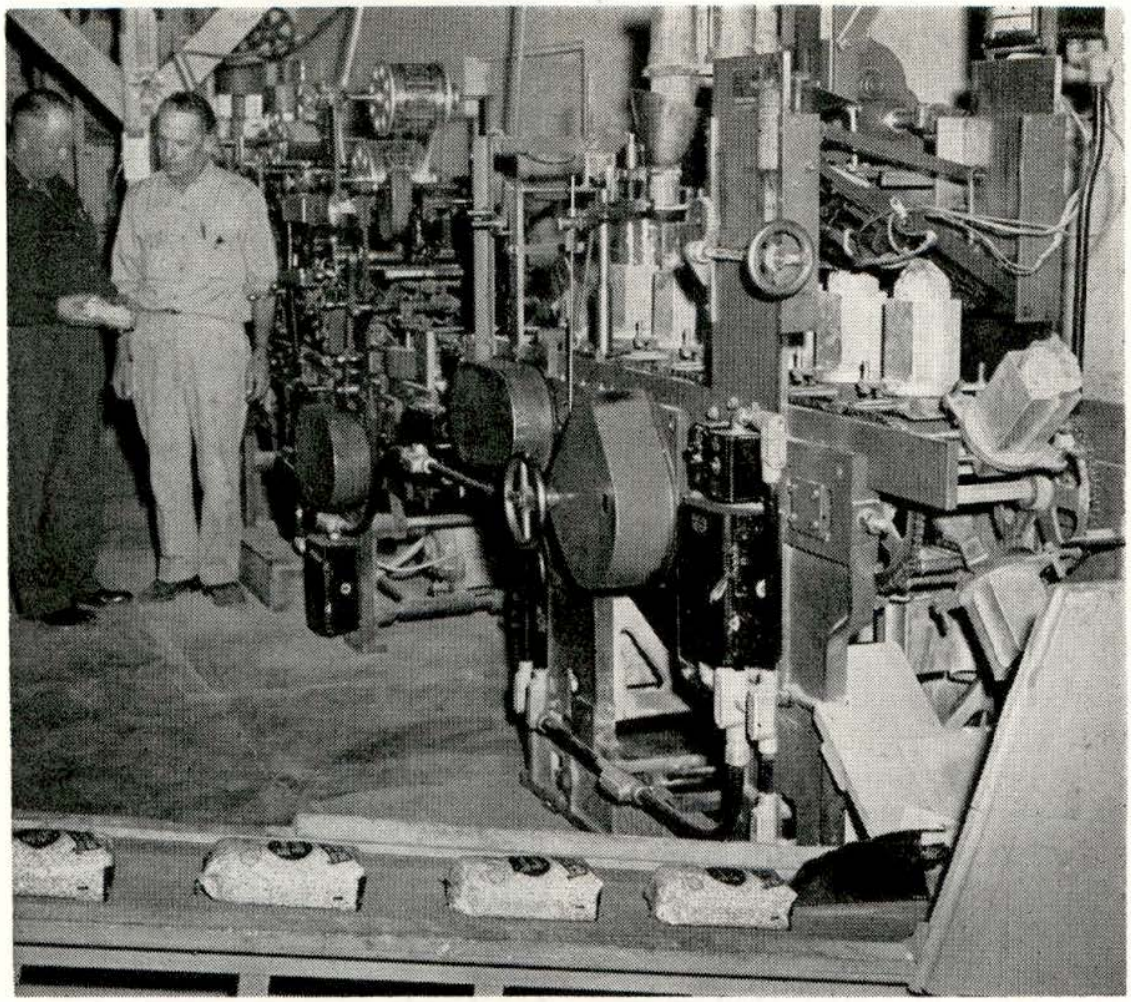
Morrison's Feeds and Feeding states: "Damaged or cull beans can be used satisfactorily for livestock feeding if attention is paid to their limitations. Beans are not very palatable to stock; their digestibility is not high when they are fed raw, especially to swine; and their protein is not of good quality."[4] Chemical analysis shows field beans have as much total digestible nutrients as cottonseed or soybean meal (Table 4).



An electric eye sorts out the beans.

Variable results as to the value of cull beans for fattening lambs have been obtained in feeding tests at the Scotts Bluff Experiment Station. In some tests gains were fairly high when beans made up as much

[4] Morrison, F. B. Feeds and Feeding. (Twenty-first Edition Unabridged). Ithaca, New York. Morrison Publishing Co. 1950.



An all-mechanical packaging machine. Absolutely no hand work is necessary.

as half the grain mixture. In other tests when beans made up 25 per cent of the grain ration gains were extremely low and the use of the cull beans was not justified.

For fattening cattle cull beans can make up as much as 15 per cent of the concentrate with satisfactory results. Cull beans may be of value when they make up a small part of the protein supplement in a wintering ration for beef cows or ewes.

Ground cull beans can be fed to dairy cows as a substitute for other protein supplement, but they should not be more than one-fifth of the concentrate mixture.

Bean Straw

In order to utilize the straw when the combine is used, the straw must be raked, then stacked. During these operations many leaves, pods and fine stems are lost. The resulting straw is often coarse and its value as feed or bedding varies widely. Straw from threshing machines is of much higher quality.

Bean straw is used mainly as bedding, to a limited extent for wintering livestock, and very little for fattening livestock. A considerable demand develops for bean straw for bedding when severe winters occur. In the spring after a dry

winter in which little bedding is used, much bean straw is burned to get rid of it. A better practice would be to haul the bean straw to a corral and use the straw for bedding the following year.

In feeding rations bean straw may constitute as much as one-half the roughage. Good quality alfalfa hay or a protein supplement needs to be fed with bean straw. Livestock fed only bean straw for roughage tend to scour badly.

Bean Insects

Only a few insects are a menace to field beans in Nebraska. The following is restated from the 1952 Yearbook of Agriculture, "Insects" and from Farmer's Bulletin No. 1996, "Growing Dry Beans in the Western States." These two sources are recommended for further information on insects.

Mexican Bean Beetle: The adult Mexican bean beetle is ¼ to ⅓ inch long, hard-shelled, ovate in shape, and yellow-brown to copper colored. Sixteen black spots, eight on each wing, are arranged in three rows across the back. The yellow eggs are laid on end on the under side of the bean leaves in compact groups which may contain as many as 40 or more eggs. The yellow larvae become ⅓ inch long. They eat the underside of leaves, giving them a skeletonized appearance.

The bean beetle is not difficult to control if the insecticide is applied to the under-side of the leaves where the larvae feed. If ground machinery can still be used in the field, either spraying or dusting is effective. When ground machinery can not be used, dusting by airplanes has proven satisfactory.

Applications of insecticides should be made as soon as injury by the larvae becomes apparent. Do not delay applying control methods until the foliage is seriously skeletonized.

Control insecticides are ground derris or cube root powder (rotenone), malathion, and dilan. For a spray use 1½ pounds of cube root powder (4 per cent rotenone) or derris in 50 gallons of water. For dusting with derris or cube root containing 0.5 per cent rotenone, use 12.5 pounds and 87.5 pounds of diluent. Malathion may be used at the rate of 1 pound per acre. Dilan at ½ pound per acre has been effective.

Grasshoppers: Grasshoppers, in large numbers, can damage bean crops as they do other crops. They readily eat all parts of the plant.

Table 4. Digestible Nutrients of Dry Beans for Feed Compared with Other Feeds.[1]

Feed	Total Dry Matter	Digestible Protein	Total Digestible Nutrients
Field beans	90.0	20.2	78.7
Corn, dent, No. 2	85.0	6.6	80.1
Barley, common	89.4	10.0	77.7
Beet pulp, dry	90.1	4.3	67.8
Cottonseed meal, 45% protein	93.5	37.9	78.4
Soybean oilmeal	90.9	37.2	78.4

[1] Morrison, F. B., Feeds and Feeding, Appendix Table 1.

Damage is usually concentrated at the edges of fields, along ditch banks and fence rows. Spraying and dusting of these areas when the grasshoppers are small is recommended.

Sprays are more effective than dusts. Less material is needed and they kill over a longer period. Prepared oil solutions, emulsifiable concentrates, wettable powders, and dusts in various strengths are available at local dealers. These materials can be diluted to suit available equipment such as hand sprayers and dusters, power driven ground equipment, or airplanes. Great care should be taken in diluting insecticides and adjusting equipment to insure applications at the per acre dosages recommended.

The following per acre dosages are recommended – aldrin sprays, 2 ounces, dusts, 3 ounces; chlordane sprays, ½ to 1 pound, dusts, ¾ to 1½ pounds; heptachlor sprays, 2 to 4 ounces; toxaphene sprays, 1 to 1½ pounds, dusts, 1½ to 2½ pounds.

Use the lower rate of chlordane and toxaphene for young grasshoppers when long continued killing action is not essential. Use the higher dosages for older grasshoppers or when kills over a long period are needed.

Dry or wet baits can be used. To prepare a wet bait mix 100 pounds of coarse bran and ten gallons of water which contains one of the following: aldrin, 2 ounces, chlordane, ½ pound, heptachlor, 4 ounces, or toxaphene, 1 pound. Spread about 20 pounds of wet bait per acre.

Seed-Corn Maggot: The seed-corn maggot attacks the germinating seed or the seedling of beans, peas, and corn. The white maggots feed on decaying plants, seed, or soft sprouting seeds. The germ of the seed is eaten so that no plant is produced. Damaged beans often have root systems that develop and push the seeds out of the soil as baldheads with no foliage. Injury is usually more severe in fields high in organic matter and during wet springs.

The treatment of seed with insecticides such as lindane, dieldrin, and heptachlor has given promising results. Most bean dealers have seed for sale which has been treated with one of these insecticides. The cost is not unreasonable.

Preventive measures are recommended for the control of the seed-corn maggot; however, many of these measures are inconsistent with good bean production. Recommended practices are: (1) plow under organic matter as green manure, cover crops, weeds, and manure early enough so that they can become well rotted before bean planting, (2) delay planting until the soil is well warmed up, (3) plant as shallow as possible, (4) avoid planting in cool wet periods which slows germination and increases injury by the maggots. As soon as maggot injury is discovered, replant.

Bean Diseases

Beans are subject to many diseases. The three listed here are the ones most commonly found in Nebraska. For further information consult Nebraska Circular 1813, Farmer's Bulletin No. 1996, and

U.S.D.A. Technical Bulletin No. 868.

Common Blight (Bacterial Blight): To the casual observer common blight is first noticed as dead, dry, brittle areas of irregular size and shape appearing on the leaves. Affected leaves subsequently turn yellow and die. Actually, the earliest symptom of common blight is the development of dark green (watersoaked) spots which frequently have a yellowish border. The dead, dry spots result from these affected areas. Infection on stems show as long, reddish streaks while on pods it appears as reddish, sunken spots. Yellowish or varnish colored spots occur on infected light colored seeds. If the entire seed is infected it may become wrinkled and yellow. Discoloration is not so apparent on naturally colored seeds.

Common blight is caused by a bacterium (Xanthomonas phaseoli). This organism commonly overwinters in infected seed, infected straw, or infected soil. Initial spring infection may come from any one of these sources. The bacteria are carried within a field from infected plants in water droplets during driving rain or hail storms, and by mechanical means when the foliage is wet; for example, on cultivator parts before the morning dew has evaporated. The organism is able to enter tissues only through the plant's breathing pores (stomata) or wounds. Once inside, they multiply very rapidly, eventually causing the degeneration and death of tissues.

Common blight can be controlled by employing the following: (1) planting certified disease-free seed, (2) not planting beans in the same field oftener than once every three years, and (3) not working in the beans when the leaves are wet. It is particularly desirable to control this disease since over the years it has caused more loss in yield and quality than any other bean pest.

Bean Wilt (Bacterial Wilt): This disease may cause a sudden wilt at any stage of development of the plant. The entire plant or only a branch or two may wilt. The drooping is limited primarily to leaves and young growing shoots because the stalk and branches of the maturing bean plant are more or less woody. The wilted leaves die and after several rains they become very tattered or drop off. Elongated islands of dark green may occur along the seams of the pods. The seed frequently shows discoloration and is shrunken and wrinkled. In Great Northern variety the white seed becomes yellow and orange in color.

A bacterium (Corynebacterium flaccumfaciens) causes wilt. The organism lives generally in the plant's water conducting vascular elements. Herein they multiply rapidly, spread throughout the plant and subsequently congest the water transporting tubes. This produces an inadequate supply of water in the leaf tissues, resulting in wilting and death. Some of the bacteria are transported to developing seeds where they remain alive during the winter. Such seed may or may not show infection but if planted and they germinate, the bacteria migrate from the seed into

the vascular elements. The bacteria can also survive the winter in old bean straw left in the field. From this source they can infect bean plants the following year through wounds caused during winds, rain, and hail.

Recommendations for wilt control are the same as those given for common blight.

Rust: The principal symptom of this disease is the appearance on the leaves of reddish-brown spots about the size of the head of a pin. The reddish material can be rubbed off on one's fingers. If the spots become numerous on a leaf, it will collapse and die. Generally, rust is first found on the lower leaves in the lowest part of a field where moisture and humidity are the greatest. The disease can increase to a level where it will kill an entire field of beans.

Rust is caused by a fungus (*Uromyces phaseoli typica*). The red material in the spots is a mass of summer spores (fungus seed). These spores become caught in air currents and are distributed throughout a field and countryside. In the presence of moisture on a bean leaf the red rust spore germinates, producing an infection tube. Once inside the leaf the fungus takes its nourishment from the plant tissues. Seven to fourteen days following infection it ruptures the surface of the leaf, exposing red spores which in turn can cause more infection. As the leaf tissues die the red spores are replaced by a black type which are capable of surviving the winter and are generally not airborne. The red spores die during the winter. In the spring the black spores germinate and produce still another type of airborne spore which, when by chance falls upon a moist bean leaf, will germinate and cause infection. From this initial infection red spores will again be produced thus completing a cycle.

It is only logical that beans should not be planted on the same land in successive years since the rust overwinters on the old foliage. Nor should beans be planted close to old bean straw stacks which contain rust. During the summer rust can be controlled economically in the field by dusting with sulfur. Timely applications are necessary for obtaining successful control. Dusting a heavily rusted field will not cure it. The first application must be made before very much infection has taken place, and treatment should be repeated thereafter at seven to ten day intervals. Twenty to twenty-five pounds of sulfur should be applied per acre depending on the size of the plants.

Summary

1. Great Northern and Pintos are the two types of dry edible beans best adapted to Nebraska growing conditions.

2. Climatic conditions—temperature, moisture, and humidity—limit dry bean production to western Nebraska.

3. Field beans can be grown on a wide range of soils provided the soil is reasonably fertile, well drained, aerated, and not alkali.

4. Field beans must be rotated with other crops primarily from the standpoint of disease control. They can be grown in any position in the

rotation with respect to other irrigated crops.

5. The quantity of nitrogen fixed by field beans is approximately equal to the quantity of nitrogen removed in the beans and the straw.

6. Applications of commercial fertilizer are not recommended. Green manure and barnyard manure are beneficial for bean production. The best method for maintaining proper soil fertility for bean production is proper fertilization of all other crops in the rotation.

7. Seed bed preparation for beans is similar to that needed for other irrigated crops.

8. Certified, disease-free seed must be planted. Varieties of Great Northern and Pinto now grown show no major differences in yielding ability, maturity, and vine growth.

9. Where field beans have been grown previously, inoculation is not necessary.

10. Field beans should be planted at the rate of 60 to 70 pounds of seed per acre after the soil is thoroughly warm. Recommended date of planting is June 5 to 20.

11. Field beans obtain most of their moisture from the upper layers of soil, mainly from the first and second foot. They do not have a high water requirement. Irrigations should be applied to keep the plant growing rapidly; additional water has no value and may be detrimental.

12. Field beans are mechanically harvested by use of a cutter, a rake, and a combine or threshing machine. Proper use and adjustment of these implements is necessary for minimizing harvest losses.

13. Bacterial blight, bacterial wilt, and rust are the common and serious diseases. Planting of certified, disease-free seed and rotation of crops are recommended for control of blight and wilt.