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Safflower Production in the Western Part of the Northern Great Plains

C. E. Classen

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Dry-land safflower in cultivated rows and in solid drilling.

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CARL E. CLAASSEN AND ALBERT HOFFMAN [1]

SAFFLOWER is an oilseed crop which has been grown since ancient times in semi-arid regions of the Middle East and northern Africa. Experimental tests with this crop in the United States during the past 25 years have shown that it is well adapted to the western part of the Northern Great Plains, the area between the Cascade and Rocky Mountains, where the growing season is at least 120 days, and in the southwestern part of the United States (*2* and *5*).[2] **Although safflower has considerable tolerance to drouth, best yields are obtained when there is a good supply of soil moisture combined with hot, dry atmospheric conditions.**

Commercial production has begun in western Nebraska, eastern Colorado, eastern Wyoming, eastern Montana, California and southern Arizona, and is being considered in parts of Oregon, Washington, Idaho, Utah and the Dakotas. The recent development of new varieties which average 32 to 36 per cent oil gives safflower a good chance of becoming an important oilseed crop in the United States. It is the purpose of this circular to acquaint farmers with the crop, describe the varieties and their regions of adaptation, and to outline the most promising production practices for those who undertake its production in the western part of the Northern Great Plains.[3]

CHARACTERISTICS AND GROWTH HABITS

Safflower, botanically a member of the Composite family, is a coarse, erect, annual herb which usually grows 18 to 40 inches in height. Seed does not begin to germinate until soil temperatures are 40° F. or higher, and the rate of germination increases only slightly as temperatures exceed 60° F. After planting, 5 to 20 days are required for emergence of plants, depending upon soil temperatures. Young seedlings that emerge during cool weather are usually not damaged by temperatures as low as 10° to 15° F.; seedlings 4 to 6 inches in height may be damaged by temperatures below 25° F.; and after plants have

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[2] Figures in parentheses refer to References, page 22.

[3] Acknowledgment for providing facilities for research on safflower is made to Harold Chapman, Box Butte Experiment Farm, Alliance; to Lionel Harris, Scottsbluff Substation, Mitchell; to James C. Adams, North Platte Substation; and to various cooperating farmers.

flowered they are damaged by any temperature below freezing. Varieties that make an early rapid growth are more susceptible to frost damage than varieties that make slow early growth.

After emergence, the growth of most varieties is slow for the first two or three weeks, but during the fourth and fifth weeks growth is very rapid (Figure 1). In areas where safflower is planted in the fall, growth is very slow during December, January and February. Branching begins when plants are 8 to 15 inches in height. The extent of branching depends largely upon the distance between rows, the stand obtained in the rows and the amount of available soil moisture (Figure 2). Soon after branching begins, one to five flower buds are formed on each main branch.

Varieties vary markedly in degree of spininess. Some have no spines (spineless), some have a few short spines and still others have many long spines. In the spiny varieties spines become prominent at the time of bud formation. Personal contact in handling a spiny variety after bud formation is disagreeable, but such handling is not necessary in commercial production when good cultural practices are followed.

Plants begin to flower four or five weeks after the first buds appear. In the western part of the Great Plains, this usually occurs during the last two weeks of July. Different heads on a plant flower over a period of 15 to 40 days, depending upon width of row, rate of planting, and

FIG. 1.—Solid-drilled safflower five weeks after emergence (left), and two weeks after emergence (right).

FIG. 2.—Typical safflower plants produced under conditions of solid drilling (left), in 24-inch cultivated rows (center), and in 42-inch rows (right).

available soil moisture. Most varieties are naturally cross-pollinated from 5 to 30 per cent. Insects, primarily wild bees, account for the transfer of the pollen in cross-pollination. Honey bees have been observed to work safflower during some years and not during others. Research is needed to determine whether safflower has possibilities of making good bee pasture.

Each flower bud has from 20 to 100 individual florets, each of which may bear one seed. Best seed set occurs when plants flower during hot dry weather. The seeds are somewhat similar in appearance to those of sunflower and are about the size of barley seeds. Many varieties can be identified by seed characteristics (see back cover). The test weight of good quality seed varies from 37 to 48 pounds per bushel, depending upon variety grown.

In the Great Plains area plants usually begin to mature the latter part of August. Unless moisture is deficient, complete maturity usually does not occur until the latter part of September.

Safflower may produce volunteer plants from seed that has shattered or that was blown over in combining just as do small grains. Under field conditions volunteer plants emerge in early spring (usually the latter part of March) and are easily killed by disking or other tillage operations. Volunteer plants which start along roadsides or waste areas will be eliminated by competition with weeds or grasses.

Safflower has proved susceptible to 2,4-D in both pre-emergence and post-emergence treatments. Application of 2,4-D when plants are in the bud stage usually does not kill the plants but does prevent normal seed set.

COMPOSITION OF SEED AND UTILIZATION

Safflower is a cash crop grown for its seed. The most valuable product obtained from the seed is oil. Indications are now that most safflower oil produced in this country will be used in the paint, varnish and allied industries (*1* and *4*). The variations of the major seed constituents from recommended varieties range as follows:

Oil	26 to 37 per cent
Protein	12 to 22 per cent
Moisture	5 to 10 per cent
Hull	35 to 52 per cent

Seed containing a high percentage of oil and protein contains a low percentage of hulls. An important by-product from processing the seed is the oilseed cake (meal) which remains after the oil is removed. **Feeding experiments conducted at the Nebraska Experiment Station indicate that safflower meal is equal in feeding value to soybean meal when fed on an equal protein basis** (*6*). The percentage of protein in safflower meal may vary from 18 to 60 per cent, depending upon the protein content of the seed and the percentage of hulls removed in processing. In addition to the meal most livestock and poultry relish safflower seed, and in northern Africa quantities of this seed are used for feed.

YIELDS

Dry Land

Fallow. Yields in the western part of the Northern Great Plains have ranged from 500 to 2,000 pounds of seed per acre. Most yields on fallow should average between 750 and 1,200 pounds per acre.

Nonfallow. Yields on nonfallowed land have ranged from failures to 1,300 pounds per acre. Yields of 350 to 750 pounds per acre have been most frequently obtained. Safflower yields following potatoes usually are higher than those following wheat.

Irrigation

Even though safflower requires dry atmospheric conditions for normal growth, it does respond very well to soil moisture in the form of irrigation unless diseases are a limiting factor. (Diseases are discussed on page 11.) Yields on irrigated land usually range from 1,000 to 4,000 pounds per acre. On land of average fertility yields of 1,750 to 2,750 pounds per acre should be easily attainable with two or three irrigations.

ROTATION

Safflower fits into local crop rotation systems in the same way as any other full-season, spring-planted crop. On dry land safflower, like other crops, yields highest following summer fallow. During the past eight years good yields have been obtained the year following potatoes

and fairly good yields (averaging approximately 550 pounds of seed per acre) have been obtained following wheat. During dry years safflower planted on nonfallowed land following small grain would likely be a failure. A fairly good indication of whether it would be profitable to plant safflower following a wheat crop can be obtained by determining depth of soil moisture in early April. When soil is moist to a depth of 3 or more feet in April, the possibilities of obtaining a satisfactory safflower crop are fairly good. If soil is not moist to a depth of 3 feet at time of planting, safflower is very dependent upon timely rains throughout the growing season.

On irrigated land safflower does well following potatoes, beans or beets. However, it can be grown successfully following any of the other common crops. Because of possible increase in disease, safflower should not be grown on the same field two years in succession. Sufficient safflower stubble and straw is left on fields to prevent wind erosion during the winter months. For this reason it may be advantageous to use this crop on the lighter irrigated land which is subject to soil blowing.

Any spring-planted crop can be grown following safflower. However, late-planted crops such as potatoes, beans or corn follow safflower better than do small grains. The effect of safflower straw on a following crop of small grain is similar to the effect of wheat straw on a following small grain crop. Controlled tests show that barley following safflower yields more than barley following wheat but not as much as barley following potatoes or beans. Decaying safflower or small grain straw apparently causes a temporary nitrogen deficiency during early spring months.

On dry land best results will be obtained by summer fallowing after a crop of safflower. On irrigated land, crops such as potatoes, beans, or corn should follow safflower in order to allow time for the straw to decay before the demand for nitrogen becomes heavy. If small grains are planted on irrigated land following safflower, it may be desirable to apply nitrogen fertilizer at time of planting.

SOIL REQUIREMENTS

Light clay or sandy loam soils are considered best for safflower production. **This crop can be expected to do best on deep soils that are well drained.** Safflower has about the same tolerance to alkali as has barley.

Best yields of safflower have been on land of good to average fertility. Heavy fertilizations on land of above average fertility have not resulted in a marked increase in yield. A response will usually be obtained from an application of nitrogen on soils that are known to be deficient in this element.

TABLE 1.—*Characteristics of safflower varieties.*

Nebraska variety number	Nebraska accession number	Spine index	Early growth	Flower color	Maturity	Average test weight	Average oil percentage
			Commercial Varieties Eligible for Certification				
N-852	852	45	Rapid	Yellow	Early	41	32
N-3	514-2-10-1	5	Very slow	Orange	Medium	41	29
N-6	803-16-10-2 and 3	65	Rapid	Orange	Medium	41	32
N-8	583-1-6-10 and 24	65	Slow	Orange	Late	37	34
			Other Commercial Varieties				
N-55	55	60	Slow	Orange	Early	45	29
Indian	.....	60	Slow	Orange	Early	45	28
			Experimental Varieties				
N-9	805-174-11	120	Very rapid	Yellow	Early	41	36
N-10	852-95	45	Rapid	Yellow	Early	41	34

VARIETIES

Many varieties of safflower are distinguished easily by one or more of the following characteristics: flower color, degree of spininess, degree of branching, growth habits, shape of leaves, diameter of seed heads, seed size and shape (see back cover), and oil content. To the processor, the most important varietal difference is that of oil content in the seed. The present varieties vary in oil content from 17 to 36 per cent. In Nebraska a variety is not considered for commercial production unless it averages at least 28 per cent oil.

The oil content of any variety can be expected to fluctuate 3 per cent above or below its average. Some of the more common conditions that lower the oil percentage of all varieties are: hail, grasshopper damage, severe infections of leaf spot, root rot and immaturity. Inadequate soil moisture for maximum yields raises the oil content of some varieties such as N-852 and lowers the oil content of others such as N-6 and N-8. N-852 will usually produce a higher oil percentage on dry than on irrigated land, while N-6 and N-8 will usually produce a higher oil percentage on irrigated than on dry land. The characteristics of the commercial and several experimental varieties are listed in Tables 1 and 2.

N-852 is well adapted in the extreme western part of the Northern Great Plains, in southwestern United States and in the Pacific Northwest. East of Akron, Colorado, and Sidney, Nebraska, this variety is poorly adapted. In the extreme western part of the Northern Great Plains its best adaptation is on dry land. This variety is uniform for type, but is not pure for flower color. Approximately 95 per cent of the plants are yellow-flowered and 5 per cent are orange-flowered.

N-3 is the best spineless variety so far developed. In yield and oil content N-3 is approximately equal to the Indian variety. Seed of this variety is characterized by its very small seed size. Because of its spineless nature this variety may be of interest on irrigated land. On dry land the spineless character is not particularly advantageous and varieties such as N-852 and N-6 could be grown to better advantage than N-3. **If spinelessness is not considered an advantage on irrigated plantings, then N-6 or N-8 should be planted.**

N-6 is characterized by very large open seed heads and for this reason has a tendency to shatter during harvest. On irrigated land of high fertility this variety should produce the highest yield of the varieties now available. Its range of adaptation is much greater than N-852, but not as great as N-8. Because of N-6's high yield potential and rapid growth in early spring, this variety may be of considerable interest on irrigated land. Controlled tests indicate that N-6 may not be as resistant to root rot as is N-8 and N-3.

N-7 and N-8 are sister selections from the same introduction. Experimental tests have shown that these selections do not differ significantly in oil percentage, disease reaction, yield and general appearance. Seed of these varieties in Nebraska has been combined and is now identified as N-8.

N-8 has a greater range of adaptation than any other commercial variety. It appears to be well adapted in southwest Nebraska (the area south of highway 30 between North Platte and Ogallala). **This variety has its best region of adaptation on irrigated land in the extreme western part of the Northern Great Plains and on dry and irrigated land east of the general region where N-852 is well adapted.** At North Platte N-8 can be expected to yield two to three times as much oil per acre as N-852. It is also less subject to shattering than other varieties. On dry land west of Sidney, Nebraska, N-852 and N-6 usually yield more oil per acre than N-8. This variety does not appear to be quite as resistant to drouth as N-852 and N-6.

Indian, N-55 and Rehbein 1885 average 28 to 29 per cent in oil content. It is very difficult, if not impossible, to distinguish these three varieties which are of Hindustan origin. Because of the relatively low oil percentages of these varieties, it is suggested that they be replaced as soon as newer varieties become generally available.

N-9 is characterized by many small heads and many very long spines on the leaves. It has the highest average oil percentage and the most rapid early growth of any variety so far developed. Although N-9 has a very high oil percentage in the seed, under most conditions in the Great Plains area the yield of oil per acre is lower than that of N-852, N-6 and N-8. N-9 is very susceptible to root rot which eliminates its consideration on irrigated land. It is also more susceptible to grasshopper and hail damage than other varieties. This variety will be tested for an additional year or two, and may possibly become eligible for certification during the next few years.

N-10 is a single-plant selection from N-852. In limited tests this variety has yielded 10 to 20 per cent more seed per acre and approximately 2 per cent more oil in the seed than N-852. It is being increased and may be released within the next few years. This variety should be adapted to the same general area as N-852.

During the past eight years marked improvements have been made in safflower varieties. However, additional rapid improvements should continue during the next ten years. It should be possible in a relatively short time to combine rust resistance, spinelessness, high oil, rapid early growth and high yield into one variety. There is also a definite possibility of producing synthetic or hybrid varieties by utilizing inbred lines that are more than 50 per cent crossed.

DISEASES

Rust (*Puccinia carthami* Corda.), bud rot, leaf spot caused by a species of Alternaria and root rot (causal agent a species of water mold) have been observed on safflower in Nebraska *(3)*. The varietal reaction to these diseases is given in Table 2. Experimental lines are available that are resistant to each disease. However, no line now available has resistance to all four diseases. Breeding is in progress to combine disease resistance with high oil content and good yield.

TABLE 2.—*Field reactions of safflower varieties to leaf spot, leaf rust, root rot, and bud rot.*

Nebraska variety number	Reactions to diseases [1]			
	Leaf spot	Rust	Root rot	Bud rot
	Commercial Varieties			
N-852	2	3	3	4
N-3	3	3–	1	4
N-6	2	3	2	2
N-8	3	4	1	1
N-55	3	4	3	4
Indian	3	4	3	4
	Experimental Varieties			
N-9	2	4	4	4
N-10	2	3	3	..

[1] 1 indicates high resistance, 2 indicates some resistance, 3 susceptible, but less so than 4, and 4 very susceptible.

Of the four diseases observed in Nebraska, leaf spot has been the most common. The organism causing this disease is soil-borne and seed-borne. Severe infections have been observed on some varieties in irrigated plantings when heavy dews or frequent showers occurred during July and August. Marked yield reduction may result when this disease is severe. On dry-land plantings only traces of the disease have occurred. Leaf spot is first characterized by large irregular brown spots on the lower leaves. When heavy infections occur the lower leaves turn brown and the irregular spots are also found on the outer flower bracts (lack of moisture may also cause lower leaves to turn brown). All recommended varieties have some resistance to this disease.

Rust was first observed in 1947 and has been prevalent in experimental plots and in irrigated fields in Nebraska and Colorado. This disease may also be severe on dry land. The primary rust infection from spores carried on safflower seed occurs on the first leaves of the seedling or on the portion of the stem below the first leaves. Spores from the primary sources of infection reinfect other plants and the cycle may be repeated every 10 to 15 days (Figure 3). The best control of this disease is resistant varieties. However, it will be several years

FIG. 3.—Rust on seedling safflower plants (left and right), was produced by inoculating seed with rust spores. Rust on individual leaves (center), was produced by inoculating leaves with rust spores.

before these are available. Until resistant varieties are available, planting rust-free seed (if available) may be of considerable value. This is especially true in new areas of production. Safflower planted on the same field on which rusted safflower was grown the year before is likely to be severely infected with rust regardless of seed planted.

Although root rot has been observed on dry land, this disease is more prevalent on irrigated plantings. Therefore it is important that resistant varieties be used on irrigated plantings (see Table 2).

Bud rot which appears to be associated with insect injury is usually a serious disease on susceptible varieties when grown east of the Panhandle region of Nebraska. In the Panhandle region this disease is seldom of importance on early plantings of any variety, but has been serious on late plantings of susceptible varieties.

TREATMENT OF SEED USED FOR PLANTING

Safflower seed containing weed seeds, other grains or foreign matter should be cleaned before planting. Small grains (wheat, oats and barley) are difficult to separate from safflower seed. Therefore if safflower seed has more than a trace of small grains, it is usually advisable to obtain new seed that is entirely free of small grain seed. Treating safflower seed with New Improved Ceresan, Arasan or Spergon at the rate of 1 to 2 ounces per bushel usually helps to insure uniform stands of vigorous plants. Treated seed can be stored several months before planting without damaging the seed. The value of treating seed that is bright in appearance and that germinates 95 per cent or more is doubtful.

PRODUCTION PRACTICES

Time and Depth of Planting

The optimum time of planting in the Nebraska Panhandle is April 5 to April 30. In southwest Nebraska the optimum time of planting is March 25 to April 20. If the top 3 inches of soil is dry, planting should be delayed until after a rain even if this necessitates waiting until early May to plant. Plantings made after May 25 may not mature before a killing frost in the fall. Optimum planting depth is 1 to 1½ inches. Safflower should never be planted deeper than 2½ inches.

Preparation of Seedbed

Safflower competes with weeds better than does flax, but not as well as do wheat and barley. Therefore seedbed preparation should be designed to eliminate as many weeds as possible before planting. **It is very important to disk, duckfoot or rodweed the field just prior to planting.** The last tillage before planting should be shallow, but deep enough to kill all weeds that have germinated.

Preparation of a seedbed following a crop of wheat or other small grain should start with one-waying, subtilling or disking as soon as possible after small grain harvest. In early spring, land should be disked, one-wayed or plowed to kill weeds and volunteer wheat. The amount of subsequent tillage before planting will depend upon spring rainfall and weed growth. Volunteer wheat is usually prevalent in safflower fields planted on wheat stubble. Wheat and other grains mixed with safflower seed lower the value of the seed.

Since safflower is planted in the spring, it is important when summer fallowing for safflower production to use tillage methods that

leave sufficient crop residue on the soil during winter months to prevent soil blowing. Preparation of a seedbed in the spring following fallow has usually been limited to tilling the field a day or two before planting. On irrigated land seedbed preparation similar to that used for beans works very well.

Method and Rate of Planting

Dry land. Two common methods of planting safflower are in solid drilling as with wheat and in cultivated rows 20 to 42 inches apart (see front cover). Results from many tests on summer fallow show that planting in solid drilling is the best method. On nonfallowed land, plantings made in cultivated rows often yield more than those of solid drilling. However, the difference in yield is seldom more than enough to pay for the cost of cultivation. Seed from solid-drilled plantings often has 1 to 2 per cent more oil than that grown in cultivated rows. When growing safflower for certification or maximum seed increase, planting in cultivated rows is preferred because seed can be increased more rapidly and the field can be rogued more conveniently.

In solid drilling, planting rates of 20 to 30 pounds of seed per acre are recommended. Stands of three to four plants per square foot are considered optimum. Weeds often become serious when stands average less than two plants per square foot, whereas stands of six to ten plants per square foot are often sufficient to cause yield reduction from overcrowding of plants, especially if the season is dry. The approximate numbers of seeds required per foot of row for planting in solid drilling at rates of 20 and 30 pounds per acre in rows 8, 10 or 12 inches apart are:

Distance between drill disks (inches)	Approximate number of seeds per foot of row required to plant at indicated rates per acre	
	20 pounds	30 pounds
8	3	5
10	4	6
12	5	7

In cultivated rows 36 to 42 inches apart, planting rates of 8 to 15 pounds per acre are recommended (7 to 12 seeds per foot of row). Five to ten plants per foot of row are considered an ideal stand. Surface planting is preferred to shallow listing, although both methods of planting have been used successfully. Results have been very unsatisfactory with safflower planted in deep lister furrows.

Irrigation. The most satisfactory method of planting on irrigated land has been in cultivated rows 20 to 24 inches apart at rates of 15 to 30 pounds per acre (7 to 14 seeds per foot of row). A stand of four to ten plants per foot of row is considered ideal. Somewhat better weed control within the row is obtained by planting 25 to 30 pounds per

acre. Bean planters, beet drills, or grain drills with some of the feeds closed work well for planting safflower in rows 20 to 24 inches apart.

This crop can also be grown successfully on irrigated land in solid drilling at rates of 25 to 50 pounds of seed per acre. When using this method of planting, land should be relatively free of weeds and the growing crop should be harrowed for weed control as described in the next section. With spineless varieties this method has considerable merit and may be of interest even with spiny varieties.

Harrowing for Weed Control

Since 8 to 20 days are required for safflower emergence when planted in April, weeds often emerge before or at the same time as safflower plants. Weed growth at this time is especially evident when rains occur soon after safflower is planted. Most of these small weeds can be eliminated without damaging the safflower stand by harrowing in a diagonal or crosswise direction to the rows with a peg-tooth harrow or finger weeder a few days before safflower plants emerge or even after a few plants are beginning to push through the soil. Harrow teeth can be set fairly straight and weights can be added to the harrow without causing material damage to safflower stands. Safflower at the time of emergence has developed a strong tap root which keeps the plant well anchored during harrowing. **A thorough job of weed destruction just before safflower plants emerge is usually sufficient to produce a weed-free crop in solid drilling.** When safflower is planted with a deep furrow drill, it cannot be harrowed before emergence without covering plants too deeply. Fields should not be harrowed if

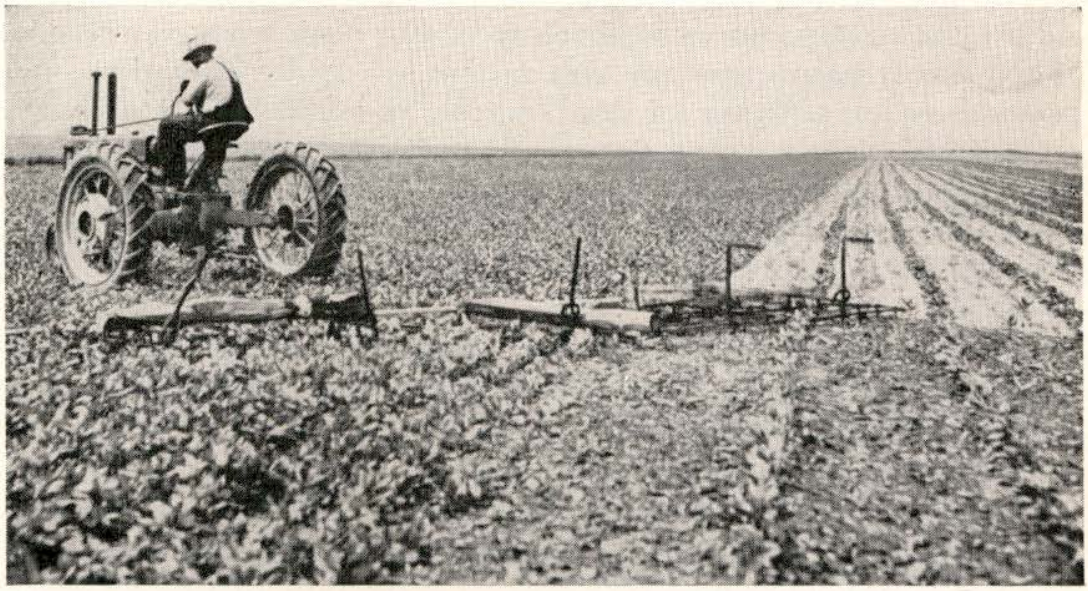

FIG. 4.—Harrowing for weed control in solid-drilled (left), and row plantings (right), at time safflower plants are 3 to 6 inches tall does very little damage to the plants.

plants are covered more than 3 inches from position of planted seed. Harrowing fields between the time safflower plants have just emerged and when they are several inches in height may cover many plants with soil, thus reducing stands.

If necessary for weed control, a harrow, rotary hoe or finger weeder can be used when plants are 3 to 6 inches in height (Figure 4). Tillage at this time has been less effective in controlling weeds than harrowing just prior to emergence. If the field was harrowed a few days before the crop came up, and weeds are again emerging during the time that safflower plants are 3 to 6 inches in height, it may be worthwhile to harrow or rotary hoe the field again. Tillage of the field for weed control will cause less damage to safflower plants when done during afternoons of days with bright sunshine and high temperatures. Growth is very rapid after safflower plants are 3 to 6 inches in height and weeds just coming up will usually be crowded out unless stands are thin (less than two plants per square foot). Working the field with a harrow or rotary hoe will not destroy weeds that are the same size as the safflower plants. After safflower is more than 6 to 8 inches in height harrowing will usually cause severe damage to plants.

Cultivation

It usually is necessary to cultivate safflower planted in rows 20 to 42 inches apart at least two and sometimes three times for adequate weed control. **Harrowing for weed control a few days before safflower plants emerge is also recommended for row plantings.** The first cultivation is usually made during the latter part of May when plants are 2 to 3 inches in height. Beet knives work well for the first cultivation. Additional cultivations with shovels should be made whenever needed. When timely harrowings and cultivations are made, it usually is not necessary to hoe safflower for weed control. Should hoeing be necessary on irrigated plantings of spiny varieties it should be done before flower buds appear in late June. The last cultivation and ditching on irrigated land usually are made the third or fourth week in June and on dry land the last cultivation usually is made in early July.

Irrigation

An irrigated field that has been planted in rows 20 inches apart must be ditched within 7 to 10 days after plants start to branch in order to avoid damaging safflower plants (Figure 5). The original ditches should be made deep enough to last all season.

In experimental plots the number of irrigations during the season have varied from one to six. If only one application of water is to be made, it is suggested that this be given at the time plants first begin to flower. When using two irrigations, the first irrigation should be given several weeks before flowering, and the second 7 to 10 days after

FIG. 5.—Irrigated safflower field at optimum height for ditching.

flowering has begun. **Two or three irrigations during the growing season usually are necessary for maximum yields.** When irrigating for maximum yield it is important that the first irrigation be given soon after flower buds start to form. The following average dates of irrigation are suggested for maximum yield in the Great Plains area: (1) latter part of June, (2) middle of July, and (3) early August. Irrigation water should not be applied after August 20. Seasonal rains and temperatures will of course have a great effect on the times and numbers of irrigations.

It is important to avoid over-irrigating safflower. Some farmers have lost entire fields by irrigating too heavily. Plants are likely to die after irrigation or heavy rains in parts of the field that are poorly drained. Plants will withstand more water in the seedling and bud stage than after flowering. **Until experience is gained in irrigating this crop, it is suggested that careful consideration be given to the amount of water applied at any one time.** It is better to give safflower too light an irrigation than one that is too heavy.

Growing Certified Seed

During the past few years some difficulty has been encountered in maintaining pure safflower seed of good quality. Much of the seed produced contained mixtures of small grain (wheat, barley and oats), and in some cases weed seed (especially wild sunflower), even after the seed had been cleaned over a fanning mill. Certification standards for

safflower have been established in Nebraska by the Nebraska Crop Improvement Association, and Nebraska varieties N-852, N-3, N-6 and N-8 have been made eligible for certification. Some of the more important points of these certification standards are: (1) Field must be isolated a minimum of 40 rods from any other variety of safflower. (2) Field must not contain more than 1 per cent of other crops and not more than 2 per cent of off-type plants at time of field inspection. (3) Seed produced should be 98 per cent or more pure seed, should have not more than 5 other crop seeds per pound, not more than 10 weed seeds per pound, should be free from noxious weed seed and should germinate 85 per cent or more. More details regarding safflower certification in Nebraska may be obtained by writing to the Nebraska Crop Improvement Association, College of Agriculture, Lincoln, Nebraska.

In order for safflower to meet certification standards a few suggestions may be helpful. Since small grain mixtures are undesirable in safflower, it is important to plant on summer fallow, or when planting on irrigated land it is important to have safflower follow some crop other than small grain. If roguing is necessary in solid-drilled fields or in those planted in rows 20 inches apart, this should be done in late June at the time buds are just starting to form. When planting in wide-spaced rows 36 to 42 inches apart on dry land, roguing can be done more effectively later in the season. **Combining should be done soon after maturity so that germination will not be reduced by weathering of the seed.**

HARVESTING

Combine Adjustments

Safflower is well adapted to direct combine harvesting (Figure 6), and no major modification of the combine is necessary. **However, to prevent cracking the seed, it is essential to reduce cylinder speed to 500-900 rpm.** When reducing cylinder speed it is important to keep other parts of the combine running at normal speeds. In combines that have tooth cylinders, all concaves should be blanked. Combines with bar-type cylinders should be adjusted to ½- to 1/16-inch clearance between concaves and cylinder, depending upon dryness of plants. Wind and sieve adjustments similar to those used with barley work well. Most safflower will have a small percentage of unfilled seed (trace to 5 per cent), and sufficient wind should be used to blow over this unfilled seed.

Shattering before and during harvest is influenced by the variety grown, length of time the crop is left standing in the field after maturity and the dryness of plants at time of harvest. Swathing the crop a few days before it is ready for direct combining and using pick-up

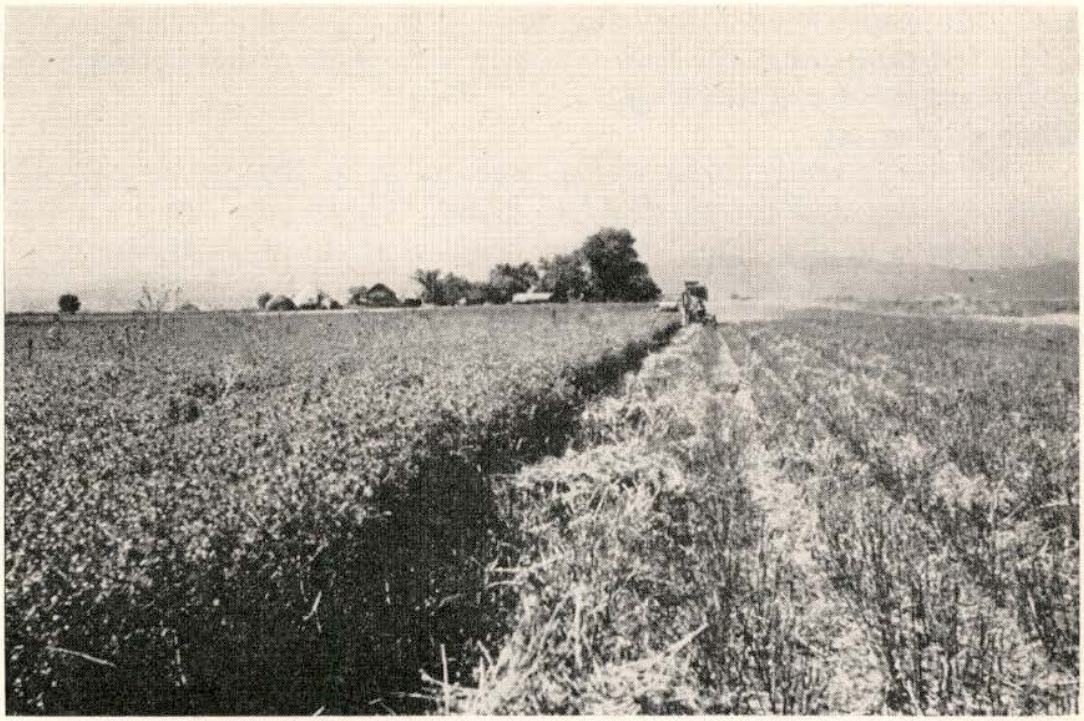

FIG. 6.—Safflower is well adapted to combine harvesting.

attachments on the combine eliminates most shattering that normally occurs from sickle and reel during direct combining. Whether safflower should be swathed before harvest may depend on how well safflower harvest fits with other farm operations. Safflower is usually mature enough for swathing by September 15, but if the field has very many weeds, it may be necessary to delay direct combining until after frost. Occasionally other farm operations interfere with safflower harvest immediately after frost and for this reason the harvest has often been delayed for more than 30 days after complete maturity. Such a delay usually results in considerable seed loss. To avoid such delays in combining, it may be worthwhile to swath safflower as soon as the seed is completely filled and use pick-up attachments on the combine to harvest this crop before other farm work becomes pressing.

If the crop can be combined as soon as mature, it usually will be merely an added expense to swath the field. Most of the seed loss from the reel can be eliminated by attaching a 4- to 6-inch strip of flexible belting to the reel slats. The reel should also be raised so that only the top of the belting hits the plants. Occasionally difficulty is encountered from plants hooking on reel slats. This loss can be eliminated by filling in the area between reel arms with plywood, canvas, or fine-mesh, heavy-gauge wire. In solid drilling, plants are small and this difficulty is seldom encountered.

Farmers who have had experience in combining safflower state that with proper cylinder adjustment no seed cracking should occur,

and with proper wind adjustment dockage in seed should not run over 2 to 5 per cent unless the field is very weedy. **Ease of harvesting is an important feature of this crop.**

Time of Harvest

Safflower is ready to harvest as soon as 98 to 100 per cent of the heads are dry and thresh easily by hand. There may still be a few green leaves at this time. Seed in heads that thresh easily by hand seldom contains more than 8 per cent moisture and is dry enough to store. **Heads that are green or that are wet from dew or rain are very difficult to thresh.** Seed in heads that are difficult to thresh is too wet to store.

INSECT, LIVESTOCK, PHEASANT AND RODENT DAMAGE

Grasshoppers may cause considerable damage to safflower. These insects usually do not become prevalent on safflower until after small grain harvest. Damage from grasshoppers usually is limited to the margins of the fields. However, under some conditions severe damage has occurred throughout sizable fields. There are varietal differences in grasshopper tolerance, but all varieties tested are subject to damage from these insects. Poisoning grasshoppers along the edges of the fields may be worthwhile before or shortly after small grain harvest.

Leaf hoppers have been observed feeding on safflower leaves during the latter part of May and early June. Damage from these insects has never been severe enough to warrant control measures.

Livestock relish safflower plants in the succulent stage and will keep plants clipped short if they are allowed access to safflower fields. Cattle will also eat unthreshed safflower heads regardless of the degree of spininess.

Pheasants are fond of safflower seed and some loss from this source can be expected, especially when harvesting is delayed for a long time after maturity. Small unharvested sections of safflower fields should have some value as a source of food for pheasants and other game birds during winter months.

Rodents also are fond of safflower seed and may cause losses in storage and along edges of fields planted adjacent to prairie land.

EFFECT OF HAIL AND SOIL BLOWING

During the past eight years observations have been made on the effect of hail on safflower at all stages of its growth. **From these observations it is apparent that the amount of damage which hail causes is dependent upon time in life cycle of plant when hail occurs, method of planting, and variety grown.** During the more succulent stage of growth, which occurs from the time plants are 6 inches in height until after all flower buds have formed, safflower is as easily damaged by hail as are the small grains. Plants are in this stage for about four

weeks, and when planted during the latter part of April the period of high hail susceptibility occurs between June 7 and July 7. Early April planting would advance this stage of growth about one week, whereas early May planting would delay this stage of growth about one week. Hail occurring before plants have attained a height of 6 inches or after plants have made their total growth in height, causes less damage to safflower than to small grains.

Solid-drilled plantings are damaged to a lesser extent than plantings made in cultivated rows. Varieties also vary markedly in ability to withstand hail. There seems to be a definite positive correlation between coarseness of stems and tolerance to hail.

Safflower subjected to a hail of light to medium intensity during the succulent stage of its growth will have lodged plants. These plants often produce a fair amount of seed even though they never straighten out. Pick-up guards should be used in combining safflower damaged by hail.

Soil blowing can damage safflower seedlings during April and May. The usual effect has been to retard growth of plants. Severe soil blowing over a period of several days can ruin a stand of safflower. However, seedlings of this crop have much more resistance to soil blowing than do beets or beans.

EVALUATION AS AN INDUSTRIAL CROP

The commercialization of safflower is now well underway. Markets for the seed have been established by Western Solvents, Inc., Longmont, Colorado; Chemical Crops, Inc., Morrill, Nebraska; and a number of oilseed processing companies in California. In past years safflower was not seriously considered by industry as a commercial crop in this country because seed of the varieties then available averaged only 24 per cent oil. Seed of varieties now eligible for certification averages 32 per cent oil. These varieties are also higher yielding than earlier varieties which averaged only 24 per cent oil.

The price per pound that industry can pay for safflower seed is largely dependent upon the oil content of the seed and the market price of the oil. Since safflower oil has not entered world trade a definite value for this oil in relation to other oils has not been established. Recent research (*1* and *4*), has shown that safflower oil should be equal in value to linseed oil when used for some purposes. However, as a general purpose oil the price will probably be established somewhere between that of linseed and soybean oils. The price that industry pays for safflower oil can be expected then to parallel the current prices of linseed and soybean oils.

In the dry-land area adapted to safflower production, varieties with 32 per cent oil should produce at 1949 price levels approximately the

same income per acre as wheat. Safflower does not compete with wheat for markets. Since there have been years when wheat has been produced in apparent surplus, the addition of safflower to the cropping system should give greater stability and diversification to agriculture in the western part of the Northern Great Plains. A combination of winter wheat and safflower in the rotation should work well because planting and harvesting of the two crops come at entirely different times of the year. On irrigated land farmers who obtained yields of 2,000 pounds or above considered safflower more profitable than barley and in a competitive position with beans. On irrigated land safflower may have a definite place on the lighter soils from the standpoint of soil conservation. **There usually is sufficient crop residue left on the soil surface after combining a safflower field to prevent wind erosion during winter months.**

The establishment of a safflower processing industry in the western part of the Northern Great Plains will provide a good locally produced protein supplement for feeder and range stock in the area. Also, the production of vegetable oil in this area is a basic industry which may lead to the development of other industries based upon safflower oil as the raw material. The establishment of safflower as a crop will require the cooperation of the farmer, industry, the chemist, and the plant breeder.

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ESSENTIALS OF SAFFLOWER PRODUCTION

1. Since commercial safflower production is just beginning, arrangements for marketing the seed should be made before planting.

2. Safflower does not compete with weeds as well as do small grains.

3. In seedbed preparation it is important to kill all weeds by tilling the field a day or two before planting.

4. Plant high quality seed of recommended varieties.

5. Plant in moist soil at depths of 1 to 2 inches.

6. On dry land, plant in solid drilling as with wheat at rates of 20 to 30 pounds per acre or in cultivated rows at rates of 8 to 15 pounds per acre. On irrigated land, plant in rows 20 to 25 inches apart at rates of 15 to 30 pounds per acre or in solid drilling at rates of 25 to 50 pounds per acre.

7. Optimum time to plant is between April 5 and April 30.

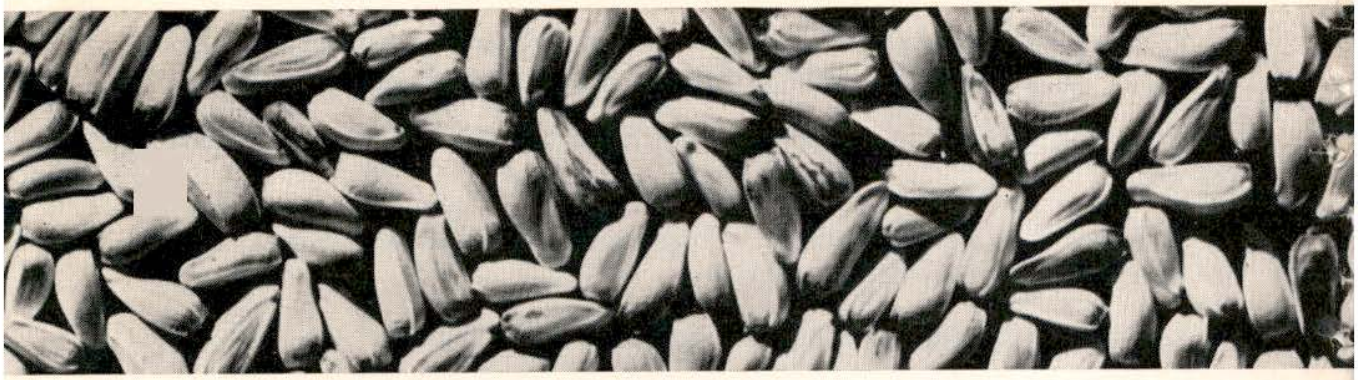
8. Harrowing fields planted to safflower just before emergence has helped in the production of a weed-free crop.

9. Safflower usually does not lodge, shatters very little, and is well adapted to direct combining.

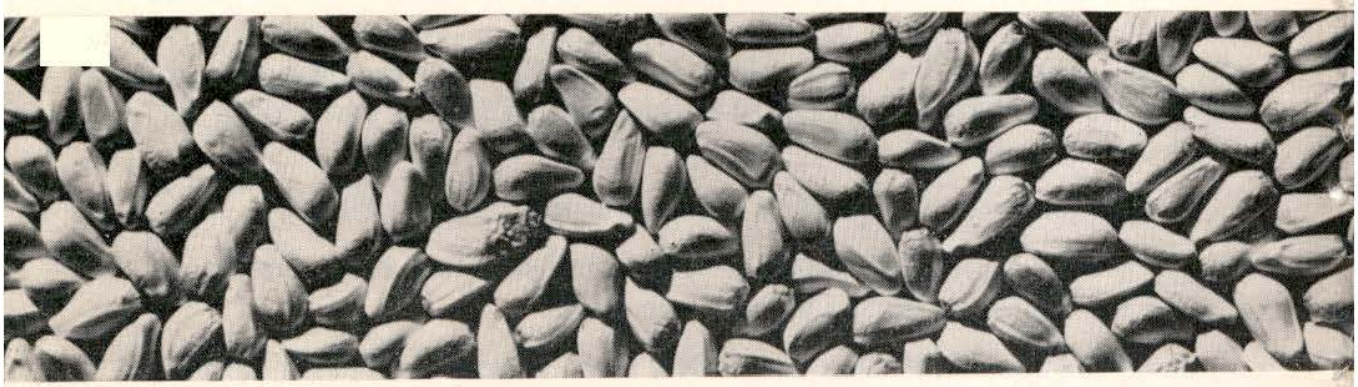
10. For best results safflower should be harvested within a few days after maturity, which usually occurs the latter part of September.

Seed from Varieties of Safflower

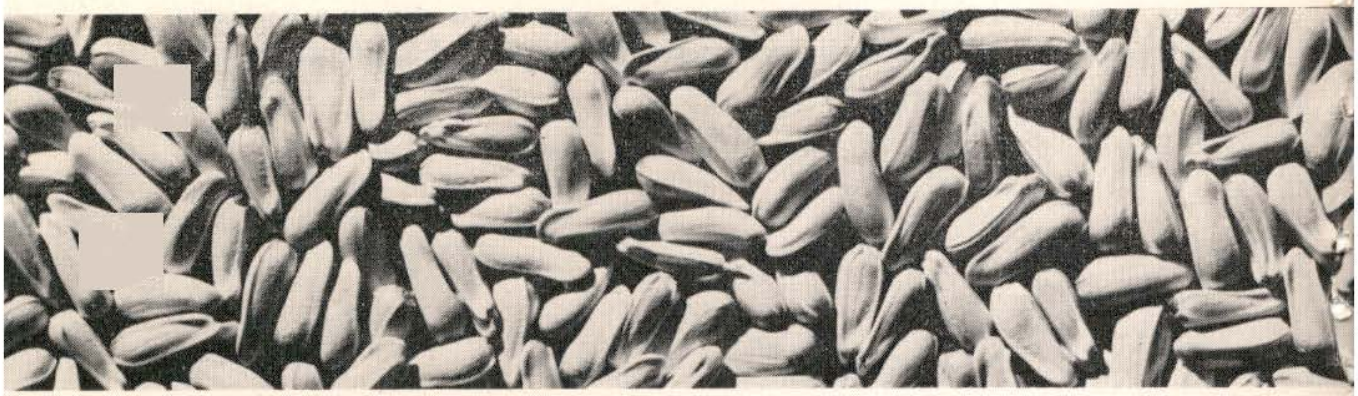
(Seed in all pictures enlarged to about twice normal size.)



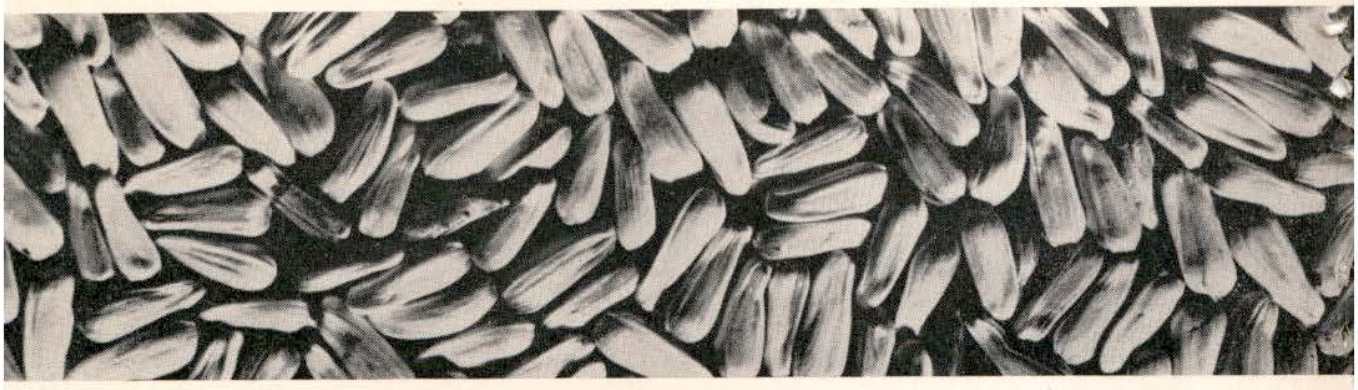
N-852. Oil content, 32 per cent. Spine index, 45.



N-3. Oil content, 29 per cent. Spine index, 5.



N-6. Oil content, 32 per cent. Spine index, 65.



N-8. Oil content, 34 per cent. Spine index, 65.