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Safflower Production in the Western Part of the Northern Great Plains

C. E. Classen

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Carl E. Claassen

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

The Experiment Station, University of Nebraska
College of Agriculture, Lincoln, Nebraska
W. V. Lambert, Director
M. L. Baker, Associate Director

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Agricultural Experiment Station
University of Nebraska College of Agriculture
W. V. Lambert, Director
M. L. Baker, Associate Director

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CARL E. CLAASSEN[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 20 years have shown that it is 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 some parts of southwestern United States (*2* and *6*).[2] In the western part of the Northern Great Plains the best area for safflower production includes that part of Colorado directly east of the Rocky mountains, the Nebraska Panhandle, all parts of Wyoming which have a growing season of at least 120 days, western South and North Dakota, and eastern Montana. It may be possible to develop varieties which are well adapted to the area east of the general region outlined above. Although safflower has considerable tolerance to drought, best yields are obtained when there is a good supply of soil moisture combined with dry atmospheric conditions (low relative humidity).

Commercial production has begun in western Nebraska, northeastern Colorado, western North Dakota and eastern Montana, and is being considered in parts of Oregon, Washington and California. Recent development of new varieties with seeds averaging more than 30 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 and to outline the most promising production practices for those who undertake its production in the western part of the northern Great Plains. Varietal recommendations are based on uniform regional variety tests which were conducted by a number of agricultural experiment stations in the area in cooperation with the Nebraska Experiment Station. Recommendations on production practices are based on experimental work conducted in the Nebraska Panhandle during the past seven years.[3]

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[1] Research agronomist, Chemurgy Project, University of Nebraska.

[2] Figures in parenthesis refer to References, page 23.

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

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 planted during April or early May comes up in 8 to 15 days, depending upon soil temperature. Seed will not start to germinate until soil temperatures are 40° F. or more, and the rapidity of germination increases very little as temperatures exceed 60° F. Seedlings are usually not damaged by temperatures as low as 10° to 15° F., but after flowering, plants are damaged by any temperatures below freezing.

Growth of most varieties is slow for the first several weeks after emergence. During the fourth to fifth weeks after emergence (latter part of May or early June) very rapid growth occurs (Figure 1). Plants start to branch when 8 to 12 inches in height. The extent of branching depends upon width of row, rate of planting, and amount of soil moisture (Figure 2). Soon after branching starts, from one to five flower buds are formed on each main branch. Plants on irrigated land usually shade the entire area between 20-inch rows by July 1.

Varieties vary markedly in degree of spininess. Some are completely spineless, others nearly spineless, and some very spiny (see Table 1 for spine index of varieties available). **In spiny varieties the spines**

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).

become especially prominent at the time of bud formation. Personal contact in handling a spiny variety after bud formation would be disagreeable, but such handling need not be involved in commercial production when good cultural practices are followed.

Plants begin to flower the latter part of July. A plant remains in flower over a period of 15 to 40 days, depending upon width of row, rate of planting, and available soil moisture. Most varieties are naturally crossed from 5 to 30 per cent. Insects, primarily wild bees, account for the transfer of most of the pollen in cross pollination.

Each flower bud has from 20 to 100 individual florets, each of which may bear one seed. 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 38 to 48 pounds per bushel, depending upon variety grown.

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 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. **Under conditions in western Nebraska safflower is not a potential weed.**

COMPOSITION OF SEED AND UTILIZATION

Safflower is a cash crop grown for its seed. The most valuable product obtained from the seed is oil. The variations in major seed constituents from recommended varieties are:

Oil	26 to 37 per cent
Protein	15 to 22 per cent
Moisture	6 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 (*7*). The percentage of protein in safflower meal may vary from 20 to 60 per cent depending, for the most part, upon the percentage of hulls removed in processing and to some extent upon protein content of the seed.

Most livestock and poultry relish safflower seed and quantities of this seed are used for feed in northern Africa. However, because of the high value of the oil in industry, it will usually be more profitable for the farmer to sell the seed to an oilseed processing plant and to buy back the oilseed meal for feed. The meal contains considerably more protein than the seed and would be more desirable for feed. Indications are now that most safflower oil produced in this country will be used in the paint, varnish and allied industries (*1* and *5*).

YIELDS

Dry Land

Fallow. Yields in the western part of the Northern Great Plains have ranged from 500 to 1,500 pounds of seed per acre. Most yields on fallow should average between 750 and 1,200 pounds per acre. Present indications are that safflower on the average can be expected to yield 50 to 60 per cent as many pounds of seed per acre as wheat. In order for safflower and wheat to be of equal value per acre on summer fallow, the price of safflower should be approximately twice that of wheat on a poundage basis. The costs of producing the two crops are about the same.

Non-fallow. Yields on non-fallowed land have ranged from failures to 1,200 pounds per acre. Yields of 350 to 750 pounds per acre have been most frequently obtained. Safflower following wheat has yielded on the average as many or more pounds of seed per acre as has wheat following wheat. If land is not to be fallowed following wheat, safflower following wheat would probably be more profitable than wheat following wheat. **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 18.) Yields on irrigated land have ranged 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. Marked improvements in the adaptation of varieties to production on irrigated land can be expected within a few years.

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 seven years good yields have been obtained the year following potatoes and fairly good yields (averaging approximately 500 pounds per acre) have been obtained following wheat. During dry years safflower planted on non-fallowed 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.

TABLE 1.—*Characterization of commercial and experimental safflower varieties.*

Nebraska variety number	Nebraska accession number	Spine index [1]	Early growth	Flower color	Maturity	Approximate av. oil percentage	Field reactions to diseases [2]		
							Rust	Leaf spot	Root rot
				Commercial Varieties					
852	852	45	Rapid	Yellow	Early	32	3	2	3
55	55	60	Slow	Orange	Early	30	4	....	....
Indian	....	60	Slow	Orange	Early	28	4	3	3
				Experimental Varieties					
1	804-32	0	Slow	Red	Late	28	3	4+	1
2	804-21-3	5	Slow	Red	Late	28	3	4	1
3	514-2-10-1	5	Slow	Orange	Medium	29	2	2	1
4	461-1-9-1	5	Slow	Orange	Medium	28	3	2	1
5	472-2	45	Intermediate	Orange	Late	31	3	2	1
6	803-16-10	80	Very rapid	Orange	Early	31	3	2	3
7	583-1-6-10	80	Intermediate	Orange	Medium	34	4+	2	1
8	583-1-6-24	80	Intermediate	Orange	Medium	34	4+	2	1
9	805-174-11	120	Very rapid	Yellow	Early	36	4	2	3

[1] The spine index is calculated by multiplying the number of spines on an outer involucral bract by the length in millimeters of the longer spines. (Spine index of 0 indicates complete spinelessness, whereas index of 120 indicates extreme spininess.)

[2] 4 indicates very susceptible, 3 less susceptible than 4, 2 moderate resistance, and 1 resistant.

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 grain is planted on irrigated land following safflower, it may be desirable to apply nitrogen fertilizer at time of planting.

During recent years weedy bromes (downy brome and hairy chess) have become troublesome weeds in some wheat fields. These weedy bromes emerge in the fall after wheat planting. After these weeds are established they are difficult to control in a rotation of summer fallow and wheat. An occasional substitution of a spring-planted crop such as safflower in the rotation will help to keep these weeds under control.

Very little is known regarding the response of safflower to commercial fertilizers. Research along this line is contemplated. It has been observed that correspondingly higher yields are obtained on more fertile soils.

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 varietal variation in oil content is 17 to 37 per cent. In Nebraska a variety is not considered for commercial production unless it averages at least 28 per cent oil. Oil content of any variety can be expected to fluctuate several per cent above or below its average.

The characteristics of a number of commercial and experimental varieties are listed in Table 1. Of the commercial varieties, Nebraska 852, an introduction from the Anglo-Egyptian Sudan, is the best now available and is the only variety now eligible for certification in Nebraska. This yellow-flowered variety is superior to Indian and Nebraska 55 in ability to produce stands, rapidity of growth in early spring, and oil content. N-852 is also equal or superior in yield of seed per acre to Indian and N-55.

N-55 is a pure orange-flowered selection from Pusa 14, which is an introduction from Hindustan. It is uniform in type, and is superior to Indian in oil content and equal to it in yielding ability.

Indian safflower as originally released in 1945 is a mixture of Hindustan introductions, Pusa 2, Pusa 7, Ahmednager 1, Simla, Sholapur 1 and Kardai. These introductions are similar in type and oil content. The predominant flower color is orange. About 5 per cent

of the plants of this variety are nearly spineless, and the seed lacks uniformity in size and oil content. This variety is slow in germinating, and growth is slow during the first three weeks after emergence. Other Hindustan introductions are grown to some extent in eastern Montana. Some of these may average more than 28 per cent oil, others less. Introductions from Hindustan tested in Nebraska have been similar in appearance but variable in oil content. Indian safflower should be replaced as soon as N-55, N-852 and newer varieties become available in quantity.

The nine experimental varieties listed in Table 1 are being increased. One or more of these varieties may be released for commercial production during the next year or two, depending upon additional yield tests.

Experimental varieties 1 to 4 are spineless. They are of interest for production on irrigated land even though oil content is below that of the newer spiny varieties. Varieties 1, 2 and 5 have a great deal more tolerance to hail than any of the other varieties listed. Varieties 1 and 2 have produced fairly good yields on irrigated land, but inferior yields on dry land. Varieties 3 and 4 have yielded well on dry as well as on irrigated land. Variety 5 in uniform regional tests has been outstanding in yield on irrigated land. Variety 6 in limited tests has been exceptionally high in yield on both dry and irrigated land. It has a small number of very large seed heads. Early growth of this variety is exceptionally rapid. Varieties 7 and 8 are very similar in appearance and may be bulked, provided performance tests in 1949 indicate equal yielding ability. Both varieties appear to have high yield potentials. From 5 to 15 per cent of the seed of these varieties has an incomplete hull. These seeds are reddish brown to black in color. Variety 9 is the highest in oil content of any variety now available. It is characterized by a high degree of spininess, much branching, fine stems, and many small seed heads. It also has good yielding ability. It is, however, very susceptible to grasshoppers and because of its fine stems is easily damaged by hail.

TREATMENT OF SEED USED FOR PLANTING

Safflower seed containing weed seed, other grains or foreign material should be cleaned before planting. It is important to treat seed with New Improved Ceresan or other mercuric dusts at the rate of 1 to 2 ounces per bushel in order to help insure uniform stands of vigorous plants and to reduce the number of primary sources of leaf rust infection. Unlike cereal rusts, safflower leaf rust is also transmitted on the seed. Treated seed can be stored several months before planting without damaging the seed.

PRODUCTION PRACTICES

Time and Depth of Planting

In Nebraska, April 10 to May 10 is the optimum time to plant. The actual time of planting within the period April 10 to May 10 should depend upon the earliness of the season and condition of the seedbed. Maximum yields usually cannot be obtained from plantings made after May 10. Plantings made after May 25 are not likely to mature before a killing frost in the fall. Optimum planting depth is 1 to 2 inches. Safflower should never be planted deeper than 2½ inches. **If the top 3 inches of soil is dry, planting should be delayed until after a rain even if this necessitates waiting until the middle of May to plant.**

Preparation of Seedbed

Safflower competes with weeds better than does flax, but not as well as do wheat or 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 which 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 or other grains mixed with safflower seed lowers 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 which 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 non-fallowed 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 40 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. With the Indian variety usually only about 50 per cent of seed planted produces plants, but about 75 to 98 per cent of the seed of other varieties can be expected to produce plants. Therefore Indian should be planted at somewhat heavier rates than other varieties. The approximate numbers of seeds required per foot of row for planting in solid drilling at rates of 20, 30 and 40 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	40 pounds
8	3	5	6
10	4	6	8
12	5	7	9

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 40 pounds per acre (7 to 18 seeds per foot of row). A stand of four to twelve plants per foot of row is considered ideal. Somewhat better weed control within the row is obtained by planting 25 or more 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 40 to 60 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 of planting has considerable merit and may be of interest even with spiny varieties.

Harrowing for Weed Control

Since 8 to 15 days are required for safflower emergence when planted in April or early May, weeds often begin to emerge before or at the same time as safflower plants. Weed growth at this time is especially evident when rains occur soon after safflower planting. 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 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 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, safflower can be harrowed again during the period when plants are 3 to 6 inches in height (Figure 3). Harrowing at this time has been less effective in controlling weeds than harrowing just prior to emergence. If the field was harrowed

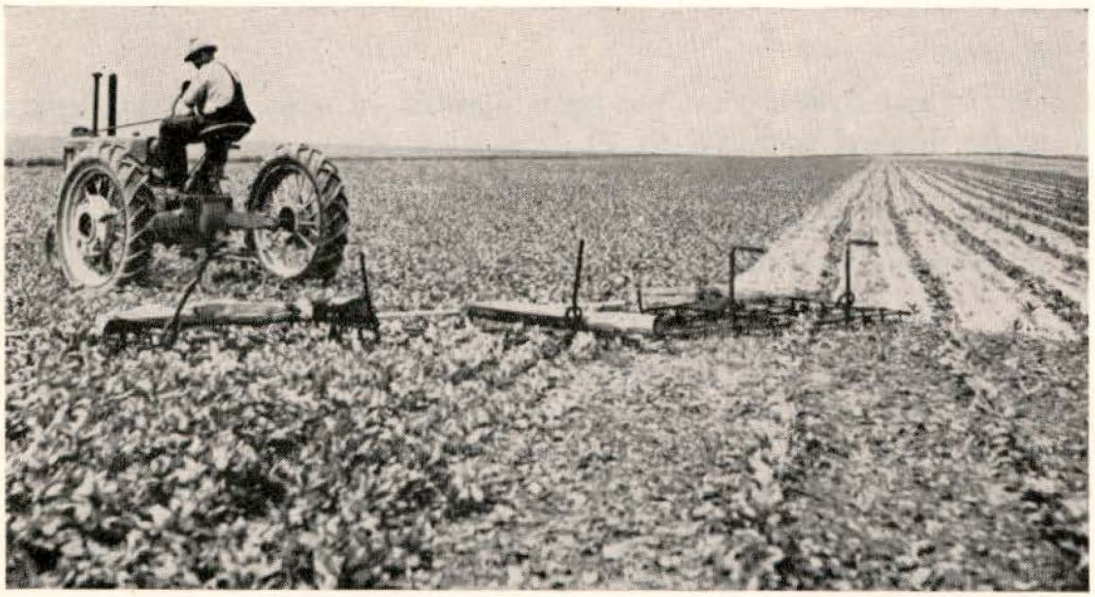

FIG. 3.—Harrowing for weed control in solid-drilled (left), and row plantings (right), at time safflower plants are 3 to 6 inches tall does very little damage to the plants.

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 again for weed control. Harrowing 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). Harrowing at this time will not destroy weeds which have been up for more than two weeks. After safflower is more than 6 to 8 inches in height harrowing will cause severe damage to plants.

Cultivation

It is usually 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 is usually 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 are usually made the third or fourth week in June and on dry land the last cultivation is usually 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 4). 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 four. 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 flowering has begun. **Three irrigations during the growing season are usually necessary for maximum yields.** When irrigating for maximum yields 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 yields: (1) latter part of June, (2) middle of July, and (3) early August. During exceptionally dry seasons four irrigations appear to be necessary for max-

FIG. 4.—Irrigated safflower field at optimum height for ditching. Photographed June 20.

imum yield. Irrigation water should not be applied after August 20. Seasonal rains will of course have a great effect on the time of irrigation.

Irrigations made before flowering commences may be heavy. Those made after flowering has begun should be medium to light. Plants are likely to die after irrigation or heavy rains in parts of the field which are poorly drained. More research is needed to determine the effects of time and rates of water application on yields, oil content, and diseases in safflower.

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 the Nebraska 852 variety has 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 pro-

duced 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 plant following 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 5), and no major modification of the combine is necessary. **However, in order to prevent cracking the seed, it is essential to reduce cylinder speed to 500-700 RPM.** When reducing cylinder speed it is important to keep other parts of the combine running at normal speeds. In

FIG. 5.—Safflower is well adapted to combine harvesting.

combines which have tooth cylinders, all concaves should be blanked. Combines with bar-type cylinders should be adjusted for 1/4 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.

Although safflower usually does not shatter before harvest, the reel may cause some shattering while combining. This shattering is especially serious when seed heads are large and when plants are very dry. Most of this loss from the reel can be eliminated by attaching a 4- to 6-inch strip of flexible belting to the reel slats. This reduces the jar of the reel against seed heads. The reel should also be raised so that only the top of the belting hits the plants. Occasional 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

For best results safflower should be harvested as soon as all leaves have turned completely brown. This usually occurs between September 15 and September 30. On irrigated land it often requires a killing frost to turn all leaves brown. Since the crop does not shatter or lodge, harvesting can be delayed two to four weeks after maturity, if necessary, to fit into labor needs on the farms. It is easier, however, to adjust the combine for an excellent job of cleaning the seed, if harvesting is done within one week after maturity. The stems on plants which are very dry become brittle and in combining the cylinder breaks these brittle stems into small pieces which are difficult to separate from seed. Furthermore, more reel shattering occurs when plants are very dry. Seed in heads which thresh easily by hand 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 which 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 is usually limited to the

margins of the fields, but under some conditions severe damage has occurred throughout sizable fields. There are varietal differences with respect to grasshopper tolerance, but all varieties tested are subject to damage from these insects. Poisoning grasshoppers along the edge of 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 are also fond of safflower seed and may cause losses in storage and along edges of fields planted adjacent to prairie land.

DISEASES

Leaf rust (*Puccinia carthami* Corda.), leaf spot caused by a species of Alternaria, and root rot (causal agent not yet determined) have been observed on safflower in Nebraska (*3*). The varietal reaction to these diseases under field conditions is given in Table 1. Experimental lines are available which are resistant to each disease. However, no line now available has resistance to all three diseases. Breeding is now in progress to combine disease resistance with high oil content and good yield.

Of the three 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. 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 found on the upper leaves (lack of moisture may also cause lower leaves to turn brown). Research is in progress to determine the feasibility of controlling this disease with chemical dust or sprays until resistant varieties are made available.

Leaf rust was first observed in 1947 and has been prevalent only in experimental plots. It will probably occur in commercial plantings

FIG. 6.—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.

during the next few years. 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 reinfest other plants and the cycle may be repeated every 10 to 15 days (Figure 6). Treating seed with New Improved Ceresan at the rate of 1 to 2 ounces per bushel greatly reduces the number of primary sources of leaf rust infection. This disease causes marked yield reduction only when plants are heavily

infected early in the season. If all seed is treated this disease will probably not become severe (*3* and *4*).

Just how severe root rot on safflower may become is not yet known. Since most of the newer varieties are resistant, this disease will probably not be serious.

EFFECTS OF HAIL AND SOIL BLOWING

During the past seven years observations have been made as to the effects 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 about 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 wind than do beets or beans.

EVALUATION AS AN INDUSTRIAL CROP

Markets for safflower seed have been established by Western Solvents, Inc., of Longmont, Colorado, and Chemical Crops, Inc., of Scottsbluff, Nebraska. 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 available for commercial 1949 plantings is mostly of the Indian variety

which averages 28 per cent oil. New varieties which average 31 or more per cent oil (see Table 1) are being increased and sufficient seed should be available to plant 100,000 acres in 1950. Present indications are that varieties with high yielding ability and oil contents of 35 to 38 per cent should be available within a few years.

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 *5*), has shown that safflower oil should be equal in value to that of 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 which 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 31 per cent oil should produce at 1948 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 production 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 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 the 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 clean seed of recommended varieties which has been treated with New Improved Ceresan or other mercuric dusts.

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 40 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 40 pounds per acre or in solid drilling at rates of 40 to 60 pounds per acre.

7. Optimum time to plant is between April 10 and May 10.

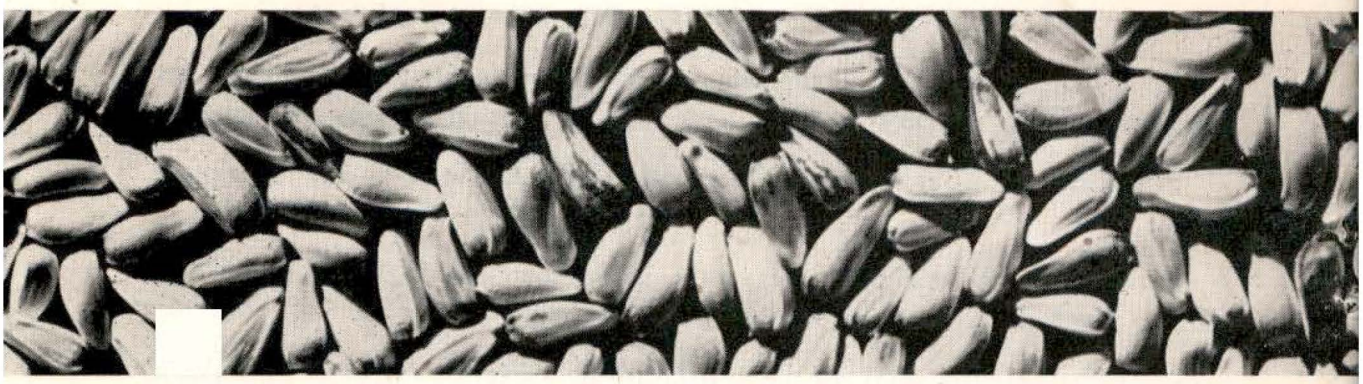
8. Harrowing field planted to safflower just before emergence has helped in the production of a weed-free crop.

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

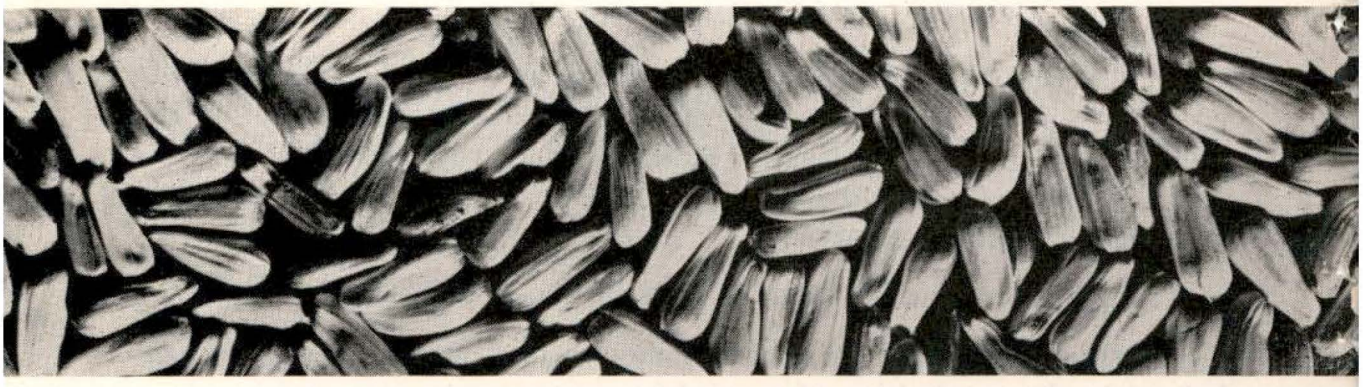
10. For best results safflower should be harvested within a week to ten days after maturity, which usually occurs the latter part of September.

Seed from Varieties of Safflower

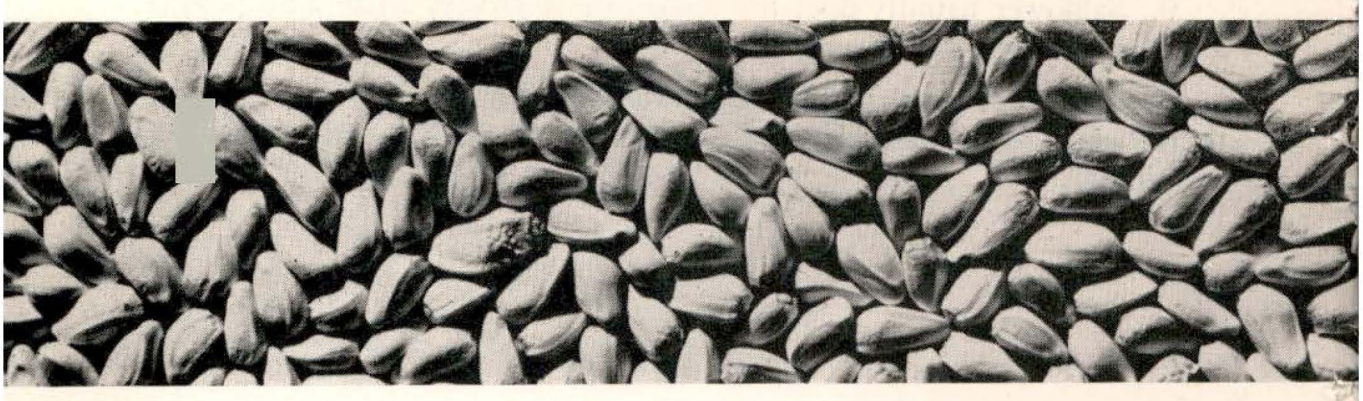
(Seed in all pictures enlarged to about twice normal size.)



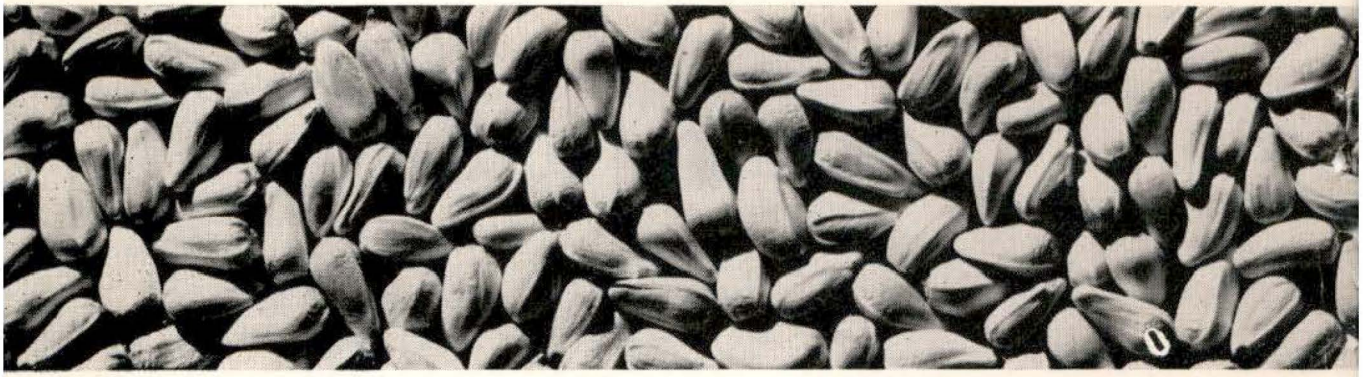
N-852. Oil content, 32 per cent. Spine index, 45.



N-8. Oil content, 34 per cent. Spine index, 80.



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



N-55. Oil content, 30 per cent. Spine index, 60.