Safflower Production in Fresno County
by Shannon Mueller, 1990

History
Safflower (Carthamus tinctorius L.) is a member of the thistle family and produces a seed high in polyunsaturated oil which has been identified as reducing the incidence of heart disease for some people. Safflower oil is also used in paints and varnishes, but the major demand for oil has been for use in human diets in such products as margarines, cooking and salad oils, and mayonnaise. Residue remaining after the extraction of the oil is used as a livestock feed because of its high protein content.

California and Arizona contribute about half to the nation's safflower production. California acreage for 1989 was estimated at 125,500 acres. The national acreage is estimated to total 217,000 to 317,000 acres. The highest California acreage of safflower was 301,000 in 1963, which produced nearly 308,000 tons. Arizona production was in 1967 when its 96,000 acres produced 87,200 tons.

This oil crop, which was first grown in California, is now grown in several states. It is best adapted to areas not too far from yellow or black cotton. It is a typical warm weather crop. California growers have experienced favorable results with safflower.

The maturing of safflower sets the stage for several stages of management. Once the plant has grown from yellow to green in the central head (known as the 'greenhead'), the crop is ready for harvest. In California, the disagreement as to when the crop is ready for harvest is illustrated by those who look at the yellow color of the head. A high yellow color indicates a low oil content, while a green color indicates a high oil content. As such, plants flower at about the same time, but harvesting should be delayed until the heads have turned green.

Planting Date
Safflower is an annual crop which tends to grow a deep tap root, 8 feet in permeable soils. Therefore, the crop should be grown on deep, well-drained soils with neutral pH, preferably with a water table at about 4 to 6 feet. Planting of safflower takes place between December and February, about the same time as small grains. Plants will mature in late July. Planting earlier than December produces taller plants that are difficult to harvest. The plant is very sensitive to daylength, and will flower when the daylength reaches a critical time. Consequently, planting later than February creates plants short in both stature and yield. During the cool winter weather safflower remains in a low-growing rosette stage, but with warmer spring temperatures the plant produces a central stem which grows rapidly. The crop will withstand frosts down to 10-15°F. Once in flower, it is sensitive to temperatures below freezing. Minimum temperatures are about 20°F in the seedling stage, 25°F when the stems are elongating, and 32°F after the bud stage. Maximum temperature tolerances are not precisely known. Temperatures above 105°F may interfere with pollination and increase irrigation problems.

Seedbed Preparation
The type of seedbed prepared for preirrigated, drilled cereals works well for safflower. The ideal safflower seedbed has a firm surface free from large clods, with good moisture beginning about 1 inch below the soil surface. When the crop is to be furrow irrigated, raised beds like those used for cotton and sugar beets have proved satisfactory. When safflower is grown as a winter crop, it is extremely important to prepare a seed bed that is free of weed seeds and seeds of other crops. Safflower should become established before summer weeds are serious, and clean stands result. Drilling seed has resulted
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This oil crop became economically viable only about 35 years ago when University of Nebraska researchers brought genetically improved varieties to California. Since then, University of California, USDA, and private breeders have made improvements, and growers have become experienced in growing the crop, so California quality, year in and year out, is hard to beat. Most California safflower has been grown under contract to oilseed processors. the contracting processors have provided a grower price and supplied planting seed as well as advisory help.

The mature plant has several branches each terminating in a flower. The flower actually consists of several small individual flowers grouped to form a head. Each small flower, which may vary in color from yellow to orange or red, gives rise to a white or cream-colored seed, there are 20 to 100 seeds per head. The whole seeds resemble small sunflower seeds. From the farmer’s standpoint, the most disagreeable feature of commercial varieties of safflower is the presence of spines on the leaves and head. Although breeders worked to develop spineless varieties, the spined materials had higher oil contents than selections without spines. The spines do not develop until about two weeks before the plants flower, and have not been a problem in growing or harvesting the crop.

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in better stands than broadcasting. However, for early spring plantings, broadcasting both from ground rigs and from the air is satisfactory if the soil moisture situation is good. Follow broadcasting with the harrow or disk. The important point is to place the seed in moist soil, whether drilled or broadcast-sown. Subsequent cultivation will not be possible if the safflower is broadcast.

Seeding Rate
Safflower has been grown solid (broadcast or in close-drill rows) on the flat, or in rows on beds of various widths. A preirrigation filling the soil to field capacity to a depth of 6 or more feet is desirable before planting even in areas with more than 20 inches of rain. Generally, drilling has been preferred to broadcasting particularly in the latter part of the planting season. Raised beds are desirable where safflower is to be irrigated because this reduces the danger of safflower standing gin water and developing root rot.

15 to 35 lbs/acre for row spacings up to 18 inches
Above a row spacing of 18 inches, the seeding rate should be 8 to 20 lbs/acre.
20-25 lbs/acre, row planted, 20' rows
Increase seeding rate 10 lbs. per acre for drilled plantings on sub-irrigated lands.
Seed should be placed 1 to 1.5 inches deep.
A satisfactory stand in close drill rows (solid stands) on dry land is 3 to 5 plants per square foot. On irrigated or high water table land, up to 5 to 10 plants per square foot. Row grown safflower (irrigated or dry farmed) should average 5 to 12 plants per foot of row in rows 18 to 30 inches apart.
20 - 40 pounds per acre for solid stands (drill rows 6 - 12 inches apart)
Use higher seeding rates if the crop is planted in the fall since the crop may suffer severe competition from weeds. Lower seeding rates may be used in the spring if winter weeds are killed before the crop is sown.

Safflower seed should not be sown deeper than 2.5 inches, and best results are obtained when seeding depths vary from 1 to 2 inches.
Seed about 1 inch into the moisture and not more than 4 inches below the soil surface.
Bob’s cost sheet said 40 pounds per acre
Rate of seeding will depend on method of culture, time of seeding, row spacing, method of seeding and size of seed. Safflower runs through a drill faster than barley. To seed 30 pounds of safflower per acre, adjust the grain drill to seed 20 pounds of barley or 45 pounds of wheat per acre.

Fertility
Compared to other crops, safflower makes poorer growth on soils lacking in fertility or moisture supplies. Fertilize with 75 to 150 pounds of nitrogen per acre (20 to 50 pounds if dry farmed), depending upon previous crops and soil moisture conditions. Safflower is an efficient forager for residual nitrogen from previous crops. 15-20 lbs. of Phosphorus should be applied in deficient areas. Fertilizers should be applied are worked into the seedbed before planting.

Irrigation
Compared to small grain, safflower matures later. Considerable soil moisture should be completed about the middle of June. Rainfall has been the main reason for low safflower yields, the greatest water requirement where safflower should be avoided during this period since irrigation should be applied when the irrigation requirement for safflower is variable. Safflower requires three to four irrigations. Safflower requires 20-24 inches of water.

Spring planted safflower used 24-36' square feet of irrigation to reach its greatest yield under dryland conditions at 18-24 inches. Bob’s cost sheet says 3 inches of irrigation at least one week past full bloom is necessary, but it is difficult to move the precise time of the plant. Some soil types are able to use it blossoms and develops from the top of the plant. Some soil types are able to move it blossoms and develops from the top of the plant. Some soil types are able to move it blossoms and develops from the top of the plant.
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Irrigation
Compared to small grain, safflower will require more moisture in the late spring because it blossoms and
matures later. Considerable soil moisture is necessary up until blossoming is completed. Blossoming
should be completed about the middle of June in the San Joaquin Valley. Lack of adequate soil moisture
has been the main reason for low safflower yields. Moisture is critical during the summer months with
the greatest water requirement when the plants are flowering and setting seed. Moisture stress should
be avoided during this period since it will result in non-filled seed and lower yields. The irrigation
requirement for safflower is variable. In Fresno county, depending on the amount of rainfall, the crop is
irrigated three times. Safflower requires the equivalent of of about 16 to 18 acre-inches of water.
Spring planted safflower used 24-36' of water in producing good yields (18-24 in Central Valley). For
top yield under dryland conditions a total of about 25 acre-inches is necessary. Under irrigation 24-35
acre inches. Bob's cost sheet says 3 irrigations with 2.5 acre feet of water. 3 to 4 irrigations. Continue
irrigation at least one week past full bloom to insure filling of the seeds. Sprinkler irrigation may be
used, but it is difficult to move the pipes after the crop has developed heads because of the spiny nature
of the plant. Some soil types are able to store this moisture in the upper 10 to 12 feet of soil so little or
no water need be supplied by irrigation during the growing season if the soil is moist at planting down to about 12 feet. This moisture may be either from residual moisture from the previous crop, rainfall, or preirrigation. Dryland soils with a limited moisture supply may respond better to late March or early April planting because a shorter plant will result, requiring less moisture to mature a crop than the taller plants resulting from February or early March sowings. Tight subsoils retard or stop root development and water penetration and reduce the amount of water plants can get from the soil. Irrigating during the cropping season under such modifying conditions normally would be considered necessary to supply the plants with needed water. Surface irrigation frequently is very dangerous on such soils because excess water drains very slowly through tight subsoils and root rot kills many plants reducing yields. It is probably best to thoroughly preirrigate soils with claypan and hardpan layers as well as tight clay soils and grow the crop without irrigation, realizing that yields probably will be reduced by drought.

For maximum production, safflower will require from 36 to 44 inches of water as rain or applied irrigation. Safflower cannot be economically grown with less than 18 inches of available water. As much water as possible should be stored in the soil prior to planting to depths of 6 or more feet. The soil should be well drained, particularly at the surface. Water standing on the crop for prolonged periods will usually cause severe losses from either Phytophthora root rot or oxygen deficiency. Safflower is very susceptible to root rot, so it is easily injured or killed by surface irrigation except under very favorable conditions. The safest procedure is to minimize the amount of irrigation water applied during the growing season by supplying as much of the required moisture as possible in the form of water to be stored in the soil prior to planting time. Production has been very successful without surface irrigation in some areas where moisture at planting time is supplemented by natural subirrigation from a high water table from 2.5 to 5 feet below the soil surface. There usually is no serious root rot problem on naturally subirrigated land if the surface soil does not get wet.

High water table land, with no serious salinity problems has usually grown safflower successfully, if not water logged near the surface. Where the crop is irrigated, you can reduce damage from root rot by not allowing the crop to become stressed from lack of water before irrigating, 2) planting on beds and providing for good field drainage, 3) irrigating as rapidly as possible, 4) applying the irrigation water at night if daytime temperatures are high.

High humidity appears to be the most important drawback to safflower production in the central or eastern states and the coastal district of California, mostly because of its effect on disease. In foggy coastal areas, safflower cannot be grown because the frequent fogs favor severe attacks of Botrytis blight which destroys the maturing seed heads. High humidities and frequent rains also increase the incidence of rust.

In some areas, safflower is planted to deplete the moisture present in the soil. For example, in northern California, safflower is planted in areas where rice has been produced to dry out the soil. In the lake bottom areas found in Kings county, the crop is irrigated only once during the season. Some growers find that crops following safflower will have enhanced yields. In the Tulare Lake basin, safflower is used to enhance cotton yields.

Safflower which is to be surface irrigated in the summer months should not be planted on soils with slow internal drainage. This would generally include clay soils, stratified soils, soils with high water tables, and soils with claypans or hardpans. If there is any doubt about rapidity of internal drainage, plant on beds and furrow irrigate. Furrows also facilitate surface drainage. Provide complete surface drainage, particularly on soils where internal drainage is moderately slow. Land should be well-leveled and graded and excess surface water should be drained promptly. Where the crop is to be surface irrigated, it should be planted on raised beds or should be furrow-irrigated. Raised beds reduce the two problems of root rot and ponding of irregularly leveled soil.

The crop is intolerant of excess surface moisture. Safflower is susceptible to irrigation-induced
Phytophthora root rot if stressed for moisture prior to being irrigated. Plant one of the varieties more resistant to root rot and irrigate before the appearance of severe drought symptoms. Drought stressed plants markedly increase their susceptibility to root rot injury, so it is necessary to irrigate before any drought symptoms appear. Thus the decision as to whether or not to irrigate cannot wait until plants begin to suffer from lack of water. In general, early crop irrigation in cool weather is less injurious than later when temperatures are higher. Avoid prolonged irrigation, especially in warm, or hot weather. In general, early crop irrigation in cool weather is less injurious than later when temperatures are higher. The safest procedure is to minimize the amount of irrigation water applied during the growing season by supplying as much of the required moisture as possible in the form of water to be stored in the soil prior to planting time.

The key feature of successful safflower irrigation is a thorough preirrigation to wet the soil to a depth of about 12 feet if possible. Where surface irrigation is used, from 3 to 5 irrigations are usually applied. Minimize the number of irrigations after planting by storing as much useable water as possible in the soil at planting time. The percentage of this depth that can be stored depends on water storage capacity of the soil, the effective depth of root penetration, and the rate at which the root system increases in depth. The moisture may be supplied by either residual moisture from the previous crop, rainfall, or preirrigation. Production has been very successful without surface irrigation in some areas where moisture at planting time is supplemented by natural subirrigation from a high water table from 2.5 to 5 feet below the soil surface. There is usually no serious root rot problem on naturally subirrigated land if the surface soil does not get wet.

Cultivation
Preemergence cultivation is recommended.

Equipment
Equipment for seeding and harvesting small grains can be used for safflower. Only minor adjustments need to be made in their operation. Corn, cotton, and sugar beet planters can be easily adapted to plant safflower in rows.

Soil Type
Safflower has been grown successfully on a wide variety of soils. Sandy soils have not been too successful because of their low water-holding capacity. Shallow soils, less than 5 feet in depth, have usually run out of water unless carefully irrigated before the crop matured.

Surface irrigation during the growing season should be attempted only with the root rot tolerant varieties on soils which drain rapidly following irrigation. Rapidly draining soils may be recognized by previous observations of moisture conditions following rain or surface irrigation; by absence of restricting layers such as plowpans, hardpans, claypan, and by absence of pronounced stratification in layers of different texture. Fine clay soils usually drain too slowly to avoid root rot problems. Additional cues are provided in soil survey information. In general, soils classed in Profile Groups I and II are suitable for surface irrigation of safflower, those in Group III would be questionable, and most unsuitable, and soils in Profile Group IV, V, and VI would be unsuitable. Drainage classes are also helpful, and soils having imperfect or poor subsoil drainage ratings are largely unsuitable for surface irrigation of safflower.

Vegetation Management
Weeds can be a serious problem in safflower since postemergence herbicides are not available. One objectionable feature of safflower is that it grows slowly in early stages, especially when it is grown as a winter crop. For this reason, it may be difficult to obtain clean stands of safflower if it is sown early in the fall on land heavily infested with seeds of winter weeds such as chickweed or wild oats. The most effective weed control is a sound crop rotation plan that keeps weeds in check. Treflan, the most commonly used herbicide presents a risk to the following crop, and is tolerated by sunflowers and perennial weeds such as johnsongrass. Because safflower grows slowly during the cool winter weather,
weeds may become a problem. Use preplant soil incorporated herbicides if the field has any history of summer annual weeds. Let fall rains produce a weed crop before the initial plowing or disking. Then time spring operations to kill one or two crops of germinating weed seeds before seeding. Shallow harrowing may be used to control seedling weeds either before the safflower emerges or in young stands when the plants are 3 to 6 inches tall. Such shallow cultivation should be made crosswise or at an angle to the rows, and is most successful in a finely worked trash-free seedbed. In the afternoon, the plants are less brittle and less liable to injury from harrowing. Cultivation is possible in row planted safflower. EPTC preplant, soil-incorporated into the top 3 to 6 inches has been used to control watergrass, lambsquarters, and pigweed, three of the most serious weeds of safflower. Trifluralin preplant, soil incorporated,

Diseases
Heavy losses can be caused by safflower rust in fields of safflower following safflower. Phytophthora root rot, associated with excess surface moisture during warm weather is the greatest hazard in growing safflower under irrigation. Other diseases affecting safflower are Verticillium and Fusarium wilts, rust, and Botrytis blight. To minimize disease problems, do not grow two crops of safflower in succession on the same fields.

Insect Pests
Although the plant is a host to many insects, such as lygus bugs and thrips, insects are seldom a problem, other than aphids on late plantings. Although lygus problems build up in safflower, they are not of economic importance to the crop. Lygus bugs must be present in very large numbers of about 40 per standard sweep to be economically injurious. We know that the safflower plant can tolerate quite a large amount of insect damage without loss of seed yield. Lygus are controlled in safflower to prevent them from migrating to cotton or alfalfa seed crops as the safflower begins to dry down. Safflower is a major breeding habitat for lygus in some westside areas of the San Joaquin Valley. Area-wide insecticide applications to safflower in late May or early June will greatly reduce the need for early season treatment of cotton for lygus bug control and will reduce the migrating lygus bug population moving into alfalfa seed crops. Early plantings are best because they allow the plants to set their full quota of buds and develop their seed heads before damaging insect populations occur.

Bees are probably helpful in pollinating safflower, but are not absolutely essential. If insecticides are necessary to control harmful insects after the crop is in flower, select on which is the least injurious to bees and apply int at the time when the bees are not present - either in the early morning or late evening.

Salinity
Safflower is highly salt tolerant (only slightly less tolerant than cotton, sugar beets and barley). At 6-7 millimhos, yield just begins to be affected. 50% yield reductions occur at 13-15 millimhos. Safflower tolerates only half as much salinity during germination as at later stages of development. Salinity affects plant height, stem diameter, and seed production. Salinity also has a pronounced effect on maturation with increases in salinity hastening final maturation.

No information available on the tolerance of safflower to exchangeable sodium-alkali.

Harvest
Because the crop will not shatter or lodge seriously, harvesting may be delayed 10 days to two weeks. If the straw is too brittle, it will break up into small segments that are difficult to separate from the seed. Harvest takes place 120 to 150 days after planting, which occurs during late July and early August when planted at the recommended time in Fresno county. All or most of the leaves should be brown with dry stems. Seed should be white, down to 8 or 11% moisture (?) or less, and easily squeezed out of the latest heads. In excessively dry weather, harvesting may have to be done at night to reduce seed shattering. Many growers harvest with the header reel removed to reduce shattering. Harvesting is done with a standard combine, but ground speed is greatly reduced from what is used with cereal crops. Clearance and screen size must also be changed to adjust for the size of safflower seed. Reduce the peripheral speed of cylinders to 2500 per minute. About 2 mph is recommended depending on yield.

Store seed safely @ ~8% moisture, will heat @ 1-2%

August September after seed

[10-12,000 seeds/lb]
Yields
Yields vary tremendously with the amount of water applied, and range from 500 to 1000 lbs/acre in dryland areas to 1500 to over 4000 lbs/acre when ample water is available. The average yield under irrigated conditions is approximately 1600 pounds per acre. (1.5 to 2 tons is average).

Cost of Production
Safflower will cost slightly more to grow than barley, due to higher harvesting costs and irrigation. In Kings county, the cost estimate (cash costs plus depreciation) for 1988 was $18.30 for 2000 pound yields and $9.28 for 4000 pound/acre yields.

\[ \frac{3000 \text{#} \text{acre}}{2000 \text{#}} = 1.5 \text{ tons} \times \frac{300 \text{$/ton}}{2000 \text{ lbs}} = 0.45 \text{$/acre} \]

Too high: $300 \#/acre if irrigated properly\pre + rain + 2 irrig

1500# pre + 1 irrig

$18.30/2000 lbs

Cost of production on East Side of Slough

25% lower yields