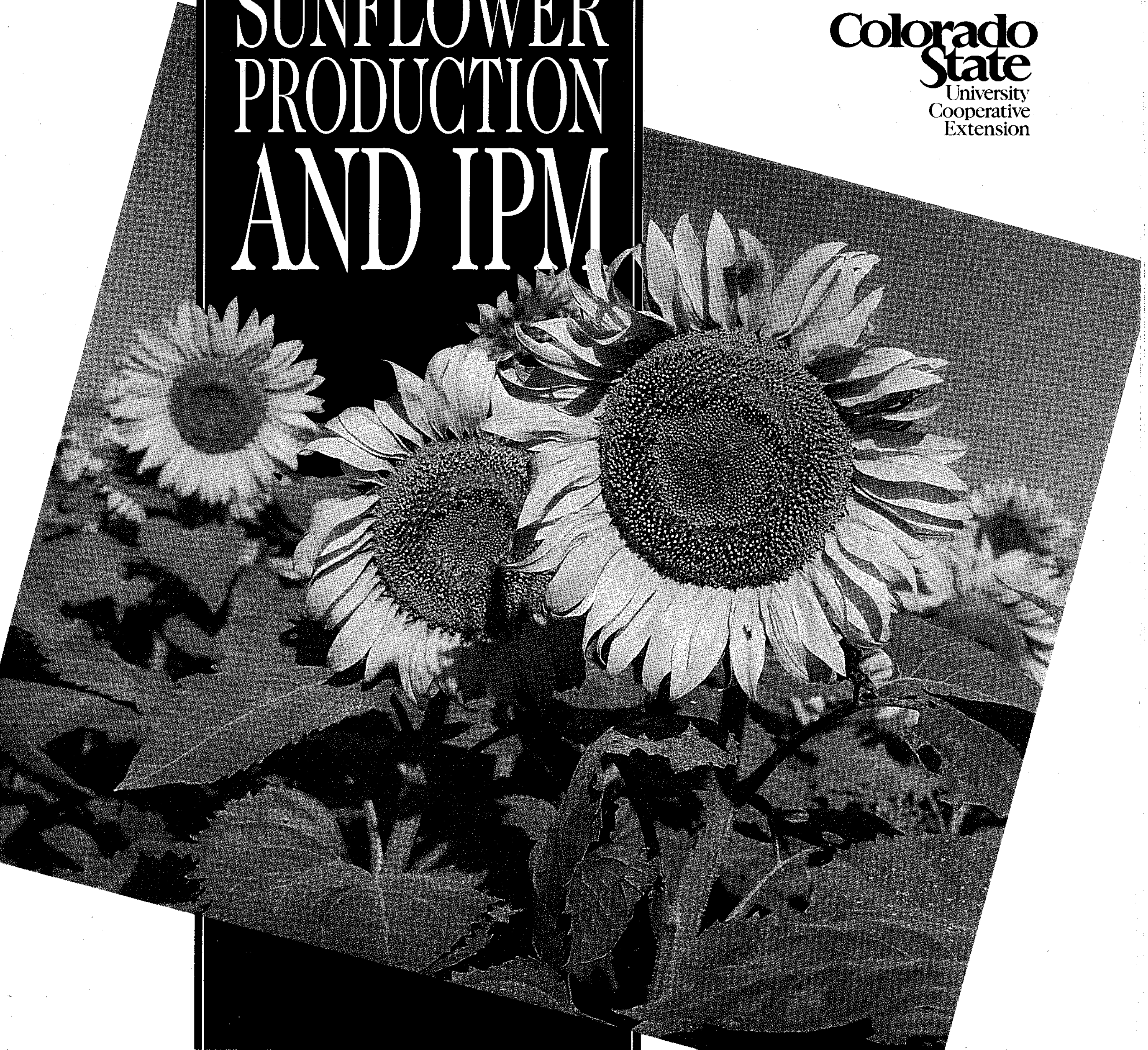
HIGH PLAINS SUNFLOWER PRODUCTION AND IPM

Bulletin 556A

Colorado State University Cooperative Extension



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Colorado State University
Agricultural Experiment Station and
Cooperative Extension Bulletin

F.B. Peairs[1], B.C. Kondratieff[1],
R.F. Meyer[2], H.F. Schwartz[3]
R.L. Croissant[4], D.D. Baltensperger[5],
M.J. VanGessel[3], and J.M. Krall[6]

[1] Department of Entomology, Colorado State University, Fort Collins, CO 80523
[2] Golden Plains Area Cooperative Extension Agronomist, Burlington, Colorado 80807
[3] Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins, CO 80523
[4] Department of Agronomy, Colorado State University, Fort Collins, CO 80523
[5] Panhandle Research and Extension Center, University of Nebraska, Scottsbluff, NE 69361
[6] University of Wyoming Research and Extension Center, Torrington, WY 82240

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INTRODUCTION

There is renewed interest in sunflower production in Colorado, Nebraska, and Wyoming (from this point on referred to as "the region"). Production of both oil and confectionery types can fit well into both dryland and irrigation cropping systems. While sunflower is well adapted to the region, a number of sunflower pest concerns might become associated with expanded production.

The purpose of this bulletin is to review basic sunflower production and protection practices, emphasizing the growing conditions and requirements within the western High Plains. This publication is divided into four sections: hybrid selection and production practices, insects, diseases, and three appendices containing a variety of related information.

Additional information and publications may be available from local Cooperative Extension offices, regional research and extension centers, and from sunflower industry representatives.

SUNFLOWER PRODUCTION PRACTICES

1. HYBRID SELECTION

Successful sunflower production reflects desirable yield, oil percentage, insect and disease resistance, and other hybrid characteristics. Correct hybrid selection is extremely important for top yields and producers should use current performance tests when selecting a hybrid to plant. Sunflower varieties are tested annually in the region. Nebraska and Wyoming results are published in the Nebraska Proso and Sunflower Variety Tests (Nebraska Cooperative Extension Publication E.C. Annual-107). Colorado results are available in mimeo form from the Variety Testing Program, Department of Agronomy, Colorado State University. Commercial seed companies also can provide hybrid performance information. Both oil type and confection type (also referred to as non-oil type) sunflower are produced in the region, each requiring specific management and marketing techniques.

When deciding to grow oil type sunflower, hybrids producing satisfactory seed yields and oil percentages should be selected. Domestic sunflower processors pay a premium for oil content higher than the current 40% standard, while discounts are assessed for seed lots yielding oil content below this standard.

Test weight is important from a quality standpoint. USDA grade for oil type sunflower cannot be met with test weights of less than 25 pounds per bushel. Confection type sunflower normally will have lower test weights than oil type sunflower. To achieve the best test weights, hybrids should be selected that will mature within the frost-free growing season. This is especially important for later summer plantings.

Pest resistance is becoming more common in current sunflower hybrids. Hybrids with tolerance to rust, some races of downy mildew, and other pests are available. In addition, strong stalk characteristics reduce lodging and allow easier harvesting. Seed companies will furnish this information upon request.

Semidwarf sunflower hybrids are 25 to 40% shorter than conventional hybrids. The main advantage of planting semidwarf types is reduced lodging. Their disadvantage is reduced yield potential in comparison to hybrids of conventional height.

2. SEED

Seed for hybrid sunflower production must be purchased from commercial seed companies every year. Sunflower seed is sold either by weight or seed numbers per bag. Regardless of sunflower type, larger seed sizes may have some advantages when it is necessary to plant deep. Oil type hybrid seed sizes are #2, 3, and 4. Size #2 is the largest and size #4 the smallest, with the latter having more seeds per pound and per bag. Price for oil type sunflower is normally set per seed bag. Size #3 is most commonly used when planting oil type hybrids.
Confection seed sizes are small, medium, large, and extra large. Price is normally set per 1000 seeds. The medium size is most commonly used.

3. SOIL FERTILITY

Sunflower is adaptable to many soil types but grows best on fertile, well-drained soils, near-neutral in pH. At present, very little soil fertility research has been conducted on sunflower in the region. Nitrogen and phosphorus deficiencies, described below, are common and response to added nutrients is expected when sunflower is grown on low testing soils. Deficiencies of potassium, iron or zinc are not expected in the High Plains.

Nitrogen deficiency is the most common nutritional disorder found in sunflower. Although this disorder is common, it may sometimes be difficult to recognize. As with other crops, the first symptom of nitrogen deficiency is a reduction of growth. During the vegetative stages, deficient plants may show symptoms by having leaves showing from a lighter green to definite yellowing in coloration. Nitrogen deficiencies occurring later in the season show definite chlorotic yellowing of lower leaves.

Phosphorus deficiencies are likely to occur in sunflower growing regions and first appear as stunted plants. Phosphorus responses are expected to occur in very low testing soils. Necrotic gray lesions may or may not occur on older leaves. Phosphorus deficiency symptoms are difficult to interpret.

Potassium deficiencies are not likely to appear in High Plains soils. Deficiencies first affect the lower leaves. In seedlings, the older leaves develop a yellow color and have large necrotic patches. Leaf cupping, both upward or downward, occurs toward the leaf tip.

As the disease progresses, leaf senescence may occur.

The availability of **iron** decreases with increasing pH. However, sunflower is tolerant of low iron availability. Sunflower production is usually successful on soils causing deficiencies on sensitive crops such as corn, sorghum or potatoes. Iron deficiency of sunflower in the seedling stage shows interveinal chlorosis on the youngest leaves.

Zinc deficient plants are stunted with distorted upper leaves. As the deficiency intensifies, leaves tend to wilt. Zinc deficiencies or responses to added zinc are not likely in the region.

Nitrogen and phosphorus are always the most limiting soil nutrients in the High Plains and a soil test is the only accurate way to determine fertilizer need. A good rule of thumb is that a 2000 pound per acre sunflower crop requires approximately the same amount of fertilizer as a 40 bushel per acre wheat crop.

Nitrogen fertilizer should be applied preplant or sidedress, and not applied at planting unless drilled between the rows. For maximum efficiency of nitrogen fertilizer apply broadcast to sunflower fields in the spring, close to the planned planting date. Phosphorus fertilizer can be placed with the seed at planting.

When setting yield goals, considerations must include individual management skills, soils, and normal weather conditions. Adequate fertilizer nutrients must be provided as required for selected yield goals. The most limiting factor, however, for yield on dryland sites is often stored soil water and effective summer precipitation. Decisions for choosing yield goals therefore should be based on past yield histories and future expectations.

Tables 1, 1a, and 2 are guides for use in fertilizing sunflower based on soil test recommendations. Soil samples were taken from 0-12" in depth. For more details on these tables refer to Follett, R.H, P.N. Soltanpour, D.G. Westfall, and J.R. Self. 1991. Guide to fertilizer recommendations in Colorado. Colorado State University Cooperative Extension Bulletin XCM 37.

4. WATER REQUIREMENTS

Specific water requirements differ on every field because of differences in soil type, temperatures, wind and plant requirements. The ability of sunflower to produce under dry soil conditions is due to the extensive heavily branched root system capable of growing to a depth of six feet. Sunflower has the ability to extract more soil moisture than corn. See Figure 1 for sunflower water use profile in relation to crop growth stages. Total water requirements will vary over location depending on soils, plant population, yield, and environmental conditions, but highest water needs are during flowering.

The most limiting factor for yield in dryland sunflower production is available water. Management practices that promote water infiltration and eliminate soil compaction will produce highest yields. These include leaving previous crop stubble over the winter to catch winter snow and reduce wind erosion. In addition, eliminating tillage operations during wet soil conditions will reduce the potential for soil compaction. Soil layers that restrict rooting depths will decrease yield accordingly. Reduced-till systems with sunflower also have shown promise.

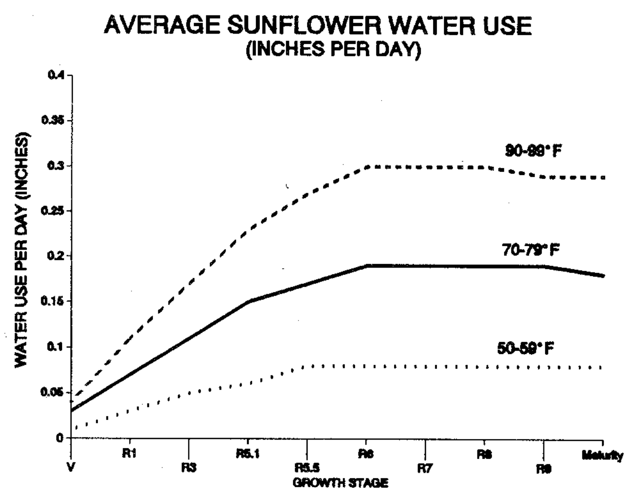

Figure 1. Daily water use by sunflowers at different temperatures. (adapted from Lundstrom, D. and E. Stegman. 1988. Irrigation scheduling by the checkbook method. ND State Univ. Bull. AE 972.)

4. IRRIGATION

Irrigation of sunflower is less common than dryland plantings. However, yield results are available from irrigated sunflower tests. Irrigation scheduling is very important to minimize moisture stress. Regardless of the irrigation scheduling method used (checkbook, gypsum blocks, tensiometer, etc.), irrigation scheduling is a good investment of time. Irrigation is most

Table 1. Nitrogen recommendations for irrigated sunflower. Yield goal: 2400 lbs/acre*

NO_3-N SOIL TEST (ppm)	PERCENT SOIL ORGANIC MATTER				
	0.0 - 0.5	0.6 - 1.0	1.1 - 1.5	1.6 - 2.0	>2.0
	FERTILIZER N - LBS PER ACRE				
0-6	135	125	115	105	100
7-12	115	105	100	90	85
13-18	100	90	85	75	70
19-24	85	75	70	60	50
25-30	65	60	50	45	35
31-36	50	45	35	25	20
37-42	35	25	20	0	0
43-48	20	0	0	0	0
>48	0	0	0	0	0

* Adjust nitrogen recommendation by 6 pounds for each cwt difference in yield.

Table 1a. Nitrogen recommendations for dryland sunflower in the region. Yield goal: 1500 lbs/acre*

NO_3-N SOIL TEST (ppm)	PERCENT SOIL ORGANIC MATTER		
	0.0 - 1.0	1.0 - 2.0	>2.0
	FERTILIZER N - LBS PER ACRE		
0-6	75	55	35
7-12	55	35	15
13-18	35	15	0
19-24	15	0	0
25-30	0	0	0

* For yields >1500 lbs/acre, increase N by 6 lbs N per cwt up to maximum of 75 lbs/acre.

Table 2. Phosphorus and potassium recommendations for irrigated and dryland sunflower.

PHOSPHORUS SOIL TEST (ppm)*	LBS P_2O_5 PER ACRE	POTASSIUM SOIL TEST (ppm)*	LBS K_2O PER ACRE
0-3 (low)	40	0-60	30
4-7 (medium)	20	>60	0
>7 (high)	0	---	---

* Ammonium bicarbonate extraction - DPTA.

important at preplant to charge the profile, at bud stage and post bloom. Peak water use in sunflower occurs at flowering (6 weeks after emergence). Sunflower is most sensitive to moisture stress in the bud stage, but can withstand moisture stress rather well both before and after flowering. It is important to note that limited irrigation has produced more seed yield than full irrigation. Best sunflower yields are obtained when irrigation practices prevent severe water stress and promote slow continuous growth throughout the growing season. Do not overwater sunflower as it responds unfavorably to saturated soil moisture. Overwatering may also increase white mold disease losses.

5. ROTATION

Sunflower yields are highest in rotations as opposed to continuously planted sunflower. According to research results, lack of rotation can promote increased incidence of disease, insect problems, and additional weed problems. Crop rotations do not eliminate pest problems but will reduce them, thus enabling more effective pest management.

Because of its deep rooting habit, sunflower does well in rotation after crops with shallow rooting systems. Sunflower has performed well in several rotations that are productive in this region. Among the most useful are several wheat, sunflower, fallow combinations that appear to have advantages for both crops, including winter wheat-sunflower-fallow and winter wheat-fallow-sunflower-fallow. Keep in mind that adequate soil moisture following wheat is required for proper sunflower germination. In rotations in which sunflower follows wheat, a insecticide seed treatment for control of wireworms has been important in certain parts of the region.

6. PLANTING PROCEDURES

Proper planting procedures will provide optimum seedling establishment. Errors at planting time will handicap the crop over the course of a growing season and will often be reflected at harvest. Seedbed preparation, soil conditions, planting date, row width, and plant population should be managed as conditions dictate.

Correct seedbed preparation includes an environment that allows seed germination to progress optimally. A moist, firm seedbed free of weeds is desirable. Sunflower seed should be planted in moist soil about 2 inches deep. The seed should always be placed into moist soil, but never covered more than 3 inches. Semidwarf hybrids should not be covered more than 2 inches.

Sunflower may be planted over a wide range of dates. Highest yields occurred with sunflower in Kit Carson County, Colorado when planted during the first two weeks in June (Figure 2). Sunflower yields were lower when planted after the second week in June; however, seed weevil counts were highest for sunflower planted during second week in June (Figure 3). The agronomic advantages in these studies of planting early far outweigh any advantages due to lower insect pest densities that might be expected on sunflower planted at later dates. Seed quality was higher for early planting dates. In addition, test weight decreased while harvest moisture increased as planting date was delayed.

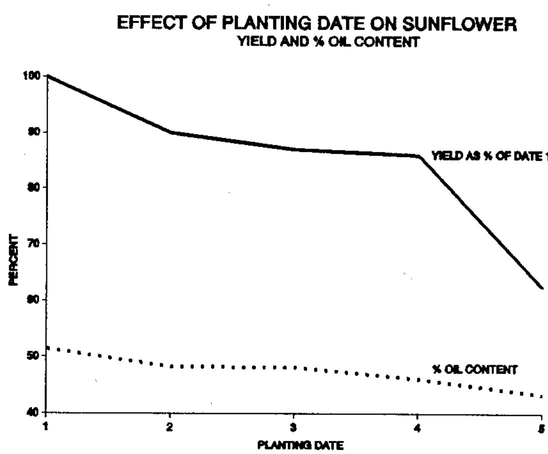

Figure 2. Effect of planting date on sunflower production at Burlington, CO. 1991-92.

(Planted weekly from first week in June. Four dates in 1991, five dates in 1992. Yields average of 1992 oil type and confection type trial and 1991 confection type trial. Oil content data from 1992 oil type trial. Meyer, R.F., S. Pilcher, and F. Peairs. Colorado State University Cooperative Extension.)

Early planting dates work well in the region, however, seeding sunflower in soil cooler than 50°F is not recommended. Planting sunflower into soils averaging less that 50°F will delay germination and increase the likelihood of seedling disease, insects, and soil herbicide damage.

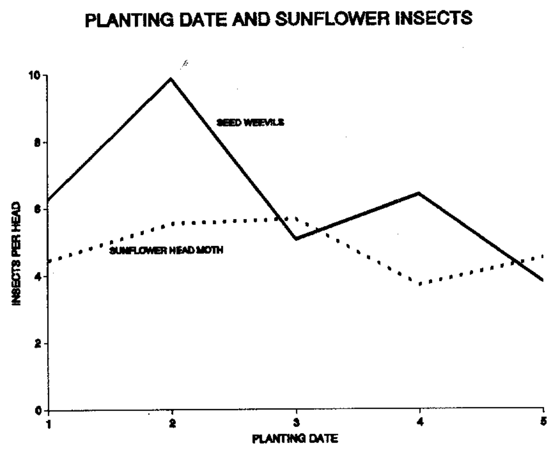

Figure 3. Effect of planting date on sunflower pests at Burlington, CO. 1991-92.

(Planted weekly from first week in June. Four dates in 1991, five dates in 1992. Averaged from 1992 oil type and confection type trial and 1991 confection type trial. Meyer, R.F., S. Pilcher, and F. Peairs. Colorado State University Cooperative Extension.)

How late in the season can sunflower be planted? Colorado State University Cooperative Extension trial results indicate that mid-season hybrids planted during the first week of July will mature with 1500 degree days (base 50°F). Although later planted sunflower yields less than those planted earlier in the season, later plantings are effective under normal summer conditions if they become necessary in your operation.

7. PLANT POPULATIONS

Row crop equipment currently available should dictate row spacing used. Solid seeded sunflower is feasible but yield performance has been best with row spacing between 20 and 30 inches. Currently, a 30 inch row spacing is most popular, and is considered to be standard.

Adequate plant population also is important for highest possible yields. Sunflower, however, will compensate somewhat for differences in plant populations through changes in head size. Higher populations are generally planted for oil type than for confection type hybrids. Plant populations for oilseed hybrids grown under dryland conditions should be between 14,000 and 18,000 plants per acre, adjusting for yield potential. Moisture in the soil profile is the most important criterion for adjusting plant populations within this recommended range. Lower populations are recommended for lower yield potentials (drier soils). Plant populations for irrigated oil type sunflower should be between 20,000 and 25,000 plants per acre. Confection hybrids should be planted between 12,000 and 18,000 plants per acre. Higher populations will allow faster preharvest drydown as head size will be smaller and may result in smaller seed size.

Table 3. Seed spacing required for various populations, assuming 90% germination and 10% stand loss.

Plants per Acre	Row Spacing				
	36"	30"	26"	22"	18"
	Inches between seeds in the row				
12,000	13.0	15.6	18.0	21.3	26.1
14,000	11.2	13.4	15.5	18.3	22.4
16,000	9.8	11.8	13.5	16.0	19.6
17,000	9.2	11.1	12.7	15.0	18.4
18,000	8.7	10.5	12.0	14.2	17.4
19,000	8.3	9.9	11.4	13.4	16.4
20,000	7.8	9.4	10.8	12.8	15.7
21,000	7.5	9.0	10.3	12.2	14.9

8. HARVESTING

The sunflower plant is physiologically mature when the back of the head turns from green to yellow. Physiological maturity occurs approximately 30-40 days after bloom; however, seed moisture levels are still 40 percent at this point. Safe storage moisture for sunflower is below 10 percent.

A killing frost (28°F) after physiological maturity is reached, is the most economical way to dry standing sunflower. Certain herbicides (for example, Gramoxone Extra[R]) are labelled for use as a harvest-aid in sunflower. It can be used to defoliate plants and facilitate harvesting. If a frost occurs before physiological maturity is reached, yield, test weight, and oil percentage will be reduced. Sunflower seed can be harvested at high moistures (up to 30%) but commercial crop drying is mandatory for safe seed storage, and high moisture sunflower delivered to a grain elevator will be highly discounted. Further difficulties in harvest of high moisture sunflower may be experienced because moist stalks can clog the combine head. Seed going in to long term storage must be dried to below 10% moisture.

Sunflower grown on the High Plains normally field dry very well. At times sunflower in the region will dry too much in the field, often to 6-7% moisture. Begin harvesting at 14% moisture and air dry seed in the bin to 10% moisture. This allows top quality seed, a minimum of foreign material, and reduces potential losses to birds. Harvesting and marketing sunflower seed below 10% moisture reduces test weight and yield. The market does not pay a premium for seed below this moisture level.

Air drying in-bin without heat works extremely well in the High Plains. Following drying, a sample should be moisture tested, then stored in a jar for 12 hours and retested. The delay allows an accurate moisture test of dried sunflower (moisture migrates from inside to outside the kernel over time). In the unlikely event that air drying is not possible, grain dryers that are used for corn also work well for artificially drying sunflower seed. However, fire hazards exist with sunflower drying.

Combines used for harvesting small grains and corn can be adapted to harvest sunflower. A number of different head attachments are available with most using a head-stripping principle. Sunflower header catch pans are available in different widths. Narrow and wide pans both work well; however, narrow pans (9 inch) allow sunflower harvest on any row spacing and in any direction. Wide pans necessitate harvesting a fixed row spacing in the same direction as the field was planted. An airfoil chaffer will reduce foreign matter in the harvested seed.

Forward harvest speeds can range from 3 to 5 mph. Combine cylinder speed should be adjusted as slow as possible while still doing an adequate job of threshing seeds from heads. Generally, a cylinder speed of 300 rpm or lower will do a satisfactory job. Concave adjustment should be based on seed moisture. Seed that is less than 10 percent moisture should have the combine concave clearance approximately 1 inch at the front and 0.75 inch at the rear. Correct threshing strips seed from the head but otherwise leaves head intact as it leaves the combine. Large numbers of broken sunflower heads are an indication that the combine needs to be adjusted. When seed moisture is higher, the concave clearance should be decreased accordingly.

Sunflower seed is light in weight compared to many other crops and as a result, combine wind should be reduced enough to keep the trash floating across the sieves but without expelling seed. Keep in mind, ten seeds per square foot on the ground is equivalent to 100 lbs per acre yield loss. When properly set, the combine should produce less than 5 percent dockage per sample.

9. WEED CONTROL

Utilizing sunflower in rotation with fall-seeded crops allows effective control of certain troublesome weed species. Since sunflower is planted in late spring, winter annuals, such as mustards, downy brome, and jointed goatgrass, are easier to control. If the field is prepared with tillage, winter annuals will be destroyed during the field preparation. If sunflower are planted under no-till situations, an application of a broad spectrum herbicide (such as Roundup 30 days prior to planting or Gramoxone Extra^R at planting) will provide good weed control.

Table 4 is meant to serve as a guide to select effective herbicides for controlling various weeds commonly found in sunflower. Specific herbicide recommendations and labels change frequently. Refer to your state's recommendations (see reference section) or a current product label for the most up-to-date information on available herbicides. BE SURE TO READ AND FOLLOW ALL LABEL INSTRUCTIONS WHEN USING ANY HERBICIDE OR OTHER PESTICIDE.

Grasses and small-seeded broadleaf weeds in sunflower can be controlled with dinitroaniline herbicides (such as Prowl or Treflan - see Table 4). These herbicides need to be applied pre-plant and incorporated evenly 2 to 4 inches deep, and require moisture to be activated.

If soil incorporation is not feasible, certain herbicides (for example, Gramoxone Extra^R, a restricted use pesticide) will control grassy and broadleaf weeds if applied as labeled for use at planting or later, but prior to crop emergence. Any sunflower plants emerged at time of treatment will be killed. Young grass seedlings may re-grow after treatment. Be sure to check the label for a surfactant requirements.

Table 4. Weed response to sunflower herbicide treatments*.

	TREFLAN	POAST	GRAMOXONE EXTRA	PROWL
FOXTAILS	E	E	E-G	E
BARNYARDGRASS	E	E	E-G	E
WITCHGRASS	E	G	E-G	G
SANDBUR	E	G	E-G	G
WILD OAT	G	F	E-G	-
SHATTERCANE	E	G	E-G	G
WILD PROSO MILLET	P	G	E-G	P
BLACK NIGHT SHADE	P	N	E-G	P
WILD BUCKWHEAT	P	N	E-G	-
BUFFALOBUR	P	N	E-G	P
FANWEED (PENNYCRESS)	P	N	E-G	P
FLOWER-OF-AN-HOUR	F	N	E-G	F
KOCHIA	F	N	E-G	F
LAMBSQUARTERS	F	N	E-G	G
VELVETLEAF	P	N	E-G	F
ANNUAL MUSTARDS	P	N	E-G	P
BLUE MUSTARD	P	N	E-G	P
TANSY MUSTARD	P	N	E-G	P
PIGWEED	F	N	E-G	G
PUNCTUREVINE	P	N	E-G	-
PURSLANE	F	N	E-G	-
COMMON RAGWEED	P	N	E-G	-
RUSSIAN THISTLE	P	N	E-G	P
WILD SUNFLOWER	F	N	E-G	P
ANNUAL SPURGE	F	N	E-G	P
CROP TOLERANCE	-	E	P	G
SOIL CARRYOVER	2-11	1	0	4-12

* E = Excellent control (90-100%); G = Good control (75-90%); F = Fair control (50-75%); P = Poor control (0-50%); N = No control; - = No information.
** Months

Postemergence herbicides (such as Poast) are available for control of most emerged grasses, but not broadleaf weeds. Refer to labels for application rate for specific weeds and weed growth stages. Apply to actively growing grasses. Such herbicides may require the use of a crop oil concentrate or other spray additive. Cultivation may have to be delayed after application of postemergent grass herbicides.

Cultivation can be an effective weed control measure in sunflower. Cultivation is most effective on weeds under 3 inches in height. If cultivation is done within 2-4 weeks of the application of a soil-incorporated, preplant herbicide, such as one of the dinitroanilines, the cultivator should be set to run no more than 2 inches deep to avoid disturbing the herbicide layer.

10. BIRD CONTROL

Sunflower is susceptible to bird damage after seeds are formed (Photo 1) Under certain conditions, birds have been known to consume considerable quantities of seed in the field. The complete loss of seed production from a two acre test plot in 1991 at the University of Wyoming Research and Extension Center at Archer, Wyoming exemplifies how serious the problem can become.

Here are some suggestions for dealing with birds that feed on the seed of standing sunflower. These approaches have been used with varying degrees of success. Some of these cultural practices may work in your situation.

1. Select varietal plant types with head types that turn down after flowering.

2. Plant early varieties at early planting dates.

3. Avoid planting sunflower within a quarter mile of marshes or sloughs that consistently harbor large quantities of birds and contain water in later summer.

4. Leave at least a 100 yard buffer strip of a crop not as attractive to birds such as small grains adjacent to shelter belts, groves, or other wooded areas.

5. Do not plow or till old sunflower fields in the vicinity, since these areas can act as alternative seed reservoirs. After harvest leave all stubble standing until all sunflower is harvested, again birds will be attracted to these areas in search of food.

In addition, bird deterrent practices have been used. These practices fall into two categories: 1) Mechanical frightening and 2) chemical agents. Protection of sunflower by mechanical means, particularly on large acreages, is an especially formidable task and one likely to discourage the protector long before harvest. Frightening devices will likely be most effective if employed early in the season before flocks become "entrenched" in a field. Devices also should be more effective if they are employed at times of day just prior to early morning or late afternoon feeding periods. Gas-powered propane and acetylene exploders probably have been used to the greatest extent. Use one exploder per ten acres and plan on moving exploders frequently as birds will become accustomed to them. Other devices include guns with "cracker" loads and recorded amplified sound. At printing, several chemical agent formulations were labelled for use in sunflower, either at planting or after flowering. They are: Improved Isotox 25, Isotox Seed Treater 75, Avitrol FC, and Sevana Bird Repellant. Little regional research has been conducted on these products. Contact your local county agent or state department of agriculture for current registration status and always read and follow label instructions.

SUNFLOWER ENTERPRISE COST ESTIMATES

Enterprise cost and return estimates for sunflower grown in northeastern Colorado in 1992 are presented in Tables 5, 6, and 7. (Estimates made by Don Nitchie (Colorado State University Cooperative Extension Area Farm/Ranch Management & Marketing) and Dave Schaubert (Colorado State University Cooperative Extension Regional Farm Management Economist) for 1992 crop year in NE Colorado. Taken with permission from Colorado State University Cooperative Extension Golden Plains Area 1993 Agriculture Handbook.) These budgets are intended to be "typical" rather than "average", as it represents a group of individuals each with unique management techniques, machinery, chemical applications, market timing and uncontrollable fortune with frost, hail, rain and insects. Fifteen producers from the four counties in the area were interviewed to collect the primary data. Secondary data were acquired from Dalsted, Gutierrez, Sharp and Schaubert, 1992, Selected 1990-1991 Crop Enterprise Budgets for Colorado, Colorado State University Department of Agriculture and Resource Economics Information Report 92-1.

Traditional economic methods of accounting for all variable and fixed costs of production are utilized. Then, expected returns on land and machinery investments are capitalized. The capitalization rate is based on the "real" rate of interest, which is the rate of interest paid minus the inflation rate. The real rate of interest used for capital was 5% and 4% for land. Net receipts are first allocated to cover all fixed and variable costs with any residual allocated as a return to land, machinery and equipment investments. If receipts are large enough to cover these items, the operator then has a positive return to management and risk and therefor an "economic profit." From a business management standpoint, farmers must earn positive net receipts in order to provide for family living expenses, pay debt, earn positive returns on their investments and make new investments when feasible.

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SUNFLOWER MARKETING

Sunflower seed produced on the High Plains is characterized by low moisture content and large size that makes it desirable in many markets in addition to the crushing market. Because of recent availability of USDA minor oilseed marketing loans and loan deficiency payments, sunflower producers now have a price floor that has caused a trend towards the production of sunflower without contracts. Further information on these programs is available at local ASCS and Cooperative Extension offices. The exception to this is the production of specialty sunflower such as confection and oleic types, which are still typically produced under contract.

Oil type sunflower is sold for vegetable oil or to bird seed packaging plants. Oil type seed destined for the vegetable oil markets is tested for oil content and price premiums or discounts are then used to determine its value. These premiums and discounts do not normally apply to oil type seed destined for bird seed packaging plants. Confection type sunflower seed is marketed as edible in-shell products, hulled nut-meat products or bird seed ingredients. Confection type seed normally would not be tested for oil content, as its value is determined primarily by seed size. Examples of marketing contracts for oil and confection sunflower types are as follows.

At current markets, oil seeds are sold on a clean seed basis and a 40% oil standard. There is no discount for dockage (foreign matter) other than it is weighed and subtracted on a per pound basis. Premiums are paid for each 1% oil content above 40%, with smaller premiums paid for each additional 1% oil content above 42%. Discounts are charged for every 1% reduction in oil content. Seed with test weight below 25 lbs can also be discounted. Seed with less that 32% oil is usually weather damaged and can be marketed as livestock feed. Specifications for seeds sold for bird feed include 28 lb test weight, no oil percentage premium or discount, and 1:1 dockage reductions.

Confection type seed sold on the edible market is graded by size and is generally purchased in this area on a two tier bid to reflect the premium for large seed. For example, a two tier, 14 - 10 bid means that a price of $14.00 will be paid for each hundredweight of seed collected above the 20/64 inch screen, while $10.00 will be paid for each hundredweight of seed falling through that screen but remaining above the 14/64 screen. Other important quality factors for confection type sunflower include color, insect damage, test weight, and frost and moisture damage. All confection sunflower seed sold in the region is subject to the clean seed standard set by the National Sunflower Association. Confection seed sold for bird feed is subject to the same standards as oil types.

Seed sold or marketed through local dealers would be subject to the above guidelines. Premiums and discounts may vary over locations and years as does the market or contract price of oil type or confection type seed. Oil premiums and discount scales also can vary among buyers. Know the current scales of various buyers before making a final marketing decision. Forward contracting of both confection type and oil type sunflower is available.

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TABLE 5. ESTIMATED PRODUCTION COSTS AND RETURNS - IRRIGATED SUNFLOWERS (OIL) IN NORTHEASTERN COLORADO (Center Pivot Sprinkler-Limited Irrigation)

	Unit	Price or Cost/Unit	Quantity	Value or Cost per Acre	Value or Cost/Cwt Production	Your Farm
GROSS RECEIPTS:	Cwt	9.00	25.00	225.00		______
DIRECT COSTS:						
Operating--Preharvest:						
Nitrogen (actual)	Lbs	0.15	60.00	9.00	0.36	______
Phosphate (actual)	Lbs	0.17	30.00	5.10	0.20	______
Seed	Acre	10.00	1.00	10.00	0.40	______
Herbicide	Acre	5.00	1.00	5.00	0.20	______
Pesticide	Acre	5.00	1.00	5.00	0.20	______
Custom Air Application	Acre	3.50	1.00	3.50	0.14	______
Irrigation Energy	AcIn	4.15	6.00	24.90	1.00	______
Irrigation Repair	Acre	5.00	0.99	4.95	0.20	______
Irrigation Labor	Hrs	5.25	0.48	2.52	0.10	______
Sprinkler Lease	Acre	50.00	1.00	50.00	2.00	______
Machinery Fuel & Lube	Acre			6.53	0.26	______
Machinery Repairs	Acre			7.94	0.32	______
Interest on Op. Capital	Dols	0.10	55.75	5.57	0.22	______
Total Preharvest:	Dols			140.01	5.60	______
Operating - Harvest:						
Custom Harvest	Acre	18.00	1.00	18.00	0.72	______
Custom Truck	Acre	6.60	1.00	6.60	0.26	______
Grain Drying	$/Acre			0.00	0.00	______
Machinery Fuel & Lube	Acre			0.00	0.00	______
Machinery Repairs	Acre			0.00	0.00	______
Interest on Op. Capital	Dols	0.10	3.00	0.30	0.01	______
Total Harvest:	Dols			24.90	1.00	______
Total Operating Costs:	Dols			164.91	6.60	______
Property & Ownership Costs:						
Machinery Replacement	Dols			19.77	0.79	______
Machinery Taxes & Insurance	Dols			7.65	0.31	______
General Farm Overhead	Dols			10.00	0.40	______
Real Estate Taxes	Dols			10.00	0.40	______
Total Property & Ownership Costs:	Dols			47.42	1.90	______
TOTAL DIRECT COSTS:	Dols			212.33	8.49	______
NET RECEIPTS, At Market Price:				12.67	0.51	______
RETURN TO - Operator's Land, Labor & Capital:				12.67		______
Capital @ 5.00% = 19.12						
Labor @ 5.25 = 8.70						
Land @4.00% = 26.00						
Required 53.82						
RETURN TO - Management & Risk:				-41.15	-1.65	______
BREAKEVEN PRICES - Required to Pay Direct Costs @ Various Yields:			@ 20 cwt/ac		10.62	______
			@ 25 cwt/ac		8.49	______
			@ 30 cwt/ac		7.08	______
BREAKEVEN PRICES - Required to Pay Direct Costs Plus Land, Labor & Capital @ Various Yields:			@ 20 cwt/ac		13.31	______
			@ 25 cwt/ac		10.65	______
			@ 30 cwt/ac		8.87	______

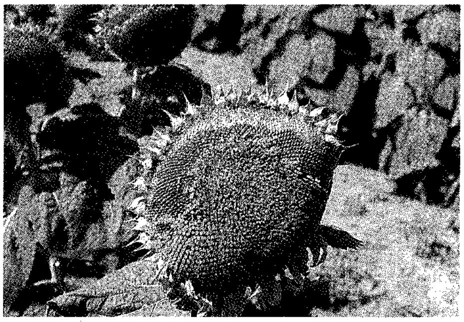
TABLE 6. ESTIMATED PRODUCTION COSTS AND RETURNS - DRYLAND SUNFLOWERS (OIL) IN NORTHEASTERN COLORADO

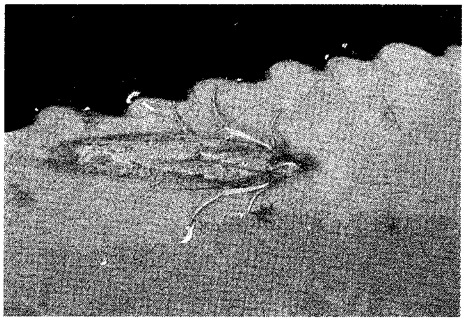
	Unit	Price or Cost/Unit	Quantity	Value or Cost per Acre	Cost Per Cwt of Production	Your Farm
GROSS RECEIPTS:	Cwt	9.00	13.50	121.50		______
DIRECT COSTS:						
Operating - Preharvest:						
Nitrogen (Actual)	Lbs	0.15	30.00	4.50	0.36	______
Phosphate (Actual)	Lbs	0.17	20.00	3.40	0.27	______
Seed	Acre	8.00	1.00	8.00	0.59	______
Herbicide	Acre	5.00	1.00	5.00	0.37	______
Machinery Fuel & Lube	Acre			6.53	0.48	______
Machinery Repairs	Acre			7.94	0.48	______
Interest on Op. Capital	Dols	0.10	22.22	2.96	0.22	______
Total Preharvest:	Dols			38.33	2.84	______
Operating - Harvest:						
Custom Harvest	Acre	13.00	1.00	13.00	0.96	______
Custom Truck	Acre	2.50	1.00	2.50	0.19	______
Grain Drying	$/Acre			0.00	0.00	______
Machinery Fuel & Lube	Acre			0.00	0.00	______
Machinery Repairs	Acre			0.00	0.00	______
Interest on Op. Capital	Dols	0.10	22.22	2.22	0.16	______
Total Harvest:	Dols			17.72	1.31	______
Total Operating Costs:	Dols			56.05	4.15	______
Property & Ownership Costs:						
Machinery Replacement	Dols			19.77	1.46	______
Machinery Taxes & Insurance	Dols			7.65	0.57	______
General Farm Overhead	Dols			5.00	0.37	______
Real Estate Taxes	Dols			4.00	0.30	______
Total Property & Ownership Costs:	Dols			36.42	2.70	______
TOTAL DIRECT COSTS:	Dols			92.47	6.85	______
NET RECEIPTS, At Market Price:				29.03	2.15	______
RETURN TO - Operator's Land, Labor & Capital @ Market Price:				29.03		______
Capital @ 5.00% = 19.12						
Labor @ 5.25 = 8.70						
Land @4.00% = 13.00						
Required 40.82						
RETURN TO - Management & Risk:				-11.79	-0.87	______
BREAKEVEN PRICES - Required to Pay Direct Costs @ Various Yields:				@ 10.0 cwt/ac	9.25	______
				@ 13.5 cwt/ac	6.85	______
				@ 17.0 cwt/ac	5.44	______
BREAKEVEN PRICES - Required to Pay Direct Costs Plus Land, Labor & Capital @ Various Yields:				@ 10.0 cwt/ac	13.33	______
				@ 13.5 cwt/ac	9.87	______
				@ 17.0 cwt/ac	7.84	______

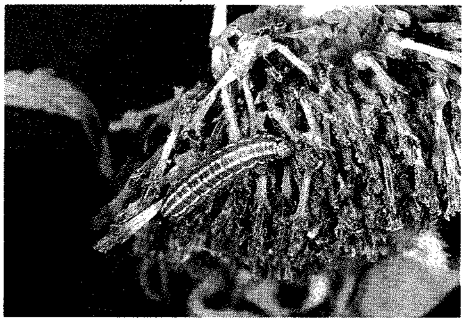
TABLE 7. ESTIMATED PRODUCTION COSTS AND RETURNS - DRYLAND SUNFLOWERS (CONFECTION) IN NORTHEASTERN COLORADO

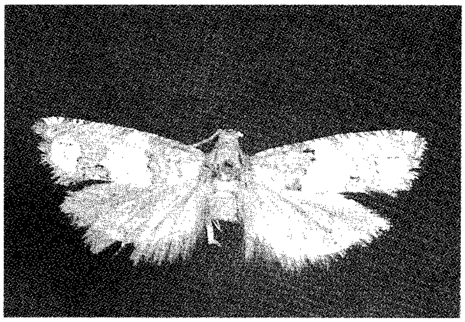
	Unit	Price or Cost/Unit	Quantity	Value or Cost per Acre	Cost Per Cwt of Production	Your Farm
GROSS RECEIPTS:	Cwt	12.60*	10.00	126.00		______
DIRECT COSTS:						
Operating - Preharvest:						
Nitrogen (Actual)	Lbs	0.15	30.00	4.50	0.45	______
Phosphate (Actual)	Lbs	0.17	20.00	3.40	0.34	______
Seed	Acre	10.00	1.00	10.00	1.00	______
Herbicide	Acre	5.00	1.00	5.00	0.50	______
Pesticide	Acre	5.50	1.00	5.50	0.55	______
Custom Air Application	Acre	4.00	1.00	4.00	0.40	______
Machinery Fuel & Lube	Acre			5.82	0.58	______
Machinery Repairs	Acre			2.68	0.27	______
Interest on Op. Capital	Dols	0.10	26.77	2.68	0.27	______
Total Preharvest:	Dols			43.58	4.36	______
Operating - Harvest:						
Truck Driver	Hrs	5.25	0.25	1.31	0.13	______
Grain Drying	$/Acre			0.00	0.00	______
Machinery Fuel & Lube	Acre			5.32	0.53	______
Machinery Repairs	Acre			1.41	0.14	______
Interest on Op. Capital	Dols	0.10	1.34	0.13	0.01	______
Total Harvest:	Dols			8.17	0.82	______
Total Operating Costs:	Dols			51.75	5.18	______
Property & Ownership Costs:						
Machinery Replacement	Dols			34.73	3.47	______
Machinery Taxes & Insurance	Dols			7.41	0.74	______
General Farm Overhead	Dols			5.00	0.50	______
Real Estate Taxes	Dols			4.00	0.40	______
Total Property & Ownership Costs:	Dols			51.14	5.11	______
TOTAL DIRECT COSTS:	Dols			102.89	10.29	______
NET RECEIPTS, At Market Price:				23.11	2.31	______
RETURN TO - Operator's Land, Labor & Capital @ Market Price:				23.11		______
Capital @ 5.00% = 37.06						
Labor @ 5.25 = 16.09						
Land @4.00% = 13.00						
Required 66.15						
RETURN TO - Management & Risk:				-43.04	-4.30	______
BREAKEVEN PRICES - Required to Pay Direct Costs @ Various Yields:			@ 8 cwt/ac		12.86	______
			@ 10 cwt/ac		10.29	______
			@ 12 cwt/ac		8.57	______
BREAKEVEN PRICES - Required to Pay Direct Costs Plus Land, Labor & Capital @ Various Yields:			@ 8 cwt/ac		21.13	______
			@ 10 cwt/ac		16.90	______
			@ 12 cwt/ac		14.09	______

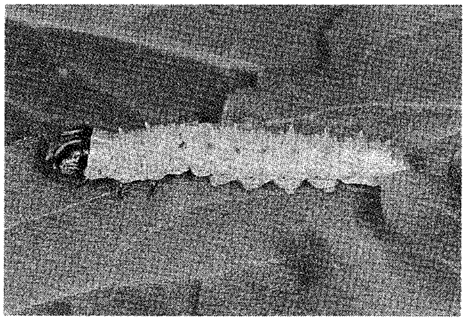
*Note: $12.60/cwt = 65% large seeds @ $14/cwt & 35% small seeds @ $10

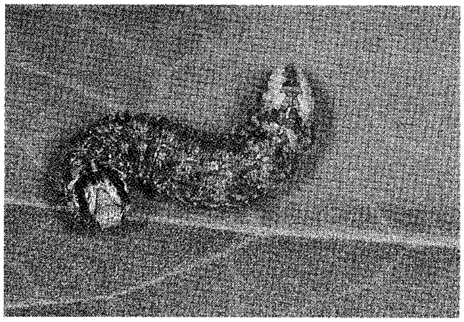

1. Bird damage to sunflower

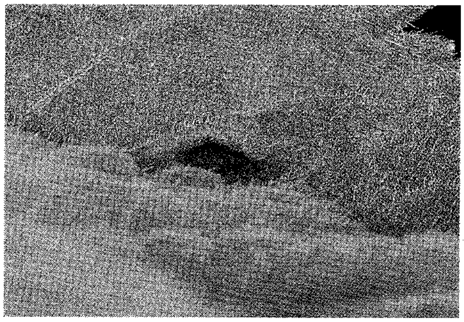

2. Sunflower moth


3. Sunflower moth larva

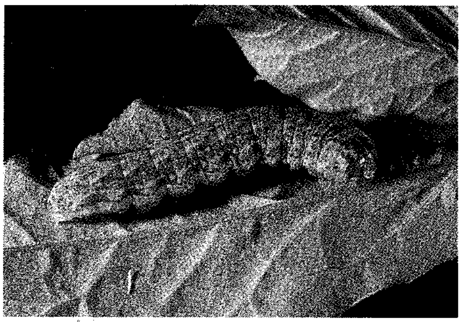

4. Banded sunflower moth

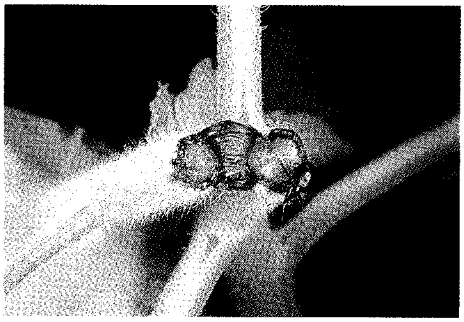

5. Banded sunflower moth larva

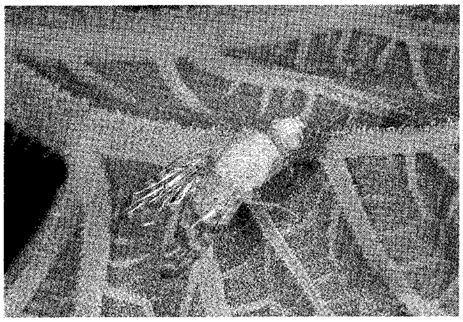

6. Banded sunflower moth larva


7. Red sunflower seed weevil

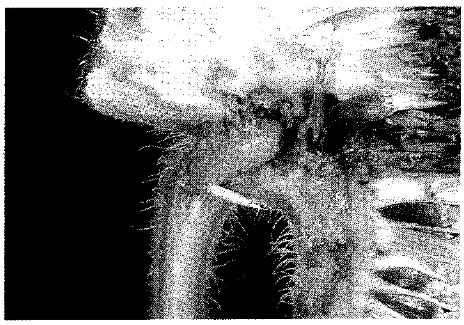

8. Grey sunflower seed weevil


9. Darksided cutworm

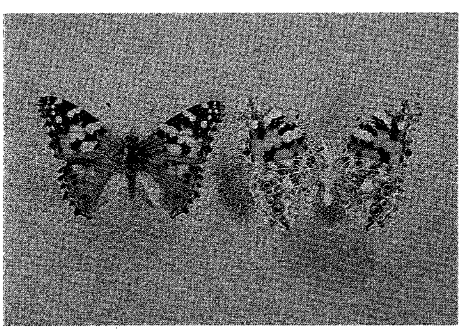

10. Head-clipper weevil



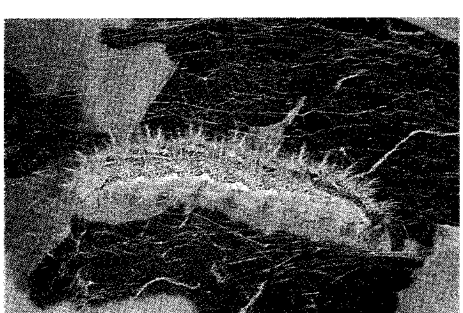
11. Sunflower receptacle maggot adult



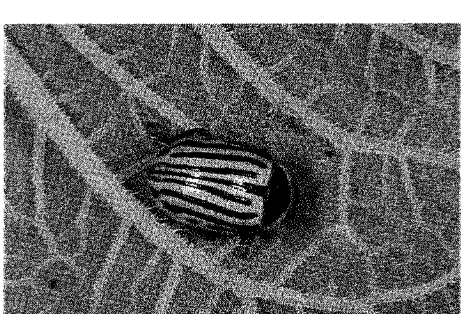
12. Sunflower receptacle maggot



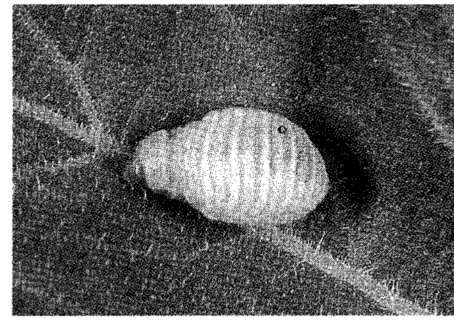
13. Painted lady butterfly



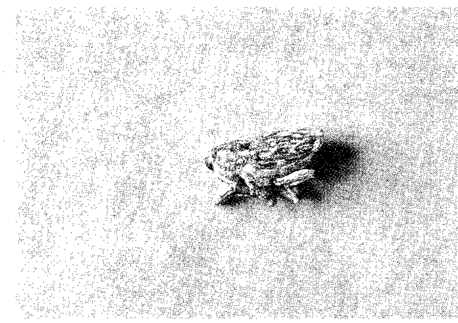
14. Painted lady caterpillar



15. Sunflower beetle

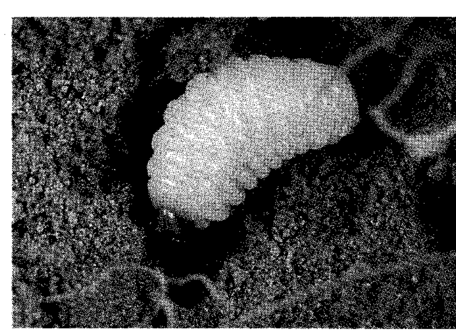


16. Sunflower beetle larva



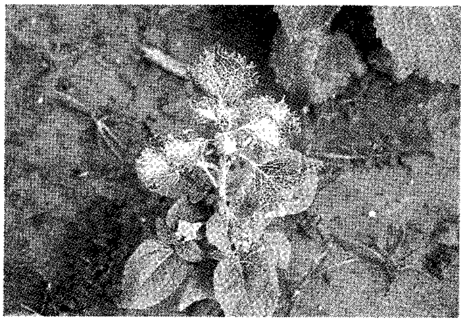
17. Sunflower stem weevil

18. Sunflower stem weevil larva

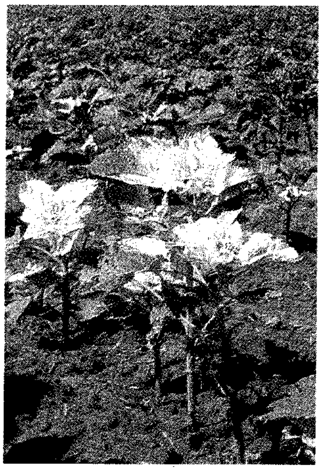


19. Sunflower root weevil larva

20. Carrot beetle



21. Phenoxy herbicide injury to sunflower



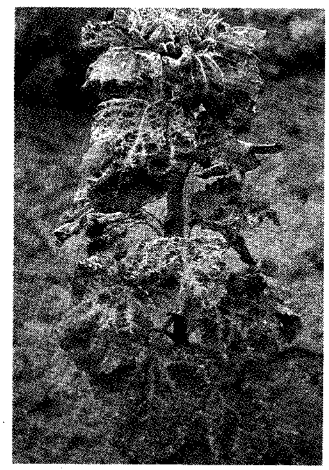
22. Apical chlorosis

23. Bacterial stalk rot

24. Alternaria symptoms on head

25. Alternaria symptoms on leaf

26. Alternaria symptoms on stem

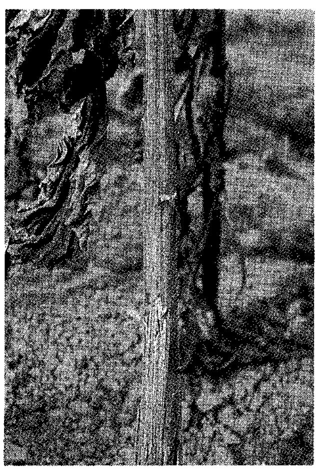


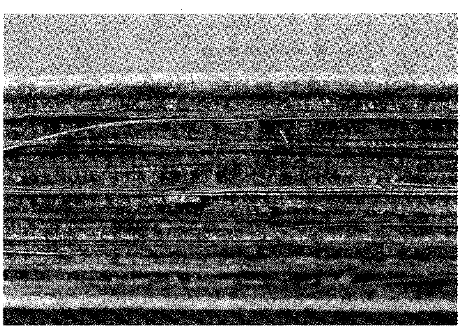
27. Downy mildew

28. Powdery mildew

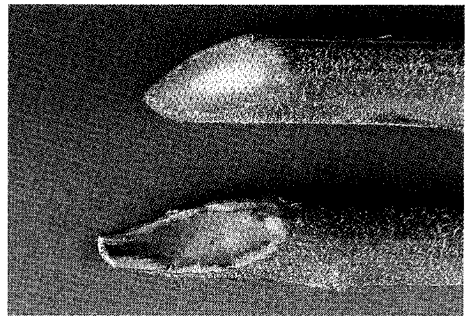

29. Sunflower leaf rust


30. Septoria leaf spot


31. Charcoal rot – symptoms on stem


32. Charcoal rot – sclerotia and internal symptoms

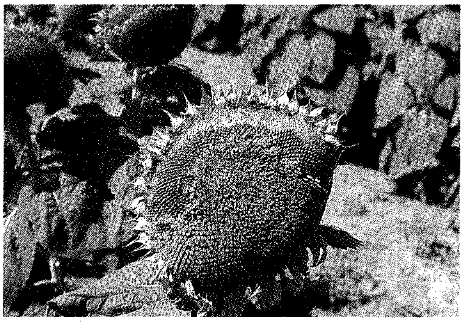

33. Verticillium wilt – leaf symptoms

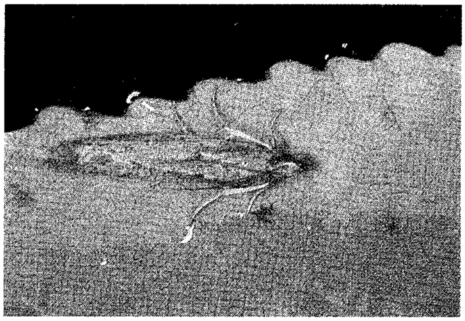

34. Verticillium wilt – stem symptoms

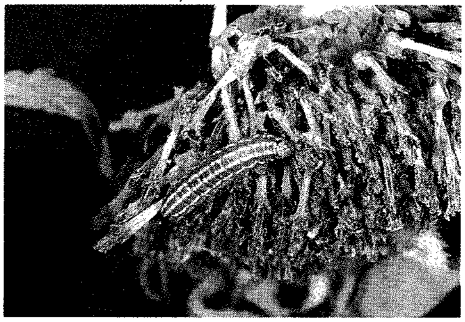

35. Phoma black stem

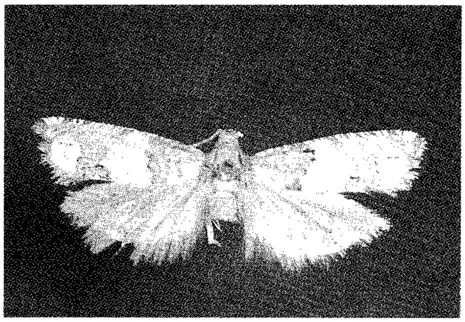

36. Sclerotinia wilt (white mold)

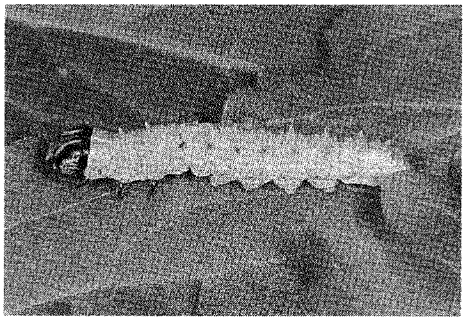

37. Rhizopus head rot

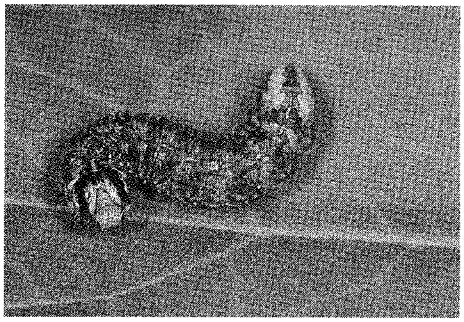

1. Bird damage to sunflower

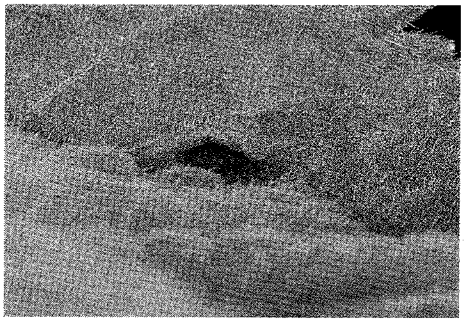

2. Sunflower moth


3. Sunflower moth larva

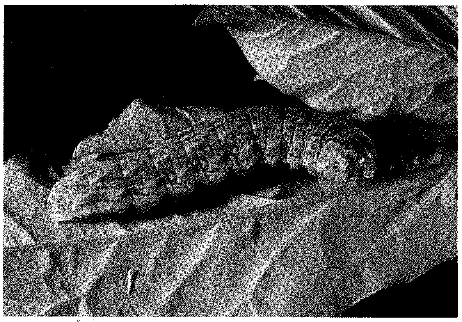

4. Banded sunflower moth

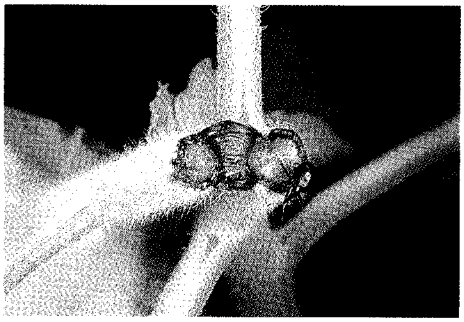

5. Banded sunflower moth larva

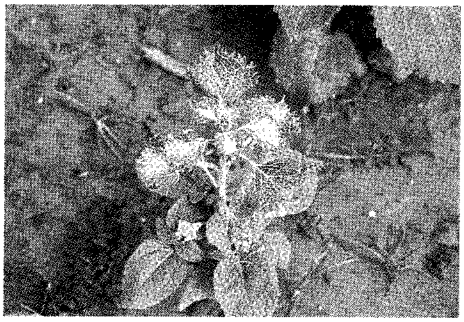

6. Banded sunflower moth larva


7. Red sunflower seed weevil

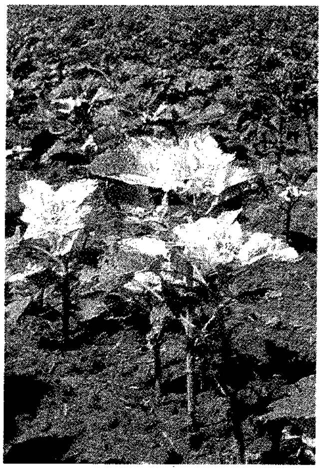

8. Grey sunflower seed weevil


9. Darksided cutworm


10. Head-clipper weevil



21. Phenoxy herbicide injury to sunflower



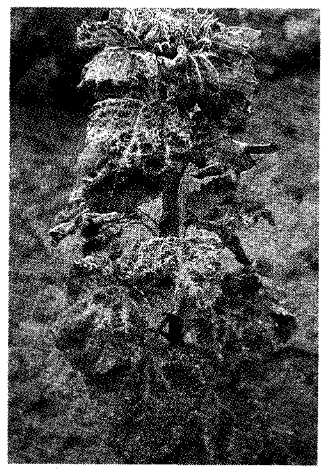
22. Apical chlorosis

23. Bacterial stalk rot

24. Alternaria symptoms on head

25. Alternaria symptoms on leaf

26. Alternaria symptoms on stem



27. Downy mildew

28. Powdery mildew

US GRADES AND STANDARDS FOR SUNFLOWER

Table 8 lists the U.S. grade requirements for sunflower seed. These standards were revised 25 May, 1985. The table lists minimum limits for test weight and maximum limits for damaged and dehulled seed.

Table 8. USDA grade requirements for sunflower seed

U.S. Grade	Minimum test weight (lbs) per bushel	Maximum limits (%) of damaged sunflower seed		
		Heat dmg.	Total dmg.	Dehulled seed
No. 1	25.0	0.5	5.0	5.0
No. 2	25.0	1.0	10.0	5.0

U.S. Sample grade shall be sunflower seed that:

1. Does not meet requirements for grades U.S. Nos. 1 or 2; or

2. In a 600 gram (1.3 lb) sample, contains 8 or more stones that have aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.), 4 or more particles of an unknown substance(s), or 10 or more rodent pellets, bird droppings, or an equivalent quantity of other animal filth; or

3. Has a musty, sour, or commercially objectionable foreign odor; or

4. Is heating or otherwise of distinctly low quality.

SUNFLOWER INSECTS

1. DETERMINING THE NEED FOR INSECTICIDE TREATMENTS

Native sunflower and other related native plants provide a constant source of potential insect pests for cultivated sunflower in the region. It is not unusual for sunflower crops grown here to require at least one insecticide treatment.

The need for an insecticide should be determined by scouting the field at least once a week. Optimal scouting patterns may vary from pest to pest. A good general procedure is to cross the field on a diagonal or zig-zag pattern, stopping a minimum of 10 times. At each stop, examine 5-10 plants for insects and damage. Use this scouting information and the action thresholds given in this publication to determine if an insecticide treatment is necessary. The thresholds given here should be used only as guidelines. Producers should adjust these guidelines to their conditions. For example, a lower action threshold might be used for situations when higher crop values are expected or for fields with high yield potential, while higher thresholds should be used for lower expected crop value or for lower yield potential situations such as dryland production.

Because insecticide registrations change constantly, complete insecticide recommendations are not given here. Insecticides currently registered for use against a given sunflower pest can be found in a state insect control recommendation guides. These are updated every year and are available from Cooperative Extension county offices and the state university publication distribution centers.

2. CULTURAL CONTROLS FOR SUNFLOWER INSECTS

There are several cultural practices that may reduce insect pressure:

A. ROTATIONS

Rotation will prevent many insect problems by helping reduce insect populations of overwintering species such as spotted stem weevil, sunflower seed weevils and sunflower bud moth. Avoid planting sunflower adjacent to a sunflower field of the previous year or fallow field with wild sunflower.

When to treat

Applications are made to prevent moths from laying eggs. Moths are best scouted in the evening when they are active. Pheromone traps can be used to determine when scouting should be started. Consider an insecticide treatment if banded sunflower moths are observed in field margins when 35-100% of the plants are beginning to bloom. Treatments should include field margins were adults congregate when they are not active in the field. Effective insecticide treatments currently used against banded sunflower moth include: Asana XL, Furadan 4F, and Lorsban 4E.

C. Sunflower Seed Weevils

Red sunflower seed weevil, Smicronyx fulvus LeConte, gray sunflower seed weevil, Smicronyx sordidus LeConte. Adults range from 1/10 to 1/5 of an inch long. S. fulvus adults are reddish-brown (Photo 7). S. sordidus are gray (Photo 8). Females lay eggs between the pericarp and developing achene, usually 1/seed. Larvae feed on the inner meat of seeds. When growth is completed, larvae exit the seed and drop to the ground from August to early October and overwinter in below-ground cavities. Pupation occurs in June, lasting 8-10 days. Adults may be found from June to September. There is a single generation/year.

When to treat

Applications are made to prevent adults from laying their eggs. While the action threshold for gray sunflower seed weevil is not well defined, it will be higher than that for the red sunflower seed weevil. Use the formulas that follow to determine action thresholds for red sunflower weevil on oil types, applying treatments when about 30% of the plants have reached the R5.1 stage. Confection types should be treated to avoid quality penalties if less than 10-15% of the plants have reached R5.1 and 1-2 red sunflower seed weevils can be found per head. Treatments for gray sunflower seed weevil should be made earlier, when 10-15% of the plants have reached the R4 stage. Effective insecticide treatments currently used against seed weevils include: Asana XL, Furadan 4F, and Lorsban 4E.

Scouting for red sunflower seed weevil can be difficult because of its distribution in the field and because of its habit of hiding in the heads. Start scouting when the yellow ray petals are first visible and stop when the majority of the plants in the field have passed 70% pollen shed (R5.7), or when the action threshold has been exceeded (see below for calculations). Avoid taking seed weevil counts from plants in field margins as they tend to congregate in these areas and counts will not be representative of the entire field. Red sunflower seed weevils can be dislodged from the head for counting by brushing the face of the head vigorously. An alternative is to spray the head with an aerosol containing the insect repellent "deet'. This will flush the insects from their hiding places, allowing them to be counted easily. Count five sets of five plants, distributed across the field in an "X" pattern. If the insect repellent method is used, counts will need to be converted to absolute numbers before comparing them to the economic threshold calculations described below. Use the following table to convert from total weevils flushed from a head to an absolute count to compare to your calculated threshold shown in step 3.

Weevil count in field	Absolute weevil count	Weevil count in field	Absolute weevil count
1	1.4	11	19.5
2	2.9	12	21.3
3	4.4	13	23.1
4	5.8	14	24.9
5	7.3	15	26.6
6	10.7	16	29.3
7	12.4	17	31.1
8	14.2	18	32.9
9	16.0	19	34.7
10	17.8	20	36.6

Steps for calculating a red sunflower seed weevil action threshold in oil type sunflower

1 Breakeven threshold = Per acre cost of treatment/per pound market value of crop

example: $\frac{\$7.00}{\$0.09}$ = 77.8 lbs

or loss per acre to break even on an insecticide application when sunflower price is $0.09 per lb.

have a brown lace-like appearance. The larvae attain a length of 1/5 inch at maturity. Adults emerge during early July and egg deposition occurs on the corolla of incompletely opened sunflower inflorescents. The total larval period is 14 days. There are two generations. The first generation pupates in the head, whereas the second generation overwinters in the soil as pupae. Larval damage is largely dependent upon the state of larval and seed development. Seed sterility occurs when newly hatched larvae tunnel into the corolla of young blooms. Young larvae can destroy up to 15 ovaries. Larger larvae can destroy up to 3 seeds during development.

<u>When to treat</u>

Significant yield losses have not been demonstrated with this insect. Insecticide treatments are not considered necessary under most conditions.

4. Sunflower Receptacle Maggot

<u>Gymnocarena</u> <u>diffusa</u> (Snow). Adult body is about 1/2 inch in length with a wingspan of about 3/4 inches. The eyes are bright green and wings have a yellowish-brown mottled pattern (Photo 11). Adults emerge in late June to early July. Eggs are laid on bracts of developing sunflower heads. Upon hatching, larvae tunnel into the spongy tissue of the receptacle and upper stem (Photo 12). After about 30 days, the mature larvae cut a small emergence hole on the underside of the receptacle and drop to the soil to pupate in late August or early September. Overwintering pupae are found over 6 inches deep. Some larvae will pupate in the sunflower head. There is one generation per year in the region.

<u>When to treat</u>

Significant yield losses have not been demonstrated with this insect. Insecticide treatments are not considered necessary under most conditions.

C. FOLIAGE FEEDERS

1. Painted Lady

<u>Vanessa</u> <u>cardui</u> (L.). Also known as the Thistle Caterpillar. This butterfly has a wingspread of 2 inches, upper wing surface brown with red and orange mottling and white and black spots (Photo 13). Larva is light brown to black, spiny, with a pale yellow stripe on each side (Photo 14). Adults appear in May and June with larvae appearing shortly thereafter. Larvae feed on leaves and can often be detected by webbing.

<u>When to treat</u>

Insecticide treatments are only recommended for larvae under 1 1/4" in length, because larger larvae are about to stop feeding. Consider a treatment if defoliation averages 25% on the plants examined.

2. Sunflower Beetle

<u>Zygogramma</u> <u>exclamationis</u> (F.). Adults are about 1/4 to 1/2 of an inch long and have a reddish-brown head, cream colored back with 3 dark reddish-brown stripes on each wing cover (Photo 15). Larvae are yellowish-green, and hump-backed in appearance (Photo 16). The overwintering adults become active in the region in June and July to mate and deposit eggs on stems and leaves. Larvae may be found soon afterwards. Both adults and larvae are defoliators, but larvae are considered to be more economically significant.

<u>When to treat</u>

Adults attack early in the season, defoliating seedlings. One adult per plant is considered to be economic. Later the larval stage feeds on larger plants. Fifteen larvae/plant or 25% defoliation would justify an insecticide application.

D. STEM FEEDING SPECIES

1. Sunflower Stem Weevil

<u>Cylindrocopturus</u> <u>adspersus</u> (LeConte). Adults are about 3/16 of an inch long and grayish-brown with varying shaped white spots on the wing covers and thorax (Photo 17). Mature larvae are 1/4 inch long. They are creamy white with a small, brown head capsule. Larvae appear C-shaped when in the vascular and pith tissue of the stalk (Photo 18). Adults can be found on plants in June and July. Newly hatched larvae feed on leaf tissue, but latter stages move into the stalks from July to late September. A chamber is formed by mature larvae (4th instar) near the base of the stalk where they remain all winter. The presence of larval chambers can weaken the stalk, causing infested plants may lodge as plants dry down. Pupation occurs in to May to June of the next year.

<u>When to treat</u>

Applications are made to prevent adults from depositing their eggs in the stalk. A treatment should be considered when two or more adults are found per plant from the 14-leaf stage to the early bud stage.

E. ROOT FEEDING SPECIES

1. Sunflower Root Weevil

<u>Baris strenua</u> (LeConte). The black adults of <u>B. strenua</u> are oval shaped, almost 1/4 inches in length, and have a snout. Adults appear in fields by June in the region. Adults are often found in numbers around the root zone at the soil surface. Larvae (Photo 19) can be found in stalks by mid-July. By September and early October larvae form a "soil cocoon" around roots at a depth averaging 2-5 inches and where they overwinter. Numerous larvae in the stalk will cause serious stalk breakage. Adults are known vectors of such fungal diseases as charcoal rot and Phoma black stem disease.

<u>When to treat</u>

Significant yield losses and stalk breakage have not been demonstrated with this insect. Insecticide treatments are not considered necessary under most conditions.

2. Carrot Beetle

<u>Ligyrus gibbosus</u> (DeGeer). A moderate size (1/2 - 2/3 inch) and oblong-ovate, dark reddish-brown to black beetle (Photo 20). Pronotum with a low tubercle at middle. Wing covers with longitudinal depressed furrows with punctures. Hind tibiae are expanded and truncate at apex.

<u>When to treat</u>

No control is currently recommended for this insect.

SUNFLOWER DISEASES

1. INTRODUCTION

Various fungal and bacterial plant pathogens (Figure 4) affect or could affect sunflower productivity in this and other regions in the United States. The more common diseases and pest management strategies are summarized in this section. Consult your local extension agent and industry representatives for current management recommendations. Good color illustrations of many of these diseases and other pests also are available in other sunflower publications, such as McMullen (1985).

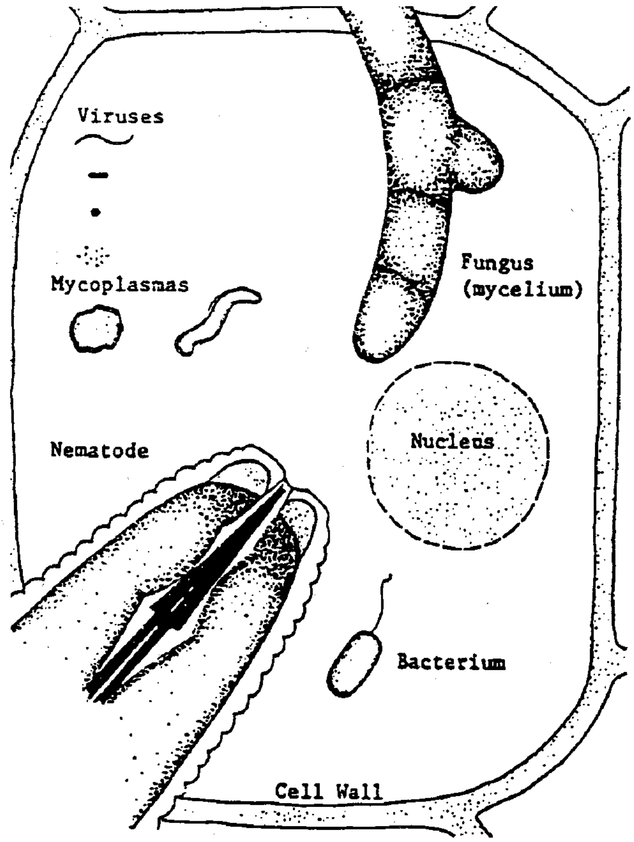


Figure 4. Plant pathogens in a cell. Courtesy of W.M. Brown, Jr.

Most fungal and bacterial diseases are more severe under irrigated than under dryland conditions. Over-irrigation increases these problems as does frequent irrigation, especially with center pivots.

2. NONPARASITIC PROBLEMS

A. Bract Necrosis

High temperatures (greater than 100° F) cause a brown discoloration of disk flowers and bracts. This discoloration becomes black after a rain. When bract necrosis occurs during the bud stage, buds may remain unopened. Some injured buds may open but produce few or no disk flowers and little pollen. There is no control reported.

B. Hail Injury

Sunflower plants can be defoliated and/or destroyed during severe wind, rain and hail storms. The extent of yield loss depends upon the stage of plant development and the amount of damage inflicted at that time. Defoliation, breakage, bruising and stand reduction can occur as a result of storm damage. When injury to the terminal bud occurs during early reproductive stages, plants often die. When injury occurs near or after flowering, the plants usually remain green and continue to live but do not produce seed. Physical injury on the back of the sunflower head at or near flowering can result in Rhizopus head rot, especially if wet or humid conditions are present.

Lightning damage may appear as the sudden death of plants (sunflower and weeds) in the affected circular area (50 - 100 feet in diameter). Near the edge plants may wilt but not die, and stalks often have a brown to black pith. The affected area does not increase in size after the first two weeks.

C. Herbicide Damage

Herbicide drift occurs when herbicides move to areas where application was not intended. Drift is generally caused by movement of spray droplets applied in proximity to a sensitive crop such as sunflower, or by movement of herbicide vapors during windy, hot periods in proximity to or at some distance from the sensitive crop. Sunflower is susceptible to many postemergence herbicides such as 2,4-D, MCPA, picloram (Tordon), dicamba (Banvel), bromoxynil (Buctril, Brominal), chlorsulfuron (Glean), atrazine, cyanazine (Bladex), bentazon (Basagran), glyphosate (Roundup), and paraquat. Sunflower yield may be severely reduced 25 - 80% by herbicides such as 2,4-D or dicamba, depending on the growth stage when the drift occurred. Damage is greatest when sunflower is in the bud stage, and least when applied during bloom.

Herbicide drift symptoms commonly consist of an abnormal bending or twisting of stems and/or leaf petioles, within 24-48 hours after contact with a growth regulator herbicide such as MCPA, 2,4-D (especially ester formulations), dicamba and picloram. Sunflower growth is often slowed or stopped, and young leaves that emerge after exposure to the herbicide are often cupped and/or elongated (Photo 21). Some plants die without further growth, some remain green and do not grow the remainder of the season, and other plants will begin growing later after the herbicide is partially metabolized by the plant. Multiple heads may develop, and heads may be malformed or partially filled.

Herbicide carryover (picloram, Banvel, Glean, atrazine) from previous crops may also be a potential problem for sunflower, depending upon the chemical, application rate, soil moisture and soil pH. This type of damage may be evident as poor emergence; stunted leaves, stems and roots; and yellowed and/or burned leaves.

Manage herbicide carryover and drift problems by careful crop rotation, avoid application of herbicides near sensitive crops such as sunflower, and monitor wind and high temperatures to avoid spraying when adverse weather conditions may develop. Notify local aerial applicators of the location of sunflower fields.

3. BACTERIAL CAUSES

A. Apical Chlorosis

This disease is caused by <u>Pseudomonas syringae</u> pv. <u>tagetis</u> (Hellmers) Young et al. which can be seedborne. Symptoms include younger leaf yellowing without evidence of lesions, and can be more severe on seedlings. Affected leaves, including veins, are pale yellow to white. Only a portion of the initially affected leaf may be yellow, but subsequently formed leaves are uniformly chlorotic, including veins (Photo 22). Infected seedlings are stunted and usually die. Affected plants are usually scattered throughout a field, occurring singly or in small groups within a row. Other bacterial blights (<u>P. cichorii</u> , <u>P. syringae</u> pv. <u>helianthi</u>, <u>P. syringae</u> pv. <u>aptata</u>, <u>P. syringae</u> pv. <u>mellea</u>, <u>Xanthomonas heterocea</u>), wilt (<u>P. solanacearum</u>) and crown gall (<u>Agrobacterium tumefaciens</u>) have not been detected or caused problems yet on sunflower in the U.S.

Control by planting resistant varieties.

B. Bacterial Stalk Rot

This disease is caused by Erwinia carotovora subsp. carotovora (Jones) Bergey et al. and E. carotovora subsp. atroseptica (van Hall) Dye. It occurs after extended wet periods late in the growing season, and infection probably occurs at the axil of a petiole. This area often collects water and may serve as a favorable site for bacterial and insect activity. Infection is aided by wounding from hail, mechanical damage or insect feeding. Stalks are black on the outside and hollow on the inside with an ink-black, watery breakdown of the pith. Plants often lodge as heads develop and mature, and the head may also develop soft rot symptoms (Photo 23).

Control by crop rotation (no potatoes).

4. FUNGAL CAUSES

A. Seedling Blight and Seed Rot

Sunflower seed may be attacked by various soilborne and seedborne pathogens. Affected seeds may rot after emergence, or emerging seedlings are killed. Such seedlings exhibit damping-off, root rot, or stem rot symptoms. Fungi associated with such diseases include Aspergillus niger, Pythium aphanidermatum, Rhizopus arrhizus, R. stolonifer, Rhizoctonia species, and Sclerotium rolfsii.

Control by applying seed fungicides and planting high quality seed after soil temperatures favor rapid germination in adequate soil moisture.

B. Alternaria Diseases

Alternaria leaf blight, stem spot, and head rot (Alternaria helianthi (Hansf.) Tubaki & Nishihara = Helminthosporium helianthi Hansf., A. helianthicola G.N. Rao & Rajagopalan, A. zinniae M.B. Ellis, A. leucanthemi E.S. Nelson, and A. tenuissima (Kunze: Fr. Wiltshire) can be seedborne and overwinter in stem residue on and near the soil surface. Infection is favored by warm, humid conditions that promote extended periods of leaf wetness. Early-planted seedlings may be more severely diseased than later-planted ones. Plants are most susceptible at flowering or seed-fill stages. Dark brown, oval, necrotic spots occur on the heads (Photo 24), leaves (Photo 25), petals, petioles, and stems. Stem lesions start as black flecks or streaks (Photo 26) that later enlarge to cover large areas of the stem which may be girdled. The plant may die, be defoliated and frequently lodges. Disease losses include reduced head diameter, seed number per head, and oil content.

Control by timely applications of seed and foliar fungicides, crop rotation, sanitation of previous crop debris, and delayed planting.

C. Downy Mildew

Plasmopara halstedii (Furl.) Berl. & De Toni in Sacc. survives in the soil and seed, and may systemically infect roots after emergence. Seedlings become increasingly resistant with age. Infected seedlings have a light green or yellowish area that spreads from the midribs of leaves. During wet conditions, a downy, whitish, fungal growth develops on the lower surface of leaves and spores can be blown to other leaves and plants. As plants continue to grow, leaves become wrinkled and distorted (Photo 27) and the entire plant may be stunted. Infected plants usually produce normal-sized heads that remain upright and contain mostly empty seeds.

Control by planting clean seed that has been treated with an appropriate fungicide, following a 3-4 year crop rotation with small grains, sanitation of previous crop debris and volunteer plants, planting resistant varieties, and practicing good weed control.

D. Powdery Mildew

This disease is caused by Erysiphe cichoracearum DC. f. helianthi (Leveillula compositarum Golovin f. helianthi, L. taurica (Lev.) G. Arnaud, Sphaerotheca fuliginea (Schlechtend.: Fr.) Pollacci) that survives on previously infected crop residue. Normally the lower leaves become more heavily infected than upper leaves on a plant. Spores are then blown by wind between leaves and plants. Symptoms usually appear after full flowering as white powdery areas on the upper surface of leaves (Photo 28) or other plant parts. Later the white fungal growth becomes gray and speckled with small, black overwintering structures (cleistothecia). Severely infected leaves may curl, turn yellow, and dry up.

No control is recommended because infection usually occurs too late in the season to affect plant development and yield, however, varieties may vary in their disease reaction.

E. Rusts

There are various rust diseases of sunflower that are reported to occur in the United States. Coleosporium or yellow rust (Coleosporium helianthi (Schwein.) Arth.) occurs on the west coast of the U.S. Rust pustules (uredia) appear as golden yellow pustules that contain thousands of spores that are spread by wind. This rust has an alternate host (Monterey Pine). No control is reported.

The more common rust is caused by Puccinia helianthi Schwein. which produces all of its spore stages on sunflower. Infection is favored by temperatures less than 90°F and high moisture. The perfect stage of this rust may appear as small clusters of pale yellow or orange spots (pycnia) on the upper surface, followed by yellow or orange spots (aecia) on the lower surface of leaves in late spring or early summer. Brown pustules (uredia) appear on both surfaces of lower leaves and sometimes stems later in the season. Severely diseased leaves dry up and die. Telia occur as plants mature and appear as dark brown to black spots (Photo 29).

Severe infection may reduce seed size and test weight. Control by crop rotation, sanitation of previous sunflower debris and volunteers, avoiding late planting, and planting resistant varieties.

White rust or white blister is caused by Albugo tragopogonis (Pers.) S.F. Gray which overwinters in previous crop debris and volunteer sunflower. Infection is favored by temperatures less than 90°F and high rainfall. Creamy white, blisterlike pustules appear on the lower surface of leaves near the bottom of the plant. Tissue on the upper surface of leaves, opposite a pustule, is raised and yellow green.

No control is reported or necessary.

F. Septoria Leaf Spot

Septoria leaf spot is caused by Septoria helianthi Ellis & Kellerm. which overwinters on crop residue and is favored by high moisture and temperatures greater than 85°F. Symptoms appear on plants of any age but are more common after flowering on lower leaves. Water-soaked, circular spots, 1/4 - 1/2 inches in diameter form and are gray with a dark margin ((Photo 30). A diffuse narrow yellow ring may surround the spot. Spots may coalesce and produce irregular-shaped dead areas on leaves. Defoliation may occur.

No control is reported.

G. Charcoal Rot

Charcoal rot is caused by Macrophomina phaseolina (Tassi) Goidanich which can be seedborne. The disease is favored by temperatures greater than 90°F and low soil moisture. The sunflower stem weevil can transmit fungal spores as they emerge from overwintered roots and stalks. Symptoms usually appear after flowering. Premature ripening of stalks and poor filling of heads occur. Stalks have a gray discoloration at the base (Photo 31), with only the vascular bundles or fibers remaining, giving the internal stem a shredded appearance. The vascular tissue become covered with small, black flecks or sclerotia (Photo 32).

Control by crop rotation with small grains, sanitation of previous crop debris, plant resistant varieties, and if possible irrigate at or during flowering.

H. Verticillium Wilt

Verticillium wilt or leaf mottle is caused by Verticillium dahliae Kleb (V. albo-atrum Reinke & Berthier) which survives in soil and seed. Symptoms are most obvious at flowering when infected plants occur singly or in groups. Symptoms appear on lower leaves first and gradually progress up the plant. Tissue between leaf veins becomes yellowed, then brown, giving the leaf a mottled appearance (Photo 33). Black areas occur on the stem, particularly near the soil line. The vascular system of the stem is brown to black (Photo 34). Severely infected plants are stunted and may ripen prematurely or die before flowering.

Control by crop rotation to small grains, using clean seed and planting resistant varieties.

I. Phoma Black Stem

Phoma black stem or girdling is caused by Phoma macdonaldi Boerema which overwinters in previous crop debris. Infection is favored by moist conditions during and after flowering. Symptoms are most noticeable after flowering. Lesions normally start at the base of leaf petioles and spread along the stem. Large dark patches may also develop on leaves and flowers. Small black spots (pycnidia) may be observed in mature spots. Infected plants may produce small heads with few seeds, and stems may be weakened and lodge. Leaves wilt and dry up, and stalks often turn dark brown to black (Photo 35). Premature death may occur in a circular patch in the field, although scattered plants may die.

Control by crop rotation, and planting less susceptible varieties.

J. Phomopsis Brown Stem Canker

This disease is caused by Phomopsis helianthi M. Muntanola-Cvetkovic et al. which overwinters on previous crop debris. Symptoms appear as brown areas surrounded by yellow tissue on the apical end or edge of the leaf. Leaf veins and petioles darken and brown to black cankers develop around petiole bases. These cankers later turn ash gray. Stem spots are initially light brown and measure about 1/2 inches wide. These spots become darker with a wet appearance and increase to 1 inch wide and girdle the stem. Pycnidia form in the diseased tissue. Several internodes may be discolored, and the interior of the stalk becomes hollowed. Plants ripen prematurely and oil content in seeds decreases.

No control is reported.

K. Sclerotinia Diseases

Sclerotinia wilt (base, crown, root, stalk and stem rots, white mold) and head rot are caused by Sclerotinia sclerotiorum (Lib.) de Bary which survives in the soil as sclerotia. The fungus produces mycelium that directly infects stalks (Photo 36) and roots; or mushroom structures (apothecia) that release windblown ascospores that then colonize senescent flowers and infect heads. The diseases are favored by high moisture, especially during and after flowering. Symptoms include soft, water-soaked spots that later dry out, leaving plant tissue with a somewhat pinkish color. Wilted plants have a soft, water-soaked canker completely encircling the stem that extends 2 - 4 feet or higher above the soil line. A white, cottonlike mold may grow over the diseased area. Heads eventually become partially or entirely rotted, leaving only vascular bundles and fibers that give the head a shredded or brushlike appearance. Seed hulls may be discolored and scurfy. Large black sclerotia form within the stalk and beneath the seed layer while others form around the seeds. Sclerotia are about the size and density of the seed, are difficult to remove in the threshing and cleaning operations, and may be a common fungal contaminant in seed stocks.

Control by fallow or crop rotation with small grains (not other hosts such as dry beans), planting clean seed, controlling weeds, sanitation of previous crop debris, and using a moderate fertility program.

L. Rhizopus Head Rot

Head rot can be caused by various species of Rhizopus (Rhizopus microsporus Tiegh., R. arrhizus A. Fischer, and R. stolonifer (Ehrenb.: Fr.) Vuill). The windblown spores reach heads during wet weather and enter tissue damaged by birds, hail, or insects such as the sunflower moth. Head tissue turns brown and soft (Photo 37). In wet weather or in the hollow part of the flower receptacle, the coarse threadlike strands of the fungus may be seen. Later, small black fruiting structures form on fungal strands. As the head dies, the plant tissue appears to shred.

Control by avoiding damage to head, particularly by sunflower head moth.

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APPENDIX 1: KEY TO FIELD PROBLEMS AFFECTING SUNFLOWER

1. PROBLEMS AFFECTING SEEDS AND SEEDLINGS

Plants missing or cut at base. Chewing injury may be present on leaves. Damage usually patchy, not uniform throughout field. Caterpillar-like larvae usually cream color to gray-brown, often with dark mottling or stripes can be found in soil or under debris (Photo 9) . . . . **Cutworms**

Poor emergence; stunted leaves, stems and roots; and yellowed and/or burned leaves. . . . . **Herbicide carryover injury**

Younger leaves pale yellow to white. Portion of first affected leaf may be yellow, but subsequently formed leaves are uniformly chlorotic, including veins. Seedlings are stunted and usually die. Affected plants are usually scattered throughout a field, occurring singly or in small groups within a row. (Photo 22) . . . . **Apical chlorosis**

Older leaves yellow with large necrotic patches. Leaf cupping, both upward or downward, occurs toward the tip of the leaf. Leaf senescence may occur. . . . . **Potassium deficiency**

Interveinal chlorosis on the youngest leaves. . . . . **Iron deficiency**

Seedlings exhibit damping-off, root rot, or stem rot symptoms. May be fairly uniform throughout field . . . . **Seedling Blights and Seed Rots**

Seedlings with light green-yellow areas spreading from the midribs of leaves. During wet conditions, a downy, whitish, fungal growth develops on the lower surface of leaves (Photo 27). . . . . **Downy mildew**

Missing plants usually associated with a pattern of one or more rows . . . . **Planter problems**

2. PROBLEMS AFFECTING FOLIAGE

Light brown to black, spiny caterpillars, with a pale yellow stripe on each side, feeding on leaves in late June or early July. Larvae can often be detected by webbing (Photo 14) . . . . **Thistle caterpillar**

Defoliation caused by 1/4 to 1/2 of an inch long beetles with reddish-brown head, cream colored back with 3 dark reddish-brown stripes on each wing cover and/or yellowish-green, hump-backed larvae during June and July (Photos 15, 16) . . . . **Sunflower beetle**

Sudden death of plants (sunflower and weeds) in the affected circular area (50 - 100 feet in diameter). Stalks often have a brown to black pith . . . **Lightning**

Brown pustules on lower leaves and sometimes stems later in the season. Severely diseased leaves yellow, dry up and die (Photo 29) . . . . **Rust**

Creamy white, blisterlike pustules on lower leaves. Tissue on upper leaf surface opposite a pustule, is raised and yellow green . . . . **White rust**

Lower leaves mottled by yellow or brown tissue between veins. Black areas on stem near soil line. Stem interior brown to black. Severely infected plants are stunted and may ripen prematurely or die before flowering (Photos 33, 34) . . . . **Verticillium wilt**

Water-soaked, circular spots, gray with a dark margin and perhaps surrounded by a diffuse narrow yellow ring. Defoliation may occur (Photo 30) . . . . **Septoria leaf spot**

Lighter green to definite yellowing of leaves. Definite chlorotic yellowing of lower leaves later in season . . . . **Nitrogen deficiency**

Stunted plants. Necrotic gray lesions possible on older leaves. . . . . **Phosphorus deficiency**

Plants stunted, upper leaves distorted, leaves may wilt . . . . **Zinc deficiency**

3. PROBLEMS AFFECTING THE STEM

Small spotted weevils found on plants of 2 to 4 leaf stage from June to July. Creamy white, C-shaped, 1/4" larvae found in stem, forming pupation chamber at base of plant at end of season. (Photos 17, 18) . . . . **Sunflower stem weevil**

Stalks black on the outside, hollow inside with ink-black, watery tissue breakdown. Lodging after flowering, heads with soft rot (Photo 23) . . . . **Bacterial stalk rot**

Premature ripening of stalks and poor filling of heads. Stalks with gray basal discoloration and shredded internal tissue with small black flecks (Photos 31,32) . . . . **Charcoal rot**

Lower leaves mottled by yellow or brown tissue between veins. Black areas on stem near soil line. Stem interior brown to black. Severely infected plants are stunted and may ripen prematurely or die before flowering (Photos 33, 34) . . . . **Verticillium wilt**

Leaves first develop petiole lesions, then large dark patches on leaves and flowers, then leaves wilted and dry. Stalks often dark brown to black. Premature death may occur in a circular patch in the field, although scattered plants may die. Associated with moist conditions at flowering (Photo 35) . . . . **Phoma black stem**

Brown areas surrounded by yellow tissue on the apical end or edge of the leaf. Leaf veins and petioles dark. Brown to black cankers at petiole base, later turning ash gray. Stem spots girdling stem. Internodes may be discolored and hollow. Plants ripen prematurely with reduced oil content. . **Phomopsis brown stem canker**

Wilted plants with soft, water-soaked canker girdling the stem for at least 2 - 4 feet above soil line. A white, cottonlike mold may grow over the diseased area. Heads may rot and shred. Seed hulls may be discolored and scurfy. Sclerotia bodies replace the pith (Photo 36) . . . . **Sclerotinia**

4. PROBLEMS AFFECTING THE ROOTS

Black, oval, 1/4" weevils found at the soil surface in June. Larvae found in stalks by mid-July. Forms pupation cell around roots in fall. Associated with stalk breakage and Phoma black stem disease (Photo 19). . . . . **Sunflower root weevil**

Oval, 1/2 - 2/3", reddish-brown to black beetle gouging roots (Photo 20) . . . . **Carrot beetle**

5. PROBLEMS AFFECTING THE HEAD

Tan-gray moths present at bloom. Caterpillars with dark and light stripes on body found tunneling in seeds during July, August (Photos 2,3) . . **Sunflower moth**

Moths with 2 dark bands on front wings. Cream-colored caterpillars found feeding in receptacle area in July or August . . . . **Sunflower bud moth**

Yellowish moths with brownish-black band on front wings. Pink to reddish brown caterpillars feeding on heads to early October (Photos 4,5,6) . . . . **Banded sunflower moth**

Small grey or reddish brown weevils on heads. Small, white larvae feed in interior of seed (Photos 7,8) . . . . **Seed weevils**

Shiny-black, 1/3" weevil found clipping heads in mid-July to early August. Cream colored, C-shaped grubs founds in fallen heads (Photo 10) **Head-clipper weevil**

Flies with brown lace-like wings in early July and again in August. Cream-colored, headless maggots found either tunneling in corolla of young blooms or in seeds . . . . **Sunflower seed maggot**

Flies with bright green eyes and yellowish-brown mottled wings on buds in July. Cream colored, headless maggots tunnel in spongy tissue of the receptacle (Photo 11, 12). . . . . **Sunflower receptacle maggot**

Brown discoloration of disk flowers and bracts that turn black after rain, associated with temperatures above 100°F . . . . **Bract necrosis**

Flowers remain green, because small, leaflike structures replace floral parts. Affected portions die with a narrow brown stripe extending down the stem. A black slimy rot on the stalk below the head may replace the head symptoms. Infected plants may be stunted or break over . . . . **Aster yellows**

Leaves wrinkled, distorted and plant may be stunted. Normal-sized heads remain upright and contain mostly empty seeds (Photo 27) . . . . **Downy mildew**

Abnormal bending or twisting of stems and/or leaf petioles. Growth slowed or stopped with young leaves cupped and/or elongated. Plants may die, remain green without further growth, or later resume growth. Multiple heads may develop, and heads may be malformed or partially filled (Photo 21) . . . . **Herbicide drift**

Younger leaves with mosaic and chlorotic rings. Plants are stunted, perhaps with narrow, light brown streaks on petioles and stems. Malformed heads producing shriveled seed . . . . **Sunflower mosaic**

Dark brown, oval, necrotic spots occur on the heads, leaves, petals, petioles, and stems. Stem lesions eventually girdle stem. Plant death, defoliation and lodging common (Photos 24, 25, 26) . . . **Alternaria**

Wilted plants with soft, water-soaked canker girdling the stem for at least 2 - 4 feet above soil line. A white, cottonlike mold may grow over the diseased area. Heads may rot and shred. Seed hulls may be discolored and scurfy (Photo 36) . . . . . . **Sclerotinia**

Brown, soft head tissue. Strands of fungus visible in wet weather or in receptacle. tissue appears to shred as head dies (Photo 37) . . . . **Rhizopus head rot**

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APPENDIX 2: INFORMATION SOURCES

1. PUBLIC RESEARCH AND NONPROFIT ASSOCIATIONS

A. State Agricultural Experiment Stations and Cooperative Extension Service

The Agricultural Experiment Stations that conduct research, and Cooperative Extension Services that conduct adult education programs in the major sunflower production areas are located at:

Colorado State University, Ft. Collins, CO 80523
North Dakota State University, Fargo, ND 58105
Texas A&M Univ., College Station, TX 77843
Kansas State University, Manhattan, KS 66506
University of Nebraska, Lincoln, NE 68583
Univ. of Minnesota, St. Paul, MN 55108, and Crookston, MN 56716
South Dakota State Univ., Brookings, SD 57006
Univ. of California, Davis, CA 95616

B. Federal Research

Agricultural Research Service (ARS) of the USDA has developed inbred lines for hybrids, conducted research and provided information on production, utilization, and marketing aspects at the following locations: Fargo, ND; Bushland, TX; Beltsville, MD; and Athens, GA.

Sunflower production and farm price statistics and research are released by Statistics Division, Crops Branch, Economics, Statistics, and Cooperative Service, USDA Washington, DC 20250.

Agriculture Canada Research, Box 3001, Morden, Manitoba ROG 1JO CANADA is responsible for federal sunflower research in Canada.

C. Private Associations

The National Sunflower Association, 4023 State St., Bismarck, ND 58501 was organized in 1975 to promote the sunflower industry and to solve common problems. This association is intended to represent the interest of growers, processors, seed companies, including country elevators, exporters, and other merchandisers. It publishes **The Sunflower** magazine and sponsors The Sunflower Forum, a meeting devoted to scientific reports and topics of general interest.

The International Sunflower Association, P.O. Box 337, Toowoomba 4350, Queensland, Australia was formed to improve international cooperation and to exchange information in the promotion of research of agronomics, processing techniques, and nutrition associated with the production, marketing, processing, and use of sunflower. This objective is accomplished by sponsoring and publishing the proceedings of international conferences and by publishing the Sunflower Newsletter, a quarterly periodical.

2. REFERENCES

Cobia, D. and D. Zimmer. 1975. Sunflowers: Production, Pests and Marketing. North Dakota State University Extension Bulletin 25.

Blamey F.P.C., D.G.Edwards and C.J.Asher. 1987. Nutritional Disorders of Sunflower. Department of Agriculture, University of Queensland, St Lucia, Queensland, Australia. 72pp

Carter, J.F., ed. 1978. Sunflower Science and Technology. Monograph 19. American Society of Agronomy, 677 South Segoe Road, Madison, WI 53711, 1978, 459 pages. $17.50. (This book, currently under revision, is a technical treatment of several topics primarily associated with research on agronomic aspects of sunflower. Abbreviated chapter titles are: History and present world status, Taxonomy and origin, Morphology and anatomy, Production and culture, Harvest and storage, Insects, Diseases, Bird damage, Breeding and genetics, Cytology and hybridization, Planting, seed production, Production costs and marketing, Processing and uses of oil sunflower, Processing and uses of nonoil-type sunflower, and Future as an economic crop.)

Croissant, R.L. and R.H. Follett. 1991. Sunflower Production in Colorado. Colorado State University Service in Action .102, 4 pages.

Hein, G.L., R.J. Wright, F.P. Baxendale, S.D. Danielson, J.F. Witkowski, J.B. Campbell, K.J. Jarvi, R.C. Seymour, and J.A. Kalisch. 1992. Insect Management Guide for Nebraska Sugarbeets, Dry Beans, Sunflowers, Vetch, Potatoes, and Onions. Nebraska Cooperative Extension Publication EC 92-1537-D.

Heiser, C.B., Jr. 1976. The Sunflower. Univ. of Oklahoma Press, Norman, OK 73069, for $10.95. (This 200-page book, authored by a botanist and written in layman's language, covers historical development, the distribution, and interrelationships of sunflower species. It describes sunflower as an international commercial crop, ornamental, and weed.)

Jarvi, K. and J. Witkowski. 1980. Sunflower insect pests. University of Nebraska NebGuide G80-498, 4 pp.

Kolte, S.J. 1985. Diseases of Annual Edible Oilseed Crops. pp. 9-96, in Vol. III: Sunflower, Safflower and Nigerseed Diseases. CRC Press Inc., 2000 Corporate Blvd., Boca Raton, FL 33431.

Martens, J.W., W.L. Seaman and T.G. Atkinson. 1984. Diseases of Field Crops in Canada. 1984. pp. 125-128. The Canadian Phytopathological Society, P. O. Box 437, Harrow, Ontario, Canada NOR 1GO.

Martin, A., R. Stougaard, F. Roeth, R. Moomaw, R. Wilsen, G. Wicks, R. Klein, and D. Lyon. 1993. Guide for Herbicide Use in Nebraska. University of Nebraska Bulletin EC 93-130-D.

McBride, D.K., D.D. Kopp, and C.Y. Oseto. 1985. Insect pest management for sunflower. North Dakota State University Extension Bulletin 28. 24 pp.

McMullen, M.P. 1985. Sunflower production and pest management. North Dakota State University Extension Bulletin 25. (currently in revision, available spring 1993)

National Sunflower Association. 1992-1993 Sunflower Directory. National Sunflower Association. 4023 State Street, Bismark, ND 58501, $10.00. (Lists over 150 companies, trade organizations, government agencies, and universities that have a unique function in the sunflower industry. Individual experts in sunflower also are listed.)

National Sunflower Association. The Sunflower. National Sunflower Association. 4023 State Street, Bismark, ND 58501. (The Sunflower magazine is published 6 times a year by the National Sunflower Association. It is intended for growers, merchandisers, processors, hybrid seed companies, researchers, and other legitimate interests in the sunflower industry.)

Nelson, B. and H.A. Lamey. 1984. Sclerotinia Diseases of Sunflower. 1984. North Dakota State University Cooperative Extension Bulletin PP-840, 8 pages.

Nyvall, R.F. 1989. Diseases of Sunflower (Helianthus annuus L.). pp. 639-659, in Field Crop Diseases Handbook, 2nd edition. AVI Publishing Co. Inc., New York.

Peairs, F.B., K.G. Beck, W.M. Brown, Jr., H.F. Schwartz, M.J. VanGessel, and P. Westra. 1993. 1993 Colorado Pesticide Guide - Field Crops. Colorado State University Cooperative Extension Bulletin XCM 45.

Schwartz, H.F. 1986. Sunflower Diseases. Colorado State University Service in Action 2.944, 4 pages.

Spackman, E. 1990. Control of Field Crop Insects. University of Wyoming Cooperative Extension Service Publication B-543R.

Whitsen, T., S. Dewey, and P. Fay. 1993. Montana, Utah and Wyoming Weed Control Handbook. Montana State University Bulletin EB-0023, Utah State University Bulletin EC301, and University of Wyoming Bulletin B-442.

APPENDIX 3: SUNFLOWER GROWTH STAGES[1]

CODE	DESCRIPTION
	VEGETATIVE EMERGENCE
VE	Seedling has emerged and the first leaf beyond the cotyledons is less than 1.5" (4 cm) long
	VEGETATIVE STAGES
V1 V2 V3 etc.	These are determined by counting the number of true leaves at least 1.5" (4 cm) in length, beginning as V1, V2, V3 etc. That is, a plant with two true leaves longer than 1.5" would be at the V2 stage. If lower true leaves have senesced, be sure to count leaf scars to get a correct count. Do not count scars where the cotyledons were attached.
	REPRODUCTIVE STAGES
R1	The terminal bud forms a miniature floral head rather than a cluster of leaves. When viewed from directly above, the immature bracts form a many-pointed star-like appearance.
R2	The immature bud elongates 1/5 to 4/5 inches (0.5 to 2.0 cm) above the nearest leaf attached to the stem. Disregard leaves attached directly to the back of the bud.
R3	The immature bud elongates more than 4/5 inch (2.0 cm) above the nearest leaf.
R4	The inflorescence begins to open. When viewed from directly above, immature ray flowers are visible
R5 (R5.1, R5.2, R5.3, etc.)	This stage is the beginning of flowering. The stage can be divided into substages, depending on the percent of the head area (disk flowers) that is flowering or has completed flowering. For example, in R5.3 30% of the head area is flowering or has completed flowering. In R5.8 80% of the head area is flowering or has completed flowering.
R6	Flowering is complete and the ray flowers are wilting.
R7	The back of the head has started to turn a pale yellow color.
R8	The back of the head is yellow, but the bracts remain green.
R9	The bracts become yellow and brown. This stage is regarded as physiological maturity.

[1]Drawings and descriptions from taken from McBride, D.K., D.D. Kopp, and C.Y. Oseto. 1985. Insect pest management for sunflower. North Dakota State University Extension Bulletin 28. 24 pp.

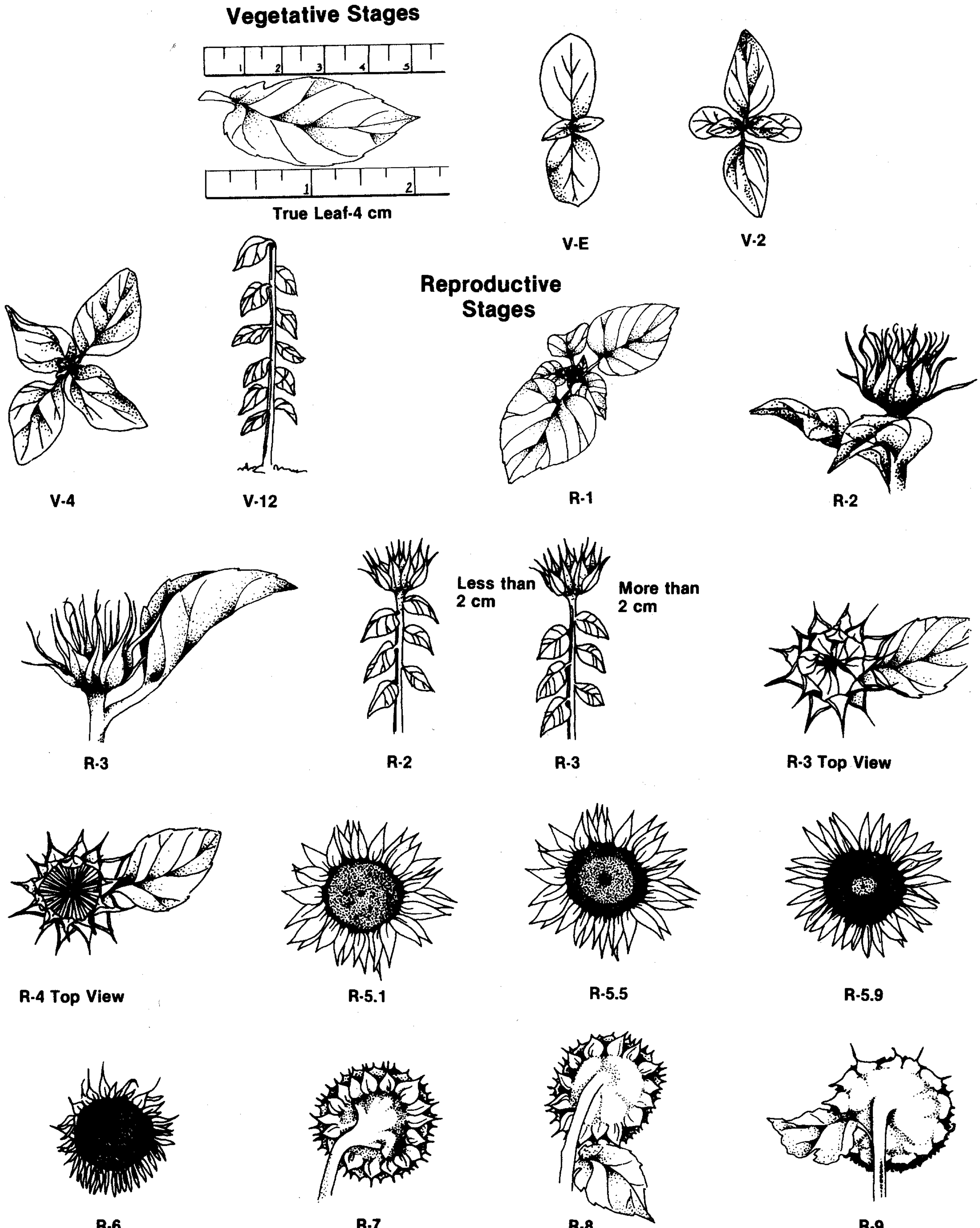
Vegetative Stages
True Leaf-4 cm
V-E
V-2
V-4
V-12
Reproductive Stages
R-1
R-2
R-3
Less than 2 cm
More than 2 cm
R-2
R-3
R-3 Top View
R-4 Top View
R-5.1
R-5.5
R-5.9
R-6
R-7
R-8
R-9

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PHOTO CREDITS

J.S. Baumer, University of Minnesota (23*, 26*, 32*)
G.N. Fick, Sigo Research (24*, 25*, 30*)
T. Gulya, Jr., North Dakota State University (22*)
Boris C. Kondratieff, Colorado State University (13, 17)
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