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ORIGIN AND HISTORY OF SUNFLOWER

Sunflower is native to North America and can be found growing wild from the northern part of the Canadian prairies to Mexico and farther south into Latin America. The sunflower belongs to the genus *Helianthus*, in which there are 67 species. The annual species *H. annuus* L. is known to North Americans as the cultivated oilseed and confectionary types, as the wild sunflower (Fig. 1), and as the state flower of Kansas. The wild form crosses readily with the cultivated types and is a source of pollen contamination in pedigreed sunflower seed production. Another annual species, *H. petiolaris* L. (Fig. 2), occurs commonly in the sunflower-producing areas of Canada and the USA. It does not cross easily with the cultivated sunflower and is not a problem in seed production.

Seed of the wild sunflower was used by the North American Indians in dyes, food preparations, and medicines. There is evidence that they also used the present cultivated type with a large head and single stem. The early European explorers, who found this type unusual and appealing, introduced it as an ornamental plant to Europe in the sixteenth century. Late in the nineteenth century sunflower became established as an edible oil crop in Russia. In 1930 sunflower ranked 10th as a world source of vegetable oil, and by 1970 it was second only to soybean (Table 1). Two-thirds of this production was in Russia.

Cultivated sunflower was reintroduced to North America with the immigration of the Mennonites and other Eastern Europeans about 1875. Commercial production of sunflower in Canada began during World War II on 1600 ha (4000 ac) in Saskatchewan and Manitoba in an effort to develop domestic sources of vegetable oil. In 1946 an oil extraction plant was constructed at Altona, Man., which assured a market outlet for locally produced seed.

Canadian production peaked in 1971 with the decline in cereal prices and low delivery quotas. In need of a cash crop, dryland growers in Saskatchewan and Alberta contracted 32 000 ha (80 000 ac) of sunflower. Plantings in southern Manitoba increased to 55 000 ha (135 000 ac). However, as delivery quotas and prices for cereals improved, plantings declined to 10 000 ha (25 000 ac) in 1974.

The recent discovery of a fertility restorer system in sunflower for cytoplasmic male sterility has made hybrid seed production commercially viable in North America. The first oilseed hybrid based on this system of seed production was licensed in Canada in 1978. The development of high-yielding hybrids, new herbicides, and planters for the precise placement of fertilizer and seed have given the growers opportunities to produce yields 30–50% higher than those obtainable in the 1960s. In 1978 sunflower plantings in North America set new records when 1.4 million ha (3.4 million ac) were planted to oilseed and confectionery types.

CHARACTERISTICS OF SUNFLOWER SEED, OIL, AND MEAL

Interest in sunflower as an oil crop in North America increased in the 1960s when cultivars of high oil content became available from the USSR. Most cultivars grown in Canada are produced for oilseed. Cultivars with larger seed but a lower oil content, commonly termed confectionery type, are grown on a limited area for the snack and birdseed markets.

The seed of oilseed cultivars is substantially smaller in size and higher in test weight than that of the confectionery cultivars (Fig. 3, Table 2). Therefore it is more economical to transport than confectionery seed. Premiums are often paid for oilseed sunflower with an oil content of over 44% (dry basis). In confectionery seed, large size and a prominent white stripe are the important quality characteristics that determine the value. Surplus confectionery seed enters into oilseed channels and is crushed.

The valuable components of oilseed sunflower are the edible oil and the protein of the kernel contained inside the hull. Sunflower oil is a premium salad oil with a very light color and a bland flavor. A high smoke point makes sunflower oil useful as a cooking oil. Of all the vegetable oils produced in North America, only safflower oil exceeds Canadian sunflower oil in the content of the desirable polyunsaturated fatty acid, linoleic acid (Table 3). The oil from sunflower seed produced in Canada contains more linoleic acid than oil from seed produced in the southern United States. The cooler climate in Canada, particularly during seed development, favors the synthesis of linoleic acid in sunflower seed.

In the commercial processing of sunflower seed for oil, the removal of the hulls before oil extraction is highly desired to maximize the crushing capacity. The protein content of meal from dehulled sunflower seed can equal that of soybean meal under optimal dehulling conditions.

Seed of the oilseed cultivars is much more difficult to dehull than confectionery seed. Within the oilseed type, cultivars differ in their ease of dehulling. Those with small seed are generally more difficult to dehull than the cultivars with large seed and can present problems in dehulling.

HYBRID SEED PRODUCTION

Hybrid sunflower composed the main part of the farm plantings in Canada until the arrival of the cultivars of higher oil content from the USSR. The seed of the hybrid Advance, an early release from the

Research Station at Saskatoon, and the successive rust-resistant forms Advent and Admiral from the Research Station at Morden often did not contain a high percentage of actual hybrid seed. This prevented the growers from realizing the full yield potential of the hybrid combination of the parental lines used. It is only with the recent discovery of cytoplasmic male sterility that F_1 hybrid planting seed can be produced with a high percentage of actual hybrids at a reasonable cost. A sunflower patch containing the male-sterile cytoplasm and not possessing fertility restoring genes fails to produce pollen (Fig. 4). To produce viable seed, florets of the male-sterile plant must receive pollen from a pollen donor such as a second inbred line that sheds pollen.

For commercial hybrid seed production based on a fertility restorer system for plants with cytoplasmic male sterility, three different lines are required. Two lines are required to maintain and increase the female parent of the hybrid. One line (A) does not produce pollen and is always used as a female in a crossing block. To increase this female line, a maintainer line (B) that is identical with the sterile female but produces pollen is planted alternately with the A line. Pollen must be transferred from the B to the A line by insects to produce seed. Seeds of the A and B lines are harvested separately and each continues to breed true to its character in the next generation; A remains sterile and B produces pollen.

The third line is a fertility restorer line (R), which is always used as the male parent in a crossing block. It produces pollen and restores the pollen production in hybrid plants of the cross A $\times$ R. To maintain the purity of the hybrid seed and the inbred parents, all crossing blocks and plantings for the increase of the parents must be isolated and free from contaminating pollen. The sources of this pollen include plantings of other hybrids for both pedigree seed and commercial seed production as well as the wild sunflower, *H. annuus*.

To produce commercial hybrid planting seed, the A line is planted alternately with the R line in a crossing block (Fig. 5). The ratio of A to R plants can be from 2:1 to 6:1 depending on the pollen production of the R line. The A plants that yield the F_1 hybrid seed are harvested separately; the R line can be harvested and the seed can be used in another crossing block.

Schematically, hybrid seed production is represented in Fig. 6.

LICENSED OILSEED AND CONFECTIONERY VARIETIES

The agronomic characteristics of the licensed open-pollinated varieties are given in Table 4. The reporting of average performances for these varieties can mask variations that may occur from region to region. In the short-season areas early varieties tend to perform more consistently than late-maturing varieties.

SATURN descended from an introduction from the USSR by the Research Station at Morden and was licensed in 1977. It exceeds Krasnodarets in yield and oil content and matures 2 days earlier.

CORONA descended from a USSR introduction and was developed at the research stations at Saskatoon and Morden and was licensed in 1978. This dwarf variety is 30 cm shorter than Krasnodarets. It flowers 3–7 days earlier than Krasnodarets and matures 1 day earlier. Corona performs well in the drier parts of the prairies.

PEREDOVIK was introduced from the USSR. Because it matures later than Krasnodarets, it usually exceeds the early varieties in yield under optimal growing conditions.

COMMANDER is a confectionery variety, which was developed at the Research Station at Morden and was licensed in 1964. It is similar to Peredovik in maturity but is susceptible to rust and verticillium wilt.

SUNDAK is a confectionery variety, which was developed at the USDA Experiment Station, Fargo, North Dakota, and was licensed in 1976. Sundak is a rust-resistant selection from Commander. It has high yield potential and produces a high percentage of large seed.

Breeding programs are being carried out at the research stations at Morden and Saskatoon. In the United States extensive breeding programs are funded by public and private agencies. Because of the short season of the southern Canadian prairies, Canadian breeding programs give more attention to early maturity than do the American programs. In general, varieties from Canada are earlier than American varieties. Present data indicate that new hybrids from Canadian programs will be released soon. Before making decisions about varieties, consult the local agricultural representative, county agent, or the nearest Agriculture Canada Research Station for the most up-to-date information.

CHOICE OF LAND AND ROTATIONS

Areas of adaptation

Formerly sunflower production in Canada was centered in a few municipalities in the Red River valley of southern Manitoba where the climate and soils favored the crop. In recent years production in Manitoba has been expanding westward in the area south of Brandon and now there is significant production in over 20 municipalities. The length of the growing season is the primary consideration in identifying production areas because the crop may require approximately 120 days to mature.

Most of the farm-scale trials conducted in southern Alberta and Saskatchewan in 1975–77 showed that oilseed sunflower can be grown over a much wider area than has been recognized. In these trials

sunflower yields were 61–79% of spring wheat on Dark Brown soils (Table 5). However, on Brown soils in Saskatchewan north of Swift Current sunflower yielded less than 50% of wheat and the oil content fell below the desirable level of 44% (dry basis). Oilseed sunflower yielding 65% of wheat would provide a greater cash return than wheat if the farm-gate price for sunflower seed was 150% of wheat.

In Manitoba sunflower is usually grown on stubble land and is used to extend the crop rotation. In the newer areas being identified for the crop in Manitoba and Saskatchewan, the sunflower is often grown on summerfallow because good stands are established more easily on summerfallow with the grain drills used for seeding.

Yields of crops grown after sunflower are encouraging. Recent farm experience in southeast Saskatchewan on Dark Brown and Black soils has suggested that yields of wheat grown on sunflower stubble can equal or exceed those of wheat grown on wheat stubble. However, on Brown soils precipitation after the sunflower crop can be insufficient to replenish soil moisture reserves and to facilitate the complete breakdown of the selective herbicides used.

After a sunflower crop, it is desirable to grow a cereal crop in preference to another oilseed or grain legume so that volunteer sunflowers can be eliminated with a selective herbicide. Extending the rotation between sunflower and other oilseed and grain legume crops is also desirable to minimize the buildup of diseases common to these crops.

Row crop planting

Sunflower has been viewed as a row crop that requires specialized equipment. In the main sunflower-growing areas of the Red River valley row-crop sunflower fits well into production practices used for other crops such as corn and sugarbeets. With row-crop planters, variables such as plant population, row spacing, and seeding depth can be controlled precisely. The effective placement of fertilizers, particularly phosphate, can be optimized with the equipment for banding installed on many planters. Prior to the registration of selective herbicides to control grassy weeds and volunteer grain, interrow tillage was essential to obtain vigorous sunflower stands.

Solid seeding

Solid seeding or seeding of sunflower with a standard grain drill has become more common in recent years. For a grower undertaking sunflower production on a limited scale, this practice reduces the investment in specialized equipment. To maximize from solid seeding, care must be taken to obtain an even distribution of seeds. A uniform

stand and even emergence can be obtained with proper control of the seeding depth and the packing of the soil after seeding. Grain drills used to seed cereals are usually not fitted with band fertilizer attachments. Unless such attachments are available, do not use fertilizer settings above 50 kg/ha (44 lb/ac) at a 23 cm (9 in.) fertilizer row spacing. Germination can be reduced if the fertilizer comes into direct contact with the seed.

SEED AND SEEDING PRACTICES

Seed treatment

Treating sunflower seed with a fungicide may be considered where seeding is done very early when the soil is still cold and germination is delayed. Where wireworms are a problem, use an insecticide-fungicide seed treatment.

When to seed

Seed sunflower early, preferably before wheat. The plant has good frost tolerance up to the four-leaf stage. Seeding the cultivars of the maturity range of Corona, Krasnodarets, or Saturn after May 25, or of the maturity of Peredovik after May 15 will increase the risk of damage by early fall frosts, which will reduce yields and seed quality. Seeding in June is not recommended in any province, but particularly in Saskatchewan and Alberta.

Seeding depth

Sunflower seed has a thick hull and needs good seedbed moisture to germinate. The seed will emerge from as deep as 12 cm. The key to good germination is to seed into moisture. If moisture conditions are adequate, a shallow seeding of 3–5 cm will allow more rapid emergence than deeper seeding. Packers can be used to seal the soil surface and reduce moisture loss through evaporation.

Plant populations and row spacings

Sunflower compensates for differences in plant populations by producing larger seeds and heads at lower populations. Yields are relatively constant through a wide range of populations from 40 000 to 85 000 plants/ha (16 000 to 35 000 plants/ac). Row spacings of 30–90

cm have little effect on seed yield. There is no evidence that high populations are best for high rainfall areas and low populations for arid areas on sandy soil as with corn.

Recommended plant populations are different for oilseed and confectionery types because the standards of seed quality differ. For oilseed cultivars the recommended plant population is 40 000–75 000 plants/ha (16 000–30 000 plants/ac). Because large seed size is more important than oil content or test weight in confectionery cultivars, a low population of 37 000–44 000 plants/ha (15 000–18 000 plants/ac) is recommended. The seed spacings for various plant populations are given in Table 6.

In addition to changes in seed size, plant populations affect other important plant characteristics. High populations encourage small heads, which remain upright and dry faster than large heads. Planting at low populations to reduce seed costs results in larger plants, which take longer to dry. As a result, harvesting can be delayed. However, planting at populations above 85 000 plants/ha (35 000 plants/ac) may result in an increase in lodging and plant height so that seed losses due to shattering and stem breakage become significant. The dwarf cultivar, Corona, is well suited to planting at 75 000 plants/ha (30 000 plants/ac) because of its short height and strong stem.

Seeding rate and equipment

Because sunflower seed varies considerably in size, it is recommended that the seeding rate be set in seeds per hectare rather than kilograms. The number of seeds per kilogram or in a bag is usually supplied by the seed company. Seed cost may be reduced by using smaller seed grades of the desired variety. Crops produced from large, medium, or small seed have not differed in yield or seed quality characteristics. Use seeding rates of up to 12 000 seeds/ha (5000 seeds/ac) higher than the desired population at flowering time. The higher seeding rate allows for variable germination and emergence rates and harrowing losses after emergence.

Planting plates are usually supplied by seed companies with hybrid seed. These plates are designed to produce the desirable population with a certain seed size, when used with a row-crop planter.

Present grain drills employ three main types of seed metering mechanisms: the fluted seed cup with adjustable gates, the internal double-run seed cup, or the external feed wheels in the seed cup. Machines with the fluted seed cup tend to bunch the delivered seed at the slow feed-shaft speeds and seed breakage of 2–5% can occur with the adjustable gates in the top position. Machines with the internal double-run seed cup space seeds more uniformly with little breakage. On all implements block off every second or every second and third run to provide for proper plant spacings. Some machines require speed

reduction kits between the drive wheel and the feed shaft to obtain low enough seeding rates.

Calibrate the seeding implement as soon as the planting seed arrives in the spring. One method of adjusting a grain drill to solid seed sunflower is as follows:

Determine the row width of the drill or disc. For a disc, measure the width of the cut of the disc in the field and not the total length along the blades. Divide the width of the cut by the number of rows used to seed sunflower.

Use masking tape to block the alternate seed runs or two of each three runs.

Tie small plastic bags or some other containers on the five seed spouts to be used.

After consulting Table 7, drive the grain drill the distance required to cover 1/1000 of an acre per seed run at the appropriate row width.

An alternative to driving the required distance is to raise the wheel that operates the seed drive, measure the circumference of the wheel (metres) and divide the length of row (metres) corresponding to the row width by the circumference of the wheel. The resulting answer gives the number of rotations the seed drive has to be turned by hand to cover the required distance.

Count the number of seeds fallen from each spout and calculate the average number of seeds delivered per spout.

Multiply the average seeds per spout by 1000 to give the seeds per acre; to calculate the seeds per hectare multiply by 2.47.

Adjust the metering mechanisms until the desired seeding rate is obtained.

FERTILIZER PRACTICES

The fertilizer nutrients most likely to be required for sunflower are nitrogen and phosphorus and occasionally potassium on light textured soils. Apply all fertilizers on the basis of a soil test. Where soil test data are not available, the following general guidelines will assist in maximizing fertilizer efficiency.

Sunflower seed is sensitive to fertilizer. Reduced or delayed emergence and poor stands may result when fertilizer is placed near the seed under certain conditions. Sunflower responds well to both nitrogen and phosphorus when properly applied under favorable growing conditions.

Where soil-available nitrogen (N) levels are low, which is usually on stubble or sandy soils, fertilizer at up to 100 kg/ha (90 lb/ac) may be required. An average application rate of N is 33–67 kg/ha (30–60 lb/ac). Under irrigation N at up to 110–135 kg/ha (100–120 lb/ac) may be required.

Band nitrogen fertilizers about 4–5 cm (2 in.) to the side of the seed or broadcast and incorporate it before seeding. Banding is preferred to a broadcast application because only the sunflower row is fertilized; weeds do not benefit as much as from broadcasting.

Soils that are very low in phosphorus may require phosphate fertilizer (P_2O_5) at up to 45 kg/ha (40 lb/ac). An average requirement of P_2O_5 is 17–28 kg/ha (15–25 lb/ac). Studies have demonstrated that a band application of P_2O_5, 2.5 cm (1 in.) below and 2.5 cm (1 in.) to the side of the seed, is preferred to the placement of the fertilizer with the seed (Table 8). Seed yields and oil contents were substantially higher with band placement in 5 years of trials at Scott, Sask. A band application has consistently hastened flowering and maturity by several days.

If banding is not possible, place P_2O_5 at no more than 22 kg/ha (20 lb/ac) with the seed in the row. This rate is based on fertilizer row spacings of 23 cm (9 in.). For wider row spacings reduce the rate of P_2O_5 with seed placement proportionately with the increase in row width to limit the fertilizer in the row to the same concentration. For 76 cm (30 in.) row spacings, the P_2O_5 required would be about 6–11 kg/ha (5–10 lb/ac).

CHEMICAL AND CULTURAL WEED CONTROL

Chemical weed control

Success in growing sunflower depends greatly on establishing a clean, uniform stand of plants. Procedures for establishing a clean seedbed may be started in the fall prior to freeze-up by applying and incorporating herbicides. Several herbicides are registered for preplant application and incorporation in the fall or spring to control certain grassy and broad-leaved weeds in sunflower. Under conditions in Western Canada, incorporation 8–10 cm deep in the spring tends to dry the soil and may result in poor sunflower germination. With a fall application only a shallow tillage is required in the spring before seeding.

On soils that are prone to erosion, an application of preplant herbicides may be preferable in the spring. When herbicides are applied and incorporated in the spring, good packing is necessary to reduce moisture loss and to establish a firm seedbed to assure germination and emergence.

Crop residues can present some problems when sunflower is to be grown on stubble. If preplant herbicides are to be considered, work the trash well into the soil before application and also work the herbicide well into the soil for effective weed control. This means extra tillage operations and good packing to minimize moisture loss. In many

instances trash reduces the effectiveness of a soil-applied herbicide. Granular forms of herbicides may be more effective when applied on soils with stubble and trash.

Because the practices in the use of herbicides change rapidly, no recommendations are given here. Consult your agricultural representative or district agriculturist for the most recent information.

Sunflower is extremely susceptible to damage by 2, 4-D or MCPA herbicides. It is especially hazardous to use the more volatile ester formulations of 2, 4-D and MCPA near sunflower fields. The amine and sodium salt formulations do not produce vapor and can be used near sunflower with precautions to minimize droplet drift. Spray cereal crops adjacent to sunflower fields only when there is a definite breeze blowing away from the sunflower.

Sunflower is very susceptible to atrazine residues from previous corn crops. The length of time that atrazine remains in the soil depends on soil conditions and weather. Damage to sunflower has occurred in fields where atrazine has not been used for 3 years.

Cultural weed control practices

When extensive weed growth is present before seeding a preplant cultivation can be very effective, particularly to control wild oats. If a disc-type implement is used, pack or harrow the field immediately to seal the soil surface and minimize moisture loss.

Often weeds emerge before the sunflower seedlings. This will permit harrowing once while the weeds are very small and easy to uproot. Do not harrow as the seedlings emerge through the soil surface. Harrowing may commence again when the seedlings have reached the two– to six–leaf stage. Harrowing is best done during the heat of the day when the sunflower seedlings are flexible and the weeds are most easily killed (Fig. 7). Each harrowing can reduce a solid-seeded field by 7400–12 000 plants/ha (3000–5000 plants/ac). When calculating seeding rates assume some loss in plant populations if harrowing is contemplated.

HARVESTING

Sunflower matures in mid-September when the back of the head turns yellow and the bracts around the head turn brown. At this stage the seed moisture content is about 50%, but harvesting is usually delayed until the seed has dried to less than 12% moisture. Sunflower can be threshed cleanly at a seed moisture content of 20%. This allows early harvesting, which reduces shattering and bird losses. However, artificial drying of the seed will be necessary to reduce the seed

moisture content to 10%. Leaving a crop to field dry to less than 8% seed moisture may result in extensive dehulling and large amounts of trash.

Sunflower is harvested with a grain combine fitted with a sunflower header attachment. Attachments are available commercially and have been made in local machine shops. One such attachment consists of a reel and shield that is designed to remove the heads from the sunflower stalk (Fig. 8). Long pans extend in front of the cutter bar to collect seed that shatters from the head during the cutting operation. Another type of attachment is the rotating drum (Fig. 9). Although not as efficient as the reel and shield type, it is easier to make and is much more popular in Canada.

Sunflower seed threshes easily. Reduce the cylinder speed to 200–400 rpm or less. Excessive cylinder speed causes considerable dehulling of seed, and the chaffer, sieve, and tailings return may become overloaded with small pieces of head material. Depending on weather conditions, set the concaves half to fully open.

DISEASES

Sclerotinia diseases (wilt and head rot), verticillium wilt, rust, downy mildew, and head rots caused by species of *Botrytis* and *Rhizopus* are important diseases of sunflower in Canada. The fungi that cause these diseases occur on diseased roots, stalks, and leaves that overwinter in the soil.

Sclerotinia sclerotiorum (Lib.) de Bary overwinters in the form of black, hard mycelial bodies, or sclerotia. Wilt results when roots are infected by mycelium from germinating sclerotia. Roots may become infected throughout the growing season. Typically diseased plants wilt suddenly and show a wet, brown or white, small or large lesion at the stem base, and sclerotia develop inside and outside the stems and roots (Fig. 10). The disease spreads from plant to plant by root contact. Sclerotinia head rot occurs in seasons of high rainfall at flowering and seed set. Sclerotia near the soil surface germinate to produce mushroomlike bodies, or apothecia. These release airborne ascospores that infect the heads and also the stalks. To control sclerotinia diseases, do not overseed and space the plants as widely and uniformly as possible. Use seed that is free from sclerotia. Crops such as beans, mustard, peas, and rapeseed, and many broad-leaved weeds are hosts of the sclerotinia pathogen. Avoid host crops, control weeds, and alternate sunflower with cereals, corn, grasses, and fallow. Do not grow sunflower on the same land more than once every 5 years and if possible make the period longer. There are no sclerotinia-resistant cultivars.

Wilt incited by *Verticillium dahliae* Kleb. is characterized by interveinal mottling of the leaves. Affected areas yellow and turn brown. Symptoms appear near flowering time and develop first on the lower

leaves and gradually on leaves higher along the stems (Fig. 11). Black masses of overwintering bodies (microsclerotia) are evident on sectioning the tap root, and the water-conducting tissue at the outer edge of the stem is discolored brown. A crop rotation as described previously and that avoids potatoes partially controls the disease. Open-pollinated cultivars are moderately susceptible, but most hybrid cultivars have good resistance.

In earlier years rust caused by *Puccinia helianthi* Schw. resulted in severe losses of sunflower production in Manitoba. The pathogen forms masses of chocolate brown, powdery pustules on leaves and other plant parts (Fig. 12). When severe, leaves wither and plants are defoliated. Open-pollinated oilseed cultivars are fairly tolerant. The confectionery cultivar Commander is susceptible, whereas Sundak is resistant. Oilseed hybrid cultivars may be tolerant or highly resistant to rust.

Downy mildew is caused by *Plasmopara halstedii* (Farl.) Berl. & deToni, which persists for many years in the soil. The fungus is also borne by seeds and has been disseminated into new production areas. Plants infected early through roots show systemic symptoms of stunt and leaf discoloration; they have an erect, stiff habit (Fig. 13). Wet soils promote root infection, but plants are susceptible only during the seedling stage. Under moist conditions discolored leaf areas produce airborne spores, which cause angular leaf spot. Because open-pollinated cultivars are susceptible, avoid infested wet soils. Most hybrid cultivars are resistant to downy mildew.

Head rot caused by *Botrytis cinerea* Pers. may reduce yield, especially when harvesting is delayed by wet weather. Lesions that occur at the back of the head are brown and become gray when the fungus is sporulating. Rhizopus rot occurs in heads that have been damaged mechanically, e.g., by birds, hail, or insects. Woolly masses of white mycelium interspersed with numerous, black, spherical sporangia may be externally evident and are conspicuous inside the fleshy part of the infected head.

For other diseases and more details consult *Diseases of Field Crops in the Prairie Provinces*, Agriculture Canada Publication 1008. It is available from the Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec, K1A 0S9.

INSECTS

Wireworms, cutworms, beet webworms, and grasshoppers attack sunflower as well as other crops. Because specific control measures change rapidly, consult your agricultural representative or district agriculturist for the latest information. Sunflower is extremely susceptible to 2,4-D or similar herbicides. Thoroughly clean sprayers that have

been used for the application of herbicides before using them to apply insecticides on sunflower.

The larvae of a number of insects attack sunflower heads. The larvae of the sunflower moth, also called the sunflower head moth, *Homoeosoma electellum* (Hulst) (Fig. 14), are striped and those of the banded sunflower moth, *Phalonia hospes* (Walsingham) (Fig. 15), are of one color. However, the basic color of the larvae of the latter species changes from white to cream to red and finally to green during development. Larvae of both species feed on pollen and florets of the young blooms and damage seeds in the older heads. The sunflower moth (Fig. 16) does not overwinter in Canada, but the adults fly or are blown north during late June or early July from infested fields farther south. If the moths arrive when, or just before, the local crop is in bloom, the growers may have to use insecticide applications. However, crops that do not bloom until at least 2 weeks after the last moth arrives will not be seriously damaged by this species. Pheromone-type traps that monitor the time and numbers of moths arriving each year have been developed at Saskatoon. Growers interested in obtaining a few traps to determine when the moths arrive in their area should contact Dr. Alfred P. Arthur, Research Station, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask., S7N 0X2. This species caused serious damage to a few fields in southeastern Saskatchewan in recent years.

The banded sunflower moth is a northern species, which overwinters as a larva within a silk covering in the soil. This species has not required control measures on the Canadian prairies in recent years.

A small fruitfly, *Neotephritis finalis* (Loew), was the most abundant pest of sunflower heads in Alberta during recent years. Each maggot may damage several florets in the early blooms or up to three seeds later in the season. Maggots of this pest pupate in the central part of newly opened heads and cause sap to seep from the wound. Older heads contain scattered areas of damaged seed. Head clipping by the weevil *Rhynchites (Haplorhynchites) aeneus* (Boheman) is on the increase in Manitoba and the insect may become a serious pest. Larvae of the sunflower maggot, *Strauzia longipennis* (Wiedemann), feed on the pith within the sunflower stem. They do not cause direct crop loss, but the infested plants are susceptible to wind damage.

The adults of larvae of the sunflower beetle, *Zygogramma exclamationis* (Fabricius), have caused extensive defoliation in a few fields in Manitoba. The adult (Fig. 17) resembles a potato beetle but is smaller and has a characteristic exclamation-shaped stripe near the outer edge of each wing cover. The larva (Fig. 18) is humpbacked and yellowish green in color. Adults that have overwintered may cause extensive defoliation to seedlings in the spring. The larvae feed on the upper leaves and may be found between the bracts of the buds or heads. The painted lady, *Vanessa cardui* (Linnaeus), is another migrant from the south. The large spiny larvae cause extensive defoliation to a few plants in a field, but they seldom cause economic damage.

BLACKBIRDS

Generally, damage from birds has never been serious, but blackbirds can destroy entire isolated fields that are near areas of still water bordered by a rank growth of weeds or similar nesting sites. These areas are natural breeding and roosting grounds for blackbirds. Very large flocks gather in them before migrating in the fall. Avoid planting sunflower near these areas.

Scaring devices help to control blackbirds. Acetylene or propane exploders are the most effective and will protect up to 5 ha (12 ac). Start the exploders as soon as the blackbirds begin to feed in the field and change their location frequently so that the birds do not become accustomed to them. Repellents and fright-inducing chemicals have been only moderately successful in reducing bird damage.

Additional information on blackbirds is provided in *Blackbirds and the Protection of Field Crops,* Agriculture Canada Publication 1652.

MARKETS AND CONTRACTS

Oilseed sunflower seed produced on the Canadian prairies is crushed domestically or exported to offshore markets, usually in Europe. Seed destined for the export market must usually be delivered as soon as possible after harvest so that contracting firms may market it prior to the closure of the ports for the winter season. Seed for domestic crushing is called for by the processor as required or may be accepted throughout the crop year subject to available storage.

Several companies offer contracts for oilseed and confectionery sunflower seed. Pricing, farm storage payments, premiums for oil content, and delivery options differ in the contracts offered by the various firms. Many growers exercise an option offered in some contracts of forward selling part of the anticipated production at prices established during the growing season.

Table 1. Contribution of main oilseed and tree crops to the world production of edible and industrial oils, 1973–76

Oilseed or tree crop	Annual production, % 1973	1974	1975	1976	10-year average
Soybean	27.3	30.6	27.5	30.7	25.4
Sunflower	13.1	14.7	13.2	10.8	14.5
Peanut	10.7	10.2	10.4	11.2	12.7
Cottonseed	11.4	10.3	10.8	8.4	11.0
Rapeseed	9.1	7.9	8.7	8.6	8.3
Other oilseeds[1]	4.3	3.7	3.7	3.9	4.4
Palm	9.9	10.2	11.5	11.0	9.2
Laurics	8.9	7.3	9.5	10.1	9.2
Olive	5.3	5.0	4.7	5.3	5.4
	Millions of tonnes				
Total edible	27.2	30.6	30.3	33.1	25.6
Total industrial[2]	1.3	1.5	1.3	1.4	1.5

Source: Canadian Grains Industry Statistical Handbook 77.
[1]Primarily sesame, corn, and safflower.
[2]Approximately 60% is linseed oil.

Table 2. Characteristics of sunflower seed

Cultivar	Type	% oil whole seed basis	% oil nutmeat basis	% hull whole seed basis	Seed weight mg	Test weight kg/hL
Krasnodarets	oil	43.5	60.8	28.5	78.7	39.2
Saturn	oil	46.3	62.2	25.6	67.4	39.7
Corona	oil	46.3	62.0	25.3	61.1	40.1
Sundak	conf.	31.7	59.0	46.4	104.5	33.8

Table 3. Fatty acid composition of major vegetable oils in percent

Fatty acid		Vegetable oil						
		Sunflower						
Name	Symbol	Canada	Southern USA	Safflower	Corn	Soybean	Peanut	Canola Rapeseed
Palmitic	16:0	5.9	5.9	7.2	11.5	15.0	9.2	3.2
Stearic	18:0	5.2	4.3	1.9	2.2	4.0	3.1	1.5
Oleic	18:1	15.9	46.6	12.4	26.6	24.0	57.2	60.2
Linoleic	18:2	72.5	41.6	78.5	58.7	49.0	23.4	21.3
Linolenic	18:3	trace	0.2		0.8	8.0	trace	10.9

Table 4. Main characteristics of varieties

Variety	Yield, % of Krasnodarets	Oil %	Days to flower	Days to mature	Height cm	Resistance to rust	Resistance to verticillium
Oilseed							
Krasnodarets	100	44.6	75	119	142	fair	fair
Saturn	105	45.5	74	117	147	fair to poor	poor
Corona	102	45.6	71	118	108	fair	fair
Peredovik	108	45.1	79	125	165	fair	fair
Confectionery							
Commander	104	28.9	78	125	156	poor	poor
Sundak	111	29.4	79	126	160	good	poor

Table 5. Performance of solid-seeded oilseed sunflower grown on summerfallow in Saskatchewan and Alberta, 1975–77

Location	No. farm tests	Soil*	Standing yield kg/ha	Standing yield % of wheat	Oil %
Saskatchewan					
Carnduff	4	dk.br.	1470	71	46.1
Trossachs	4	dk.br.	1550	73	45.8
Yellow Grass	4	dk.br.	1140	74	44.9
Regina	2	dk.br.	1450	61	40.7
Lemsford	3	br.	1010	47	40.8
Cabri	3	br.	890	40	39.8
Alberta					
Claresholm	3	dk.br.	1800	68	45.4
Mossleigh	3	dk.br.	1210	67	44.7
Pulteney	2	dk.br.	1250	79	47.1
Drumheller	2	dk.br.	1580	69	37.3

*dk.br. Dark Brown; br. Brown.

Table 6. Average seed spacings within the row for various plant populations assuming 90% plant survival

Plants/ha	Row spacing, cm			
	46	61	76	91
	Average seed spacing within row, cm			
40 000	49	37	30	25
45 000	44	33	26	22
49 000	40	30	24	20
59 000	33	25	20	17
69 000	28	21	17	14
Plants/ac	Row spacing, in.			
	18	24	30	36
	Average seed spacing within row, in.			
16 000	19	15	12	10
18 000	17	13	10	9
20 000	16	12	9	8
24 000	13	10	8	7
28 000	11	8	7	6

Table 7. Row length required to cover 1/1000 ac with different row widths

Row width		Length of row to cover 1/1000 ac per seed run	
in.	cm	ft	m
12	30	43.6	13.3
14	36	37.3	11.4
16	41	32.7	10.0
18	46	29.0	8.8
21	53	24.9	7.6
24	61	21.8	6.6
30	76	17.4	5.3
36	91	14.5	4.4

Table 8. Effect of placement of phosphate fertilizer on yield and oil content of sunflower grown on summerfallow on a Scott loam in Saskatchewan

Placement*	Seed yield†		Oil %†
	kg/ha	lb/ac	
With seed	890	790	31.3
Banding	1200	1070	35.3
No fertilizer	760	680	30.4

*P_2O_5 applied at four rates of 22–90 kg/ha (20–80 lb/ac) based on 23 cm (9 in.) fertilizer row spacings.
†Five-year averages, 1973–77.

Fig. 1. *Helianthus annuus* (wild sunflower).

Fig. 2. *Helianthus petiolaris*.

Fig. 3. Seeds of oilseed (*left*) and confectionery (*right*) sunflower.

Fig. 4. Male sterile sunflower.

Fig. 5. Crossing block for production of hybrid seed; strip in bloom is the restorer (R) line.

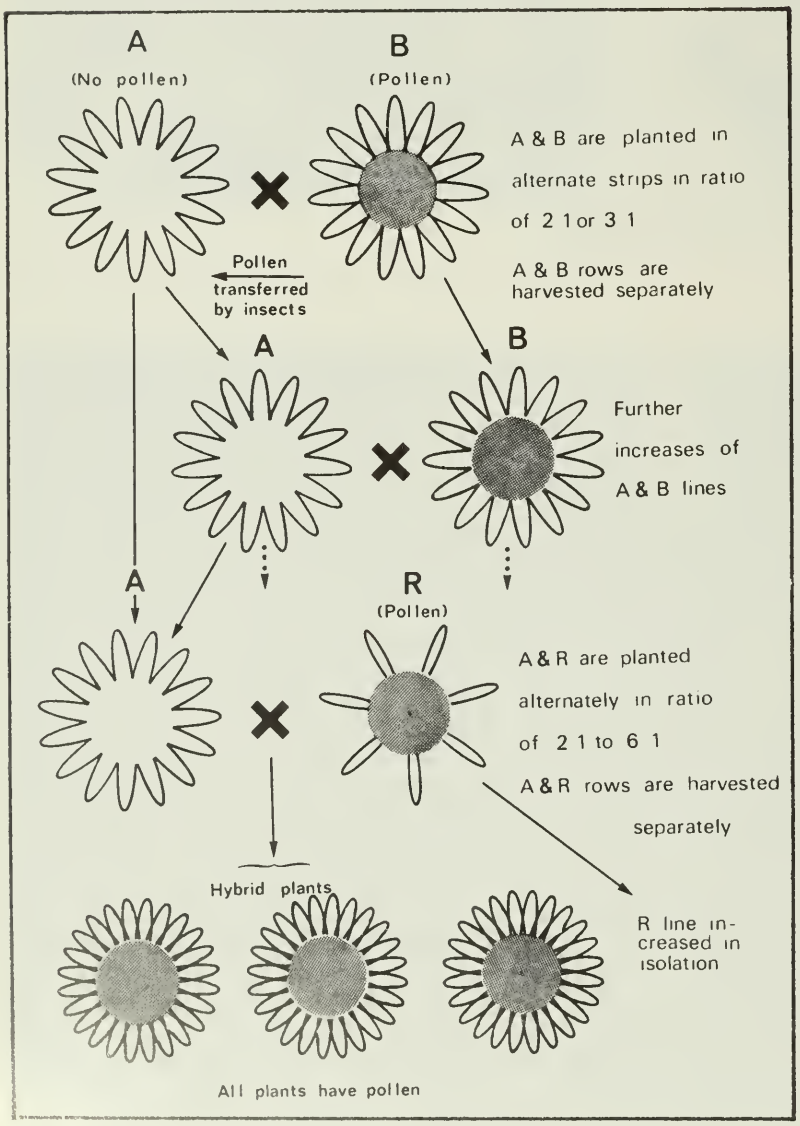

Fig. 6. Schematic diagram for hybrid seed production.

Fig. 7. Field after harrowing.

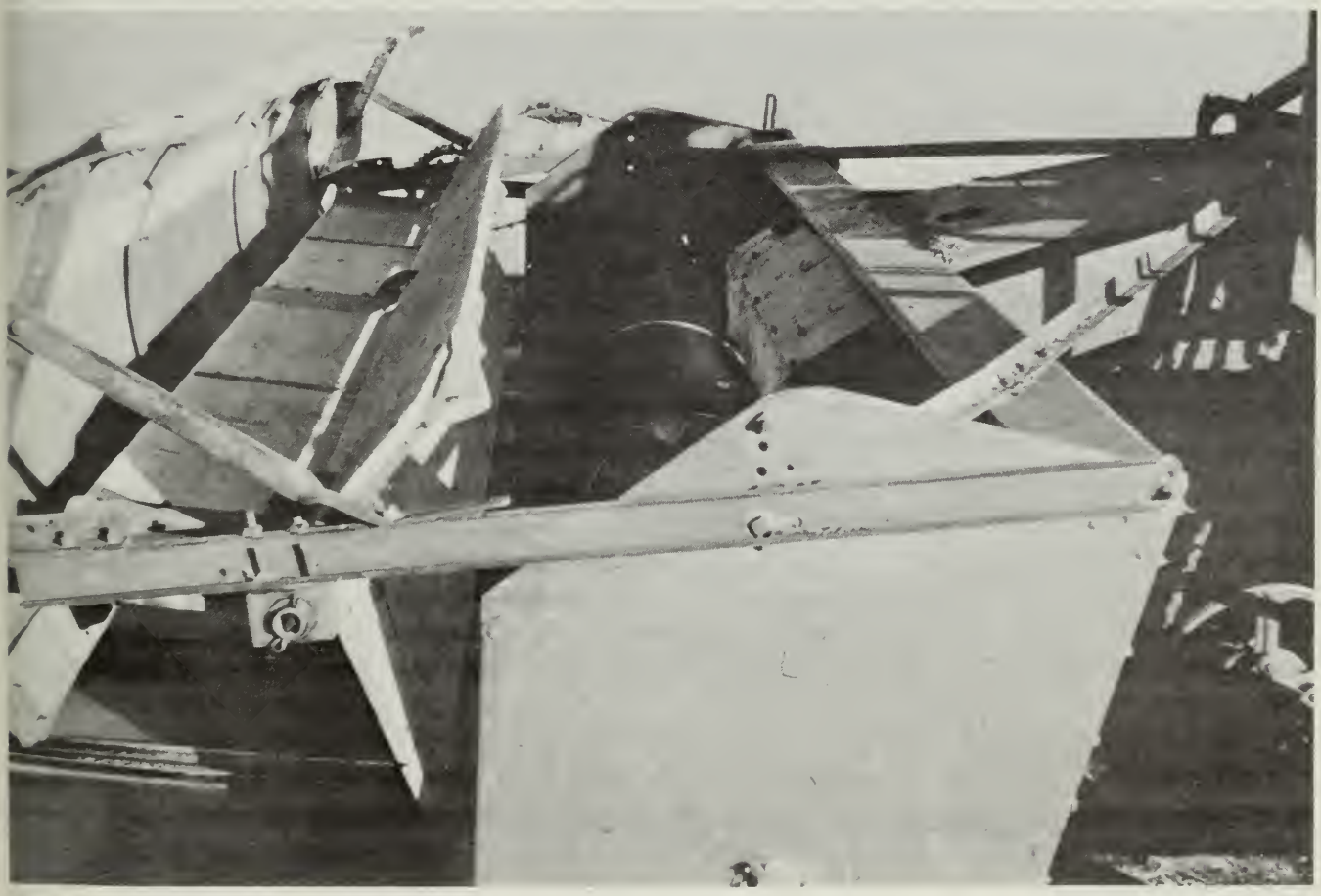

Fig. 8. Combine with reel and shield attachment.

Fig. 9. Combine with rotating drum.

Fig. 10. Sclerotinia wilt.

Fig. 11. Verticillium wilt.

Fig. 12. Sunflower rust.

Fig. 13. Downy mildew.

Fig. 14. Sunflower moth larvae.

Fig. 15. Banded sunflower moth larva.

Fig. 16. Adult sunflower moth.

Fig. 17. Adult sunflower beetle.

Fig. 18. Sunflower beetle larva.