Introduction

(Duane R. Berglund)

Two primary types of sunflower are grown: (1) oilseed for vegetable oil production and (2) nonoilseed for human food and bird-food markets (Figure 1). The oilseed hybrids may be of three fatty acid types: linoleic, mid-oleic (NuSun) or high oleic. They are usually black-seeded and have a thin hull that adheres to the kernel. Seed of the oilseed varieties contains from 38 percent to 50 percent oil and about 20 percent protein. Some black-seeded oil types go into the hulling market for birdseed. Nonoilseed sunflower also has been referred to as confectionery sunflower, and is usually white striped and/or comes in large-seeded varieties.

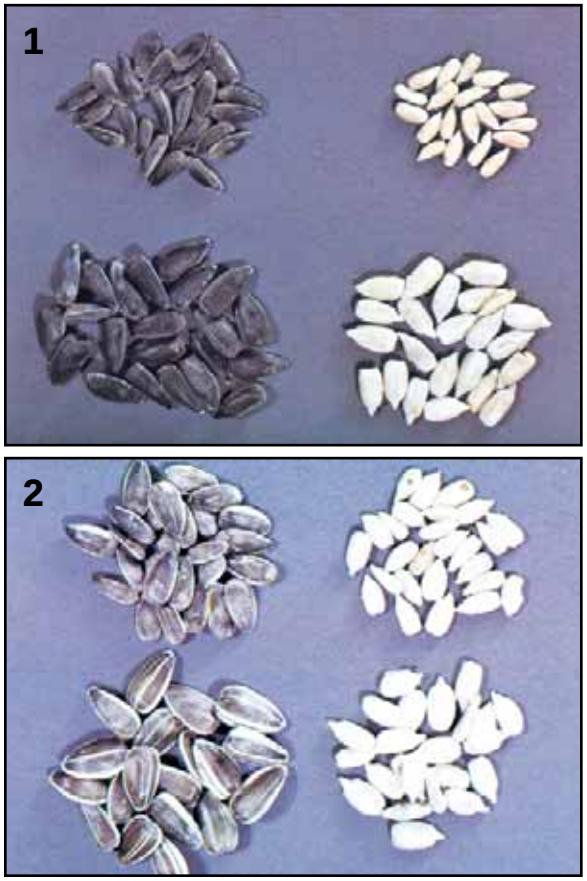


Figure 1. The two classes of sunflower based on seed characteristics: (1) oilseed hybrids grown as a source for oil and meal, and (2) nonoilseed hybrids-grown for human and bird food. Wholeseed and kernel types for both are shown. (Gerhardt Fick)

Nonoilseed sunflower generally has a relatively thick hull that remains loosely attached to the kernel, permitting more complete dehulling. Seed of the nonoilseed hybrids generally is larger than that of the oilseed types and has a lower oil percentage and test weight.

Sunflower is a major source of vegetable oil in the world. Worldwide production of sunflower has increased since the last revision of this publication and peaked during the 1998-1999 period. The former Soviet Union remains the highest producer, followed by Argentina and then the U.S., which is third in production worldwide. Domestic use and exportation of nonoilseed sunflower also have increased. The majority of U.S. production of sunflower oil is exported, although domestic use is increasing.

The following chapters provide a historical perspective and background of the sunflower as a viable economic crop and provide the current information on worldwide and U.S. production, U.S. production practices, current pest identification and pest management practices, hail injury, herbicide use and damage, harvesting, drying, storing, and U.S. grades and standards for market.

Historical Perspective

Sunflower, native to North America, is the state flower of Kansas and grows wild in many areas of the U.S. Sunflower has a long and varied history as an economic plant, but the time and place of its first cultivation is uncertain. Sunflower was used by North

American Indians before colonization of the New World. Spanish explorers collected sunflower in North America and by 1580, it was a common garden flower in Spain (Figure 2). Early English and French explorers, finding sunflower in common use by the American Indians, introduced it to their respective lands. It spread along the trade routes to Italy, Egypt, Afghanistan, India, China and Russia. Sunflower developed as a premier oilseed crop in Russia and has found wide acceptance throughout Europe. Oilseed sunflower has been an economically important crop in the U.S. since 1966. Before 1966, sunflower acreage in the U.S. was devoted primarily to nonoilseed varieties.

The center of sunflower origin has been identified as limited to the western Plains of North America, but whether the domesticated type originated in the Southwest or in the Mississippi or Missouri River valleys has not been determined. The wild form of the cultivated sunflower is well-known, which is not true with most of our cultivated crop species today.

Figure 2. A 1586 drawing of sunflower.
(Mattiolus from Heiser)

The American Indians used sunflower as a foodstuff before the cultivation of corn. Sunflower also was used as a medicinal crop, source of dye, oil for ceremonial body painting and pottery, and as a hunting calendar. When sunflower was tall and in bloom, the bison fed on it, and according to stories told, the fat and the meat were good.

Cultivation of sunflower was undertaken by New World settlers as a supplementary food. Later, sunflower was grown primarily as a garden ornament. It also was grown as an ensilage crop in the late 1800s and early 1900s.

Expanded world production of sunflower resulted primarily from development of high-oil varieties by plant scientists and more recently by the development of hybrids. Sunflower is widely grown in the world where the climates are favorable and a high quality oil is desired.

Taxonomy

The cultivated sunflower *(Helianthus annuus L.)* is one of the 67 species in the genus *Helianthus.* All are native to the Americas and most are found in the U.S. It is a member of the Compositae family and has a typical composite flower (Figure 3). Jerusalem artichoke *(H. tuberosus L.)*, another species, is grown on a limited basis for food and livestock feed in the U.S. A few species are grown as ornamentals and the rest are weeds, usually found in pastures or disturbed areas.

The basic chromosome number for the *Helianthus* genus is 17. Diploid, tetraploid and hexaploid species are known. The majority of the species are perennial, with only about a dozen annual species. Plant breeders have made interspecific crosses within the genus and have transferred such useful characteristics as higher oil percentage, cytoplasmic male sterility for use in production of hybrids, and disease and insect resistance to commercial sunflower.

Growth Stages

The division of growth into vegetative and reproductive stages as developed by Schneiter and Miller is shown in Figure 4. This scheme is important as it gives producers, scientists and the industry a common basis to discuss plant development.

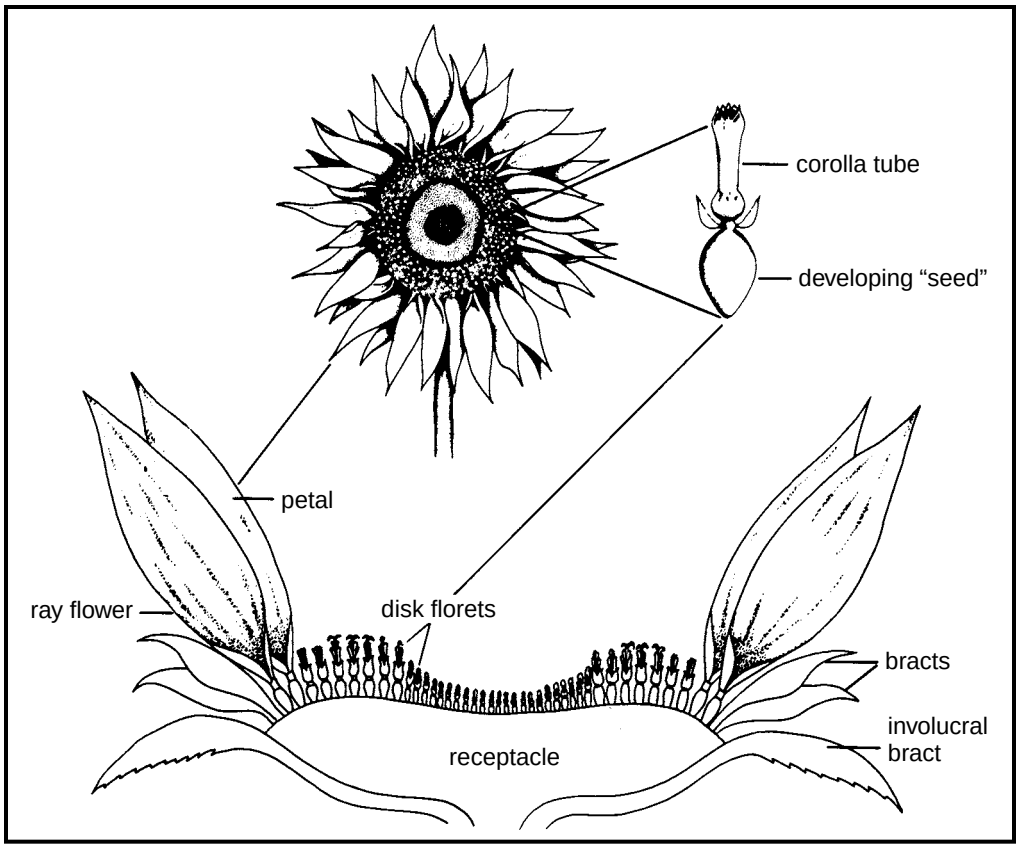


Figure 3. Details of the head of a sunflower and selected parts. (J. Miller and Christian Y. Oseto)

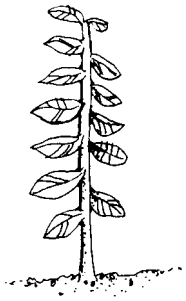
Table 1. Growing Degree Days: Sunflower Growth and Development

		Ave. days and GDD** units accum. from planting	
Sunflower Stage	**Plant Description**	**GDD units**	**Days**
VE	Emergence	167	10
V4	4 True Leaves	349	20
V8	8 True Leaves	545	28
V12	12 True Leaves	690	34
V16	16 True Leaves	772	38
V20	20 True Leaves	871	44
R1	Miniature Terminal Bud	919	46
R2	Bud <1" From Leaf	1,252	61
R3	Bud >1" From Leaf	1,394	67
R4	Bud Open Ray Flowers Visible	1,492	71
R5.1	Early Flower	1,546	73
R5.5	50% Flowered	1,623	77
R6	Flowering Complete	1,780	84
R7	Back of Head - pale yellow	2,052	86
R8	Bracts Green - head back yellow	2,211	104
R9	Bracts Yellow - head back brown	2,470	119

*Source: NDSU Carrington Research Extension Center - 2 years of data averaged from five sunflower hybrids.
**Sunflower growth and development responds to heat units similar to corn and several other crops. In sunflower, the base temperature of 44 F is used to determine Growing Degree Days (GDD). The daily GDD formula is: GDD=[(daily maximum temperature + daily minimum temperature) ÷ 2] – 44 degrees F.

Vegetative Stages

True leaf — 4 cm



V-12

V-E

V-2

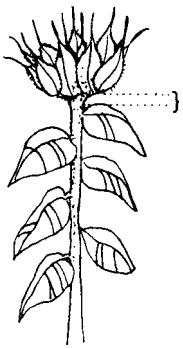
V-4

Figure 4. Stages of sunflower development.
(A. A. Schneiter and J.F. Miller.)

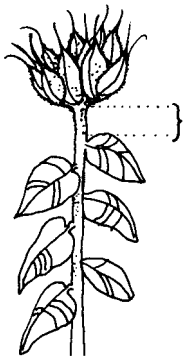
Reproductive Stages

R-1

R-2



R-2



R-3

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

Description of sunflower growth stage

The total time required for development of a sunflower plant and the time between the various stages of development depends on the genetic background of the plant and growing season environment. When determining the growth stage of a sunflower field, the average development of a large number of plants should be considered. This staging method also can be used for individual plants. The same system can be used for classifying either a single head or branched sunflower. In the case of branched sunflower, make determinations using only the main branch or head. In stages R-7 through R-9, use healthy, disease-free heads to determine plant development if possible because some diseases can cause head discoloration. Also, in a number of recently released and grown hybrids, the stay-green characteristic is present, which means the yellowing or browning of the bracts may not be a good indicator of plant maturity.

Stage	Description
V (number) Vegetative Stages (e.g., V-1, V-2, V-3, etc.)	These are determined by counting the number of true leaves at least 4 cm in length beginning as V-1, V-2, V-3, V-4, etc. If senescence of of the lower leaves has occurred, count leaf scars (excluding those where the cotyledons were attached) to determine the proper stage.
R-1 Reproductive Stages	The terminal bud forms a miniature floral head rather than a cluster of leaves. When viewed from directly above, the immature bracts have a many-pointed starlike appearance.
R-2	The immature bud elongates 0.5 to 2.0 cm above the nearest leaf attached to the stem. Disregard leaves attached directly to the back of the bud.
R-3	The immature bud elongates more than 2 cm above the nearest leaf.
R-4	The inflorescence begins to open. When viewed from directly above, immature ray flowers are visible.
R-5 (decimal) (e.g., R-5.1, R-5.2, R-5.3, etc.)	This stage is the beginning of flowering. The stage can be divided into substages dependent upon the percent of the head area (disk flowers) that has completed or is in flowering. Ex. R-5.3 (30%), R-5.8 (80%), etc.
R-6	Flowering is complete and the ray flowers are wilting.
R-7	The back of the head has started to turn a pale yellow.
R-8	The back of the head is yellow but the bracts remain green.
R-9	The bracts become yellow and brown. This stage is regarded as physiological maturity.

From Schneiter, A.A., and J.F. Miller. 1981. Description of Sunflower Growth Stages. Crop Sci. 21:901-903.