

Sunflower: An Alternative Crop for Tennessee Producers

Production Guidelines and Tennessee Hybrid Trials



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Introduction

Tennessee producers are interested in crops that can be grown to diversify and/or complement their current cropping systems that include corn, cotton, soybeans and wheat. There is a growing demand for birdseed, and sunflower is an important component of that feed, either as a sole ingredient or in a blend with other seeds such as millet, corn, sesame, sorghum, wheat and oats. Sunflower oil is used for human consumption and is also a suitable feedstock for biodiesel. An increasing demand for biodiesel will increase the demand for oilseed crops such as sunflower. Thus, there may be increased opportunities for some Tennessee producers to grow sunflower for these markets.

This publication provides general information about the growth, development and production of sunflower. Results from four years of sunflower hybrid trials conducted in Tennessee are included to provide producers with information about how these hybrids perform under Tennessee conditions.

History – Past and Recent

Sunflower is one of a few crops that originated in the U.S., with the southwestern U.S. likely its center of origin. Records show that wild sunflower was used as a food by Native Americans and was domesticated and spread by their movements (Seiler and Rieseberg, 1997). Archaeological evidence uncovered from a site in Middle Tennessee indicates that sunflower was being grown in Tennessee by Native Americans more than 4000 years ago (Crites, 1993). Following the discovery and settlement of the U.S., sunflower was spread to other parts of the world, with European countries and Russia being the major producers (Putt, 1997).

Modern sunflower varieties in North America trace much of their lineage back to reintroduced varieties that were developed in Europe and Russia. Sunflower was not an important agronomic crop in the U.S. until the 1950s, and oilseed sunflower has been an economically important crop in the U.S. only since the mid-1960s. Expanded world production of sunflower resulted from development of high-oil varieties and more recently from the development of hybrids.

Table 1. Acres of sunflower harvested in the U.S. in 2008.

State	Seed for oil	Seed for non-oil use	All types
Colorado	155,000	23,000	178,000
Kansas	205,000	20,000	225,000
Minnesota	77,000	38,000	115,000
Nebraska	42,000	18,000	60,000
North Dakota	915,000	145,000	1,060,000
South Dakota	522,000	48,000	570,000
Texas	59,000	33,000	92,000
All other states	74,000	11,000	85,000
United States total	2,049,000	336,000	2,385,000

Source: USDA-NASS, 2008

Presently, most U.S. commercial sunflower production is in the Great Plains states of Colorado, Kansas, Minnesota, Nebraska, North Dakota, South Dakota and Texas (USDA-NASS, 2007). Most acreage is grown to produce seeds for vegetable oil (**Table 1**) with a small portion used for birdseed production. In 2009, average U.S. yield of sunflower seed was 1538 pounds per acre (USDA-NASS, 2009). Even though sunflower is adapted to Tennessee conditions, its primary production is in the western and upper Great Plains.

Types and Uses

There are two types of sunflower hybrids: 1) the oilseed type that is grown for vegetable oil, and 2) the confection or non-oilseed type (**Fig. 1**). The oilseed type has a higher oil composition in the seeds than the non-oilseed type. Oilseed types produce smaller black seeds and the oil is primarily used for human consumption. The oilseed types are also marketed as a sole ingredient for birdseed or in birdseed blends. The non-oilseed type produces the large, striped seeds that are used for human food snacks in the shell or as kernels, in baking ingredients, and in birdseed mixes. Because each type has a separate and distinct market, they cannot be mixed in storage (Johnson et al., 2009).

Commercial oilseed sunflower hybrids are divided into three categories based on the fatty acid profiles (types of saturated and unsaturated fats) of the oil in the seeds. The categories are 1) standard or linoleic, 2) NuSun or mid-oleic, and 3) high oleic. A comparison of the fatty acid profiles of seeds of these sunflower types and other oilseed crops is shown in **Table 2**.

Vegetable oil from sunflower seeds is lower in saturated fats than most vegetable oils. Linoleic oil processed from sunflower oil is used as a low-saturated fat cooking oil. Linoleic types were the predominant oil-sunflower hybrid produced, but their acreage has decreased. NuSun is currently the predominant oil-type sunflower grown, because seeds produce a healthier oil that contains less saturated fat than oil from linoleic types. Oil from seeds of NuSun types does not have to be hydrogenated, which makes it an excellent frying oil with a long shelf life. High-oleic hybrids produce seeds that contain specialty oil that is very low in saturated fats. This specialty oil is used in lubricants (both food grade and industrial) and food coatings. It is grown by contract only (Johnson et al., 2009).

Oil from sunflower seeds comprises 7.8 percent of the world's vegetable oil consumption, which is the fourth leading oil consumed behind palm (31.8 percent), soybean (30 percent) and rapeseed (14 percent) (ASA, 2008). Its seed typically contain about 38 to 44 percent oil and 18 to 25 percent protein. In contrast, soybean seeds typically contain about 20 percent oil and about 40 percent protein, or a mirror image of sunflower oil and protein content. Non-dehulled or partly dehulled sunflower meal has been substituted for soybean meal in diets for ruminant animals, swine, poultry and catfish.



Fig. 1. The two classes of sunflower based on seed characteristics: (1) oilseed type grown for oil and meal, and (2) non-oilseed or confection type grown for human and bird food. [From Berglund (2007a, Fig. 1); original photo credited to Gerhardt Fick; used with permission]

Table 2. Fatty acid profiles of oil from seeds of sunflower and other crops (normalized to 100).			
Oil source	Monounsaturated	Polyunsaturated	Saturated
	-----%-----		
High-oleic sunflower	82	9	9
Olive	72	11	17
NuSun sunflower	65	26	9
Rapeseed (Canola)	62	32	6
Peanut	49	33	18
Lard	47	12	41
Beef fat	44	4	52
Palm	39	10	51
Butter fat	34	2	64
Corn	25	62	13
Soybean	24	61	15
Linoleic sunflower	20	69	11
Cottonseed	18	55	27
Safflower	13	77	10

Source: [National Sunflower Association](#)

Growth and Development

Sunflower is an annual, erect, broadleaf plant with a strong taproot and prolific lateral root system. It emerges from the soil with two large cotyledons. Emergence will take four to five days when planted an inch deep in warm soil, but will take a few days longer in cooler soils or when planted deeper. Soil crusting can make it difficult for the large-cotyledon seedlings to push out of the soil. A rotary hoeing may be necessary to mitigate the soil crusting problem for easier emergence.

Sunflower grows rapidly, producing large, rough leaves. Current sunflower varieties in Tennessee reach an average of 6 feet in height, varying between 5 and 7 feet depending on planting date, variety and soil conditions. After reaching full height at blooming, heads on commercial cultivars turn downwards, a trait that inhibits bird feeding on the seeds.

Each sunflower head, or inflorescence, is not a single flower, but rather 1,000 to 2,000 individual flowers joined at a common receptacle (**Fig. 2**). The head is actu-

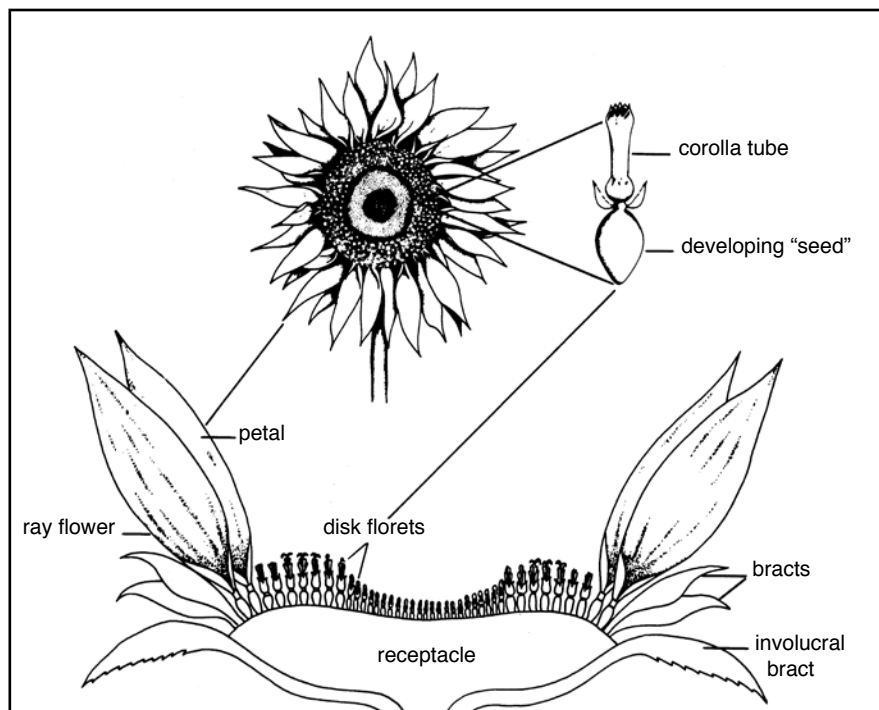


Fig. 2. Details of a sunflower head with selected parts labeled. [From Berglund (2007a, Fig. 3); original photo credited to J. Miller and Christian Y. Oseto; used with permission]

ally composed of two types of flowers. What appear to be yellow petals around the edge of the head are actually individual ray flowers. The face of the head is comprised of hundreds of disk flowers, which each form into a seed (achene). Commercial sunflower has flowers that are self-compatible for pollination, meaning they do not require a pollinating insect. However, some studies have shown that bee pollination provides a slight yield boost. Sunflower heads turn with, or track, the sun early in their development, but later stay east-facing before facing downwards. A common practice is to plant rows north and south so that the heads can lean into the between-row space rather than bumping against an adjacent in-row plant and causing some seeds to fall. Heads on commercial varieties turn downward after blooming, which makes it more difficult for birds to eat the seeds.

Table 3 contains a description of sunflower growth stages. Pictorial views of the growth stages defined in **Table 3** are shown in **Fig. 3**. Determining stage of development is based on using the main branch or head and not branch heads. Generally, sunflower reaches R1 or bloom stage about 65 to 70 days after planting and maturity about 105 to 115 days after planting (Aiken, 2005). Hybrid differences in maturity are usually associated with differing lengths of the vegetative period before the head is visible (Putnam et al., 1990).

Table 3. Description of sunflower growth stages. See Fig. 3 for color photos of various growth stages.	
Stage†	Description
VE	Emergence
V1 to n— Vegetative stages	Determined by counting the number of true leaves at least 1.5 inches in length beginning as V-1, etc. If lower leaves have dropped, count leaf scars.
V20	20 true leaves
R1—beginning of Reproductive stages	The terminal bud forms a miniature floral head rather than a cluster of leaves. When viewed from above, the immature bracts have a many-pointed, star-like appearance.
R2	Immature terminal bud < 1 inch above nearest leaf attached to the stem. Disregard leaves attached to the back of the bud.
R3	Immature bud > 1 inch above the nearest leaf.
R4	The inflorescence or bud begins to open. When viewed from above, immature ray flowers (on outer edge of head) are visible.
R5	Beginning of flowering. Can be divided into sub-stages dependent on the percentage of the head area (interior disk flowers) that has completed or is in flowering; e.g., R 5.3 = 30 percent of head area completed flowering, R 5.8 = 80 percent, etc.
R5.5	50 percent flowered
R6	Flowering is complete and ray flowers (on outer edge of head) are wilting.
R7	Back of head has started turning pale yellow.
R8	Back of head is yellow but bracts (behind ray flowers) remain green.
R9	Bracts become yellow and brown. Physiological maturity.
Berglund (2007a) (Also color photos of various growth stages.)	

Vegetative Stages



True leaf - 4 cm

Fig. 3. Stages of sunflower development. See Table 3 for description of stages. [From Berglund (2007a, Fig. 4); original credited to A. A. Schreiner and J. F. Miller; used with permission]



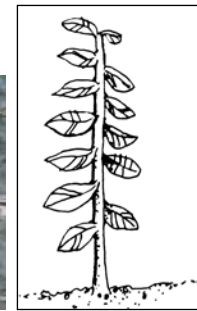
V-E



V-2



V-4



V-12

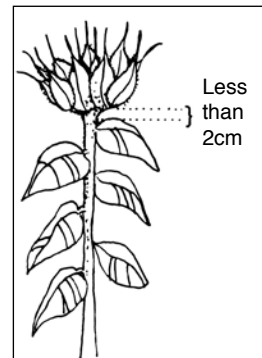
Reproductive Stages



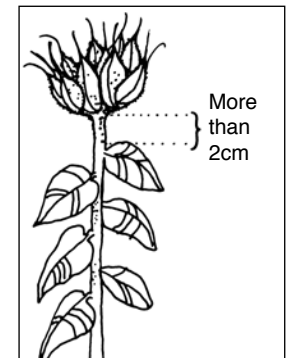
R-1



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

Cultural Practices

Guidelines for growing sunflower in the U.S. are available. The following information is a composite of the material from sources shown in **Table 4** plus sources cited at specific locations throughout the report.

Table 4. Information sources for U.S. sunflower production.	
Publication	Institution and Web site
ProCrop Sunflower Menu (ProCrop, 2008)	North Dakota State Univ. Ext. Serv.
Sunflower – Alternative Field Crops Manual (Putnam et al., 1990)	Univ. of Wisconsin and Univ. of Minnesota Ext. Serv.
Sunflower Production (Berglund, 2007b)	North Dakota State Univ. Ext. Serv.
High Plains Sunflower Production Handbook (Meyer et al., 2009)	Kansas State Univ. Coop. Ext. Serv.
Sunflower (Myers, 2008)	Thomas Jefferson Agricultural Institute

Hybrid Selection

Almost all commercial varieties of sunflower are hybrids, so new seeds should be purchased each year. Hybrids should be selected on the basis of high yield with high seed oil content (at least 40 percent), a test weight of at least 25 pounds per bushel, and disease and insect resistance if available. Hybrids with resistance to rust, Verticillium wilt and certain races of downy mildew are available. Given a choice, select a high-oil hybrid instead of a low-oil hybrid with the same yield potential. The oilseed market pays a premium for seeds with more than 40 percent oil (at 10 percent moisture), and discounts seeds with less than 40 percent oil.

The University of Tennessee conducts periodic sunflower variety trials at the Research and Education Centers to identify varieties with desired traits that are less prone to lodging and more productive under Tennessee growing conditions. Hybrids with traditional (linoleic), mid-oleic (NuSun) and high-oleic oil composition are tested. Newer Clearfield® hybrids are tolerant to Beyond® herbicide. Lodging and yield data from the Tennessee tests are available at <http://varietytrials.tennessee.edu>.

Planting

Sunflower should be planted 1 to 2 inches deep. The shallower planting depth is preferred in cool, wet soils or when planting small seeds. Sunflower can be planted anytime after soil has warmed to about 44 degrees F; however, it is preferable to delay planting until soil has warmed to at least 50 degrees F. This occurs in early April at Jackson ([USDC-NCDC, 2008](#)). Planting early generally will result in higher yield, test weight and oil content of the seeds in the northern U.S. sunflower-growing regions ([Meyer et al., 2009](#); [ProCrop, 2008](#)). It remains to be seen how early planting will affect sunflower yield and seed characteristics in the southern U.S. Planting date can be used in the management of some insects, but not all affected species respond similarly to early or late planting. Sunflower can be doublecropped with wheat, but yields will be considerably lower.

Row Spacing and Plant Population

A 30-inch row spacing is the most popular and considered standard, although narrower rows and solid seeding can be used. Wide rows offer more options for weed management and allow harvesting with a row-crop header. Sunflower will compensate to some extent for differences in plant population through adjustments in head size, number of seeds per plant and seed size. Plant populations for oilseed hybrids should be between 14,000 and 22,000 final plants per acre. The higher populations may be helpful for weed management. Sunflower is not particularly sensitive to seeding rate, since head size (and seed number) per plant will increase in a thinner stand. A lower population of 14,000 final plants/acre is suitable for non-oilseed types in order to ensure large seeds.

Sunflower seeds for planting are sold either by weight or seeds per bag; however, sunflower seeding should be based on number of seeds per acre and not weight. Oil-type hybrid seed sizes are #2 (largest), #3 and #5 (smallest). Size #3 is most commonly planted. Size of the seeds can affect maximum depth of planting and what type of

planter modifications are necessary, such as seed plates or finger pickups. The size of planted seeds has no apparent effect on agronomic performance.

Dr. Emerson Nafziger (Nafziger, 2008) of the University of Illinois Department of Crop Sciences has published an [online calculator](#) for determining soybean seeding rate, seeds per foot of row and associated costs for an intended plant population in a chosen row spacing. This calculator also can be used for sunflower seeding rate calculations. An example calculation using this calculator is as follows:

A row spacing of 30 inches with a desired final population of 20,000 plants per acre is entered. This example assumes that 80 percent of planted seeds will become viable plants. Thus, $20,000/0.80 = 24,700$ seeds per acre to plant. In 30-inch-wide rows, this equates to 14.3 seeds per 10 feet of row, or 8.5 inches between seeds within a row. **Table 5** contains other values (obtained from the online calculator) that can be used to make the proper planter setting to achieve a desired final stand.

Table 5. Seed spacing (distance between seeds in a row rounded to nearest 0.5 inch) required for desired final populations in indicated row spacings assuming 80 percent final stand (90 percent germination and 10 percent stand loss).

Final stand (plants per acre)	Row spacing (inches)				
	(7.5)	(15)	(20)	(30)	(40)
14,000	48.0	24.0	18.0	12.0	9.0
16,000	42.0	21.0	15.5	10.5	8.0
18,000	37.0	18.5	14.0	9.5	7.0
20,000	33.5	16.5	12.5	8.5	6.5
22,000	30.5	15.0	11.5	7.5	6.0
24,000	28.0	14.0	10.5	7.0	5.5
26,000	26.0	13.0	9.5	6.5	5.0

Source: [Nafziger \(2008\)](#).

Soil Fertility and Fertilizer Recommendations

A summary of typical nutrient content of sunflower stover and seeds is shown in **Table 6**. Using these values as a guide, a sunflower seed yield of 1,500 pounds per acre removes about 75, 23 and 55 pounds of N, P and K from an acre of soil. Thus, these amounts must be present to ensure this yield level according to these values. A soil test should be used to determine nutrient levels in the soil before growing sunflower. Only those nutrients determined to be below levels for optimum production should be re-supplied as fertilizer.

Research results indicate that sunflower requires 6 to 7 pounds of N for every 100 pounds of seed production.

Using these values, a yield of 1,500 pounds of seed per acre requires 90 to 105 pounds of N per acre. Fertilizer N rates should be lowered if sunflower is planted after wheat or if legumes are grown in rotation before sunflower. In Tennessee, this legume would likely be soybean, which provides an N credit of up to 20 pounds per acre (Savoy and Joines, 2009). It is important to apply only the amount of N needed to reach the desired yield goal, because excessive N can result in decreased oil content and increased lodging, as well as N loss to the environment. When properly applied, N source materials are not agronomically different; thus, N source should be based on cost and N content of the various N fertilizers ([USDA-ERS, 2008](#)) and availability. Nitrogen application can be made preplant, sidedress or a combination of the two. Applications should be timed to ensure N is available for rapid growth and development.

Phosphorus (P) and potassium (K) fertilization should be done according to soil test recommendations. If soils test medium or higher, response to P fertilization likely will be small to none. Phosphorus fertilization is recommended for soils that test below medium. Periodic soil tests will determine if adequate P remains in the soil to produce a crop in subsequent years. Phosphorus should be applied preplant-broadcast, preplant-knifed or banded at planting. Potassium deficiencies are not likely unless soil test levels are low. Potassium should be applied preplant-

Table 6. Nutrient content (pounds per acre) in a sunflower crop producing 1,000 pounds of seed per acre.

Element	Seed	Stover	Total
Nitrogen (N)	30	18	48
Phosphorus (P)	12	3	15
Potassium (K)	8	28	36
Sulfur (S)	2	4	6
Magnesium (Mg)	2	5	7
Calcium (Ca)	1.2	18.5	19.7

Source: [Vigil, Hergert, and Mengel \(2009\)](#).

broadcast and incorporated. Selection of P and K fertilizer materials should be based on cost (USDA-ERS, 2008) and availability. Liming is recommended for sunflower on soils with a pH of 6.0 or less.

Weed Management

Using best management practices for sunflower production will reduce the negative effects of weeds. However, sunflower does not provide a quick ground cover, so early-season weed control is essential. Thus, good production practices must be supplemented with chemical and cultural weed control measures, particularly in the southern states. Conventional tillage sunflower can be row-cultivated as late as the 4- to 6-leaf stage, as long as the soil is not disturbed any closer to the row than the plant leaf spread. This will minimize root pruning during cultivation.

Only a limited number of herbicides are labeled for use in sunflowers, but good weed control can be obtained with proper application of what is available. Included in these herbicides are those that can be applied preplant, preemergent or post-emergent. Annual grass weeds and small-seeded broadleaf weeds can be controlled with soil-applied pendimethalin, trifluralin, ethafluralin and S-metolachlor. The tillage-incorporation requirement for some of these herbicides will interfere with no-till production. Sulfentrazone can be applied preplant if sunflower is planted in rows where seed depth can be assured to prevent injury. After sunflower emergence, emerged grasses can be controlled with clethodim or sethoxydim. Where Clearfield® sunflower hybrids are used, emerged broadleaf weeds can be controlled with imazamox. Where non-Clearfield® hybrids are planted, row-cultivation is the only option for controlling broadleaf weeds once the crop has emerged.

Sunflower is sensitive to the carryover of sulfonylurea (Steadfast®, Resolve®, Classic®), imidazolinone (Pursuit®) and sulfonamide (FirstRate®) classes of herbicides. These products require a rotation interval of up to 18 months between herbicide use and planting back to sunflower. Check all herbicide labels for crops grown in the year preceding sunflower for precautions and rotation restrictions.

Two southern information sources provide up-to-date sunflower weed control recommendations. They are University of Tennessee Extension Publication PB 1580 (Steckel, 2008) entitled “[Weed Control Manual for Tennessee](#)” and Mississippi State University Publication 2434 (Rankin, 2007) entitled “[Sunflower Weed Control Recommendations for Mississippi](#).”

Insect Management

Insects are occasionally a problem in sunflower production. Sunflower seeds can be treated commercially with an insecticide such as imidacloprid (Gaucho®) or thiamethoxam (Cruiser®) for protection from soil insect pests. Some insects such as the sunflower midge, sunflower beetle, sunflower stem weevil, red sunflower seed weevil, headclipping weevil and the banded sunflower moth, need to be monitored for infestation levels that justify application of control measures. Growers should minimize insect damage by applying integrated pest management practices that combine biological, cultural and chemical control measures to minimize economic, health and environmental risks. Application of control measures should be based on economic threshold levels, when available, to maintain pest populations below levels that cause unacceptable crop quality and yield losses.

Treatment thresholds should be used as a guide based on yield potential and crop value. For example, lower thresholds might be warranted where higher crop values or yields are expected. This is the case for non-oilseed types because of the requirement for seeds that are free of insect damage. In fact, insect-damaged non-oilseed types will be discounted or rejected by processors, whereas premiums for large, insect-free seeds are common. Conversely, when the crop is expected to be lower in yield or value, higher thresholds might be used.

Many insects feed on sunflower foliage but the defoliation level rarely is high enough to cause significant yield loss during vegetative development (Table 7). Defoliating insects cause the most damage from about R1 to R3. Insects that infest flowers and seeds are the most damaging to yield and quality potential; therefore, thorough scouting should be conducted during the reproductive period to monitor levels of these insects.

Insect management in sunflower is covered in detail by Knodel and Charlet (2007) and Sloderbeck et al. (2009). Both of these sources have textual and pictorial descriptions to aid in the identification and symptoms of damage of the various insect species, and provide information on scouting methods, economic thresholds if available, and management and/or control options for common insect species. Insecticides labeled for sunflower are available,

and their use is described by Sloderbeck, Michaud, and Whitworth (2008). Not all insecticide products that are labeled for use in the Great Plains area can be used in Tennessee. Check all insecticide labels prior to their use.

Disease Management

The most serious diseases of sunflower are caused by fungi. Major diseases include sclerotinia stalk and head rot, verticillium wilt, rust, phoma black stem and downy mildew (Putnam et al., 1990). Sclerotinia (white mold) is also found in soybean, canola and certain other broadleaf plants. In cool wet soils, seeds or seedlings may be attacked by fungi, so seeds are typically treated with fungicide [e.g., Maxim XL (McMullen and Bradley, 2007)]. Hybrids with tolerance to races of rust, some races of downy mildew, verticillium wilt, and other disease pathogens are available. The most economical and effective management of sunflower diseases is the planting of resistant or tolerant hybrids, and using a rotation scheme that allows a minimum of three to four years between successive sunflower crops. Excellent and detailed textual and pictorial descriptions of disease symptoms can be found in [Bradley et al. \(2007\)](#) and [Jardine \(2009\)](#). Specific management recommendations for the various sunflower disease pathogens can be found in [ProCrop \(2008\)](#).

Bird Control

Birds can be major pests in sunflower. Ripening seeds are exposed and the large head serves as a ready perch during feeding. Problem birds feed on insects and weed seeds in sunflower fields before the crop is vulnerable to damage, and thus become accustomed to feeding in that location. Cultural practices in combination with mechanical and chemical practices can and should be used to control birds in sunflower fields.

Bird damage to sunflower is imminent. Thus, prevention of bird infestations that will damage sunflower is the first line of defense. Sunflower should not be planted near cattail marshes or woodlots. All planting in a region should be done at or near the same time because earlier and later-maturing fields will sustain more damage. Weeds and insects in the crop should be controlled early because insects and weed seeds are often a source of food for the birds before the crop becomes susceptible to bird feeding. Planting a small plot of oilseed sunflower near high-value non-oilseed and oilseed crops can provide a trap crop to protect the higher-value crop. Providing alternative food plots will likely enhance the efficacy of any repellent or scare device and should be included in bird damage management plans. Delayed plowing down of harvest stubble until after harvest is completed should provide an alternate feeding area. Harvesting sunflower as early as possible will avoid prolonged exposure of the seeds to bird damage.

Physical disruptions to bird feeding on sunflower seeds include guns, automatic exploders and electronic frightening and pyrotechnic devices. However, none are 100 percent effective. Repellent baits are available, but their efficacy is inconsistent. The effectiveness of bird-repellent materials applied to the head is limited because the orientation of the head prevents contact of the applied material with the developing seeds. This is an important factor to consider before using any chemical bird repellent since sunflower heads are downward-oriented when bird damage potential is greatest. A detailed outline of measures to control bird damage to sunflower is provided by [Linz et al. \(2006\)](#) and [Latzke \(2007\)](#).

The U.S. Department of Agriculture’s Animal and Plant Health Inspection Service (USDA-APHIS) has a [Wildlife Damage Management Division](#). Within this agency, there is a Wildlife Services Division that conducts research to evaluate methods for managing and/or controlling bird damage to crops. Online information for the

Table 7. Approximate percentage yield reduction when sunflower is defoliated the indicated amount at each indicated growth stage (See Table 3 for growth stages).

Plant stage	Percentage defoliation				
	10	30	50	70	100
	(Approximate % yield loss)				
V-4 to V-5	0	2	4	5	21
V-9 to V-11	0	3	5	7	24
R1	2	6	7	16	47
R3	2	15	24	44	99
R5	1	7	16	37	90
R7	0	3	10	16	22
R8	0	2	5	8	11

Source: [Sloderbeck et al. \(2009\)](#)

Wildlife Services Division in Tennessee can be accessed by going to the above [Web site](#), searching “Tennessee,” and then accessing the “Wildlife Services – Tennessee” listing.

Crop Rotation and Residue Management

Sunflowers can be rotated with corn, soybean and/or sorghum. Yields of sunflower doublecropped with wheat may be too low to be profitable. Regardless of cropping system, sunflower should not be planted in the same field more than once every three to four years. Sunflower, like soybean, does not leave very much residue, so a fall cover crop should be considered on erosive fields. Sunflower grows best on well-drained soils, which means they are probably not suited for the alluvial clay soils along the Mississippi River.

Harvesting and Storage

Sunflower seeds are generally physiologically mature when the back of the flower head is yellow. When the head turns brown on the back, seeds are usually ready for harvest. Platform, row-crop and corn heads can be used to successfully harvest sunflower. Row-crop heads can be used without modification. Corn heads need to be modified with a stationary cutting knife. Platform heads can be used without modification, but often have a higher amount of seed and head loss than a row head. Adding pans to the front of the platform and/or modifying the reel can improve efficiency ([Myers 2008](#)). Because getting sunflower heads into the combine is probably the biggest problem when harvesting, header performance can often dictate combine efficiency.

Combine settings must be adjusted for sunflower versus other crops. A good description of these settings is provided by [Myers \(2008\)](#). The overall goal of the threshing process should be passing the head nearly intact through the combine, or in a few large pieces, with all developed seeds removed from the head. If the head is being ground up into small pieces, the grain will have an excessive trash content ([Myers 2008](#)).

During colder periods, sunflower can be safely stored at 10 percent moisture or less, but during warmer months the storage moisture should be at 8 percent or less. Proper moisture sampling procedures during storage, storage bin requirements, and air temperatures for drying are provided by ([Myers 2008](#)). Be aware that sunflower dries more rapidly than corn or soybeans, and should be monitored to avoid overdrying. Also, be aware that sunflower drying has a higher risk of fire hazard than some crops, because small fibers that rub off the sunflower hulls and float in the air can readily burn. Precautions to avert this hazard are provided by [Myers \(2008\)](#).

Marketing and Economics

The easiest way to market sunflower is often to the birdseed market. However, many current or potential sunflower producers are interested in non-oilseed confection sunflower because of its higher price. As stated previously, this market has a more demanding standard for a high-quality, undamaged seeds suitable for human food. Most sunflower producers grow the oilseed type.

With the emergence of NuSun and high oleic types, opportunities for a price premium of 10 to 20 percent exist. Until sufficient markets develop for these specialty oil types, growers may be required to ship them long distances and this should be considered before growing for this market. No processing plants are located in Tennessee at this time. The nearest processors accepting sunflower for oil are in Georgia (AG Strong, Dalton, GA), Alabama (AG Strong, Athens, AL), and Missouri. It is critical that growers make local arrangements for storage and shipping and have a contract with a processor prior to planting a crop of sunflower where the intended market is crushing for oil and meal.

Representative budgets using October 2008 input costs and commodity prices for oil type and non-oilseed type sunflower are provided by [Dumler et al. \(2008\)](#) of Kansas State University. According to their budgets (with modifications for Tennessee conditions and lower fertilizer prices), breakeven yields needed to cover all costs except management and overhead for oil type and non-oilseed type sunflower are about 1800 and 1200 pounds per acre, respectively. These yields are based on receiving \$17.06 and \$26.50 per hundredweight for the two types, respectively. These yield levels will be used to assess yields obtained from the following Tennessee yield trials. Of course, alternative prices paid (especially for fertilizers) and received, as well as inputs and their amounts used (fertilizers, herbicides, and pesticides) by individual Tennessee producers will result in deviations from these estimates.

2004 - 2007 Performance of Sunflower Hybrids in Tennessee

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Experimental Procedures

Sunflower hybrid trials were conducted at the East Tennessee (Knoxville) and Milan Research and Education Centers (REC). The trials contained 15 (2004), 17 (2005), 25 (2006) and 31 (2007) hybrids at each location. Nitrogen at 90 pounds per acre was applied in split applications to each test site each year. A recent Mississippi study confirms that this amount of N is sufficient for maximum sunflower yield in the southern U.S. (Zheljazkov et al., 2008). Plots were two rows wide (30-inch row width) and 30 feet long. Plots at each location were replicated three times in a randomized complete block design.

Planting dates, seeding rates, harvest dates and soil series for each site are shown in **Table 8**. All monocropped tests were planted in May and doublecropped tests at Milan in 2006 and 2007 were planted in June.

Interpretation of Data

Tables list entries in descending order of performance at each location. All yields were adjusted to 10 percent moisture. LSD (least significant difference) values for each test are shown at the bottom of each respective table. Average yields of any two varieties being compared must differ by at least the LSD to be considered different in yielding ability at the 5 percent level of probability. For example, if the LSD for a test is 450 lbs/a and the average yield of Hybrid A is 1700 pounds per acre and the average yield of Hybrid B is 1300 pounds per acre, then the two hybrids are not statistically different in yield because the difference of 400 pounds per acre is less than the minimum of 450 pounds per acre required for them to be significantly different. Similarly, if the average yield of Hybrid C is 2200 pounds per acre then its yield is significantly greater than yields of both Hybrids A and B because the difference between B and C (900 pounds) and between A and C (500 pounds) exceeds the LSD value of 450 pounds.

The coefficient of variation (C.V.) value shown in each table is a measure of the variability associated with each experiment. A C.V. of 10 percent indicates that the error variation of the experiment is about 10 percent of the size of the experiment's average. Similarly, a C.V. of 30 percent indicates that error variation is nearly one-third as large as the experiment's average. The goal in conducting each yield test is to keep the C.V. as low as possible, preferably below 20 percent.

Growing Season Weather

2007. The growing season was characterized by extremes. A late frost and very low temperatures in the first portion of April caused wheat and corn crop damage. The remainder of the season was characterized by record-setting heat and drought that lowered yields. Daytime temperatures were high (several days above 100 deg. F) during flowering and seed fill at many locations throughout the state.

2006. The growing season was characterized by hot, dry conditions through most of the growing period. Daytime temperatures across Tennessee were high (several days above 90 deg. F) during flowering and seed fill.

2005. The growing season was characterized by several timely rainfall events during critical periods. Rainfall events were prompted by hurricane aftermaths (especially Dennis, Katrina and Rita) passing through the state. Daytime temperatures across Tennessee were high (several days above 90 deg. F) during flowering and seed fill.

2004. The growing season was characterized by very favorable temperatures and rainfall for seed production. Adequate amounts and very timely distribution of rain, as well as lower than normal day and night temperatures, resulted in an exceptionally good growing season.

Results

2007. The vast majority of the hybrids had test weights that exceeded the industry standard of 25 pounds per bushel (**Table 9**). Yields from the Knoxville site and from the doublecropped trial at the Milan site were extremely low. About half of the hybrids in the May planting at Milan produced yields that exceeded 1800 pounds per acre. Yield of the non-oilseed type ‘Triumph 777 C’ hybrid exceeded 1200 pounds per acre only in the May-planted Milan trial.

2006. Average yields of all hybrids grown at the Knoxville and Milan sites were below 1800 pounds per acre (**Table 10**). The vast majority of the hybrids had test weights that exceeded the industry standard of 25 pounds per bushel. A majority of the hybrids suffered minimal bird damage. Average yields of hybrids grown at the Knoxville site were greater than those at the Milan site. Yield from several of the hybrids grown at Knoxville exceeded 1800 pounds per acre, whereas none did at Milan. Yields from hybrids planted in June following wheat at Milan were generally greater than yields from May-planted hybrids, and two of the later-planted hybrids produced yields that exceeded 1800 pounds per acre. Yield from the non-oilseed type hybrid ‘Triumph 777 C’ was near or exceeded the breakeven yield in all tests.

2005. Only the 1750 pounds per acre average yield of ‘Triumph 636’ approached 1800 pounds per acre (**Table 11**). A majority of the hybrids suffered significant bird damage, and several hybrids had a test weight below the 25 pounds-per-bushel industry standard. Yields at Knoxville were generally greater than those at Milan. Yield of several of the hybrids grown at the Knoxville site exceeded 1800 pounds per acre, whereas none did at Milan. Yield of the non-oilseed type hybrid ‘Triumph 777 C’ exceeded the arbitrary breakeven yield of 1200 pounds per acre at Knoxville but not at Milan.

2004. Average yields from the Knoxville and Milan sites were generally lower than the arbitrary breakeven yield of 1800 pounds per acre (**Table 12**). Only the ‘Triumph 636’ average yield of 1953 pounds per acre exceeded 1800 pounds per acre. Low yields were generally associated with significant bird damage. Test weight of all hybrids exceeded the industry standard of 25 pounds per bushel. Several hybrids at the Knoxville site exceeded 1800 pounds per acre, whereas none of the hybrids grown at Milan exceeded this yield.

Combined. Average yields of all hybrids that were grown at both locations during the 2005-2007 period were below 1800 pounds per acre (**Tables 13-15**). This resulted from the erratic yield performance of all hybrids across years at both locations. Average test weights of most hybrids across the three-year period exceeded the industry standard. Over the four-year period (2004-2007), the same trend occurred in both average yields and test weights. However, the average yield of ‘Triumph 636’ did approach 1800 pounds per acre at Knoxville, and this hybrid had the highest average yield at Milan. Across the 2006-2007 period, average yields from the doublecropped trials at Milan were low and well below the average yields from the May-planted trials at both locations.

Summary and Conclusions

Several factors should be considered when assessing the results from these yield trials. First, the significant bird damage in some years indicates that the bird problem will have to be mitigated if sunflower is to provide consistently profitable yields in Tennessee. Second, as discussed previously, sunflower can be planted in early April in Tennessee. It is unknown how this might affect yield potential. Third, using the above-cited economic parameters and these four years of variety trial results, it is obvious that yields from sunflower grown in Tennessee will have to consistently equal or exceed those from the best hybrids in these trials. Fourth, these results indicate that yields of sunflower grown in Tennessee will be erratic across years. The generally low average yields in these trials (for whatever reason) compared to the U.S. average yield (1454 and 1334 pounds per acre for oil type and non-oilseed type, respectively, in 2007; USDA-NASS, 2008) indicate that Tennessee producers should consider producing for a premium market to realize a profit. Fifth, these limited data indicate that sunflower should not be considered as the summer crop in a doublecropping system.

There are items that should be addressed if sunflower production is to gain a foothold among Tennessee producers. First, the best planting date for maximum yields should be identified. Second, there is no knowledge about

the pressure from insect and disease infestations that may occur with increased sunflower plantings across a wide area. Third, access to markets must be ascertained before sunflower is promoted for wide-scale planting in the southern U.S. Fourth, limited herbicides for use in sunflower that has no transgenic weed control component may be problematic. Finally, rotational crops should be identified for use with sunflower since its monoculture is not recommended.

Table 8. Location information from Tennessee Research and Education Centers (REC) where sunflower hybrid tests were conducted in 2004-2007.				
REC	Planting Date	Harvest Date	Seeding Rate	Soil Type
			seed/acre	
2007				
Knoxville	May 8	September 6	25,000	Stasser Silt Loam
Milan	May 8	August 29	25,000	Grenada, Henry Silt Loam
Milan (DC†)	June 15	October 10	25,000	Grenada, Henry Silt Loam
2006				
Knoxville	May 9	August 21	19,000	Sequatchie Silt Loam
Milan	May 19	August 28	25,000	Grenada, Henry Silt Loam
Milan (DC)	June 7	October 3	25,000	Grenada, Henry Silt Loam
2005				
Knoxville	May 12	August 26	25,000	Sequatchie Silt Loam
Milan	May 20	September 6	25,000	Falaya Silt Loam
2004				
Knoxville	May 21	August 31	25,000	Sequatchie Silt Loam
Milan	May 20	September 13	25,000	Loring, Henry Silt Loam
†DC = doublecropped – planted following wheat.				

Table 9. Mean yields and agronomic characteristics of 31 sunflower hybrids evaluated in three environments in Tennessee during 2007.

Brand	Hybrid	Avg. Yield† ± Std. Err. (n=3)	Knoxville \$ lbs/a	Double Crop		Test Weight (n=3) lbs/bu	Oil (n=3) %	Head Diameter (n=1) in.	Plant Height (n=3) in.	Lodging (n=3) score	Bird Damage (n=1) %
				Milan	Milan						
Traditional Hybrids											
Dekalb	DKF 39-01	712 ± 79	285	1642	210	30.0	42.3	4.2	45	1.4	2.8
Pioneer	63A70	666 ± 100	359	1363	275	27.1	44.2	5.5	45	1.4	2.7
Mycogen	8N270	574 ± 73	512	969	242	30.4	41.1	4.5	38	1.9	2.5
Mid Oleic Hybrids (NuSun)‡											
Croplan	356 NS	962 ± 73	729	1722	433	30.3	42.3	5.0	43	1.2	1.8
Triumph	636	944 ± 95	345	1998	489	28.1	43.2	4.8	50	2.1	2.5
Pioneer	63M80	934 ± 72	298	2037	468	30.0	42.4	5.3	47	1.3	2.8
Mycogen	8N453	930 ± 72	669	1871	251	27.3	44.6	4.7	48	1.3	2.8
Triumph	645	911 ± 72	401	1798	533	30.6	44.6	4.2	49	1.9	2.0
Dekalb	DKF 37-31	900 ± 78	519	1774	406	30.1	42.2	5.0	46	1.5	2.0
Triumph	660 CL	885 ± 79	588	1711	356	25.5	41.7	4.3	47	1.3	3.2
Dekalb	DKF 35-10	866 ± 73	642	1632	323	29.1	40.1	5.2	49	1.4	2.0
Mycogen	8N520DM	849 ± 78	374	1739	435	27.3	42.5	4.3	45	1.4	2.7
Mycogen	8N386CL	827 ± 73	334	1787	359	27.5	42.8	3.7	48	1.4	2.5
Pioneer	63M91	826 ± 78	184	2099	196	28.1	43.8	4.7	49	1.3	2.5
Dekalb	DKF 38-30	826 ± 73	312	1937	229	31.4	41.4	4.8	46	1.3	2.8
Mycogen	8N462DM	819 ± 73	634	1680	142	30.1	44.3	5.0	46	1.4	3.3
Triumph	s678	814 ± 74	331	1744	368	30.3	44.2	4.0	43	2.1	2.7
Mycogen	8D310	668 ± 73	334	1203	468	24.7	38.9	4.2	50	1.3	1.7
Triumph	665	650 ± 80	232	1535	181	29.7	43.6	4.2	47	2.0	2.3
Triumph	620 CL	631 ± 95	236	1623	35	27.1	42.2	3.3	47	1.7	2.8
Dekalb	DKF 38-80 CL	564 ± 78	204	1334	154	26.9	40.1	4.3	42	1.2	3.0
Croplan	3080 DMR NS	513 ± 78	290	1020	230	24.3	42.6	4.3	42	1.2	3.0
Mycogen	8N337DM	479 ± 72	391	964	82	24.7	41.2	4.7	44	1.4	2.2
High Oleic Hybrids ¶											
Triumph	847HO CL	925 ± 79	227	2130	419	28.1	43.4	4.3	52	2.2	2.7
Triumph	855HO	925 ± 79	354	2250	171	24.7	43.8	4.7	54	2.4	2.2
Croplan	378 DMR HO	829 ± 73	306	1762	419	30.9	43.3	5.5	50	1.4	3.0
Mycogen	8H419CL	816 ± 79	355	1740	351	24.9	42.7	4.2	46	1.3	2.7
Pioneer	64H41	807 ± 72	204	1908	311	30.5	42.6	4.0	47	1.3	3.0
Triumph	845HO	743 ± 72	324	1518	388	26.7	44.4	4.0	45	2.4	2.0
Triumph	859HO CL	728 ± 100	394	1634	156	22.6	41.0	4.8	40	1.2	3.5
Confectionary (non-oilseed) Hybrids											
Triumph	777 C †	993 ± 80	636	1956	387	20.2	29.2	5.2	54	2.4	1.3
Avg.		829	387	1682	329	28.2	42.4	4.5	46	1.5	2.5
L.S.D.⁻⁰⁵		199	269	449	285						
C.V. (%)		24.6	42.2	15.8	44.1						

† All yields adjusted to 10% moisture § Severe heat and drought at Knoxville during the growing season.

‡ Confectionary Type

¶ CL = tolerant to imazamox (Beyond) herbicide

‡ CL = tolerant to imazamox (Beyond) herbicide

‡ CL = tolerant to imazamox (Beyond) herbicide

‡ CL = tolerant to imazamox (Beyond) herbicide

Table 10. Mean yields and agronomic characteristics of 25 sunflower hybrids evaluated in three environments in Tennessee during 2006.

Brand	Hybrid	Avg. Yield†		Double		Test		Plant		Bird	
		(n=3)	± Std. Err.	Crop	Milam	Moisture	Weight	Head	Height		Lodging
		----- lbs/a -----				lbs/bu		in.		score	
				%		(n=1)		(n=3)		(n=1)	
Traditional Hybrids											
Dekalb	DKF 39-01	1688 ± 160		1154	1108	15.4	25.5	6.3	57	1.4	1.3
Mycogen	8N270	1478 ± 159		1293	1415	17.2	26.7	5.7	55	1.3	1.7
Mid Oleic Hybrids (NuSun) †											
Mycogen	8N453	1628 ± 160		840	1736	14.7	28.6	6.3	61	1.2	1.7
Triumph	s678	1573 ± 173		1454	1509	17.9	25.7	5.5	51	1.2	1.5
Triumph	636	1502 ± 159		992	1158	18.4	25.2	5.7	59	1.6	1.5
Triumph	645	1405 ± 159		1346	883	16.3	24.1	5.0	62	1.7	1.5
Mycogen	8N386CL	1397 ± 172		1685	1204	13.3	25.8	5.8	62	1.1	1.3
Mycogen	8D310	1389 ± 160		1257	1442	12.2	22.3	4.6	56	1.1	1.5
Dekalb	DKF 35-10	1318 ± 160		928	1804	17.9	26.4	4.4	59	1.3	1.5
Dekalb	DKF 38-80 CL	1316 ± 160		1226	1223	17.2	25.2	5.0	51	1.3	1.5
Mycogen	8N462DM	1298 ± 159		1345	1489	17.1	27.2	5.3	58	1.1	2.2
Triumph	658	1290 ± 160		1189	1453	16.2	24.5	5.3	61	1.8	1.3
Dekalb	DKF 38-30	1235 ± 173		1141	1327	14.2	26.2	5.1	60	1.5	1.7
Triumph	620 CL	1189 ± 173		1061	1282	14.1	26.3	4.6	59	1.4	2.0
Mycogen	8N337DM	1082 ± 160		1203	1050	11.7	26.3	4.3	57	1.6	2.0
Triumph	660 CL	1039 ± 159		922	1355	21.3	24.5	4.8	58	1.2	1.8
Triumph	TRX S5322CL	1037 ± 173		1207	826	16.2	24.2	4.6	46	1.6	1.5
Dekalb	DKF 37-31	1021 ± 173		756	1130	14.7	24.4	4.5	54	1.3	1.5
Mycogen	8N520DM	1018 ± 160		763	1288	15.0	25.4	5.2	58	1.2	1.8
Triumph	s672	976 ± 159		787	1170	12.9	26.2	4.6	45	1.2	1.5
Triumph	665	910 ± 159		679	1174	12.2	25.5	5.6	55	1.7	1.5
High Oleic Hybrids †											
Triumph	845HO	1432 ± 173		1150	1297	19.5	23.2	4.9	60	1.3	1.5
Mycogen	8N419CL	1334 ± 159		1370	1269	12.6	25.9	5.2	62	1.0	2.0
Mycogen	8H350DM	1265 ± 185		1290	1379	10.9	25.0	5.0	58	1.2	1.5
Confectionary (non-oilseed) Hybrids											
Triumph	777 C ‡	1392 ± 159		1122	1845	18.2	16.2	5.2	64	1.1	1.7
AVG.		1289		1409	1164	15.5	25.1	5.1	57	1.3	1.6
L.S.D..05		442		1027	755						
C.V. (%)		35.9		43.1	37.3						

† All yields adjusted to 10% moisture
 ‡ Confectionary Type
 †† CL = tolerant to imazamox (Beyond) herbicide
 ††† lbs / ac + 25 = bushels per acre
 Lodging = 1 to 5 scale; where 1 = 95% of plants leaning at an angle ≥ 45°; 2.5 = ~50% of plants leaning at an angle ≥ 45°.
 Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed remaining; 2.5 = ~50% of plant seed eaten; 5 = 95%+ of plant seed eaten.

Table 11. Mean yields and agronomic characteristics of 17 sunflower hybrids evaluated in two environments in Tennessee during 2005.

Brand	Hybrid	Avg. Yield† ± Std. Err. (n=2)	Knoxville		Milan		Moisture at Harvest (n=2) %	Test Weight (n=1) lbs/bu	Head Diameter (n=1) in.	Plant Height (n=2) in.	Lodging (n=2) score	Bird Damage (n=1) %
			lbs/a	-----	-----	-----						
Traditional Hybrids												
Mycogen	SF270	1557 ± 162	1601	1512	7.4	26.2	5.0	69	3.0	3.0	3.0	
Mid Oleic Hybrids (NuSun) ††												
Triumph	636	1750 ± 163	2250	1250	7.8	23.6	6.3	70	3.2	2.0		
Dekalb	DKF 35-10	1575 ± 162	1761	1389	7.7	25.3	4.9	68	2.4	2.8		
Monsanto	MH 4331 B	1571 ± 163	1980	1162	7.6	25.4	5.3	67	2.6	2.5		
Triumph	658	1539 ± 164	1559	1519	7.8	23.2	5.0	69	3.4	3.5		
Mycogen	8N429 CL	1482 ± 162	1964	999	7.5	24.7	4.9	72	3.0	2.3		
Mycogen	8N352	1475 ± 163	1568	1381	7.4	26.9	4.7	66	3.3	4.0		
Dekalb	DKF 38-30	1454 ± 162	1492	1417	7.6	25.3	4.2	68	2.3	3.3		
Advanta Pacific	444 NS/CL	1428 ± 162	1458	1399	7.4	24.5	4.8	69	2.5	1.5		
Triumph	645	1387 ± 163	1580	1195	7.3	22.8	5.3	72	3.8	3.5		
Triumph	620 CL	1153 ± 162	907	1399	7.4	26.6	4.5	65	3.2	4.0		
Dekalb	DKF 38-80 CL	1126 ± 164	1396	855	7.5	24.1	5.1	63	3.2	2.0		
Triumph	s672	1117 ± 164	996	1239	7.4	26.8	4.5	50	2.1	3.2		
Mycogen	8N251	1074 ± 161	1392	755	7.4	23.0	4.8	60	2.8	1.8		
Advanta Pacific	461 NS	1057 ± 164	908	1206	7.6	23.0	4.1	64	2.2	2.3		
Triumph	660 CL	934 ± 163	649	1219	8.1	23.5	4.4	68	3.5	4.0		
Confectionary (non-oilseed) Hybrids												
Triumph	777 C ‡	1249 ± 162	1717	781	8.9	16.0	5.5	79	3.6	1.5		
Avg.		1344	1473	1215	7.6	24.2	4.9	67	2.9	2.8		
L.S.D.⁰⁵		440	830	341								
C.V. (%)		28.3	33.8	16.8								

† All yields adjusted to 10% moisture

‡ Confectionary Type

†† CL = tolerant to imazamox (Beyond) herbicide

lbs / ac + 25 = bushels per acre

Lodging = 1 to 5 scale; where 1 = 95% of plants erect; 2.5 = ~50% of plants leaning at an angle ≥ 45°; 5 = 95+% of plants leaning at an angle ≥ 45°.

Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed remaining; 2.5 = ~50% of plant seed eaten; 5 = 95+% of plant seed eaten.

Table 12. Mean yields and agronomic characteristics of 15 sunflower hybrids evaluated in two environments in Tennessee during 2004.

Brand	Hybrid	Avg. Yield†		Moisture at Harvest		Test Weight		Head		Plant		Bird Damage (n=1) %
		(n=2) ± Std. Err.	(n=2) ± Std. Err.	(n=1) %	(n=1) %	(n=2) lbs/bu	(n=2) lbs/bu	(n=2) Diameter	(n=2) Diameter	(n=2) Height	(n=2) Height	
		----- lbs/a -----	----- lbs/a -----	----- % -----	----- % -----	----- lbs/bu -----	----- lbs/bu -----	(n=2) in.	(n=2) in.	(n=2) in.	(n=2) in.	score
Traditional Hybrids												
Mycogen	SF270	801 ± 155	706	897	9.4	33.2	5.8	70	3.1	3.0		
Mid Oleic Hybrids (NuSun) ††												
Triumph	636	na	---	1776	9.3	29.8	7.3	72	3.1	---		
Mycogen	8N429 CL	1624 ± 137	1520	1729	9.2	30.3	6.4	68	2.3	1.5		
Deklab	DKF 38-80 CL	na	---	1772	9.5	30.5	6.5	59	2.8	---		
Monsanto	MH 4231	1430 ± 154	2222	639	11.2	31.3	5.9	65	2.3	1.5		
Interstate	HySun 450	1376 ± 137	1440	1313	9.6	31.5	6.3	66	2.0	2.0		
Triumph	620 CL	1329 ± 155	1520	1138	9.6	31.8	6.1	69	3.1	2.0		
Mycogen	8N251	1245 ± 137	1116	1373	9.5	33.4	6.1	66	2.5	3.0		
Triumph	645	na	---	1015	9.3	31.2	6.6	70	3.8	---		
Interstate	4880 NS/CL	1184 ± 137	1175	1192	9.2	32.3	6.7	69	2.4	1.5		
Deklab	DKF 38-30	1180 ± 137	1296	1063	10.5	32.3	6.3	68	2.5	3.5		
Deklab	DKF 35-10	1119 ± 198	1801	438	9.6	33.9	5.5	69	4.1	1.5		
Triumph	667	1091 ± 137	1743	438	9.5	32.8	5.9	51	2.7	2.5		
Triumph	s675	1014 ± 154	1057	971	10.0	32.9	5.7	48	1.8	4.0		
Mycogen	8N352	933 ± 155	536	1331	9.7	33.5	6.2	66	2.4	2.0		
Avg.		1267	1410	1154	9.7	31.9	6.2	65	2.8	2.4		
L.S.D..05		428	944	444								
C.V. (%)		26.5	30.4	22.2								

† All yields adjusted to 10% moisture

‡ Confectionary Type

†† CL = tolerant to imazamox (Beyond) herbicide

lbs / ac + 25 = bushels per acre

Lodging = 1 to 5 scale; where 1 = 95% of plants erect; 2.5 = ~50% of plants leaning at an angle ≥ 45°; 5 = 95+% of plants leaning at an angle ≥ 45°.

Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed remaining; 2.5 = ~50% of plant seed eaten; 5 = 95+% of plant seed eaten.

Table 13. Mean yields and agronomic characteristics of 21 sunflower hybrids evaluated in three environments for two years (2006-2007) in Tennessee.

Brand	Hybrid	Avg. Yield†		Knoxville		Milan		Double Crop at Harvest		Test Weight		Plant Height		Lodging Damage		Bird Damage (n=2) %
		(n=6)	± Std. Err.	lbs/a	lbs/a	Milan	Milan	Moisture (n=4) %	Weight (n=6) lbs/bu	Diameter (n=2) in.	Height (n=6) in.	(n=6) score	(n=2) %			
Traditional Hybrids																
Dekalb	DKF 39-01	1200 ± 92		1544	1398	659		9.5	27.8	5.2	51	1.4	2.1			
Mycogen	8N270	1026 ± 88		1120	1131	829		10.0	28.6	5.1	47	1.6	2.1			
Mid Oleic Hybrids (NuSun) ‡																
Mycogen	8N453	1279 ± 87		1488	1355	994		9.5	28.0	5.5	54	1.2	2.3			
Triumph	636	1223 ± 103		1351	1495	824		10.7	26.7	5.3	55	1.8	2.0			
Triumph	s678	1194 ± 92		1043	1599	938		9.3	28.1	4.8	47	1.6	2.1			
Triumph	645	1158 ± 87		1194	1572	708		9.8	27.6	4.6	55	1.8	1.8			
Mycogen	8N386CL	1112 ± 91		818	1736	782		9.0	26.6	4.7	55	1.3	1.9			
Dekalb	DKF 35-10	1092 ± 88		932	1280	1064		10.4	27.8	4.8	54	1.4	1.8			
Mycogen	8N462DM	1058 ± 88		847	1512	815		10.1	28.7	5.1	52	1.3	2.8			
Dekalb	DKF 38-30	1030 ± 91		774	1539	778		9.5	28.9	5.0	53	1.4	2.3			
Mycogen	8D310	1028 ± 88		900	1230	955		8.7	23.7	4.4	53	1.2	1.6			
Triumph	660 CL	962 ± 91		714	1317	856		11.2	25.0	4.6	53	1.3	2.5			
Dekalb	DKF 37-31	960 ± 94		848	1265	768		9.3	27.5	4.8	50	1.4	1.8			
Dekalb	DKF 38-80 CL	940 ± 91		851	1280	688		10.0	26.0	4.7	46	1.3	2.3			
Mycogen	8N520DM	934 ± 91		688	1251	861		9.3	26.5	4.8	52	1.3	2.3			
Triumph	620 CL	910 ± 106		649	1424	659		8.6	26.8	4.0	53	1.6	2.4			
Triumph	665	780 ± 92		555	1107	678		8.6	27.8	4.9	51	1.9	1.9			
Mycogen	8N337DM	780 ± 88		691	1084	566		8.8	25.5	4.5	51	1.5	2.1			
High Oleic Hybrids ‡																
Triumph	845HO	1088 ± 91		737	1684	842		9.5	25.2	4.5	53	1.8	1.8			
Mycogen	8H419CL	1075 ± 92		863	1552	810		8.7	25.4	4.7	54	1.2	2.3			
Confectionary (non-oilseed) Hybrids																
Triumph	777 C ‡	1193 ± 92		923	1539	1116		10.1	18.1	5.2	59	1.8	1.5			
Avg.		1049		930	1398	818		9.5	26.5	4.8	52	1.5	2.1			
L.S.D..05		290		595	508	380										
C.V. (%)		33.9		50.4	24.1	30.5										

† All yields adjusted to 10% moisture

‡ Confectionary Type

¶ CL = tolerant to imazamox (Beyond) herbicide

lbs / ac + 25 = bushels per acre

Lodging = 1 to 5 scale; where 1 = 95% of plants erect; 2.5 = ~50% of plants leaning at an angle ≥ 45°; 5 = 95+% of plants leaning at an angle ≥ 45°.

Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed remaining; 2.5 = ~50% of plant seed eaten; 5 = 95+% of plant seed eaten.

Table 14. Mean yields and agronomic characteristics of nine sunflower hybrids evaluated in two environments for three years (2005-2007) in Tennessee.

Brand	Hybrid	Avg. Yield†		Moisture		Test		Plant		Lodging		Bird	
		± Std. Err.	(n=6)	Knoxville	Milan	at Harvest (n=5)	Weight (n=5)	Diameter (n=3)	Height (n=6)	score (n=6)	Damage (n=3)		
		-----	lbs/a	-----	-----	%	lbs/bu	in.	in.	score	in.	score	%
Mid Oleic Hybrids (NuSun) ††													
Triumph	636	1532 ± 95	1651	1413	1413	9.8	26.0	5.6	58	2.1	2.1	2.0	2.0
Triumph	645	1384 ± 96	1322	1446	1446	9.1	25.9	4.8	61	2.1	2.1	2.3	2.3
Dekalb	DKF 35-10	1262 ± 95	1208	1316	1316	9.7	27.2	4.8	58	1.6	1.6	2.1	2.1
Dekalb	DKF 38-30	1256 ± 99	1013	1498	1498	8.9	27.7	4.7	58	1.6	1.6	2.6	2.6
Dekalb	DKF 37-31	1228 ± 99	1225	1231	1231	8.7	26.9	4.9	55	1.6	1.6	2.0	2.0
Dekalb	DKF 38-80 CL	1086 ± 96	1033	1138	1138	9.4	25.1	4.8	52	1.9	1.9	2.2	2.2
Triumph	620 CL	1075 ± 99	735	1416	1416	8.3	27.3	4.1	58	2.1	2.1	2.9	2.9
Triumph	660 CL	988 ± 96	692	1284	1284	10.5	25.1	4.5	59	1.9	1.9	3.0	3.0
Confectionary (non-oilseed) Hybrids													
Triumph	777 C ‡	1237 ± 95	1188	1286	1286	10.1	16.8	5.3	67	2.2	2.2	1.5	1.5
Avg.		1228	1119	1337	1337	9.4	25.3	4.9	58	1.9	1.9	2.3	2.3
L.S.D.^{.05}		379	612	455	455								
C.V. (%)		32.5	44.5	22.9	22.9								

† All yields adjusted to 10% moisture

‡ Confectionary Type

†† CL = tolerant to imazamox (Beyond) herbicide

lbs / ac + 25 = bushels per acre

Lodging = 1 to 5 scale; where 1 = 95% of plants erect; 2.5 = ~50% of plants leaning at an angle ≥ 45°; 5 = 95+% of plants leaning at an angle ≥ 45°.

Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed eaten; 2.5 = ~50% of plant seed eaten; 5 = 95+% of plant seed eaten.

Table 15. Mean yields and agronomic characteristics of six sunflower hybrids evaluated in two environments for four years (2004-2007) in Tennessee.

Brand	Hybrid	Avg. Yield†		Moisture at Harvest (n=6)	Test Weight (n=7)	Head Diameter (n=5)	Plant Height (n=8)	Lodging (n=8)	Bird Damage (n=4)
		± Std. Err. (n=8)	± Std. Err. (n=8)						
		----- lbs/a -----	----- lbs/bu -----	%	lbs/bu	in.	in.	score	%
Mid Oleic Hybrids (NuSun) ††									
Triumph	636	1637 ± 90	1770	1504	26.6	6.3	62	2.4	2.0
Triumph	645	1346 ± 90	1353	1338	26.8	5.5	63	2.6	2.3
Dekalb	DKF 38-30	1237 ± 83	1084	1390	29.1	5.3	61	1.8	2.9
Dekalb	DKF 35-10	1227 ± 90	1356	1097	28.7	5.1	61	2.2	2.0
Dekalb	DKF 38-80 CL	1193 ± 90	1089	1297	26.0	5.5	54	2.1	2.1
Triumph	620 CL	1139 ± 85	931	1346	28.6	4.9	61	2.3	2.8
Avg.		1296	1264	1329	27.6	5.4	60	2.2	2.3
L.S.D.^{.05}		368	602	437					
C.V. (%)		31.6	42.0	22.9					

† All yields adjusted to 10% moisture

‡ Confectionary Type

†† CL = tolerant to imazamox (Beyond) herbicide

lbs / ac + 25 = bushels per acre

Lodging = 1 to 5 scale; where 1 = 95% of plants erect; 2.5 = ~50% of plants leaning at an angle ≥ 45°; 5 = 95+% of plants leaning at an angle ≥ 45°.

Bird Damage = 1 to 5 scale; where 1 = 95%+ of plant seed remaining; 2.5 = ~50% of plant seed eaten; 5 = 95+% of plant seed eaten.

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