Cool Season Greens Production

(Spinach, Collard, Kale, Mustard, Turnip, Leaf Lettuce)

Lynn Brandenberger
Extension Vegetable Specialist

James Shrefler
Extension Horticulture Specialist

Eric Rebek
Extension Entomologist

John Damicone
Extension Plant Pathologist

Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

General Crop Information

In general, cool season leafy greens are highly nutritious and have become popular with consumers interested in improving the quality of their diets with these nutrient-dense crops. This group includes a number of different plant families including the Chenopods (spinach, Swiss chard, beet greens), Brassicas (collard, kale, mustard, turnip) and Composit family (leaf lettuce). The group in general thrives at cooler temperatures (55 F to 60 F), but vary in their tolerance to both higher and lower temperatures (Table 1). Generally, greens are cool season leafy crops grown in the field during both the spring and fall seasons. In addition, spinach is also seeded during late fall with the crop overwintering to produce an early spring harvest the following year. Greens grow best in moderately deep, friable, highly fertile soils. Recently, this group of crops was investigated in Oklahoma regarding the potential for fresh-market production in high tunnels during the fall through spring season (http://www.hortla.okstate.edu/research-and-outreach). Results of these trials showed good potential for production during this season, but as with all fresh-market crops, a market needs to be developed by those interested in pursuing this type of production (Table 2).

Table 2. Potential yield of cool season greens.

Crop	*Processing yields tons per acre*	*Fresh market yields bushels[1] per acre*
Spinach[2]	6 to 8	500 to 650
Turnip[2]	6 to 12	500 to 1,000
Mustard[2]	8 to 10	500 to 800
Collard	8 to 10	500 to 800
Kale	8 to 10	500 to 800

[1] 22 to 25 pounds per bushel.
[2] Additional harvests in the same planting can produce an additional 4 to 5 tons per acre for each harvest.

Table 1. Cool season leafy greens: growing temps, tolerance and nutritive values.

Crop	*Growing temps (°F)*	*Cold Tolerance*	*Vitamin C*	*Folate*	*Vitamin A*	*Lutein*
Spinach	60-65	H	L	H	H	H
Swiss chard	60-65	M	L	L	M	H
Collard	60-65	M	L	H	M	M
Kale	60-65	H	H	L	H	SH
Mustard	60-65	M	M	H	H	M
Turnip	55-60	M	L	L	H	H
Leaf lettuce	65-70	L	L	L	L	L

Code designations: L = low, M = medium, H = High, SH = super high.

Within Oklahoma, spinach acreage is highest among the cool season greens. It grows most rapidly under sunny conditions, with fairly long days and temperatures of 65 F to 75 F during the day and 40 F to 45 F at night. Bolting (flower-stalk initiation) can be an issue with all greens, but is most common in spinach. Bolting in spinach is initiated during early plant growth with temperatures between 57 F to 68 F., 12-hour or longer days, and increasing daytime temperatures. As all greens crops become undesirable for market if they bolt, it is important to select varieties for greens that are bolt resistant particularly for spring production.

Varieties

Recommended commercial varieties for Oklahoma can be found in fact sheet HLA-6035 "Commercial Vegetable Varieties for Oklahoma." HLA-6035 is updated every three to five years with variety recommendations based on both in-state trials and review of availability of varieties. Table 3 shows the current recommendations for cool season greens.

Table 3. Days to harvest and variety recommendations for cool season greens.

Crop	*Average days to harvest*[1]	*Varieties*[2]
Spinach	35-90	Baker, Bolero, Crescent, F 91-415/EB3, F 97-154/EB, Olympia, Regal, Teton
Turnip	45-50	Alltop, Shogoin, Southern Green
Mustard	50-55	Florida Broadleaf, Southern Giant Curled, Tendergreen, Savanna
Collard	70-85	Champion, Georgia, Top Pick, Vates, Flash, Bulldog
Kale	45-55	Blue Ridge, Lacinato, Redbor, Improved Dwarf Siberian, Red Russian, Vates
Lettuce	40-50	Buttercrunch, Nancy, Green Towers, Vulcan, Red Sails, Tropicana, Two Star

[1] Days to harvest based on direct seeding, transplanting will reduce time by 10 to 14 days.
[2] Greens for processing are normally contracted and the contract will designate the variety.
[3] EB = early bolting, fine for fall plantings, but will flower in the spring.

Soil pH and Fertilizer

Neutral to slightly acid soil (pH 5.5 to 6.8) are preferred by turnip, mustard, collard and kale. Spinach prefers a pH of 6.0 to 6.8. Apply lime if soil pH is too low. Based on OSU soil test results, the following amounts of phosphorous and potassium are recommended.

Table 4. Phosphorous and potassium requirements for cool season greens.

Phosphorous Requirements (pounds P_2O_5/Acre)					
When test shows	0	10	20	40	>65
Add lbs. P_2O_5	150	125	100	55	0
Potassium Requirements (pounds K_2O/Acre)					
When test shows	0	75	125	200	>250
Add lbs. K_2O	150	125	100	50	0

Nitrogen — Apply 70 pounds per acre of nitrogen (N) preplant. Greens should be top-dressed with an additional 50 pounds of N three weeks after emergence. Additional N may be needed for desirable color and rapid growth. When additional cuttings are to be taken from a planting, an additional 50 pounds per acre of N should be applied immediately after cutting to stimulate rapid growth.

For overwintered spinach, apply 50 pounds per acre of N preplant and 50 pounds per acre three weeks later. In January and again in February, apply 50 pounds per acre of N for a total of 200 pounds per acre of N for the overwintered spinach crop. For additional information, see OSU Extension Fact Sheet HLA-6036, “Soil Test Interpretations for Vegetable Crops.”

Soil Preparation and Planting

Proper soil preparation is important to ensure uniform stands and high yields. Work the soil before planting to destroy any weeds and to bury all crop-residue from previous crops. Make sure the depth is adequate, so future operations will not bring the residue back to the surface. Previous crop residue, tree leaves and other plant debris can end up in the harvested crop and be a serious problem. Soil preparation should result in flat or raised beds with a “table top” finish of uniform soil. This permits an even depth of planting and more efficient mechanical harvesting.

Table 5. Approximate planting dates for leafy greens grown in central Oklahoma.

Crop species	*Spring*	*Fall*	*Overwinter*
Spinach	Mid-January to late March	September to late-October	November through December
Turnip	Early-March to May	September to early-October	None
Mustard	Mid-March to May	September to early-October	None
Collard	Mid-March to mid-April	September	None
Kale	Mid-March to May	September to early-October	None
Lettuce	April after last frost	September (won't tolerate frost)	None

Dates for southern Oklahoma would be about one week earlier and northern areas one week later than the central Oklahoma dates.

Single rows may be spaced 30 to 36 inches apart for hand harvesting. For mechanical harvesting, plan the row and bed spacing to fit the harvester. As a general rule, plant four rows of turnip, mustard, collard or kale about 16 inches apart on 72-inch beds. Plant 3.5 pounds to 5 pounds of seed per acre for turnips. About 5 pounds of seed per acre is needed for mustard, collard and kale. For processing spinach, plant 15 to 20 pounds of seed per acre with six or seven rows on a 72-inch bed. Hand-harvested, fresh market spinach can be planted with 8 pounds to 10 pounds of seed per acre. Plant seeds about ½ inch deep on sandy loam soils and a more shallow depth on heavier textured soils. As a general rule, a more exacting method to determine plant populations for brassica and spinach greens would be to target somewhere between 650,000 to nearly 1,000,000 seeds per acre. The actual amount will depend on the planting system used and what type of harvested product is desired as in processing, fresh or baby-leaf products. Leaf lettuce could be direct seeded at a rate between 22,000 to 44,000 seeds per acre, depending on whether it is a Romaine or leaf lettuce. For direct seeded plantings, stands will need to be thinned to 1 to 2 square feet per plant for leaf and Romaine types. One other option for lettuce is to use transplants, which will reduce the amount of time required for cropping, but realize that cost per acre will increase accordingly.

Cultivation and Chemical Weed Control

Weed control is essential for growing leafy crops, and particularly for those that are machine harvested. Crops grown for processing will be rejected if contaminated with weed debris and fast-growing weeds easily shade and outcompete slower growing greens to reduce crop quality and yield. Cultural weed control includes selecting fields with less weed pressure, shallow cultivation and providing the crop with a good start with high quality seed, proper seeding and fertility. If chemical weed control will be used, recommendations for herbicides can be found in the latest edition of Extension publication E-832, "Extension Agents' Handbook of Insect, Plant Disease, and Weed Control" which is updated annually. Another source of information for labeled pesticides for Oklahoma is the Kelly Solutions website: http://www.kellysolutions.com/ok/pesticideindex.htm. As with any pesticide application, make certain to read and follow the label directions for both effectiveness and safety.

Irrigation

Adequate water is critical for all vegetable production because it is a key element for plant health including plant growth, movement of plant nutrients and cooling of the crop. Greens are shallow-rooted and fast growing, therefore they require irrigation under most conditions within the state. Leafy greens are produced for their leaf tissue with no concern for fruit or seed production, which means that a steady rapid growth of the crop is critical for producing high quality and good yields. Processors will not contract with growers who cannot provide irrigation. Irrigation must be applied before plants show symptoms of water stress to keep them in an active growing condition. Yields and quality are enhanced by irrigation and proper fertility.

Diseases

In the production of greens, it is important to keep foliage free of blemishes because leaves are the edible part of the crop. Spinach and brassica greens are affected by numerous diseases caused by fungi, bacteria, viruses and nematodes. Spinach and brassica greens are botanically distinct and generally are affected by different plant diseases. However, disease management strategies such as crop rotation with non-host crops and tillage to incorporate old crop reside into the soil are important for both crop groups. Frequent cropping of these crop groups on the same land can result in an increase of pathogen levels that cause severe disease in future crops. Likewise, leaving abandoned crops unattended can facilitate further growth and reproduction of pathogens after harvest and permits extended survival of many pathogens. Incorporation of crop residue into the soil soon after harvest hastens decomposition of old crop residue and reduces survival of pathogens that survive best on it.

In spinach, the most important foliar diseases are white rust (*Albugo occidentalis*) and anthracnose (*Colletotrichum dematium*). Both of these diseases are caused by fungi that produce leaf spots, which can reduce quality and commercial acceptance. White rust is best controlled by planting resistant cultivars and hybrids and by fungicide spray programs. Both strategies are required under severe disease pressure. Anthracnose is a disease of increasing importance that has proven to be difficult to control because resistant varieties are not available and fungicides are not very effective. Therefore, it is important to try to limit the introduction of the anthracnose fungus into spinach production fields on soil and plant debris.

Spinach is also affected by soilborne diseases such as Fusarium wilt (*Fusarium oxysporum* f. sp. *spinaciae*) and root-knot nematode (*Meloidogyne* spp.). Fusarium wilt is a problem on acid soils repeatedly cropped to spinach. Management strategies for Fusarium wilt include liming to raise soil pH, planting partially resistant cultivars and fungicide seed treatment. Root-knot nematode is difficult to manage once a field is contaminated, so care should be taken to prevent the introduction of nematodes with soil from infested fields.

Virus diseases sporadically occur in spinach, causing deformed plant growth and plant stunting. Cucumber mosaic virus (CMV) and beet curly top virus (BCTV) are the most com-

mon virus diseases of spinach in Oklahoma. CMV is spread by aphids and BCTV is spread by the beet leafhopper, but insecticide sprays to control the insect vectors is not effective in reducing levels of virus-infected plants. CMV is managed by planting resistant cultivars. Effective controls for BCTV are not available.

Foliar diseases of brassica greens caused by fungi include: Alternaria leaf spot black spot (*Alternaria* spp.). Cercospora leaf spot (*Cercospora brassicae*), and downy mildew (*Peronospora parasitica*). Fungicide application is effective in controlling fungal leaf spots. Bacterial diseases including black rot (*Xanthomonas campestris* pv. *campestris*), Xanthomonas leaf spot (*Xanthomonas campestris* pv. *armoraceae*), and bacterial leaf spot or peppery leaf spot (*Pseudomonas syringae* pv. *maculicola*) are important on brassica greens. Bacterial diseases are difficult to control because copper sprays are only partially effective. Incorporation of infested brassica residues into the soil reduces bacterial survival. Consult OSU Extension fact sheet EPP-7666, "Diseases of Leafy Crucifer Vegetables" for more information on diseases of brassica greens.

Both spinach and brassica greens are affected by damping off caused by *Fusarium* spp., *Pythium* spp., and *Rhizoctonia solani*. Damping off, which reduces stand establishment, is controlled by fungicide seed treatment. For a listing of seed treatment fungicides, foliar fungicides and bactericides registered for use on spinach and brassica greens, consult the current edition of Extension publication E-832, "Extension Agents' Handbook of Insect, Plant Disease, and Weed Control."

Insects

Several insect pests are common problems for growing greens, which include spinach, turnip, mustard, collard and kale. The insects described herein are common to each of these crops. The approach to managing pests of greens varies somewhat according to the crop's intended use. For example, fresh market greens can tolerate little damage to the foliage, while the primary concern for processed greens is contamination of the product with insects. For specific insecticide information, refer to the current edition of Extension publication E-832, "Extension Agents' Handbook of Insect, Plant Disease, and Weed Control."

Aphids

Aphids are small, soft-bodied insects which remove plant sap through their sucking mouthparts. Aphids are recognized by cornicles (pipe-like appendages) protruding from their abdomens, visible under light magnification. Several aphid species, including the cabbage aphid, turnip aphid and green peach aphid may be serious pests of greens. Aphids live in small, compact colonies formed after the immigration of winged adults. Females reproduce asexually and give birth to several live nymphs per day. Because generation time is short, i.e., less than two weeks, many generations per year are produced, allowing for tremendous reproductive potential. Fields are colonized by winged adults migrating from other crops or weeds, and non-winged individuals reproduce and spread throughout the field. Damage to greens by aphids is manifested as stunting of growth, distortion of leaves and potentially a reduction in tonnage. They are found on the underside of leaves and often stick to leaves after they have been killed by insecticides. Contamination of the harvested greens with aphids requires considerable effort during the washing process to remove them. The presence of aphids in greens creates a secondary problem by attracting lady beetles and parasitic wasps, which attach themselves to leaves as they reach the pupal stage. In spinach, aphid populations tend to increase faster on an overwintered crop than spring-planted spinach.

Management. Natural control from parasites, predators (such as lady beetles and lacewings) and environmental factors (such as heavy rainfall) can sometimes be effective in maintaining aphid populations, especially during fall production. However, the presence of these parasites and predators also poses a contamination problem, especially for processed greens. Wild mustards serve as hosts for cabbage aphids and may speed the colonization of aphids into greens; therefore, the destruction of these weeds before planting as well as maintenance of field margins may reduce aphid problems. Chemical control can be achieved with insecticides, provided care is taken to ensure good coverage. The problem of poor coverage is especially true for spinach with leaves that curl under or are of the savoy type. Economic thresholds for aphids are not well defined for Oklahoma production. Control procedures are usually warranted shortly after aphids initially colonize and should be maintained below one to five percent of leaves infested, if possible. Fields should be monitored twice per week to gain representative samples of each area of a field, which aids in quick detection of aphid immigrations.

Several species of foliage-feeding caterpillar pests are common in greens grown in Oklahoma, including (in order of importance) cabbage looper, diamondback moth, imported cabbageworm and occasionally armyworms.

Cabbage Looper

Cabbage loopers are generally the most prevalent pest of the caterpillar complex. Looper adults are robust moths with brownish-gray forewings that have a silver 8-shaped marking. Hindwings are light colored with dark margins. Eggs are dome shaped and laid singly, usually on the underside of leaves. The light green larvae have three pairs of jointed prolegs at the rear. The name "looper" comes from the characteristic method of moving about plants by a "looping" action. Young larvae feed on the lower surface of leaves, creating a windowpane effect. During warm temperatures, development from egg to adult takes about 18 days to 25 days. Four to five generations of cabbage loopers occur per year, with peak activity usually occurring in May or June and in late September for fall-planted crops.

Diamondback Moths

Adults of the diamondback moth (DBM) are small, grayish-brown moths whose wings have a light-colored diamond pattern when folded at rest. Larvae are much smaller than looper larvae (usually less than one-third inch long) and have a distinctive appearance. Prolegs are present on the last segment of larvae and are spread apart, forming a "V" shape. Larvae of DBM wriggle abruptly when disturbed, often dropping from the plant. Pupae are light green and are covered with a loosely spun, gauze-like cocoon. The life cycle takes about four weeks to six weeks from egg to adult. In recent years, DBM has achieved major pest status in greens and has become increasingly difficult to control with insecticides.

Imported Cabbageworm

Adults of imported cabbageworm (ICW) are white butterflies with brown or black-tipped forewings and one or two dark spots on each forewing. Eggs are cigar shaped, pale yellow and are laid singly on the underside of leaves. The velvet-like larvae of ICW are pale green with a faint stripe down the back. The chrysalis or pupa is angled and may be green, gray or brown. Cabbageworm eggs hatch in three days to seven days and larvae develop through five instars in 10 to 14 days. The entire life cycle takes four weeks to six weeks. Imported cabbageworm is better adapted to cool weather than other caterpillar pests, occurring usually in mid-April in most years.

Armyworms

This group includes several species, with the beet armyworm and yellow striped armyworm usually being most common. Adult armyworms are robust, dark moths that somewhat resemble cabbage looper adults. Eggs are laid in tight clusters, and in the case of the beet armyworm, are covered with hair-like scales from the female's body, giving them a cottony appearance. Beet armyworm larvae are usually light green with a dark spot on the side of the body above the second true leg, while the yellow striped armyworm has a pair of yellow stripes running the length of its body on top. The life cycles of armyworms take about three to five weeks to complete, depending on temperature. Many hosts can be utilized by armyworms, including other crops such as beets, peppers, tomatoes, beans and cotton. Some weeds are also good hosts, particularly pigweed (*Amaranthus* spp.)

Caterpillar Pest Damage. Cabbage loopers, diamondback moths, imported cabbageworms and beet armyworms all damage crucifers by chewing on foliage, causing ragged holes in leaves, and contaminating the harvested product with fecal material. In addition, as these caterpillars pupate, they usually attach themselves to leaf tissue and can subsequently contaminate harvested leaves. Attached pupae are difficult to remove. Defoliation of leaves can be tolerated to a certain extent on processed greens, but very little on greens intended for the fresh market.

Management. Decisions to apply insecticides should be based primarily on the presence of larvae. If the greens crop is sold for fresh market, little damage can be tolerated. Slightly more damage can be tolerated in processed greens. However, if good control is not maintained, the risk of contamination of the harvested crop increases. Recently, diamondback moth has become more difficult to control with insecticides and high levels of resistance have been observed in several production areas. Products containing *Bacillus thuringiensis* subsp. *kurstaki* (B.t.k.) can be effective for successful management of diamondback moth larvae, but reports of resistance to this microbial insecticide are now common. Destruction of crop residue and weeds that serve as alternate hosts for caterpillar pests is an important form of cultural control to reduce source populations. Because diamondback pupae survive in the soil and crop residue left behind after harvest, it is important to destroy crop residue by shredding and plowing it under the soil surface. Armyworm populations often build up on pigweed at field margins and in fields where weed control is poor. It is important to destroy any pigweed near fields where greens are grown a couple of weeks before planting.

Flea Beetles

Flea beetles are tiny beetles that vary in color from metallic green to dark brown. Flea beetles chew on foliage of greens and when present in large numbers can cause severe defoliation of plants. Although larvae can feed on the roots of plants, it is the adult beetle that causes the greatest damage. Through feeding, they make small pits in leaves that create a "shothole" appearance in the leaf. Flea beetles will feed on newly emerged plants and can destroy the cotyledons by feeding on the growing plant. Their host range is broad and they sometimes move in large numbers into crops from adjacent weeds.

Management. It is important to provide good weed control in and around the field to reduce source plants for the beetles. The use of an insecticide becomes necessary when beetles are present in fairly large numbers and a significant amount of defoliation is imminent.

Seedcorn Maggots

Seedcorn maggots can be a serious problem, especially during cold, wet seasons and on soils high in organic matter. Adults are small, gray flies that resemble small house flies. Larvae (called maggots) are white, cone shaped and legless. They feed in the terminal, damaging emerging leaves and larger plants (overwintered spinach), and their numbers peak in October and April of years with excessive rainfall. Freshly disturbed soil, fields with decaying crop residue, or soils high in organic matter are preferred egg-laying sites for females. Several generations occur per year and their host range is broad, including most vegetable crops. Survival of maggots is low during the summer months or during periods when soil moisture is limiting.

Management. In soils where crop residue has not had time to degrade sufficiently or where organic matter content is relatively high, it is advisable to broadcast and lightly incorporate a soil insecticide to prevent seedcorn maggot eggs from hatching. Plowing crop residue earlier to allow degradation may be appropriate under some circumstances.

Harvesting

Greens for processing are machine harvested and bulk loaded for delivery to the processing plant within a few hours. With good cultural practices, there is the potential for up to three to four harvests of spinach from a single planting, but multiple harvests can increase the probability of foliar diseases during the growing season and in subsequent seasons. Turnips and mustard may also be harvested more than once per planting.

Greens for fresh market are usually hand harvested except for spinach, which is often machine harvested. Turnip, mustard, collard and kale are harvested when stalks are fairly young and tender. Most fresh market greens can also be harvested multiple times if whole plant cuts are not being made. Leaf and Romaine lettuce are harvested when the plants have reached a suitable size for market with leaves being full, but not showing signs of yellowing or bolting. They should be clean and free of diseased or dying leaves. Lettuce is normally harvested as a whole plant by cutting just below the lowest leaves.

Handling and Marketing

Fresh market turnip, mustard, collard and kale greens are hand bunched with three to five stalks per bunch. Lower leaves that are discolored or dying are removed when they are bunched. Bunched greens are usually washed and packed in buckets, crates or cartons containing 24 bunches weighing 23 pounds to 24 pounds. Cartons or crates of 24 bunches of spinach usually weigh 20 pounds to 22 pounds. Fresh spinach is also packed in bushel crates (20 pounds to 25 pounds) without bunching. Spinach is often prepackaged before retail marketing in plastic bags to maintain freshness. Greens are usually top-iced before shipment, but this is a slow method of cooling. Since greens have high respiration rates, it is important to cool them quickly to reduce quality loses due to warm temperatures and the high respiration rates that accompany higher temperatures. Some wholesale buyers demand more effective cooling prior to loading for long distance shipping.

Storage

Greens are normally not stored for extended periods of time. They should be stored at high relative humidity (95 percent to 100 percent) and at temperatures of 32 F. If the proper storage conditions are met, leafy greens will remain in fairly good condition for 10 days to 14 days in fresh market situations. Greens for processing are normally processed within hours of harvest and may or may not be stored at optimum conditions due to the short time frame between harvesting and processing.

Other Information available at the following websites:

USDA Nutrient Data Lab: http://fnic.nal.usda.gov/food-composition/usda-nutrient-data-laboratory

The original text for this fact sheet was developed by J.E. Motes, Bob Cartwright and John Damicone at Oklahoma State University.

The Oklahoma Cooperative Extension Service
Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 82 cents per copy. 0116 GH.