

UC Pest Management Guidelines

MOSQUITOES

Home & Landscape

(Published: 2/98)

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There are more than 50 species of mosquitoes in California. They occur in a variety of habitats in the state, ranging from deserts at or below sea level to high mountain meadows at elevations of 10,000 feet or more. Many species of California mosquitoes are relatively uncommon and seldom pose a threat to the health or well-being of California citizens. However, there are several species that readily attack people, and some species are capable of transmitting microbial organisms that cause human diseases such as malaria and encephalitis. The mosquitoes of major concern in California belong to the genera *Culex*, *Aedes*, and *Anopheles*.

IDENTIFICATION

Mosquito adults are small, flying, midgelike insects. Female mosquitoes can be differentiated from similar insects by the presence of a long slender proboscis that is adapted for piercing skin and sucking blood, and long slender wings that are covered with small scales. Male mosquitoes have scale-covered wings, but their probosces, or beaks, are shorter and thicker than the females', and are adapted for sucking plant juices and other sources of sugar rather than blood. In the immature stages, called larvae or wigglers, mosquitoes are usually black or dark brown and occur in nonmoving or nearly still water. Most mosquito larvae have a [distinctive siphon \[59K\]](#) or air tube at the rear of their bodies. The next stage is the pupal stage; pupae, called tumblers, are also aquatic and are small, roundish forms, usually black in color.

LIFE CYCLE

The life cycles of mosquitoes vary widely from species to species. Some female mosquitoes lay single eggs on water surfaces; others lay single

eggs on moist soil where later flooding is likely. Still other species lay batches of eggs, called [rafts \[34K\]](#), 100 or more at a time on water surfaces. Eggs deposited on water surfaces usually hatch within a day or so, but eggs laid on soil surfaces do not hatch until flooding occurs, which may be months or even years later. Larvae, which are nearly invisible to the naked eye, hatch from eggs. Larvae molt three times to become 4th-stage larvae. Several days later, this larval form molts again to become a pupa. Adult mosquitoes emerge from pupae 1 to 2 days after that, with male mosquitoes always emerging first. In summer the entire life cycle, from egg to adult, may be completed in a week or less.

PUBLIC HEALTH AND VETERINARY IMPORTANCE

Female mosquitoes of nearly all species require blood from vertebrate animals to develop eggs, and many species bite people, pets, and livestock for this purpose. The most important consequence of this is the transmission of microorganisms that cause diseases such as western equine encephalomyelitis and St. Louis encephalitis. Both of these diseases can cause serious, sometimes fatal neurological ailments in people. (Western equine encephalomyelitis virus also causes disease in horses.) Western equine encephalomyelitis infections tend to be more serious in infants while St. Louis encephalitis can be a problem for older people. Some mosquitoes are capable of transmitting malaria to humans. If these mosquitoes suck the blood of a person that has malarial parasites, they may pass on the infection to the next person(s) they bite; however, malaria is currently rare in California.

Mosquitoes vector dog heartworm in California. Oak trees, common in foothill areas of California, provide tree holes that fill with water and harbor the larval stages of the principal vector of this disease. Even when no infectious diseases are transmitted by mosquitoes, they can be a health problem to people and livestock. Mosquito bites can result in secondary infections, allergic reactions, pain, irritation, redness, and itching.

MANAGEMENT

Mosquitoes are best managed on an areawide basis by public agencies that are either components of local health departments or are independent districts organized specifically for mosquito control. In California, there are more than 50 mosquito and vector control districts. Some are small and have responsibility for mosquito abatement in a few hundred square miles, while the activities of others may encompass one entire county or more. Mosquito control is accomplished by searching out mosquito larvae in standing water and treating the water with a material that kills the larvae. Many materials currently in use are biological in origin and are highly specific for mosquitoes, with little or no effect on other organisms.

On occasion, mosquito abatement agencies may also apply chemical pesticides to kill adult mosquitoes, but ordinarily only when adult populations become so large that they cause extreme annoyance to many people or when the threat of disease transmission to people is high. Control of irrigation water in agricultural areas to avoid excess runoff is an

important mosquito control method, but in recent years elimination of small bodies of water that can serve as wildlife habitat has ceased to be a mosquito control option because of habitat preservation concerns.

Around the Home

In many areas of California, efforts of public mosquito and vector control agencies keep mosquito numbers down to tolerable levels all or most of the time. However, some people in California live in areas of the state where there is no organized mosquito control. These are usually low-density areas in foothill, mountain, or desert regions. People living in these areas, or in other areas where mosquito populations become bothersome, can protect themselves from mosquitoes by using a variety of strategies that include maintaining fine mesh screens on windows and doors in good repair; checking for standing water; draining standing water or treating it with the microbial insecticide *Bacillus thuringiensis* subsp. *israelensis* or mosquito-eating fish; and wearing repellents and protective clothing outdoors during the mosquito season.

The most effective control methods are those targeted against the larval stage. Any area (excluding wildlife habitats such as wetlands or vernal pools) or object that can hold water for more than a few days should be filled with soil or cement, drained, discarded, treated with *Bacillus thuringiensis* subsp. *israelensis*, or stocked with mosquito fish. Even small containers like cinder blocks, flower pot saucers, or crotches of trees can provide a habitat for mosquito development if they remain filled with water for more than a few days. Always combine the use of any product with good sanitation practices that reduce breeding sites. Keep in mind, however, that mosquitoes can migrate several miles from where they develop. Even successful control of mosquito larvae on your premises may not result in reducing mosquito numbers or biting activity. See Table 1, below, for ways to reduce mosquito populations in a given situation.

Table 1. Checklist of Possible Mosquito Sources Around the Home	
Mosquito Sources	What to Do to Reduce Mosquitoes
Ponds	Stock pond with fish, or use <i>Bacillus thuringiensis</i> subsp. <i>israelensis</i> . Remove excess vegetation.
Swimming pools	Keep water off cover. Maintain water quality at all times.
Tree holes	Fill hole with sand or mortar.
Plastic pools	Drain water when not in use, or cover so mosquitoes cannot lay eggs.
Containers	Empty water. Store in an inverted position. Dispose. Cover so mosquitoes cannot lay eggs.
Bird baths	Change water at least once a week.

Standing water	Eliminate by draining. Fill in low areas.
Watering troughs	Stock with fish, or change water weekly.
Cooler drains	Prevent water from standing.
Street gutter or catch basins	Keep litter and garden debris out of gutter. Do not overwater yard.
Cesspool or septic tanks	Seal and cover opening so mosquitoes can't lay eggs.
Roof gutters	Clean once a year to remove debris.
Irrigated lawns or fields	Avoid overirrigation. Drain standing water.
Adapted from the Sacramento/Yolo Mosquito & Vector Control District.	

Mosquito Fish. The mosquito fish, *Gambusia affinis*, has been used worldwide for mosquito control. These fish are most effectively used in man-made bodies of water that do not connect with natural waters. They can be obtained from most vector control districts.

Bacillus thuringiensis subsp. israelensis. The bacterium *Bacillus thuringiensis subsp. israelensis* infects and kills mosquito larvae. It must be consumed by the larvae and acts as a stomach poison, damaging mid-gut cells of mosquito larvae. It is highly selective, killing only mosquitoes and larvae of a few other related flies. This pesticide is marketed in a variety of formulations for the home owner, the most common being the Mosquito Dunk, a donut-shaped float that lasts for about 30 days in water.

Outdoor Sprays. The use of insecticide sprays or outdoor foggers for control of adult mosquitoes is one option available. This option has its limitations in that while it may provide a temporary reduction of the adult population, which can be useful if the application is made shortly before a backyard picnic or family gathering, it has no lasting effect. Equipment for the application of outdoor sprays is expensive and complex.

Personal Protection

Probably the most effective method of personal protection from mosquito bites is to avoid places where mosquito densities are high and to avoid being out-of-doors at times of the day when mosquito activity is at its highest. In mountainous areas, most species of mosquitoes bite during the morning and afternoon hours and often not at all during periods of darkness. In some low elevation areas, such as the Central Valley, some mosquitoes tend to bite at night, while others bite during the day. The dominant mosquito species in an area depends on the location in the state; it is good to learn the activity patterns of the mosquitoes in your area.

Repellents. If you find yourself in a situation where you must be exposed to biting mosquitoes, there are several things you can do. First, minimize the exposed skin surface by wearing a hat or head net, long trousers, and a

long-sleeved shirt. Some mosquitoes will bite through lightweight clothing, but the number of bites received is definitely reduced if most areas of the body are covered. When mosquito densities become very high, you may want to apply a mosquito repellent. Most effective repellents contain DEET (N,N-diethyl-meta-toluamide). Commercial repellents contain varying concentrations of DEET, usually between 10 and 50%. DEET is an irritant to some people and it may damage synthetic materials such as clothing or plastics. Special formulations for children contain low concentrations of DEET in an oil-based medium that slowly releases the compound and limits its absorption through the skin; these formulations also work well for adults. The insecticide permethrin functions as a repellent when it is applied to clothing; it should not be used directly on the skin. Repellents have their drawbacks: they are effective only for about 4 hours or less depending on wind, high temperature, high humidity, and sweating. When applying DEET, thoroughly apply the material to all exposed skin, including behind the ears.

If you wish to avoid DEET, there are few, if any, effective alternatives. Plant oils such as those from birch, bluestem grass, geranium, pine, rosemary, spearmint, yarrow, lantana, and neem have been shown to be somewhat repellent to mosquitoes, but most are not available in commercial mosquito repellents.

Some body lotions such as Avon Skin-So-Soft offer a degree of protection from mosquito bites at least in part by forming an oily film on the skin's surface that prevents the insect's mouthparts from penetrating. Materials that form protective layers on the skin must be reapplied frequently.

Other Repellents. There is a vast array of other products marketed to repel mosquitoes, most of which are ineffective. These include wrist bands that contain an aromatic repellent, ultrasonic emitters, electric grids, electronic repellents, aromatic plants (the most common one is the so-called mosquito plant, *Pelargonium x citrosum*), incense coils, vitamins (B¹), and mixtures of brewer's yeast and garlic. Researchers have shown that all these methods are of little or no value in repelling mosquitoes. Oil of citronella, which is extracted from *Andropogon nardus*, has long been claimed to repel mosquitoes. Burning citronella candles or mosquito coils works best if there is relatively little air movement, but these products are only for use outdoors, which makes them mostly worthless. Electric bug zappers that are used to kill pest insects are probably counterproductive because many of the insects caught by these traps are those that prey on mosquitoes.

WARNING ON THE USE OF CHEMICALS

PUBLICATION INFORMATION

Pest Notes: Mosquitoes



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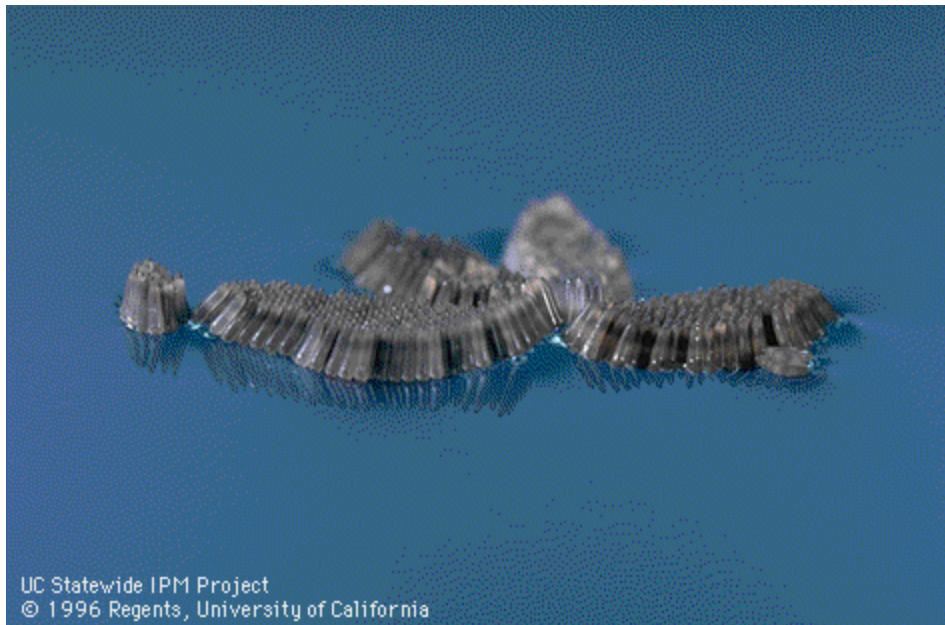
Pest Management and Identification



***Culex* mosquito larvae.**

Photo by Jack Kelly Clark.

Pest Management and Identification



Egg raft of encephalitis mosquito, *Culex tarsalis*.

Photo by Jack Kelly Clark.



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Warning on the Use of Chemicals

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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Glossary

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A

abdomen. The posterior body division of an arthropod.

abiotic disease. A disease caused by factors other than pathogens.

abiotic disorder. A disease caused by factors other than a pathogen; physiological disorder.

achene. A simple, one-seeded fruit in which the seed is attached to the ovary wall at only one point, such as the "seed" on the surface of a strawberry.

adventitious. A structure arising from an unusual place, such as roots growing from leaves or stems.

aestivation. A state of inactivity during the summer months.

albedo. White, spongy inner part of citrus fruit rind.

alkaline. Basic, having a pH greater than 7.

allelopathy. The ability of a plant species to produce substances that are toxic to certain other plants.

allowable depletion. The proportion of available water that can be used before irrigation is needed.

angular leaf spot. Bacterial blight.

annual. A plant that normally completes its life cycle of seed germination, vegetative growth, reproduction, and death in a single year.

antagonists. Organisms that release toxins or otherwise change conditions so that activity or growth of other organisms (especially pests) is reduced.

antenna (plural: antennae). The paired segmented sensory organs, borne one on each side of the head, commonly termed horns or feelers.

anthers. The pollen-producing organs of flowers.

anticoagulant. A substance that prevents blood clotting, resulting in internal hemorrhaging; may be used as a rodenticide.

apical dominance. Growth of the bud at the apex of a stem or tuber while growth of all other buds on the stem or tuber is inhibited.

apothecia (plural). Cup-shaped, spore-bearing structures produced by certain types of fungi such as *Sclerotinia*.

ascospores. A spore produced within the saclike cell of the sexual state of a fungus.

auricle. A small earlike projection from the base of a leaf or petal.

available water. The amount of water held in the soil that can be extracted by plants.

awn. A slender bristlelike organ usually at the apex of a plant structure.

axil. The upper angle between a twig or leaf and the stem from which it is growing.

axillary bud. A bud formed in an axil.

B

B.t. Abbreviation for *Bacillus thuringiensis*.

Bacillus thuringiensis. A bacterium that causes disease in many insects, especially caterpillars; formulations of the bacteria are used as insecticides.

bacterium (plural: bacteria). A single-celled, microscopic, plantlike organism that lacks a nucleus. Most bacteria obtain their nitrogen and energy from organic matter; some bacteria cause plant or animal diseases.

band application. An application in which a material such as fertilizer or herbicide is applied in strips, usually to the bed or seed row.

basin. A portion of a rice field bounded by levees.

beneficials. Organisms that provide a benefit to crop production, applied especially to natural enemies of pests and to pollinators such as bees.

biennial. A plant that completes its life cycle in two years and usually does not flower until the second season.

binomial sampling. A sampling method that involves recording only the presence or absence of members of the population being sampled (such as an insect pest) on a sample unit (such as a leaf), rather than counting the numbers of individuals; presence/absence sampling.

biodegradation. The breaking down of a chemical by organisms in the environment.

biofix. An identifiable event that signals when to begin degree-day accumulation.

biological control. The action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average level than would occur in their absence. Biological control may occur naturally in the field or result from manipulation or introduction of biological control agents by people.

biotic disease. Disease caused by a pathogen, such as a bacterium, fungus, mycoplasma, or virus.

biotype. A strain of a species that has certain biological characters separating it from other

individuals of that species.

blackarm. Bacterial blight lesions on stems.

blank. Nut with no kernel-consists of only the collapsed pellicle (skin).

blanking. Producing no grain or seed (used to describe individual florets of the rice panicle).

blight. A disease characterized by general and rapid killing of leaves, flowers, and branches.

blind node. The first node formed on a strawberry runner that usually does not form a daughter plant.

bolt. To initiate the growth of flower structures.

boot. A bulge in the upper leaf sheath caused by the expansion of the developing panicle.

bordeaux mixture. A fungicide made of a mixture of hydrated lime and copper sulfate.

border harvesting. A harvesting method that leaves a strip of uncut hay along every other border; next harvest these borders are mowed and the alternate borders are left standing.

borrow pits. Depressions on either side of a levee created when soil is removed from the field to build the levee.

botanical. Derived from plants or plant parts.

bract. A modified leaf at the base of a flower.

broad-spectrum pesticide. A pesticide that kills a large number of unrelated species.

broadcast application. The application of a material such as fertilizer or herbicide to the entire surface of a field.

brood. All the individuals of a generation that hatch at about the same time.

bud. Bud that forms in the axil of a leaf.

bulb. An underground storage organ, composed chiefly of enlarged, fleshy leaf bases.

C

calcareous soil. Soil containing high levels of calcium carbonate.

calibrate. To standardize or correct the measuring devices on instruments; to adjust nozzles on a spray rig properly.

calyx. The sepals of a flower; they enclose the unopened flower bud.

cambium. Thin layer of undifferentiated, actively growing tissue between phloem and xylem.

canker. A dead, discolored, often sunken area (lesion) on a root, trunk, stem, or branch.

canopy. The leafy parts of vines or trees.

carcinogen. A substance or agent capable of causing cancer.

caterpillar. The larva of a butterfly, moth, sawfly, or scorpionfly.

catfacing. Disfigurement or malformation of fruit; in the case of strawberries, usually the result of injury to developing achenes by Lygus bugs or low temperature.

catkin. A spikelike cluster of unisexual flowers, e.g., the male flowers of walnut.

cauda. A process resembling a tail.

certified seed or planting stock. Seeds, tubers or young plants certified by a recognized authority to be free of or to contain less than a minimum number of specified pests or pathogens.

certified transplants. Strawberry plants that have received a certification tag from the California Department of Food and Agriculture, production practices must meet standards for freedom from pest problems and plant samples from production fields must test free of viruses.

check. The part of a rice field between two levees.

chilling. In strawberries, exposure to temperatures low enough to induce the production of food reserves needed to support vigorous vegetative growth.

chlamydospore. Thick-walled spore formed from the cell of a fungus hypha.

chlorophyll. The green pigment of plants that captures the energy from sunlight necessary for photosynthesis.

chlorosis. Yellowing or bleaching of normally green plant tissue usually caused by the loss of chlorophyll.

chorion. The outer membrane of an insect egg.

circulative virus. A virus that systemically infects its insect vector and usually is transmitted for the remainder of the vector's life; persistent virus.

cocoon. A sheath, usually of silk, formed by an insect larva as a chamber for pupation.

cohort. A group.

cole crops. Any of the group of crucifer family crops that are varieties of the species Brassica oleracea, including cabbage, broccoli, cauliflower, and brussel spouts.

coleoptile. A sheathlike structure enclosing the shoot of a grass seedling.

collar region. In grasses, the region where the leaf blade and sheath meet; it is used in identifying species; in trees, the trunk area at the soil line.

companion planting. The practice of planting certain plant species-often herbs-in close association with crop plants to repel pests.

competitive exclusion agent. Organism capable of outcompeting other organisms, thus excluding them from the environment.

conidium (plural: conidia). A type of asexual fungal spore.

control action guideline. A guideline used to determine if pest control action is needed.

control action threshold. Pest population level at which treatment is necessary to prevent economic loss, also called economic threshold.

cornicle. Two tubular structures located on the posterior part of an aphid's abdomen.

cortex. Tissue between the phloem and the epidermis in roots and stems.

cotyledon. A leaf formed within the seed and present on a seedling at germination; seed leaf.

cover crops. Cultivation of a second type of crop primarily to improve the production system for a primary crop; examples include grasses or legumes maintained in orchards or vineyards and legume or other crops grown during the winter season to improve soil condition.

crawler. The active first instar of a scale insect.

crochets. Tiny hooks on the prolegs of caterpillars.

cross resistance. In pest management, resistance of a pest population to a pesticide to which it has not been exposed that accompanies the development of resistance to a pesticide to which it has been exposed.

crown. The part of the alfalfa plant from which new shoots are produced, emerging at soil surface just above taproot; the point at or just below the soil surface where the main stem (trunk) and roots join. Also used to refer to the topmost limbs on a tree or shrub; the shortened stem of a strawberry plant, from which roots, leaves, and fruit trusses arise.

culm. The jointed stem of grasses.

cultivar. A specially developed agricultural plant variety.

curing. Holding potato tubers under warm, humid conditions that favor wound healing.

cutout. A period of reduced growth and square production following a fruiting cycle.

D

damping-off. Destruction of seedlings by one or a combination of pathogens that weaken the stem or root.

daughter plants. Vegetative progeny of strawberry plants; plants that develop along the runners produced by another strawberry plant called the mother plant.

day-neutral. The term applied to strawberry cultivars that produce flower buds more or less independently of day length; everbearing.

degree-day. A unit combining temperature and time used in monitoring growth and development of organisms.

dehiscence. Opening naturally and regularly along lines of weakness; in fruits, opening along sutures to release seeds.

delayed dormant. Refers to the treatment period in fruit tree crops, beginning when buds begin to swell until the beginning of green tip development.

determinate. Having stems and branches that stop growing at a certain point, usually after producing flowers. In cotton, this term is applied to varieties with a distinct interruption in growth following fruit set.

developmental threshold. The lowest temperature at which growth occurs in a given species.

diapause. A period of physiologically controlled dormancy in insects.

disease. Any disturbance of a plant that interferes with its normal structure, function, or economic value.

disk. A type of cultivator made up of many circular blades used for weed control and soil preparation.

dormant. To become inactive during winter or periods of cold weather.

dough stage. A stage in grain development when the grain turns from a liquid to a soft doughy consistency before hardening.

drag off. The practice of removing soil from the tops of potato hills before sprout emergence.

drift. The aerial dispersal of a substance such as a pesticide beyond the intended application area.

DTPA. A chemical solution used to determine available zinc in the soil: [(carboxymethyl)imino] bis (ethyleneitrilo)l tetra-acetic acid.

dwarfing. A stunting of normal growth characterized in plants by smaller than normal leaves

and stems.

E

economic threshold. A level of pest population or damage at which the cost of control action equals the crop value gained from control action.

ectoparasite. A parasite that lives on the outside of its host.

embryo. The small plantlet within the seeds in almond, the embryo develops into the kernel.

endoparasite. A parasite that lives inside its host.

endosperm. The tissue containing stored food in a seed that surrounds the embryo and is eventually digested by the embryo as it grows.

English walnut. The walnut species (*Juglans regia*) used for the selection of commercial scion cultivars; origin believed in Persia (= Persian walnut).

entomophagous nematodes. Nematodes that eat insects.

epicotyl. The part of an embryo or seedling above the attachment point of the cotyledon(s).

epidermis. The outermost layer of living cells on the surface of a plant or animal.

evapotranspiration. The loss of soil moisture due to evaporation from the soil surface and transpiration by plants.

everbearing. Term applied to strawberry cultivars that produce flowers and fruit all year as long as temperatures are favorable; often used synonymously with day-neutral.

extrafloral nectary. A nectary located outside the flower.

eye. A collection of several buds on the surface of a potato tuber, one of which will sprout and form a new stem when conditions are favorable.

F

fallow. Cultivated land that is allowed to lie dormant, with no crops growing on it, during a growing season.

feeder roots. The youngest roots with root hairs, important in absorption of water and minerals.

field capacity. The moisture level in soil after saturation and runoff.

flag leaf. The terminal leaf of a grass plant; the last emerging leaf below the grain head.

flavedo. Outer part of the rind of citrus fruit, bearing oil glands and pigments.

flight. Period of flying activity of moths from one generation.

floret. An individual flower in a grass spikelet.

flower bud. A bud in which flower parts are contained.

frass. Solid fecal material produced by insects.

fruiting bodies. In fungi, reproductive structures containing spores.

fumigation. Treatment with a pesticide active ingredient that is a gas under treatment conditions.

fungicide. A pesticide used for control of fungi.

fungus (plural: fungi). A multicellular lower plant lacking chlorophyll, such as mold, mildew, smut, or rust. The fungus body normally consists of filamentous strands called mycelium and reproduces through dispersal of spores.

G

gall. Localized swelling or outgrowth of plant tissue, often formed in response to the action of a pathogen or other pest.

girdle. Damage that completely encircles a stem or root, often resulting in death of plant parts above or below the girdle.

glume. The outer bract of a grass spikelet.

glycoalkaloid. A bitter-tasting compound present in potato foliage and in the epidermis of potato tubers.

gossypol. A substance poisonous to many animals, produced by numerous small glands in most cotton varieties.

graft union. Place where the rootstock joins the scion or top part of a grafted tree or vine.

ground cover. Any of various low, dense-growing plants, as ivy, pachysandra, etc., used for covering the ground, as in places where it is difficult to grow grass.

H

head. The inflorescence of many grass plants, including small grains.

heat unit. Synonym for degree-day.

herbicide. A pesticide used to control weeds.

hibernaculum (plural: hibernacula). A shelter occupied during the winter by an insect, notably peach twig borer.

honeydew. An excretion from insects, such as aphids, mealybugs, whiteflies, and soft scales, consisting of modified plant sap.

horticultural oils. Highly refined petroleum (or seed derived) oils that are manufactured specifically to control pests on plants.

host. A plant or animal that provides sustenance for another organism.

hypha (plural: hyphae). One of the filaments forming the body, or mycelium, of a fungus.

hypocotyl. The portion of an embryo or seedling between the cotyledons and the developing root tip.

I

immune. Exempt from infection by a given pathogen.

incorporate. To mix a material such as an herbicide into the soil by mechanical action.

indeterminate. Having a growth pattern in which stems continue growing indefinitely; with flower clusters, the opening of the lower (lateral) flowers first, and the terminal one opening later.

indexing. Testing a plant for a virus infection, usually by grafting tissue from it onto an indicator plant.

infection. The entry of a pathogen into a host and establishment of the pathogen as a parasite of the host.

infestation. The presence of a large number of pest organisms in an area or field, on the surface of a host or anything that might contact a host, or in the soil.

inflorescence. flower cluster.

inner bark. In older trees, the living part of the bark, the phloem.

inoculum. Any part or stage of a pathogen, such as spores or virus particles, that can infect a host.

inorganic. Containing no carbon; generally used to indicate materials (for example, fertilizers) that are of mineral origin.

instar. The larval or nymph stage of an immature insect between successive molts.

integrated pest management (IPM). A pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as encouraging biological control, use of resistant varieties, and adoption of alternate cultural practices such as modification of irrigation or pruning to make the habitat less conducive to pest development. Pesticides are used only when careful monitoring indicates they are needed according to preestablished guidelines, treatment thresholds, or to prevent pests from significantly interfering with the purposes for which plants are being grown.

internode. The portion of a stem between two nodes.

invertebrate. An animal having no internal skeleton.

J

jointing. Elongation of rice internodes before flowering.

June bearing. A term applied to short-day strawberry cultivars.

juvenile. Immature form of a nematode that hatches from an egg and molts several times before becoming an adult.

K

L

larva (plural: larvae). The immature form of insects that develop through the process of complete metamorphosis including egg, several larval stages, pupa, and adult. In mites, the first-stage immature is also called a larva.

latent. Producing no visible symptoms (generally refers to an infection or a pathogen).

latent period. The time between when a vector acquires a pathogen and when the vector becomes able to transmit the pathogen to a new host; also, the time between infection of a host plant and production of inoculum by the infection.

layby application. An application, usually of fertilizer or herbicide, after the crop is well established; especially, an application at the latest time in the season when it is still possible to pass through the field with a tractor.

leaching fraction. The proportion of applied irrigation water that is added to meet the crop's leaching requirement.

leaching requirement. The amount of water in excess of a crop's evapotranspiration requirement that is needed to maintain maximum yield by leaching harmful salts from the root zone.

leaf area index. The ratio between the total leaf surface area of a plant and the surface area of ground that is covered by the plant.

leaf margin. The outer edge of the leaf; leaf margins may be smooth, lobed, indented, etc.

lenticels. Natural openings in the surface of a tuber or stem, similar to leaf stomata, that can open and close and allow gas exchange.

lepidopterous. Of or pertaining to the Order Lepidoptera, the moths and butterflies.

lesion. Localized area of diseased or discolored tissue.

ligule. In many grasses, a short membranous projection on the inner side of the leaf blade at the junction where the leaf blade and leaf sheath meet.

locule. One of the seed chambers in the ovary or boll.

lodging. The toppling of plants of a grain crop before harvest, often from wind, rain, or waterfowl.

M

mandibles. Jaws; the forward-most pair of mouthparts of an insect.

meconium. Fecal pellet excreted by a larva before pupation.

meristem. The collection of cells at the growing point of a plant that are capable of cell division.

metamorphosis. The change in form that takes place as insects grow from immatures to adults.

microbial pesticides. Pesticides that consist of bacteria, fungi, viruses, or other microorganisms used for control of weeds, invertebrates, or plant pathogens.

microorganism. An organism of microscopic size, such as a bacterium, virus, fungus, viroid, or mycoplasma.

micropropagation. Generation of new, disease-free potato plants from tiny pieces of meristem tissue.

microsclerotia (singular: microsclerotium). Very small sclerotia, such as those produced by the Verticillium wilt fungus.

milk stage. The early stage of grain development when the grain is filled with a milky liquid.

mineral oils. Synonymous with horticultural oils.

minituber. A small tuber produced under greenhouse conditions on a small potato plant generated by micropropagation.

modify environmental factors. Factors such as moisture and heat, and, in the case of

certain organic materials that decay, to gradually improve soil quality. Plant derived in (organic) or synthetic materials may be used.

molt. In insects and other arthropods, the shedding of skin before entering another stage of growth.

monitoring. Carefully watching and recording information on the activities, growth, development, and abundance of organisms or other factors on a regular basis over a period of time, often utilizing very specific procedures.

mulch. A layer of material placed on the soil surface to prevent weed growth.

mummy. Unharvested nut remaining on the tree (also called sticktight); the crusty skin of an aphid whose inside has been consumed by a parasite.

mutation. The abrupt appearance of a new, heritable characteristic as the result of a change in the genetic material of one individual cell.

mycelium (plural: mycelia). The vegetative body of a fungus, consisting of a mass of slender filaments called hyphae.

mycoplasma. A member of the genus *Mycoplasma*. Mycoplasmas, unlike viruses, can reproduce in the absence of a host and are the smallest free-living organisms; they have a unit membrane but no cell wall as do bacteria.

mycorrhizae. Beneficial associations between plant roots and fungi.

N

narrow-range oil. A highly refined petroleum or seed-derived oil that is manufactured specifically to control pests on plants, also called horticultural oil.

natural enemies. Predators, parasites, or pathogens that are considered beneficial because they attack and kill organisms that we normally consider to be pests.

necrosis. Death of tissue accompanied by dark brown discoloration, usually occurring in a well-defined part of a plant, such as the portion of a leaf between leaf veins or the xylem or phloem in a stem or tuber.

nectary. A gland that secretes nectar.

nodes. The leafbearing joints on plant stems.

nonpersistent virus. A virus that is carried on the mouthparts of its insect vector and is lost after the vector feeds once or a few times; styletborne virus.

nucellus. In plants, the watery tissue composing the chief part of the young ovule in the flower and inside the seed during early development. It furnishes nutrients to the young embryo and is digested by the developing endosperm and embryo.

nymph. The immature stage of insects such as grasshoppers and aphids, that hatch from eggs and gradually acquire adult form through a series of molts without passing through a pupal stage.

O

organic. A material (e.g. pesticide) whose molecules contain carbon and hydrogen atoms. Also may refer to plants or animals which are grown without the use of synthetic fertilizers or pesticides.

outer bark. In older trees, the dead part of the bark.

oviposit. To lay or deposit eggs.

oviposition. The laying or depositing of eggs.

P

packing tissue. Firm, membranous tissue lining the walnut shell and separating the kernel halves.

panicle. A branching cluster of flowers held on a stem, such as the flowering parts of most grasses.

pappus. The modified calyx of flowers in the sunflower family; usually takes the form of bristles, scales, or awns.

parasite. An organism that derives its food from the body of another organism, the host, without killing the host directly; also an insect that spends its immature stages in the body of a host that dies just before the parasite emerges (this type is also called a parasitoid).

parthenocarpy. Development of fruit without fertilization and seed.

parthenogenesis. Development of an egg without fertilization.

pathogen. A disease-causing organism.

peduncle. The stem of an individual flower or fruit.

peg roots. Primary roots.

pellicle. The covering (skin) that encloses the kernel; it is white during development but becomes brown at maturity.

perennial. A plant that can live three or more years and flower at least twice.

periderm. Several layers of corky cells located on the outside of the epidermis of a potato tuber and containing high amounts of suberin.

perithecium (plural: perithecia). A globular to flask-shaped fruiting body that has an apical pore through which the spores (ascospores) are released.

persistent virus. A virus that systemically infects its insect vector and usually is transmitted for the remainder of the vector's life.

pest resurgence. The rapid rebound of a pest population after it has been controlled.

pesticide. Any substance or mixture intended for preventing, destroying, repelling, killing, or mitigating problems caused by any insects, rodents, weeds, nematodes, fungi, or other pests; and any other substance or mixture intended for use as a plant growth regulator, defoliant, or desiccant.

pesticide resistance. The genetically acquired ability of an organism to survive a pesticide application at doses that once killed most individuals of the same species.

petiole. The stalk connecting the leaf to a stem.

pH. A value used to express relative acidity or alkalinity.

phenoxy herbicides. A group of herbicides derived from phenoxy-acetic acid, including 2,4-D, 2,4,5-T, 2,4-DB, MCPA and silvex.

pheromone. A substance secreted by an organism to affect the behavior or development of other members of the same species; sex pheromones that attract the opposite sex for mating are used in monitoring certain insects.

phloem. The food-conducting tissue of a plant, made up of sieve tubes, companion cells, phloem parenchyma, and fibers.

phloem-feeding. An organism that withdraws nutrients from the food-conducting tissue of a plant's vascular system.

photosynthate. The products of photosynthesis, used to support growth, respiration, and fruit production.

photosynthesis. The process by which plants convert sunlight into energy.

physiological disorder. A disorder caused by factors other than a pathogen; abiotic disorder.

phytotoxicity. The ability of a material such as a pesticide or fertilizer to cause injury to plants.

pinhead square. A square approximately 1/8 inch (3mm) or less in length.

pistil. Female part of the flower, usually consisting of ovules, ovary, style, and stigma.

pollinator. The agent of pollen transfer, usually bees.

pollinizer. The producer of pollen; the variety used as a source of pollen for cross-pollination.

pome fruit. A simple fleshy fruit, the outer portion of which is formed by the floral parts that surround the ovary.

postemergence herbicide. Herbicide applied after the emergence of weeds.

predator. Any animal (including insects and mites) that kills other animals (prey) and feeds on them.

preemergence herbicide. Herbicide applied before emergence of weeds.

primary bloom. The first production of flowers on a potato plant, occurring after 8 to 12 leaves have been formed on the mainstem and generally coinciding with the beginning of the tuber growth phase.

primary inoculum. The initial source of a pathogen that starts disease development in a given location.

primary roots. Roots that develop from the crown of a strawberry plant.

proleg. A fleshy, unsegmented leg of caterpillars.

propagules. Any part of a plant from which a new plant can grow, including seeds, bulbs, rootstocks, etc.

protectant fungicide. Fungicide that protects a plant from infection by a pathogen.

protective coverings. Any cloth, screen, plastic or other material placed over growing plants to prevent damage by pests or harsh weather.

prothorax. The anterior of the three thoracic segments of an insect.

pupa. The nonfeeding, inactive stage between larva and adult in insects with complete metamorphosis.

pupate. To molt from the larval stage to the pupa.

pustule. Small blisterlike elevation of epidermis from which spores emerge.

pycnidium (plural: pycnidia). Small, spherical or flask-shaped structure, formed by certain types of fungi, inside which spores are produced.

Q

quadrant. One of four equal parts into which a field is divided for monitoring.

R

random sample. A sampling plan in which locations for samples are not predetermined either by previous sampling in that field or the relationship of one sample site to another.

rat-tail bloom. A secondary bloom in Bartlett pears that results when terminal buds form and open on the current season's growth.

receptacle. The apex of the flower stem that bears the organs of the flower.

regrowth bud. The buds on alfalfa crowns that become new stems.

reproductive bud. The buds on alfalfa stems that become flowers.

reservoir. The site where a pest population or quantity of inoculum can survive in the absence of a host crop, and from which a new crop may be invaded.

residue management. Management of rice straw and stubble after harvest.

resistant. Able to tolerate conditions (such as pesticide sprays or pest damage) harmful to other strains of the same species.

respiration. The process by which nutrients are metabolized to provide energy needed for cellular activity.

rhizome. A horizontal, underground shoot, especially one that forms roots at the nodes to produce new plants.

rogue. To remove diseased plants from a field.

rolling. Mechanical crushing of potato vines to hasten vine death, sometimes used synonymously with vine-killing.

rootstock. An underground stem or rhizome; lower portion of a graft which develops into the root system.

rosette. A cluster of leaves arranged in a compact circular pattern, often at a shoot tip or on a shortened stem.

rosetted bloom. A flower whose petals have been tied together with silk by a pink bollworm larva.

rosetting. Abnormal growth caused by certain pathogens in which new potato foliage is stunted and tightly bunched.

rotation. The practice of purposefully alternating crop species grown on the same plot of land.

row covers. Any fabric or protective covering placed over rows of plants to protect them from pest damage or harsh climate.

rue leaf. Any leaf produced after the seed leaves (cotyledons).

rugose. A rough appearance of leaves in which veins are sunken and interveinal tissue raised, caused by certain virus infections.

ruminant. Any of the hoofed mammals (including cattle, deer, sheep) that chew the cud.

runner. Stolon of a strawberry plant, on which a daughter plant may develop.

russeting. Thickening of the periderm on tubers of russet cultivars that occurs after vine senescence.

S

sanitation. Any activity that reduces the spread of pathogen inoculum, such as removal and destruction of infected plant parts, cleaning of tools and field equipment.

scion. The portion above a graft that becomes the trunk, branch, and tree top; the cultivar or variety.

sclerotium (plural: sclerotia). A compact mass of hardened mycelium that serves as a dormant stage in some fungi.

secondary bloom. A second production of flowers on a potato plant, occurring at the end of the mainstem of an indeterminate cultivar; secondary bloom may occur on a determinate cultivar at leaf axils along the mainstem.

secondary infection. Infection by microorganisms that enter the host through an injury caused previously by another pathogen.

secondary outbreak. The increase of a nontarget pest to harmful levels following a pesticide application, caused by destruction of natural enemies that normally control the nontarget pest.

secondary roots. The network of fine roots that develops from the primary roots of a strawberry plant and picks up water and nutrients from the soil; white roots.

secondary spread. The spread of a pathogen within a field after the initial or primary infection.

secondary stems. Stems formed by stolons that emerge from the soil.

sedges. A group of grasslike, herbaceous plants that, unlike grasses, have unjointed stems. Stems are usually solid and often triangular in cross section.

seed leaf. The leaf formed in a seed and present on a seedling at germination; cotyledon.

seed piece. Portion of a potato tuber containing at least one eye that is planted to produce a new potato plant.

seedcotton. Harvested lint that is still attached to seeds; i.e., the lint before ginning.

selective pesticide. Pesticides that are toxic primarily to the target pest (and perhaps a few related species), leaving most other organisms, including natural enemies, unharmed.

self fruitful. The ability to set fruit with pollen from the same flower or tree.

senescence. The stage of growth in a plant or plant part from maturity to death, characterized by an accumulation of metabolic products, an increased respiratory rate, and a loss in dry weight.

sepal. One of the outermost flower structures which usually enclose the other flower parts in the bud.

sequential sampling. A sampling method in which the number of samples is not fixed in advance.

sessile. Attached or fastened, incapable of moving from place to place; attached directly without a stem.

seta (plural: setae). A bristle.

sheath. The part of a grass leaf that encloses the stem below the collar region.

short day. Term applied to strawberry cultivars that require a period of time with day length shorter than a minimum (about 14 hours) for the induction of flower buds; June-bearing.

side dressing. Fertilizer or other material added to the soil around a growing crop.

sieve tubes. See phloem.

skeletonize. To remove leaf tissue between the veins, leaving the network of veins intact.

soil profile. A vertical section of the soil through all its horizontal layers, extending into the parent material.

solarization. The practice of heating soil to levels lethal to pests through application of clear plastic to the soil surface for 4 to 6 weeks during sunny, warm weather.

sooty mold. A sooty coating on foliage or fruit, formed by the dark mycelia of fungi that live in the honeydew secreted by certain insects.

specific gravity. The ratio of the density of a substance to the density of pure water; specific gravity of potato tubers is used as a measure of their dry matter content.

spikelets. The collection of individual grass florets that are borne at the end of the smallest branch of the inflorescence.

spike. An elongated inflorescence in which the individual flowers are borne tightly against the main stem or rachis.

spiracle. An external opening of the system of ducts, or tracheae, that serves as a respiratory system in insects.

sporangium (plural: sporangia). A structure in which asexual spores are produced.

spore. A reproductive body produced by certain fungi and other organisms, capable of growing into a new individual under proper conditions.

sporulation. The production of spores.

spraing (sprain). Reddish brown spots, rings, or arcs in tuber tissue caused by tobacco rattle virus; corky ringspot.

sprout. The new stem formed from the eye of a potato tuber.

sprout inhibitor. A chemical applied to potato vines or to stored tubers to prevent sprouting.

spur. Short woody shoot that is the primary fruiting structure for most fruit trees.

square. A cotton flower bud.

staminate flower. A male flower.

stand decline. The gradual (over a period of 3-5 years) debilitation of the plants in an alfalfa field caused by the combined effects of pests and unfavorable environmental conditions.

stand establishment in an alfalfa field. The period of plant establishment between planting and first cutting.

stele. The central cylinder inside the cortex of the roots and stems of vascular plants; contains the vascular or conducting tissue.

sticktight. Nut that remains on the tree after harvest (also called mummy); nut with husk firmly adhering to shell.

stipe. A stalk.

stolon. A trailing aboveground stem or shoot, often rooting at the nodes and forming new plants.

stoma (plural: stomata). Natural opening in a leaf surface that serves for gas exchange and water evaporation and has the ability to open and close in response to environmental conditions.

stroma. A compact, usually spore-producing structure formed from fungal mycelium on the surface of a host.

stub cotton. A cotton crop in which the stalks are cut down after harvest but the crown and rootstock are left in the ground to regrow the following season.

styletborne virus. A virus that is carried on the mouthparts of its insect vector and is lost after the vector feeds once or a few times; nonpersistent virus.

suberin. A waxy substance, resistant to microbial attack, formed in the corky cells of periderm layers.

suberization. The formation of periderm layers on the cut surfaces or wounds of potato tubers.

substituted dinitroanilines. A class of herbicides widely used for preplant application in cotton.

sucker. Shoot arising from the trunk or rootstock.

summer planting. A system of strawberry culture in which planting occurs in summer and fruit production begins the following spring.

sun checking. Cracking or breaking of whole kernels of grain caused by exposure to alternating conditions of dew, sun, and water stress.

suture. Visible seam on hull.

synthetic organic pesticides. Manufactured pesticides produced from petroleum and containing largely carbon and hydrogen atoms in their basic structure.

systemic. Capable of moving throughout a plant or other organism, usually in the vascular system.

T

tail water. Irrigation water that has drained from a field.

taproot. The large primary root that grows vertically downward, giving off small lateral roots.

target pest. A pest species that a control action is intended to destroy.

teliospore. Thick-walled dark spore of rust and smut fungi that is able to survive adverse conditions.

tensiometer. A device for measuring soil moisture, consisting of a buried tube of water that develops a partial vacuum as surrounding soil dries out.

terminal. The growing tip of a stem, especially the main stem.

terminal spikelet stage. Stage in the development of the wheat spike when the primordia of the terminal spikelet are formed.

terrestrial biotype. A strain of an organism adapted to growing on land rather than in water.

tertiary bloom. The third production of flowers that occurs at the end of the growing stem of an indeterminate potato cultivar.

tertiary tiller. Branch of a grass plant that develops from the axil of a secondary tiller.

thorax. The second of three major divisions in the body of an insect, and the one bearing the legs and wings.

thurberia weevil. A race of the boll weevil that feeds on wild cotton.

tiller. Branch stem of a grass plant.

tolerance. Inherent lack of susceptibility to a pesticide. Also, the ability of a plant to grow in spite of infection by a pathogen.

tolerance level. Maximum percentage of a disease or pest symptom allowed during field inspections for certification of a seed lot; levels are different with each field generation and may vary from state to state.

top crop. Fruit produced in the second fruiting cycle of cotton, mainly on upper branches.

toxin. A poisonous substance produced by a living organism.

translocated herbicide. Herbicide that is able to move throughout a plant after being applied to leaf surfaces.

transpiration. The evaporation of water vapor from plants, mostly through stomata.

trap crop. A crop or portion of a crop intended to attract pests so they can be destroyed by treating a relatively small area or by destroying the trap crop and the pests together.

treatment threshold. The level of pest population at which a pesticide or other control measure is needed to prevent eventual economic injury to the crop.

true leaf. Any leaf produced after the cotyledons.

tuber. An enlarged, fleshy, underground stem with buds capable of producing new plants.

tuberization. The formation of tubers at the ends of stolons; tuber initiation.

U

unfurled. Unopened.

urediospore. Spore produced by a rust fungus that spreads the infection to other hosts.

V

variety. An identifiable strain within a species, usually referring to a strain which arises in nature as opposed to a cultivar which is specifically bred for particular properties; sometimes used synonymously with cultivar.

vascular ring. A thin area of potato tuber tissue between the cortex and the medulla in which vascular tissue is concentrated.

vascular system. The system of plant tissues that conducts water, mineral nutrients, and products of photosynthesis through the plant, consisting of the xylem and phloem.

vascular tissue. Plant tissue that conducts water and nutrients throughout the plant.

vector. An organism able to transport and transmit a pathogen to a host.

vegetative. Plant parts or plant growth not involved in the production of seed, such as roots, stems, and leaves.

vein banding. Dark brown discoloration of the veins on the undersides of potato leaflets caused by potato virus Y.

véraison. Beginning of fruit ripening, recognized by berry softening and beginning of pigmentation in colored varieties.

vigor. The capacity of a strawberry plant for active vegetative growth.

viroid. A portion of infectious nucleic acid, without the protein coat of a virus.

virulence. The relative infectiousness of a bacteria or virus, or its ability to overcome the resistance of the host metabolism.

virus. A very small organism that can multiply only within living cells of other organisms and is capable of producing disease symptoms in some plants and animals.

volunteer crop. The undesired emergence of a significant stand of a self-seeded, previously planted crop in a field purposely planted with another crop.

W

white roots. Secondary roots.

windowpane. The removal of the epidermal layer of leaf tissue leaving small segments of clear tissue.

wing. Extension of the nut shell at the suture line; varies in size according to cultivar.

winter planting. A system of planting strawberries in mid to late fall that depends on growth during winter months for production of an early spring crop.

X

xanthosis. A collection of symptoms consisting of distorted leaf growth and yellow leaf margins that develops in strawberry plants infected by mottle virus and either crinkle virus or mild yellow edge virus; yellows.

xylem. Plant tissue that conducts water and nutrients from the roots up through the plant.

Y

Y-leaf. The most recently matured leaf.

Z

zonate. Marked with zones or bands; belted; striped.



Acknowledgments

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