INSURING A BOUNTIFUL HARVEST

Understanding Ants

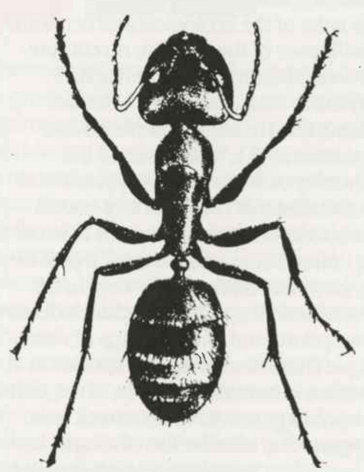
Ants have caught the imagination of careful observers for thousands of years. Though fascinating, ants can be pests in both agricultural and urban settings. Leaf-cutting ants cause billions of dollars in damage to crops in the American tropics. Closer to home, many Arizonans are familiar with the local leaf-cutting ants which can devastate the succulent and tasty efforts of urban gardeners. Other ants, particularly carpenter ants, are structural pests that damage wooden structures through their extensive tunneling. Interestingly, the key to controlling ant pests may be found in the way the ant societies regulate themselves.

Ants, like bees, live in societies that are made up entirely of females. A typical ant society contains a queen, who is the fertile female, and her workers, who are partially or completely sterilized. The queen produces nearly all the colony's eggs. From these eggs will come new workers, as well as the males and queens that will form the next generation. It turns out that in ants, whether an egg will develop into a male or female depends on whether it is fertilized or not. Males develop from unfertilized eggs. The queen herself can regulate whether the eggs she lays are fertilized or not. In many species, workers can lay eggs but do so only under unusual circumstances. As a rule, workers that retain the ability to produce eggs will lay them only in the absence of a queen. Since workers can lay only unfertilized eggs, they produce only males.

All fertilized eggs, which can be laid only by the queen, will become females. At first, the egg has the potential for developing as either a queen or a worker. The fate of the developing ant is determined in large part by the queen of the colony. The process that governs whether a fertilized egg will become a worker or a queen is called queen determination.

Two aspects of colony life are especially important to its organization. First, interactions between adult ants, especially the queen and her workers, are central to keeping order in the colony. Most important, from the queen's point of view, is that she be the only egg-layer. Second, the colony must produce only workers until the colony is large enough to gather enough food to produce what is called the sexual brood, the males and future queens that will fly from the colony and mate.

Therefore, the queen, who can be considered the pacemaker of the colony, regulates both worker fertility and queen determination. She is able to exert this control through chemicals she secretes that affect the behavior and physiology of all the other ants, both larval and adult, in the colony. What is exciting about this type of queen regulation is that the ants themselves have invented chemicals that control critical aspects of development and reproduction. By discovering what these chemicals are and how they work, we may be able to develop new pesticides that can help us control ants that have become pests. Specifically, we can learn from ant queens how they are able to sterilize their workers and then use that information to sterilize pest populations.



Dr. Diana E. Wheeler
Entomology

Learning to Control Purple Nutsedge

Ask any cotton grower how to eliminate purple nutsedge and his reply might be "quit farming". Purple nutsedge thrives on warm moist conditions that are prevalent in irrigated fields of Arizona. Purple nutsedge is a member of the "sedge" family which has characteristic three-ranked leaves. This weed is a problem in almost any irrigated, high light intensity region in Arizona. It has been a form of cancer to the homeowner, the golf course superintendent, and the landscape manager as well as any farmer growing an irrigated crop in the summer months.

Purple nutsedge is a serious perennial weed throughout temperate and tropical regions of the world. Purple nutsedge is a "C4" plant, a label given to photosynthetically efficient plants. It reaches its maximum growth rate under high light intensities and warm temperature conditions which are certainly present in Arizona's irrigated cotton fields. Purple nutsedge is difficult to control because it spreads so rapidly and a selective herbicide is not available to keep this weed under control. Purple nutsedge reproduces mainly from tubers which are formed by the differentiation of underground rhizomes, the majority of which are produced from July through September. Rhizome chains interconnect the tubers which may contain one to 13 active buds. Tuber sprouting is encouraged when these rhizome chains are broken, thus practices such as cultivation actually stimulate the sprouting of underground tubers.

Research was initiated in 1985 to study the behavior of purple nutsedge in a cotton field to identify plant characteristics, cultural practices and chemical control measures that could be used in the fight against this pernicious weed. Three years of research has provided UA scientists with partial answers of how to control this perennial weed.

Purple nutsedge is a relatively non-competitive weed in comparison to

Johnsongrass and Palmer amaranth. Our success at controlling these weeds and others has allowed purple nutsedge to have a free rein in Arizona cotton fields, competing with cotton for light, moisture and nutrients throughout the growing season. Initial field research was conducted with the preplant applications of thiocarbamate herbicides such as EPTC and butylate in cotton. These two herbicides were vey active on purple nutsedge but unfortunately they caused significant crop injury, thus fallow research was initiated.

It was hypothesized that subjecting purple nutsedge to fallow conditions (high temperatures but low soil moisture) would result in desiccation of the vegetative propagules and also improve the activity of the thiocarbamate herbicides by improving their soil longevity under low moisture conditions.

Research has shown that fallow plus an application of a thiocarbamate herbicide in late June or July provides more than 90 percent control of purple nutsedge tubers in the top 20 cm, however, it does not appear to control the deep tubers.

This research points out that chemical herbicides are nothing more than a tool of current weed management strategies. To successfully design a weed control program one must incorporate cultural and chemical control measures and exploit any weaknesses inherent in the biology of the target pest.

Dr. Jon P. Chernicky
Plant Sciences

North American Polyspores

The largest and most important family of wood-rotting fungi in North America is the Polyporaceae. These fungi play an essential ecological role as decomposers in recycling of carbon in the world ecosystem. The majority are saprophytes and decay dead standing and fallen trees, stumps, logging slash, and wood in service. However, many polypores invade and decay wood in living hosts. Most of these are heartrot fungi that decay dead heartwood in living trees and have historically been the major cause of volume loss in conifer and hardwood sawtimber in North America. Some are root-rot pathogens and invade and kill living sapwood. This latter group of root-rot pathogens is now one of the major problems in management of second growth commercial forests in North America.

Most polypores are white rot fungi and utilize the polysaccharide and lignin components in wood. Included in these white rot polypores are some that are potentially important commercially in that they selectively degrade lignin and are capable of degrading other phenolic compounds that are toxic waste materials.

The Polyporaceae also includes about 75 percent of the North American fungi that cause brown rots. These brown rot fungi selectively remove cellulose and hemicellulose from wood and leave a stable residue of slightly modified lignin. This brown rot residue is an important component in coniferous forest soils, remaining intact for hundreds of years. It greatly increases water holding capacity and cation exchange capacity. It ameliorates soil temperatures and maintains a favorable acid pH in which mycorrhizal fungi develop and form mycorrhizae and in which non-symbiotic nitrogen fixing organisms are highly active. Our vast coniferous forest ecosystems would not exist without them.

In spite of the ecological and economic significance of these fungi, no comprehensive flora for North America had previously been published . The two volume flora recently completed and published by R.L. Gilbertson of the University of Arizona and L. Ryvarden of the University of Oslo, Norway, covers 411 species, all that are known to occur in the United States and Canada. It provides dichotomous and synoptic keys to 96 genera and all species. It includes detailed descriptions and line drawings of microscopic characters of all 411 species. It also provides information on type of rot, cultural morphology, sexuality, substrata, and geographical distribution of all species.

As most of these fungi are circumglobal in the forest regions of the world, the flora immediately becomes the major source of information on the group on a world-wide basis and has already been established as the standard for definition of species and nomenclature by mycologists, forest pathologists, ecologists, and other biologists working with forest ecosystems all over the world. It has brought worldwide recognition go to the University of Arizona, the College of Agriculture, and the Department of Plant Pathology, and will remain the definitive work on this group for many years.

Dr. R.L. Gilbertson
Plant Pathology

Predicting Cotton Black Root Rot

Black root rot of cotton, caused by the soil-borne fungus, *Thielaviopsis basicola*, has been a significant disease in Arizona in fields planted to cultivars of Upland cotton at elevations above 3,000 feet. Lower soil temperatures, which favor the disease, commonly occur at these elevations during planting. The disease, which occurs during cool, wet, spring weather, causes a black root rot of the seedling tap root but does not usually cause seedling death. The most striking symptom is decreased seedling vigor and slow growth. Death results only when the seedlings are under additional stress, such as a sudden rise in temperature and low soil moisture. The fungus has the ability, under certain conditions, to girdle the tap root.

Although black rot of cotton has in the past been primarily a problem on Upland cotton, because of recent economic factors, there has been a shift away from Upland to Pima cotton. The longer growth cycle of Pima cotton has forced growers into planting at lower elevations during cool weather in March and April. Observations made during 1986 and 1987 indicated that black root rot was an important disease in Pima cotton in these early planted fields as well as in Upland cotton cultivars planted at high elevations.

The objective of this research is to develop data for cotton growers that would enable them to make a decision as to whether to plant a particular field to Pima cotton. If the field assays and laboratory results indicate high disease potential, then the grower would have the option of planting to an Upland cotton variety at a later date when soils are warmer, fallowing the field, or planting to wheat or barley.

A quantitative technique has been developed to assay cotton soils for populations of *Thielaviopsis basicola*. The procedure utilizes plating of soil dilutions on carrot extract agar containing etridiazol, Mystatin, streptomycin sulfate, chlortetracycline, calcium carbonate and PCNB.

Initial studies indicate that the two most important factors involved in seedling disease are soil temperature and inoculum density of the fungus.

When field soils containing approximately 600 propagules of the fungus per gram of air dry soil were planted to Pima S-6 in the laboratory, 75–100 percent and 50–75 percent cortical decay occurred at 20° and 28° C, respectively. This seedling damage was related to subsequent reduced seedling vigor. Lower inoculum levels resulted in less disease. This information is being used to develop a predictive system that will enable cotton farmers to select and plant fields where maximum yield can be expected.

Dr. R.B. Hine
P.A. Mauk
Plant Pathology

Crop Production Functions

Water and nitrogen are important crop inputs that Arizona farm managers can control. Agricultural managers can maximize returns if crop yield production functions are available and the cost of water and nitrogen are known. Research was initiated at the Yuma Mesa Agricultural Center to collect data that will be used to develop yield production function for several Arizona crops.

Production functions have been developed for some crops such as broccoli, cauliflower, guayule, potatoes, asparagus and wheat. There is an immediate need to develop these data for other crops such as lettuce, alfalfa, cotton, cabbage, sesame, peanuts and other new specialty crops grown in Arizona.

Proper water and nitrogen management can increase asparagus spear yields by one and one-half to two times compared to the average commercial production previously obtained in the Imperial Valley of California. The early emergence of asparagus spears was increased with the proper amount of applied nitrogen fertilizer. This early production is marketed during a period when the supply of asparagus comes mostly from foreign sources and commands a premium price. Plastic portable hot houses are being tested to increase soil temperature to initiate asparagus production during cold weather. Preliminary results show an increase in soil temperature of about 10° F which has resulted in asparagus production from mid-December through mid-February. Normal early asparagus production occurs around the first part of February when soil temperatures are warm enough for asparagus production. The use of hot houses has the potential of increasing the grower's ability to market asparagus for 120 days compared to the normal 60-day harvest period.

One year's data from alfalfa suggest that yields of about 20 tons per acre per year are possible on the Yuma-Mesa soils under sprinkler irrigation if the hay is immediately removed after cutting. Excellent yields of broccoli and cauliflower were obtained when 24 inches of water and 225 pounds of nitrogen were applied using an overhead irrigation system. Wheat yields of 4 tons per acre were obtained when 30 inches of water and 200 pounds of nitrogen were applied. Not all wheat cultivars tested responded the same to the different levels of water and nitrogen applied. This indicates that each cultivar may require different cultural management to obtain the optimum yields.

Dr. Robert L. Roth
Agricultural Engineering
Dr. Bryant R. Gardner
Soil and Water Science

A New Lettuce Downy Mildew

Commercial production of vegetable crops in greenhouses employing a recirculating hydroponic cultural system has been used worldwide for many years. One of the proposed advantages of such a system has been the avoidance of infectous diseases. While cultivation within hydroponics tends to decrease the diversity of infectious diseases, the incidence and severity of those that do occur can be greater than in the field.

In open field agriculture, the rapid development of a plant disease in a short period of time is generally regarded as a unique characteristic of foliar pathogens. The use of recirulating hydroponics, however, now imparts these same characteristics to root pathogens. Recirculation of the nutrient solution, once infested by a pathogen, guarantees the rapid and uniform dispersal of the pathogen throughout the production facility.

Although many root diseases have been reported to occur on hydroponically grown plants, the most destructive are those caused by fungi which produce a motile stage known as a zoospore. Our laboratory has been engaged for many years in the identification and control of these zoosporic fungi. Recently we discovered a new and unique zoosporic fungi.

This fungus, which belongs to a group of very destructive leaf pathogens known as the downy mildews, attacks only roots of hydroponically grown lettuce. Infected plants, which were obtained from a commercial grower in Virgina, exhibited extensive root decay and were stunted. The fungus was uniformly distributed throughout the 2.4 hectare hydroponic facility. Greenhouse pathogenicity studies have shown that this fungus, which we have named *Plasmopara lactucae-radicis*, will attack head as well as leaf lettuce cultivars. Fortunately, Sitonia (a cultivar of leaf lettuce) is apparently resistant to the fungus. Investigations on the origin of this fungus and methods of disease control on susceptible cultivars are currently in progress.

Dr. Michael E. Stanghellini
Plant Pathology

Timing: A Key To Plant Disease Control

Timing is critical to success in many endeavors of life; and controlling plant disease is no exception. The goal of this research program is to achieve maximum disease control by defining the optimum time for application of disease control measures.

Plant disease results from the interaction of a susceptible host plant, a pathogen, and an environment conducive to disease development. The activity of plant pathogens markedly affected by their environment. An unanswered question concerns the effect of the environment on perennial host plants. Is the susceptibility of perennial plants to a pathogen constant or does it change during the growing season? The answer could help refine strategies for disease control.

The host-pathogen interaction used in this study was the infection of citrus trees by *Phytophthora*. This plant pathogenic fungus causes a fatal disease when citrus trees are parasitized. For the three year duration of this study, stem and bark tissues were collected monthly from several citrus varieties, inoculated with *Phytophthora*, then incubated under conditions of constant temperature and humidity. This research revealed temporal variations in the susceptibility of citrus tree tissue to colonization by *Phytophthora*. Specifically, citrus tissue collected from November through February was less susceptible to colonization than tissue collected from March through October. Knowledge of temporal variations in susceptibility of citrus to colonization by *Phytophthora* could optimize disease control by directing fungicide applications to periods of time when citrus trees are most vulnerable to the pathogen.

Temporal or seasonal effects may play a role in disease development in other host-pathogen interactions as well. A more comprehensive understanding of temporal changes in the susceptibility of perennial plants to disease will facilitate more precise timing for application of disease control measures. The final result will be maximum disease control for minimum economic and environmental cost.

Dr. Michael E. Matheron
Plant Pathology

Molecular Diagnosis of Plant Diseases

Geminiviruses are circular, single-stranded DNA plant viruses characterized by a unique "germinate" or paired particle morphology. Geminiviruses are transmitted in nature by either a leafhopper or whitefly insect vector. Whitefly-transmitted geminiviruses have become timely and devastating pathogens in irrigated agricultural crops grown in southwestern deserts. The recent prominence of geminivirus-associated diseases in desert crops is directly related to the dramatic increase in the number of whiteflies in irrigated fields since 1981. The sweet potato whitefly is now known to vector at least four distinct geminiviruses which cause serious diseases in bean, cotton, cantaloupe, squash, tomato and watermelon, all major economic crops in the Sonoran Desert.

At the outset, the experimental determination of biological information concerning virus symptoms, host range, and virus-vector relationships was needed to gain an understanding of disease epidemiology. Out of necessity, initial diagnoses were accomplished by time-consuming transmission tests using virus-free whiteflies contained in a colony, and greenhouse-maintained virus-specific indicator plants. Once pure virus cultures were obtained, virus particles and virus DNA could be isolated from infected plants and further studies. These accomplishments paved the way for virus characterization and for the development of techniques for more rapid diagnosis of diseased plants.

Molecular methodologies are now being developed for diagnostic purposes in order to decrease diagnosis time and to increase the sensitivity and accuracy of virus detection and subsequent identification. One of these involves the use of nonradioactive labelled probes made from cloned virus genes. Labelled gene probes will pair or hybridize with a similar DNA sequence in another gene of a related or identical virus. A substrate compound is added to the bound DNA probe and a color reaction occurs indicating that the probe recognized and bound to the unidentified virus DNA. Clones made from genes that have similar or conserved sequences among geminiviruses can be used to detect the presence of many related geminiviruses. Clones made from genes that are unique to individual viruses or strains can be used for more specific identification of the virus or strain in a diseased plant.

Another technique being implemented makes use of virus-specific DNA patterns which result when the viral genome or DNA is cut into fragments using a repertoire of site-specific restriction enzymes. The so-called restriction patterns are unique to a virus strain and are therefore useful for purposes of identification and diagnosis. Techniques such as these are currently being adapted to allow for more rapid, sensitive and accurate diagnosis of geminivirus diseases in Arizona crops.

Dr. J.K. Brown
Dr. M.R. Nelson
Plant Pathology

Root Prints

The root surface (rhizoplane) is inhabited by a diverse assembly of microorganisms which influence, either directly or indirectly, the growth and development of plants. Management of these microbial populations, achieved by cultural manipulations which would 1) enhance the rhizoplane competency of native and introduced genetically engineered beneficial organisms or 2) inhibit the deleterious root-infecting organisms, will aid in the improvement of agriculture efficiency and productivity. However, such manipulations are dependent upon knowledge of the microbial population dynamics and interactions in the rhizoplane.

One of the major obstacles in elucidating microbial population dynamics and interactions on the rhizoplane resides in the lack of a technique for studying the "in situ" pattern of distribution of microbial populations under field conditions. Recently, we discovered a rather simple method for determination of the spatial distribution of microbial populations on the rhizoplane of field grown plants: namely, "root prints".

The procedure for making root prints is as follows: roots of subject plants are carefully extracted from the field. Rhizoplane sections, measuring 1 sq cm, are then excised from the root and imprinted on the surface of agar media contained in petri dishes. Printed plates are then "developed" by incubation at selected temperatures for varying periods of time. The exact position and number of developing colonies per print are then permanently recorded by simply photocopying the petri plate.

Once the photocopy has been made, individual colonies on the plate can be isolated and identified. Thus, the relative frequency of the various types of microbes and their distribution pattern can be evaluated. Additionally, our preliminary studies indicate that up to eight consecutive root prints of a single 1 sq cm rhizoplane section can be made with only a slight decrease in the total number of colonies. Thus, a single rhizoplane section can be utilized for replica plating.

The root print technique will be of value for determination of the "in situ" spatial pattern of distribution of microbial populations on the rhizoplane and provide a knowledge base for understanding microbial interactions as they exist under natural conditions in the field.

Dr. Michael E. Stanghellini
Plant Pathology