University of California Cooperative Extension

KERN VEGETABLE CROPS

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BACTERIAL DISEASES OF ONIONS

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There are three main bacterial diseases that can affect onions grown in California. These are soft rot, sour skin, and slippery skin. However, all three are very similar in the symptoms they cause. A common symptom is the breakdown of the fleshy scales inside the bulb. One or more of the inner scales become soft and watery with the affected tissue turning from a yellow discoloration to brown as the disease progresses. The neck will be soft and mushy. Also, as the disease progresses, the leaves will become yellow, wilt, and lay down. Eventually the entire bulb breaks down into a mushy, foul smelling mass. The problem may not be noticed in the field but appear later as a postharvest problem while the onions are in storage or in transit.

Again, the symptoms of these three diseases are very similar and difficult to distinguish from each other. Each of these is caused by bacteria that are commonly found in soil, particularly the soft rot organism. In addition to being found in the soil, they can be found in water, plant debris, or on other plants. Sour skin and slippery skin bacteria enter the onion plant through wounds located on the leaves. These wounds may be from thrip damage, downy mildew, or any other number of sources. The soft rot organism can enter through wounds on the neck, bulb, or roots caused by disease, insects, mites, or mechanical injury. In all cases, a film of water is required to move bacteria to the wound site and into the plant. Splashing water from sprinkler irrigation or rain are the most common ways that bacteria move from the soil up to the wounded area.

Once inside the leaves, the bacteria works it way down towards the bulb where the scales in the bulb breakdown. Often it is possible to trace the infected inner scales to the leaf that became infected. Soft rot may begin at the bulb if it follows injury caused by nematodes, bulb mites, or Fusarium.

Onions are very resistant to these bacteria before they bulb but once the plants begin to bulb, the plants then become susceptible to infection.

Because of how these diseases develop, there are measures that growers can take to avoid these problems. The simplest is unfortunately not always possible. That is to switch from sprinkler irrigation to furrow irrigation once the plants begin to form bulbs. This eliminates the splashing of water onto the leaves and bulbs. If using sprinkler irrigation, do not use re-circulated water. These bacteria survive in water very well and using tail water only spreads the bacteria onto the plants.

Be aware that if the tops show damage from insects, disease, hail, or other means, that bacterial infection is then possible after the plants bulb. Protecting the tops early is important in avoiding bacterial problems later on. Bulb mites and nematodes need to be avoided by proper field preparation and field site selection before planting.

The onions should be harvested after the tops are fully matured and cured quickly and completely so that the necks are sealed. Rough handling of the bulbs should be avoided to prevent bruising.

Onions are a long season crop and growers do not want to be surprised with problems at the end of the crop season. These bacterial problems are something that can appear late in the season or even after harvest. But again, by being aware of these problems and taking the proper precautions can go a long way to avoiding these headaches later in the year.

LATE BLIGHT MAY BE AN ISSUE THIS YEAR

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Late blight is a destructive disease of potato and tomato in all growing regions of the world. This disease first gained notoriety 150 years ago as the cause of the "Potato Famine of Ireland and Northern Europe." It was last a major issue in California after the El Niño of winter 1998-1999. Then late blight appeared in many early planted tomato fields and potato fields in Kern County. Late blight is a very explosive disease that can appear suddenly and move through a field or area very quickly. Cool, wet conditions are ideal for late blight to develop. With what appears to be another wet El Niño rainy season tomato and potato growers need to again be on the lookout for this disease.

Preventing the disease from occurring is the first step in managing late blight. The goals of a good cultural control program are to prevent introduction of inoculum, reduce inoculum buildup, reduce infection rate, and create conditions unfavorable for disease development. Growers can achieve these goals by incorporating several different techniques into their farming operation.

For transplanting tomatoes it is important to make sure that the initial source of disease is not infected transplants. Check transplants before planting and refuse plants that show signs or symptoms of late blight. Early signs of late blight on transplants can be difficult to identify and may need confirmation by a qualified expert.

Other potential sources of inoculum are potato cull piles and volunteer potatoes and tomatoes. Although not common in most parts of the San Joaquin Valley, infected tubers from potato cull piles can produce a tremendous amount of air borne spores that move by wind to shower onto nearby fields. Volunteer potatoes and tomato plants are another important source of the pathogen. These volunteer plants can be an overwintering sources for the fungus. Eliminating any near-by potato cull piles and destroying volunteer tomato and potato plants helps limit the initial source of inoculum in a region.

Regularly scouting tomato fields is important for early detection. Early detection of late blight will allow appropriate action to be taken quickly before the disease can spread to other parts of the field and having an overwhelming amount of spores blowing out into an even wider area. Diagnostic kits are another tool that can be used for early detection of the disease. Kits are available which help quickly confirm or refute whether a questionable lesion is caused by the late blight fungus. Regular field scouting and diagnostic kits are methods of early detection so appropriate action can be taken quickly.

Spot killing infected plants when the disease first appears will slow the spread of spores to other parts of the field. Plants can be quickly destroyed by burning or with the use of a fast acting herbicide. This method of cultural control will only be effective when blight first appears in a field or region. Once late blight is established in an area then the likelihood of influencing the amount spores in that area becomes negligible.

Changing the climatic environment around the plant that is less conducive to late blight can also help reduce late blight severity. Late blight spreads and develops when conditions in the canopy are moist and humid. Sprinkler irrigation creates an ideal environment by keeping the canopy wet for long periods of time. If possible, avoid sprinkler irrigation after stand establishment. Excessive nitrogen is a factor because it promotes large dense canopies which prevent air movement for drying of leaves. Dense canopies also prevent fungicides from penetrating down into the lower leaves and stems of plants. Fertilizer management can be used to a grower's advantage by making sure that the plant canopy is not unnecessarily inviting to this fungus.

Excessive nitrogen also increases the susceptibility of tomato and potato plants to infection. The late blight fungus prefers lush, young, actively growing tissue over stressed, senescing tissue. Excessive nitrogen will promote lush vegetative growth and delays maturity, which increases the chance of infection and prolongs the period that the crop is susceptible to late blight infection.

Lastly there are effective fungicides that can minimize the impact of late blight. Broad spectrum fungicides (maneb, mancozeb, chlorthalonil) should be used preventively on a 7 to 14 day schedule when conditions are favorable for late blight to occur. If late blight does appear in a field then other, more late blight specific fungicides can be used. Refer to the UC IPM website (www.ipm.ucdavis.edu) for specific details on the recommended use of these products. Good coverage of the plant canopy is really crucial to controlling late blight with fungicides.

BULB MITES

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Bulb mites are a problem of garlic and onions that often goes unrecognized. These pests can reduce stands, slow plant vigor, and increase post harvest diseases by their feeding on the roots and base of the bulb (stem plate). Bulb mites have a very wide host range, but are particularly damaging to onions and garlic. The reason that this pest often goes unrecognized it that these mites are not easily seen on the bulb, instead crawling deep into crevices between the roots and stem plate.

To determine whether they are present in the plant, the region where the roots and bulb come together needs to be teased apart. They may also be under one or two layers of scales at the lower end of the bulb or clove. Other mites may be present, but with a hand lens the bulb mites can be identified from other mites.

The bulb mite is itself bulb shaped, with its legs moved forward and a bulbous rear end. The mouthparts and legs are purplish-brown while the main bulbous body is creamy white. These mites have been described as looking like tiny pearls with legs. The mites are small ranging in size from .02 to .04 inches (0.5 to 1 mm). It is a very slow moving mite and will try to crawl back into a crevice once exposed. They are usually found in clusters underneath scales and at the base of the roots.

Garlic and onions plants are not only damaged from the direct feeding by bulb mites, but also by also allowing pathogens to enter through the wounds caused by the mites. The wounds that the mites cause are excellent entry points for pathogens like Fusarium spp. and various soft-rotting bacteria. Early in the growing season, bulb mites can responsible for poor plant stands and stunted growth as they feed on the plants. Infested plants can usually be easily pulled out of the soil because of the poor root growth. Later in the season, higher than normal amounts of soft rot and Fusarium dry rot may be seen because of the wounds caused by the mites.

Bulb mites survive in the soil on organic matter left behind from the previous crop. As long as there is decaying vegetation matter in the soil, bulb mites can survive in a field. The best way to control bulb mites is then allow the vegetation from the previous crop breakdown before any new crop, especially garlic or onions. Low areas of the field that stay wet along with high organic matter in the soil are especially prone to high levels of bulb mite survival. These mites may also come into a clean field on infected garlic cloves. So the use of clean garlic clove seed or seed that has been hot water treated should be always used.

Bulb mites should be something that onion and garlic growers and their consultants should be aware of and be able to recognize in the field. This is another example where a pest can be avoided with some planning and use of cultural control methods.

BAGRADA BUG, A NEW PEST OF COLE CROPS IN CALIFORNIA'S SOUTHERN DESERTS

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Cole crop producers in the San Joaquin Valley should be on the lookout for a new, exotic pest called the Bagrada bug. This stink bug, also known as the painted bug or harlequin bug, was first found in California in 2008 and has since become a pest of cole crops in the Imperial and Coachella Valleys of California, as well as in southwestern Arizona. The Bagrada bug is native to Southern Africa, and can also be found in southern Asia and southern Europe. In these locations it is a significant pest of a broad range of cole crops such as cabbage, cauliflower, broccoli, kale, turnip, mustard, and radishes.

Bagrada bug feeds by sucking plant juices through straw-like mouthparts that it inserts into the plants. When young seedlings are attacked, feeding at the growth terminal can cause branching such that multiple heads are formed on crops like broccoli and cauliflower. This renders the crop unmarketable. On older plants, wounds made by the bug's mouthparts gives the plants a stippled, and then scorched, appearance.

Farmers that are currently dealing with this pest have been forced to utilize broad spectrum insecticides, primarily pyrethroids, to try to knock back populations. While this is not an ideal situation, at least it has allowed the pest to be managed such that crop losses can be averted. However, pyrethroids are not an option in organic fields, and organically-acceptable pesticides such as permethrin, spinosad, and a wide range of oils and not effective. For this reason, the greatest level of damage has resulted in organic fields and in both community and residential gardens.

One of the reasons for the successful invasion of Bagrada bug is its preference for the same cool weather that allows Californians to produce cole crops. This means that it is most likely to be found in the fall through early spring in California's southern deserts and in the San Joaquin Valley: if found in coastal California areas, it could potentially become a problem all the way through the summer.

Bagrada bug can be identified by the distinctive black, white and orange markings on the shield-shaped backs of the adults. They are very similar to what we commonly refer to as harlequin bugs, but are about half the size. Nymphs are more variable in color and range from white when very young, to red with dark markings as they mature. Eggs are barrel-shaped, range from white to red depending on maturity, and can be found in clusters either in the soil or on leaf material touching the soil.

Growers or Pest Control Advisors who find Bagrada bug outside of California's southern deserts are encouraged to contact a Farm Advisor at their local UC Cooperative Extension office, or report it to the local Agricultural Commissioner.

Female and male Bagrada bugs.
(Photo: LA Ag. Commissioner's office)

DEVELOPMENT OF DISEASE SUPPRESSIVE SOILS IN THE SAN JOAQUIN VALLEY

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Carrots and potatoes are two of the most widely grown vegetables in the lower San Joaquin Valley. Both crops suffer economic losses to chronic soilborne diseases. For the most part, these diseases are managed by pesticides that have long-term efficacy and environmental concerns. For example, over reliance on a single pesticide can result in the development of resistant biotypes of pathogens and loss of effectiveness due to enhanced biodegradation; other concerns include undesirable air pollution from some soil fumigants.

Cavity spot is the most important disease of carrots in California where the majority of the crop in the U.S. is produced. One tool used by carrot growers to manage diseases and weeds is soil fumigation with metam-sodium. Approximately 6 million pounds of this material are applied annually to over 30,000 acres of California carrot fields (Calif. Dept. Pesticide Regulation). Potatoes also receive pre-plant applications of metam-sodium to control soil pests.

According to the 2006 Inventory of Volatile Organic Compound (VOC) Emissions (California Department of Pesticide Regulation, October 24, 2006), VOCs generally exceeded the state's goal of reducing emissions (a court ordered 20% reduction from 1991 levels). VOCs are an issue because they react with nitrous oxides to create ozone, an air pollutant which is regulated by the Clean Air Act. One of the areas in California designated as non-attainment, i.e., not meeting federal air standards, is the San Joaquin Valley, and pesticides represent one source of VOCs. During May-October, the peak air pollution season in California, emissions in the San Joaquin Valley can be particularly high. Fumigants account for about 50% pesticide emissions in that part of the state. According to the state, reducing pesticide VOC is a key component of the overall objective of reducing the total VOC inventory. In certain times of the year, carrot culture is among the largest agricultural source of VOCs (it should be noted that the transportation sector of the economy accounts for a much larger share). Among agricultural commodities, potato farming is among the top ten ag sources of VOCs. Similar relative contributions from these two crops occur in the southern desert area (carrots were third and potatoes fifth). The simplest way to reduce VOCs is by reducing reliance on materials like metam-sodium, which is the objective of this ongoing research.

In this study, reducing pesticide VOC emissions will be based on eliminating traditional pesticide applications and shifting to farming systems that engage the use of naturally disease-suppressive soils in a microbial rich environment. By adding organic matter such as cover crops and composts to soils, soil nutrient levels and soil structure are improved. And because a soil rich in organic matter is environmentally complex and biologically active, a buffering capacity against plant pathogens is developed. Even an increase in soil organic matter by just 1 percent can dramatically improve soil health. Since both carrots and potatoes are often grown in rotation on the same ground in the San Joaquin Valley, the management of soilborne diseases should be considered together. Other potential long-term benefits of increasing soil organic matter include an improvement in water infiltration, water-holding capacity, a reduction in nitrate leaching and runoff, and soil erosion.

To evaluate the importance of microbial activity in the soil on soilborne diseases, we designed an experiment with three agroecosystems with five replications each at the UC Kearney Ag Center in Parlier, California. Experimental units were 50 feet long and 20 feet wide. The treatments were a conventional agroecosystem (synthetic fertilizers and a fallow period), a low-input system (organic soil amendments and the incorporation of green manures), and an intermediate system (a combination of organic nitrogen from composted animal manures and synthetic sources of nitrogen and other macronutrients). A spring crop of potatoes and a fall crop of carrots were grown in rotation each year. In addition, green cover crops (a legume/oat mix in the winter and blackeyes in the summer) were grown and incorporated into the soil in the low-input system. The conventional farming system included an annual application of metam-sodium prior to planting carrots. Over a two-year period, we collected soil samples monthly and measured populations of *Pythium* species, total fungi, total bacteria, pseudomonads, nematodes, and microbial activity. Levels of organic matter were included in the monthly assays. Prior to planting potatoes or carrots, soil variables (pH, CEC, total N, ammonium + nitrate nitrogen, K, and Olsen-extractable P) were determined. Nitrogen, potassium, and phosphorus levels were equilibrated prior to planting using appropriate sources of nutrients for each agrosystem.

Microbial activity was assessed by fluorescein diacetate (FDA) hydrolytic activities. FDA is a substrate that measures general microbial enzyme activity by reacting and changing color in proportion to enzyme concentrations in the soil. A positive linear regression has been observed between FDA activity and microbial biomass, indicating that FDA is a potential biological indicator of soils. To measure the ability of the soil in the three agrosystems to suppressive diseases, we used an assay in the greenhouse. Every month soil from each plot was spiked with lab-produced *Pythium ultimum* at a known concentration and sown with an exact number of cucumber seeds. Stand emergence was then counted and used as an indicator of the ability of the soil to suppress disease. The hypothesis was that the continuous incorporation of organic matter by green manures or composted animal manures would increase microbial activity, thereby creating soil flora that would parasitize, antagonize, or compete with soilborne pathogens. In this way a soil suppressive to disease would emerge. Because propagules of pathogens such as *Pythium* do not germinate in soil unless stimulated to do so by nutrients in root exudates, a soil rich in microorganisms can prevent spore germination by removing all readily available nutrients. Soils farmed in conventional agroecosystems are often devoid of high levels of microbial activity due to excessive tillage, low organic matter, and concentrated pesticide applications. By using more plant and animal manures, reducing tillage operations, and avoiding broad spectrum general biocides like metam-sodium, increased microbial activity may limit damages due to pathogens.

In general, populations of microorganisms were greater in plots that received green or animal manures, including populations of *Pythium* (Tables 1-3). For the sake of clarity, not all data are presented. Populations of nematodes were generally light and there were no significant differences among treatments (data not presented). In general, carrot and potato yields were greater in the conventionally farmed plots than the other farming systems, probably due to a deficiency of nitrogen. Although nitrogen levels were identical between treatments prior to planting, the nitrogen in the organically farmed plots and the transitional plots was apparently not mineralized and available to the crops. It is expected that several years may be required for an organic system to stabilize.

Soil levels of organic matter fluctuated in the organic treatment since green manures were incorporated twice yearly (Fig. 1). Interestingly, the levels of organic matter in those plots quickly dipped to pre-incorporation levels, no doubt due to the warm soil temperatures and fast respiration rate of soil microbes. Microbial activity was measured monthly (Fig. 2) and soil respiration was measured periodically (data not presented). Overall, there were brief periods when microbial activity was increased in the organic and intermediate farming system treatments compared with the conventional farming system. The highest activity generally occurred in the plots that received composted animal manure and inorganic fertilizers. Profile changes in the microbial community were also measured and although microbial activity varied between treatments, diversity was not significantly affected by farming system.

In the disease assay with cucumber seedlings, disease suppressiveness was created, at least periodically, in the organic systems (Fig. 3). The benefits of the addition of green manures, which resulted in greater seedling survival, did not last more than a month. There was a positive significant relationship between microbial activity and disease suppression (Fig. 4) and between levels of soil organic matter and disease suppression (Fig. 5), providing definitive evidence that elevating microbial activity through the addition of organic matter does result in less root disease.

Conclusions:

A disease suppressive soil was successfully developed by the incorporation of organic matter. However, the window of time when the soils were suppressive was quite limited since the soil organic matter decomposed very quickly in the warm temperatures of the San Joaquin Valley. Therefore, optimal timing of the incorporation of organic matter needs to be determined in order to reduce targeted diseases. Apparently, the benefits of this method are limited to short periods, at least in the initial years of incorporating organic matter. In any case, two years is too short a period to expect soil flora to stabilize. Further research is needed to find sources of organic matter that may maintain soil microbial activity.

Table 1. Total populations of *Pythium* species in three cropping systems (colonies forming units X25/gm of dry soil).

Treatment	2007 Dec	2008 Apr	2008 Jun	2008 Sep*	2008 Nov	2009 Apr	2009 Jun	Overall mean
Conventional	2.2	1.2	1.7	0	0.6	1.6	1.7	2.5b
Organic	2.7	8.7	8.4	11	8	8.3	8.0	8.4a
Transitional	1.9	2.1	1.8	2.6	2.2	2.0	1.7	3.8b

*Metam-sodiaum was applied to the conventionally farmed plots prior to the collection of the September sample.

Table 2. Total populations of culturable bacteria in three cropping systems (colonies forming units X15^5/gm of dry soil).

Treatment	2007 Dec	2008 Apr	2008 Jun	2008 Sep	2008 Nov	2009 Apr	2009 Jun	Overall mean
Conventional	61.8	25.3	22.3	37.5	62.5	24.3	21.1	42.5b
Organic	62.8	42.6	37.3	42	82.1	40.9	35.5	61.2a
Transitional	45.8	28.3	34.8	36.4	54.1	27.1	33.1	49.9b

Table 3. Total populations of culturable fungi in three cropping systems (colonies forming units X10^5/gm of dry soil).

Treatment	2007 Dec	2008 Apr	2008 Jun	2008 Sep	2008 Nov	2009 Apr	2009 Jun	Overall mean
Conventional	1.1	0.6	1.2	0.3	0.9	0.6	1.2	1.2c
Organic	2.5	2.7	1.9	2.4	3.2	2.6	1.8	2.3a
Transitional	1.9	1.5	1.7	1.4	1.4	1.4	1.6	1.8b

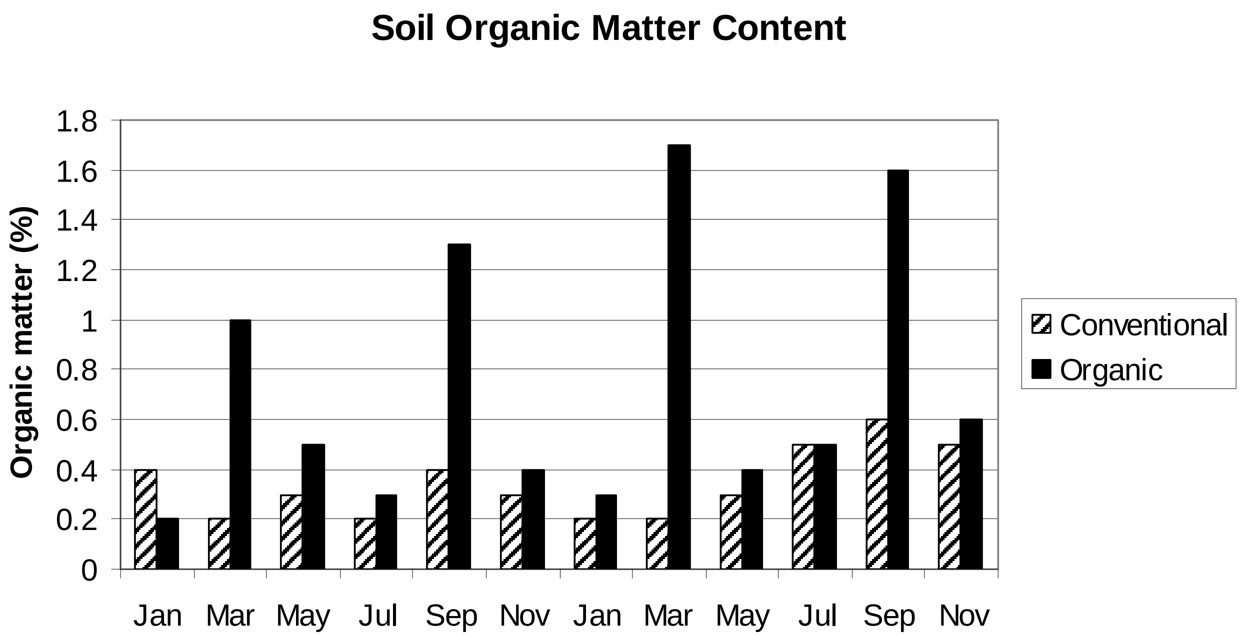

Fig. 1. **Soil organic matter content in conventionally and organically farmed Soil (2008-9). Levels of amended organic matter were short-lived.**

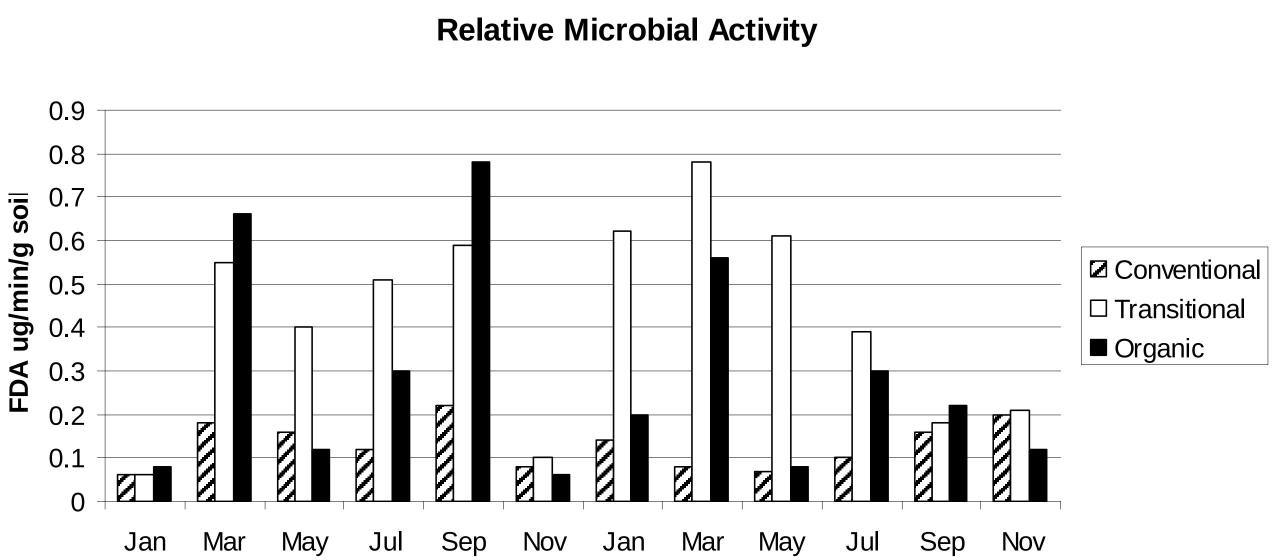

Fig. 2. **Relative microbial activity in soil samples from three cropping systems, 2008-9. The highest activity generally occurred in transitional plots, which received composted animal manure and inorganic fertilizers. The lowest activity occurred in the conventional plots.**

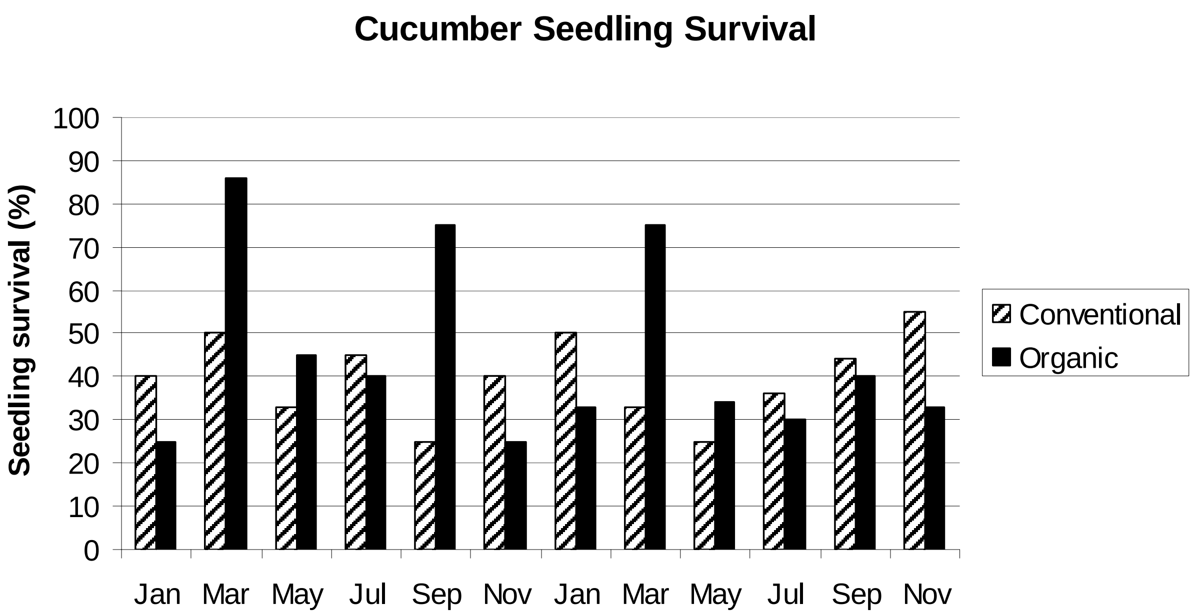

Fig. 3. **Survival of cucumber seedlings planted in *Pythium*-amended soil from conventionally and organically farmed soil (2008-9). A short-lived disease-suppressive soil was developed in the organic treatment.**

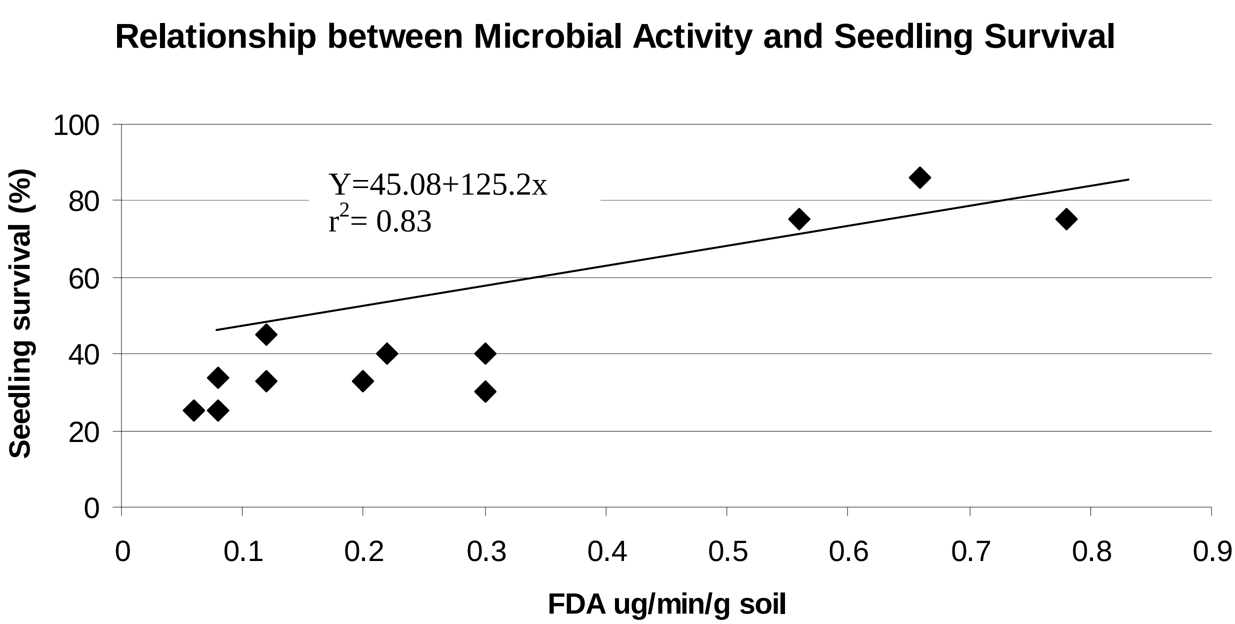

Fig. 4. **Relationship between microbial activity measured by fluorescein diacetate hydrolysis and cucumber seedling survival in *Pythium*-inoculated soil. The correlation is significant at $P<0.001$.**

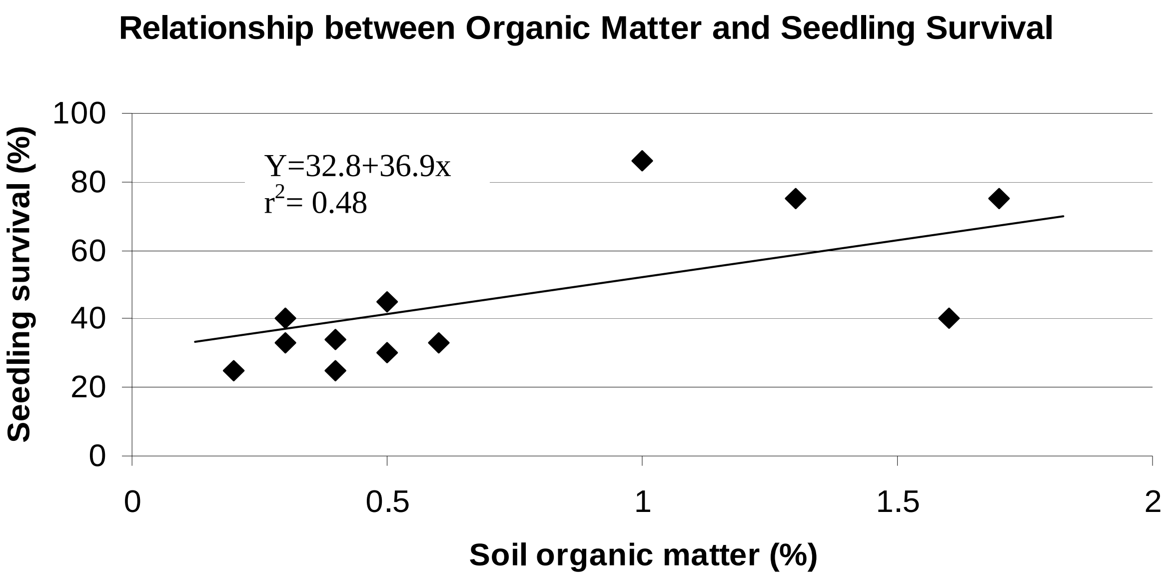

Fig. 5. Relationship between soil organic matter and cucumber seedling survival in *Pythium*-inoculated soil. The correlation is significant at P=0.01.

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