USA

MAXIMUM YIELD

INDOOR GARDENING

FREE

a Plant's LIFE

IT STARTS WITH A SEED

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INDOOR GARDENING EXPO 2012

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MAXIMUM YIELD INDOOR GARDENING expo

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March 2012

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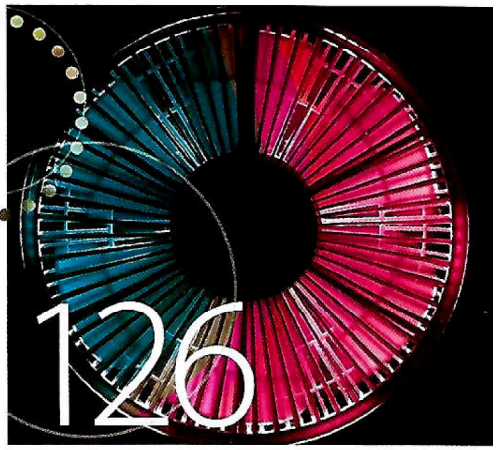


DEPARTMENTS

A plant's life is fascinating; if you pay close enough attention you might just witness extraordinary actions in motion. Plants eat, move and respirate but did you also know they excrete, sleep and communicate? The more we know about how plants exist in the world, the better able we are to maximize the myriad factors that keep them happy and growing—and keep our yields growing too!

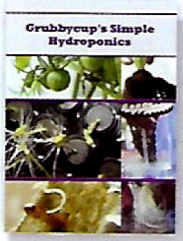
One such factor is photosynthesis—by learning how to maximize this necessary plant action we can substantially encourage growth rates and improve plant development. Another important but rarely discussed factor is how (and why) plants move and react (aka *tropisms*). You might be surprised to learn that plants move in six different ways according to light, gravity, water, force contact, chemical stimulus and temperature.

This issue of Maximum Yield offers the grand tour of a plant's life. In addition to photosynthesis and tropisms, we've also covered seedlings, soil basics and stress; food, flowering and fertilizer; and much, much more.

This issue is about more than just a plant's life; it's also about the life of food—from seed or clone to harvest and beyond—and also the life of a grower. Our experts covered every possible angle. Dive into this fascinating life story…of a plant!

Celebrate the launch of the 2012 'Grow Like A Pro' Tour with Maximum Yield in the Mile High City—Denver, Colorado—for free. You read right! Simply head to *indoorgardenexpo.com*, follow the Denver, CO link, click on the Free VIP Ticket and join us and hundreds of growers from around the world March 11 for this exciting event.

Jessica Raymond, editor
editor@maximumyield.com



GIVEAWAY

Winter months can be productive gardening months, even when the weather outside is dreary. A small indoor hydroponic garden can help chase away wintertime blues. *Grubbycup's Simple Hydroponics* is written for the complete hydroponic novice to gently introduce the concepts of hydroponics.

For your chance to win a copy of *Grubbycup's Simple Hydroponics*, simply like Maximum Yield on Facebook, or follow us or mention us on Twitter and you'll be entered into the draw. One lucky reader will be chosen from the bunch. Visit *Facebook.com/MaximumYield* and @ **Max_Yield** and enter today.

CONTRIBUTORS

Casey Jones Fraser owns Garden Grove Organics, in Northern Kentucky/ Greater Cincinnati. He has a degree in communications and electronic media. He believes that indoor gardeners can achieve the highest quality crops and maximum yields when proper science is applied. Since 1998, Casey has been testing various nutrients and supplements in search of outstanding harvests.

Chris Pianta AgroSci CEO, has over 25 years of experience in the lawn and garden market. He managed two successful startups and developed programs for Franks Nursery, FTD, Profile Soil Products, Martha Stewart, Agway and GROWELL. Chris is a holder of two United States patents. He earned his B.S. in Environmental and Professional Horticulture from UConn.

Stephen Keen has been an indoor gardening hobbyist for nearly 10 years. His personal successes with his garden led him to want to bring new ideas, mainly water-cooling, to the mainstream, which led to the founding of Hydro Innovations.

Dr. Lynette Morgan holds a B. Hort. Tech. degree and a PhD in hydroponic greenhouse production from Massey University, New Zealand. Lynette is a partner with SUNTEC International Hydroponic Consultants and has authored five hydroponic technical books. Visit www.suntec.co.nz/consultants.htm and www.suntec.co.nz/books.htm for more information.

Matt LeBannister developed a green thumb as a child, having been born into a family of experienced gardeners. During his career, he has managed a hydroponic retail store and represented leading companies at the Indoor Gardening Expos. Matt has been writing articles for Maximum Yield since 2007. His articles are published around the world.

Eric Hopper has over 10 years of experience in the hydroponic industry as both a retail store manager and owner. He continuously seeks new methods and products that could help maximize garden performance. Eric resides in Michigan where he and his family strive for a self-sufficient and sustainable lifestyle.

Evan Folds is president of Progressive Gardens, a natural approach land care company, and Progress Earth (www.progressearth.com). With a degree in biology and religion, Evan's interests include making sense of food production and bringing awareness to such topics as empty food, municipal water fluoridation and spiritual intolerance.

Frank Rauscher is a certified horticulturist and consultant for the garden industry. He's a contributing author to several publications and was writer and editor of the Green Pages. Frank finds that analyzing plant stress and finding solutions is exciting. He is very much at home bringing new ideas to the field of horticulture and indoor gardening.

Grubbycup has been an avid indoor gardener for over 20 years. His articles were first published in the United Kingdom, and since then his gardening advice has been published in French, Spanish, Italian, Polish, Czechoslovakian and German. He is also considered one of the world's leading authorities on crochet hydroponics.

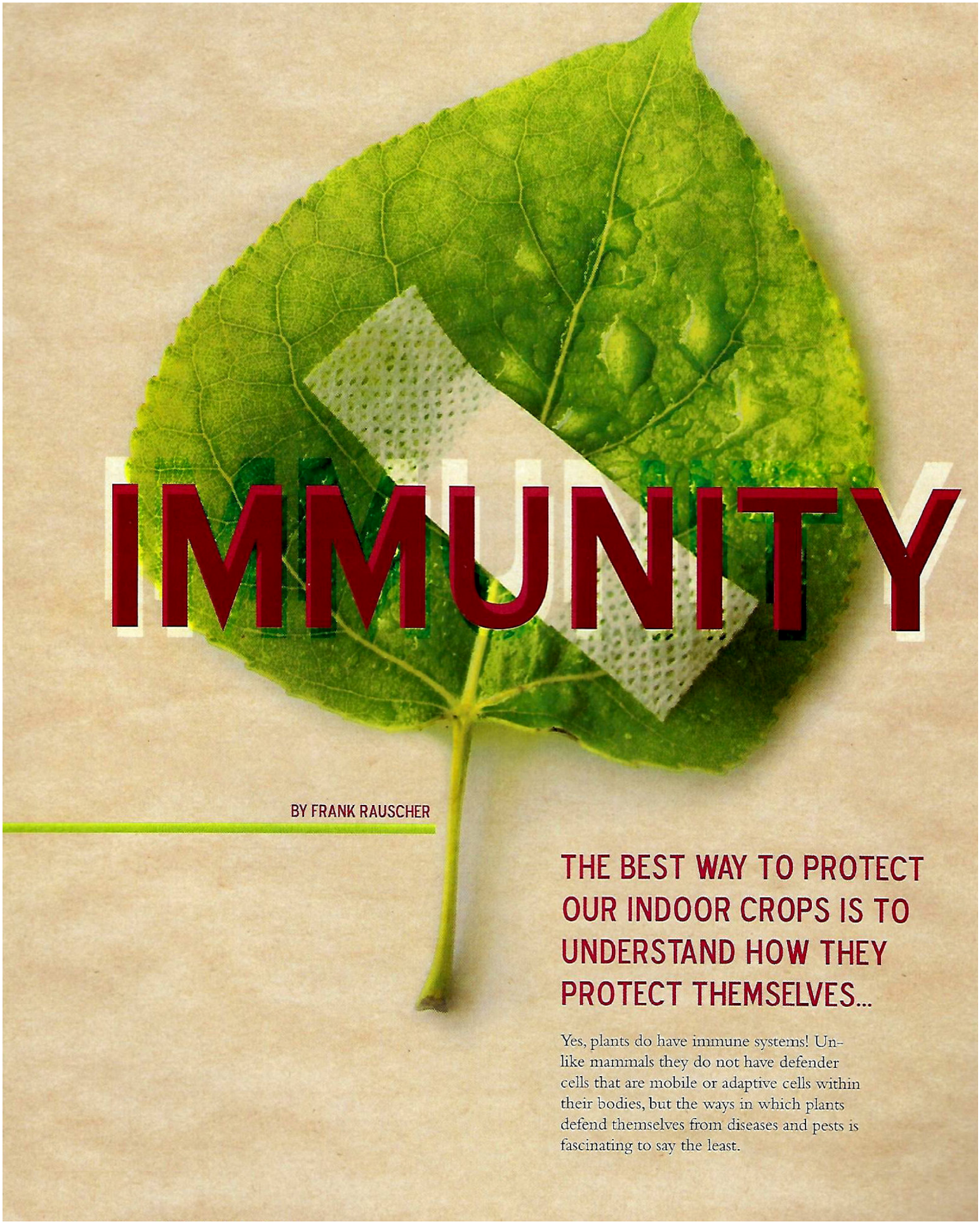
Lee McCall is an alumnus of Johnson & Wales University. His extensive culinary background helped him gain experience in and knowledge of fine dining and food production, which developed into a career in the hydroponics and year-round gardening industry. Lee and his business partner use their Denver-based businesses to educate the public on sustainable gardening and high quality produce.

Matt Geschke has a B.S. in biology from Baldwin Wallace College. He also completed an environmental geology degree from the University of Akron and received his M.S. in 2002. Matt is an adjunct professor at Kent State University.

Philip McIntosh is a science and technology writer with a bachelor's degree in botany and chemistry and a master's degree in biological science. During his graduate research he used hydroponic techniques to grow axenic plants. He lives in Colorado Springs, CO. where he teaches mathematics at Challenger Middle School.

Shane Hutto is a technical advisor at Grodan Inc. He earned a bachelor's degree in horticulture at Oklahoma State University and received a research assistantship for his master's degree. During his graduate studies he researched production and extraction of surface waxes on horticultural commodities. His passion for growing is complimented by his experience in many types of controlled environment operations and design.

Become a Maximum Yield contributor and have your articles read by 250,000 readers throughout USA, Canada, UK, New Zealand and Australia. Maximum Yield is the largest free-to-consumer indoor gardening magazine in the world. Every issue is available on *maximumyield.com*, which has thousands of unique visitors monthly.



IMMUNITY

BY FRANK RAUSCHER

THE BEST WAY TO PROTECT OUR INDOOR CROPS IS TO UNDERSTAND HOW THEY PROTECT THEMSELVES...

Yes, plants do have immune systems! Unlike mammals they do not have defender cells that are mobile or adaptive cells within their bodies, but the ways in which plants defend themselves from diseases and pests is fascinating to say the least.

Pathogens are those life forms that attack and damage our plants. Pathogens have different strategies for surviving and thriving within the plant—bacterial pathogens, for instance, proliferate in the spaces between the cell walls. They often get started by entering through a gas pore (stomata) or a water pore (hydathode) and of course they can enter through a wound as well. Some other plant invaders are aphids and nematodes—which insert their little stylets into plant cells—and fungi, which have many ways to get under the protective skin of your plants. There are many types of pathogens that try to use, feed off of or injure plants; without some system of defending themselves plants would be unable to survive.

"Pathogens have different strategies for surviving and thriving within the plant."

To obtain a basic understanding of these plant defense processes you'll need to add a few terms to your vocabulary: disease-resistance proteins (R), pathogen-encoded effectors (PE), transmembrane pattern-recognition receptors (PRR), microbial-associated molecular patterns (MAMP) and pathogen-associated molecular patterns (PAMP).

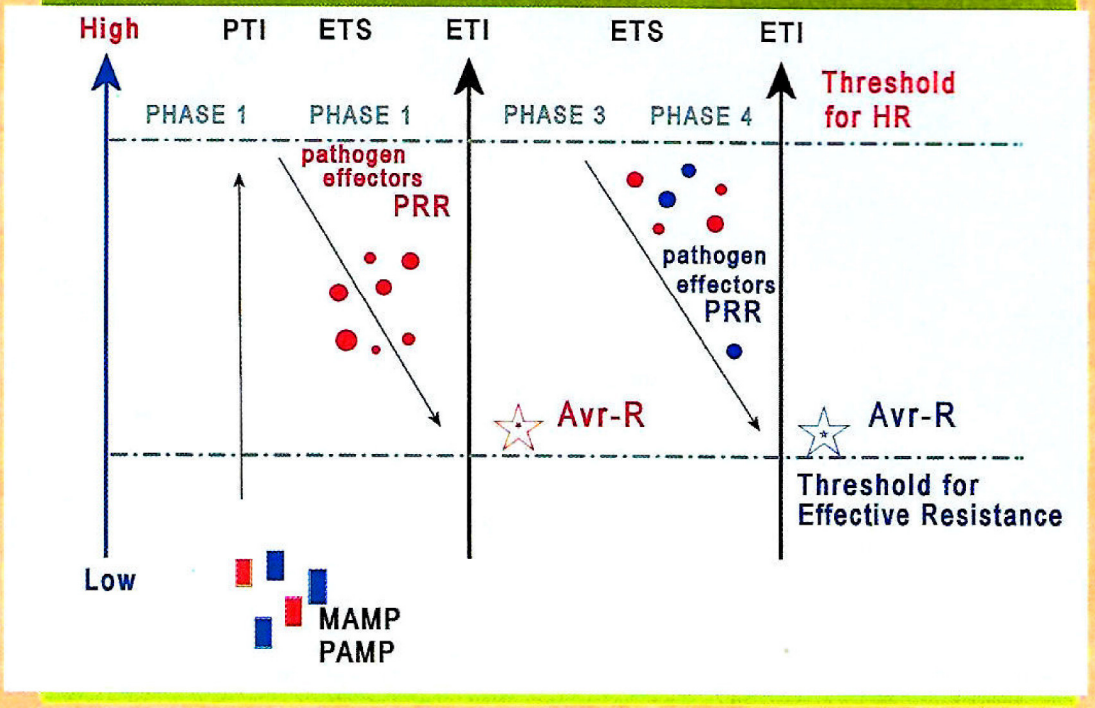
In order for a disease-resistant plant protein to be effective and result in no disease there needs to be a dominant resistance gene in the plant and a corresponding avirulence gene in the pathogen. In this type of match the right protein can trigger responses that can prevent disease from affecting the plant.

A pathogen-encoded effector is a protein secreted by a pathogen and it works to help the pathogen adjust to its new living environment within the host plant—sort of like the Trojan horse. The plant has a counter move to this attack, however, as the introduction of an effector often triggers the activation of a disease-resistant protein within the plant. The 'R' protein recognizes the modified version of the plant caused by the effector in a similar way to the 'danger signal' models that kick into action in a mammal. The war goes on.

There are two basic branches of plant immune systems—one uses transmembrane pattern receptors (PRRs) that respond to the slowly evolving changes caused by microbial- or pathogen-associated molecular patterns (MAMP or PAMP). The other acts mostly inside the cell, using protein products activated as the result of some effector.

The thin black arrows indicate the ongoing level of plant immunity. In the first phase, the plant detects the initial effectors from the microbial or pathogen-associated molecular pattern (MAMP or PAMP) and triggers increased resistance and immunity (PTI) for that pathogen. During phase two, certain pathogens deliver effectors that interfere with PTI. This enables pathogen nutrition and dispersal, resulting in effector-triggered susceptibility (ETS). During phase three, one of the effectors (Avr-R) is recognized by a plant protein, which activates effector-triggered immunity again. Sometimes the immunity response is so strong that it triggers a hypersensitive cell-death response (HR) in the plant. In phase four, pathogen isolates are selected that have lost the red effector and gained new effectors though gene flow (in blue). These blue PRRs can help the pathogens to suppress the ETI in their attempt to survive the plant's defense. This selection, however, helps the plant to again recognize the new effector and the ETI response is retriggered.

Hypersensitive cell death (or HR) is a process of programmed cell death in a plant that is associ-



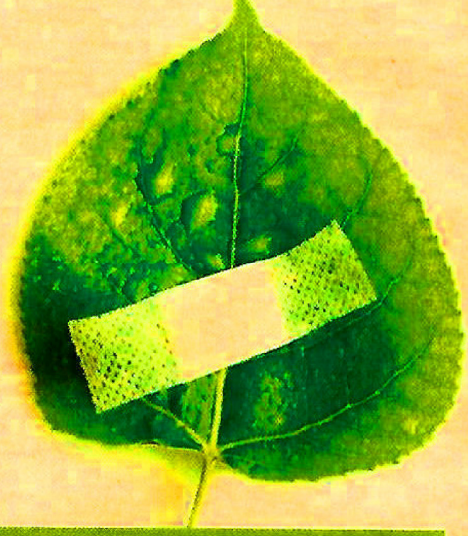
ated with the plant's reaction to pathogens. It is a kind of suicide reaction by the plant initiated in order to kill or limit the threat of the pathogen that is attempting to invade the plant—and is one of the most fascinating aspects of the plant immune system. You might have seen whole branches of a tomato plant curl up and die shortly after a bite from an insect—the concept is to burn the bridges in front of the invading pathogen in order to save the plant as a whole. This process spreads rapidly and is often quite effective. For gardeners tending plants exhibiting this reaction, the plant should be stripped back to the stem or branch just before the dying portion in order to help minimize the amount of 'HR' that will occur and the pathogens that might invade.

Other plant reactions are also initiated as a result of 'HR.' Local and systemic-acquired resistance is often found very near the site of pathogen attack—or sometimes quite some distance away, indicating the key role of these forms of resistance in the plant. Many studies have examined these plant responses and the results clearly indicate the complexity of the regulation of these responses within the plant and the interplay of the signals between the pathogen, the environment and the host plant itself. The hypersensitive cell-death response is one of the most powerful mechanisms the plant has to defend itself and as gardeners we need to be able to recognize this response as being something different from plant failure. Some pathogens—such as those

"The hypersensitive cell-death response is one of the most powerful mechanisms the plant has to defend itself."

carried by an insect—are not transferable in themselves to other plants and therefore the entire plant need not be removed. It is the insect itself in this case that spreads the disease to other plants.

Another very interesting method of plant self-defense is when they 'tag' an invading insect with a protein. When digested by the attacking insect this tagging protein converts to another chemical within the insect, a chemical that will then be recognized by a plant when the insect is feeding from it. The chemical gives off a sort of SOS to the other plants to alert them that this particular insect is a bad guy. They then immediately begin to put into force their defense systems, which will repel the insect before it has had much



"The chemical gives off a sort of SOS to the other plants to alert them that this particular insect is a bad guy."

of a chance to create trouble. In this example the plants might not know that every wasp is a menace, but they would recognize the ones that had already eaten, limiting the damage from insects to just the initial attack and avoiding any further damage. Quite fascinating. Research has also shown that bacteria and fungi can also trigger a variety of chemical warning signals, causing plants to respond by increasing hormones in order to build up their defense systems.

It is obvious that not only do plants have immune systems, but that these systems are vital to their health and productivity. If we want optimum health, vigor and production from our crops, we need to help ensure that they are given what they need to keep their immune systems strong. This is why it is so important to examine more than just the NPK of our fertilizers—micronutrients also play a large part in supporting these plant functions. For example, magnesium is one micronutrient that plays a significant role in facilitating photosynthesis. In order for the plant to synthesize chlorophyll, magnesium must be present in sufficient amounts within the plant's tissues. It is also an enzyme activator.

The plant's metabolism itself is an interwoven maze of reactions that regulate and promote growth, health and the immune system. Establishing the right protocol for everything from watering and nutrition to temperature and light control is vital for maximum plant vigor and health and will promote the effective functioning of plant immune systems. Keep your plants strong and they will be able to fight off much of the disease and pest damage they face on their own. MY

Plant Immune Systems

The best way to protect our indoor crops is to understand how they protect themselves.

Yes, plants do have immune systems! Unlike mammals, they do not have defender cells that are mobile or adaptive cells within the plant body. The ways in which plants defend themselves from disease and pests is fascinating to say the least.

Pathogens are those lifeforms that attack and damage our plants. These damage causing pathogens have different strategies for surviving and thriving within the plant. Bacterial pathogens proliferate in the spaces between the cell walls. They often get started by entering through a gas pore (stomata) or a water pore (hydathode). Of course they can enter through a wound also. Some other invaders of our little plants are aphids and nematodes; these insert their little stylets into the plants cells. Then there are fungi that have many ways to get under the protective skin of the plant. So, there are many types of pathogens that want and try to use, feed off of, or otherwise injure our plants. Our plants need to have some system of defending themselves or they can't survive.

To have a basic understanding of these plant processes we'll need to add a couple concepts or terms to our vocabulary. Disease resistance protein (R), pathogen encoded effectors (PE), transmembrane pattern recognition receptors (PRR), microbial associated molecular patterns (MAMP), pathogen associated molecular patterns (PAMP).

In the interaction between plants and their pathogens, and in order for a disease resistant protein to be effective and then result in "no disease", there needs to be a dominant resistance gene in the plants; and a corresponding avirulence gene in the pathogen. In this type of match the right protein can trigger responses that can prevent disease to the plant.

A pathogen encoded effector is a protein secreted by a pathogen and it works to help the pathogen adjust to it new living environment within the host plant. Kind of like a Trojan Horse. The plant however has a counter move to this attack, as the introduction of an effector often triggers a disease resistant protein to be activated within the plant. The 'R' protein recognizes the modified self of the plant caused by the effector in a similar way to the "danger signal" models that kick into action in a mammal. The war goes on.

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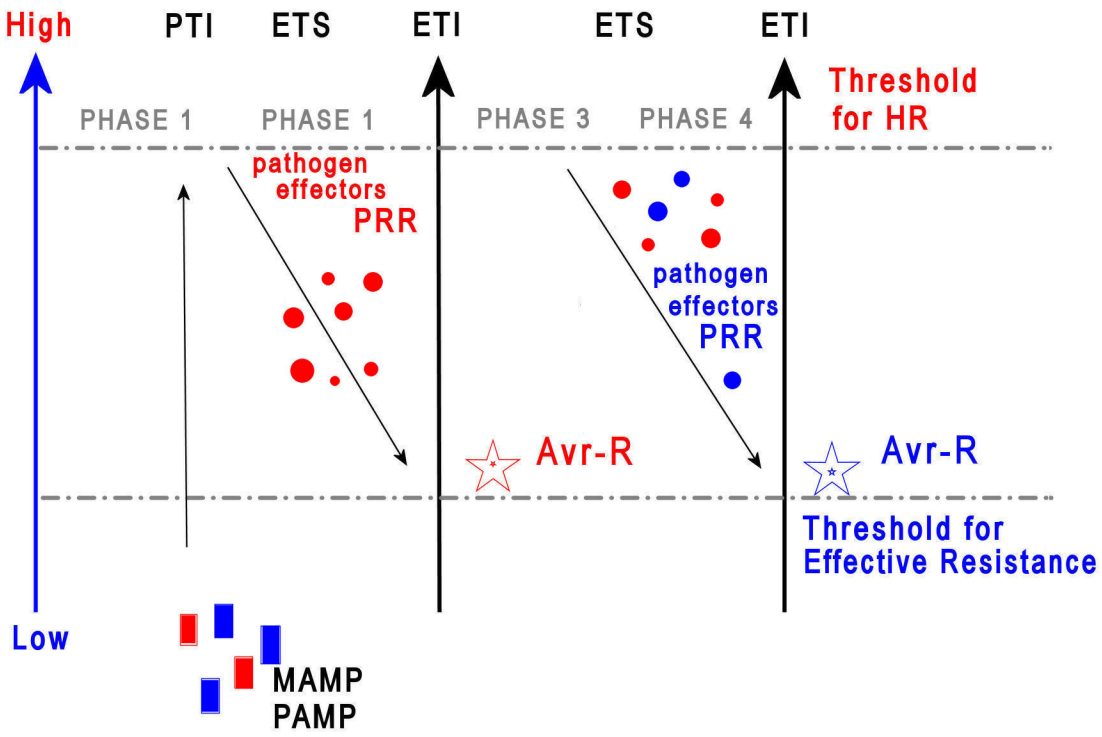

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Hypersensitive cell death 'HR' is a process of programmed cell death in a plant associated with the plants reaction to pathogens. It is a kind of suicide reaction of the plant done in order to kill or limit the threat of the pathogen that is attempting to invade or attack the plant. It is to me, one of the most fascinating aspects to the plant immune system. You may have seen whole braches of a tomato plant curl up and die shortly after a "bite" from an insect. The concept is to burn the bridges of survival for the invading pathogen in order to save the plant as a whole. This process spreads rapidly and is very often effective. For the gardener tending this plant, we should remove back to the stem or branch before the dying portion in order to help minimize the amount of 'HR' that will occur and pathogen that might invade.

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Another very interesting method for self-defense is when they "tag" an invading insect with a protein. This 'tagging' protein, when digested by the attacking insect converts to another chemical within the insect which will then be recognized by a plant when the insect is secreting onto and feeding from it. The chemical gives off a sort of SOS to the other plants, that this insect is a bad guy. They immediately begin to put into force their defense system which will repel the insect. Before it has had much of a chance for creating trouble. In this example the plant might not know that a different wasp was a menace, but it would recognize one that had already eaten. Limiting the damage from insects to just the initial and avoiding the repeating attacks. Quite fascinating! Research has also shown that bacteria and fungi (as well as insects) can trigger a variety of chemical warning signals. These plants respond by increasing hormones in order to build up the defense system.

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Enjoy!

Frank Rauscher
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