When Bugs Come to Dinner

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Perspective
Every progressive farmer of the 21st century is aware that he is not just a tiller of the land. Gone are the days when farming was merely an “honorable” profession. This is the era of the progressive farmer and the challenges of modern day farming make him an important component of the food security equation. However, in order for a farmer to be progressive he needs to board the ‘information bandwagon’ and empower himself with the appropriate scientific information. This will allow him/her to make calculated decisions to optimize the quality and quantity of his/her produce.

All organisms that have evolved and survived on this planet have inbuilt natural defenses to combat attack by other organisms. Plants are no different. Being immobile, they have evolved complex mechanisms to counteract the onslaught of diseases and pests. However, in this day of pesticides, fungicides, herbicides, insecticides, bactericides and viricides we fail to acknowledge the inherent capacity of plants to fight their own battles. In this article let us try to understand what is a disease and why does it really attack a plant, what conditions make a plant more prone to attack and what we as growers can do to minimize the onslaught.

I am not suggesting that under a pest attack one should not take protective measures to restrain the attack; I am suggesting that prevention is better than cure. Let us try to maximize the inherent disease fighting capabilities of our crops by providing them with their basic necessities

The mechanism of a parasite attack
According to the Webster’s dictionary, a disease is defined as “a condition of the living animal or plant body or of one of its parts that impairs normal functioning”. Parasites, insects, nematodes, fungus, bacteria and virus are some of the leading disease causing organisms in commercial crop production. All growers at some point have developed a strong animosity to these organisms, which come in different forms, shapes and sizes but they have the same final effect- moderate to complete devastation of the crop.

Now when does a pest attack a plant? When presented with a favorable environment and a favorable host, the pest will attack. A wide variety of parameters such as temperature, humidity, pH, water and deficiency or excess of nutrients make the conditions conducive for a pest attack. The type of pest will usually determine the severity of the attack. An obligate pest will normally weaken its host, but will not kill it since killing the host would certainly guarantee the death of the pest. However, a facultative pest, when in its parasitic mode, is likely to be aggressive enough to kill their host. The next logical question is to examine why a pest attacks the host. The primary reason is for food. Pests attack the plant to prey on the crop or lay eggs, which in turn grow and prey on it. Plants come armed with a range of pest-specific arsenal and their biochemical responses are catered to the pest in question. For the purpose of this discussion, let us talk about the influence of mineral nutrition on plant resistance to fungal attacks. So how does a fungal attack occur?

…When dinner is served.

I. Imbalance of nutrients:

Excess, insufficiency or an imbalance between the seventeen essential nutrients is likely to decrease the crop-resistance to disease. For example, under conditions of HIGH NITROGEN and/or LOW POTASSIUM excessive amounts of amino acids and sugars are produced inside the cell. Why? Because the homeostasis between protein synthesis and carbohydrate synthesis is skewed. The protein metabolic pathway stops short and instead of proceeding to form proteins, low-weight intermediate amino acids accumulate in high concentrations in the cell. Fungal spores germinate and proliferate on cell exudates containing high amounts of amino acids. These exude out of the cell and offer an ideal environment for a fungal attack (see fig.1)

FIGURE 1

II. When the plasma membrane turns leaky

Under zinc, calcium and boron deficiencies the plasma membranes become unstable. These three nutrients have specific roles to play in maintaining the cell wall integrity. Calcium binds with pectate found in the middle lamellae of cells. Calcium also binds with Boron in the cell wall and both these bonds are vital for maintaining the strength of the wall. A deficiency (actual or induced) of any of these elements will result in cell walls with increased pore size, thus making them permeable or “leaky”. A leaky plasma membrane will facilitate:

1. The movement of exudates out if the cell and
2. The unimpeded penetration of fungal hyphae into the cell

III. When the host is unable to protect itself

Chemical metabolites produced by the plant in response to parasite attack are termed as “secondary metabolites”. These are different from primary metabolites (glucose) as they are waste products of metabolism, are toxic and are produced only when a defense response is elicited. These are derived from the isoprenoid, phenylpropanoid, alkaloid or fatty acid/polyketide pathways and include products like tannins, nitrogen-based compounds (nicotine, morphine, and cyanide), terpenoids, alkaloids and phenolics (salicylic acid, lignin). Most antimicrobial plant products have relatively broad-spectrum activity, and specificity is determined by whether or not the parasite has the enzymatic machinery to detoxify the host product. Plant toxins kill the intruders, reduce their capacity for normal reproduction or cause temporary or permanent physiological change in the pest.

Extensive research has indicated that micronutrients especially Boron, Manganese and Copper play a significant role in secondary metabolism production. In the event that these micronutrients fall short, the production of secondary metabolites is hampered or blocked. Hence, the plants inherent capacity to fight disease decreases and it succumbs to disease. Flavanoids are a classic example. They have fungistatic properties, which stops the proliferation of the fungus on the plant.

Calcium also has a key role to play in disease-resistance. When a fungus attacks a plant it produces an enzyme called polygalacturonase. This enzyme degrades the pectate in the cell wall and causes disintegration and collapse of the cell wall and affected tissues. The activity of this enzyme is drastically inhibited by optimal calcium levels in the cell. However, if calcium is deficient in the plant, the activity of polygalacturonase goes unchecked and fungal invasion occurs unimpeded.

Although disease resistance and disease tolerance are genetically controlled traits, we just saw how the mineral nutrient status of a crop influences its disease fighting/tolerating capabilities (see fig 2).

Optimal Nutritional Status of Crop

All nutrients available for primary and secondary metabolic functions

Optimal Health

Optimal Immunity-all nutrients present to activate defense mechanisms if needed

If attacked a high plant resistance to disease
Damage is less or none at all!

So what can a grower do?

Now that we have seen the relationship between nutrients (macro and micro) and disease, we can try to evaluate our nutrient inputs a little better. Nutrient management is an important factor in sustainable and profitable farm management. A key aspect of nutrient management is balancing the nutrients correctly. Maximum yield results are obtained from the addition of micronutrients only when major and secondary nutrients are present in adequate amounts and in a balance required by the crop.

BALANCED PLANT NUTRITION (BPN) is NOT a revolutionary concept-----IT IS A POORLY UNDERSTOOD ONE. It encompasses the concepts of nutrient management based on crop type, soil type and stage of plant growth. Use of BPN ensures proper ratios of ALL essential nutrients and hence enables the plant to complete life cycle in the precise timeframe. Plants are very fastidious when uptake of nutrients is concerned and they preferentially exclude or absorb nutrients based on the concentration of nutrients provided to them. Therefore, any odd combination of nutrients is not going to do the trick of providing all 17 nutrients in the appropriate ratios required by the plant. There are three good reasons to practice Balanced Plant Nutrition.

1. Ratio between nutrients is important for efficient usage by crop.

2. Antagonistic & Synergistic relationships between nutrients may prevent efficient uptake and utilization. For example, excessive phosphorus in soil produces a “phosphorus induced zinc deficiency”. For a grower who is caught unawares, he assumes that there is lack of zinc in his soil and he may apply zinc to counteract this problem. However, this application may not benefit him in anyway—he has spent money on a problem that never existed! Understanding this relationship is essential for profitable agriculture.

1. Different stages of growth need different ratio of nutrients.

To assure high-quality end-products, whether it is fruits, vegetables or corn-ears, it is important to coordinate crop-physiology with crop nutrition status. It is a well-documented fact that a high percentage of micronutrient requirements are taken up during the first one third of the growing period. Therefore, it is important to have these micronutrients available at the very beginning of the plants life cycle to get the maximum utilization. If they are applied later, the crop may experience hidden hunger, and yield and quality will be affected.

In essence, food is essential for optimal growth and development of any organism. This understanding of nutrient-dynamics in a plant system will make it possible for us to sustain our farms in a productive and profitable way.