The Mechanisms of Plant Defense Response

The biological imperative for any living organism is to survive and to reproduce. In order to fulfill these objectives an organism needs to defend itself against predation. Different organisms have developed various defensive mechanisms to suite their purposes. Plants are one of the earliest organisms that appeared on earth and are amongst the few, which are capable of assimilating elements such as carbon, oxygen and nitrogen to synthesis complex molecules essential for life. In order for plants to synthesis these complex molecules they require substantial amounts of energy, which they obtain from the sun through the process of photosynthesis. As the primary food source, plants are under constant attack by other organisms, such as fungi, bacteria and animals that are incapable of synthesizing the complex molecules needed to sustain life.

In order for plants to survive, they have developed a variety of mechanisms to reduce the amount of damage caused by pathogens and herbivores. The concept of plant resistance is not new, since the earliest days of plant cultivation farmers have selected crop varieties, which not only have the highest yields but also are resistant to infection and insect feeding. For the most of the history of agriculture this was achieved through classical breeding (Mendelian Genetics) and trial an error. Only recently has the mechanisms of plant resistance been more closely studied and a clearer understanding of the pathways involved has been achieved.

Plant defense response

The resistance mechanisms developed by plants can be divided in to three broad categories

1. **Physical adaptations**
   The physical adaptation of plants are the most noticeable, these include, Rapid growth to increase height, production of thorns, or viscous resins (conifers) and latex.

2. **Protein and Enzymatic Adaptations**
   Plants also produce a number of defensive proteins such as Ricin (Castor bean; *Ricinus comununis*), Hydrolases such as, Chitinases, Glucanases, Lysozymes and proteases, as well as protease and carbohydrolase inhibitors. The function of these proteins is to attack the invading pathogen or to stop their ability to digest the plant tissues they feed on.

3. **Biochemical adaptations**
   Plants produce a variety of complex chemicals generally known as Phytoalexins, which are either toxic, such as Pyrethroids (*Chrysanthemum*), Quinine (*Cinchona*) or debilitory such as Opium (Opium poppy; *Papaver somniferum*), Cocaine (coca plant; *Erythroxylum coca*), Caffeine (tea and coffee plants) and Nicotine (*Nicotiana tabacum*). Most phytoalexins such as alkaloids, terpenes and

flavanoids are complex aromatic compounds that are synthesized by the plants via the shikimic and malonic acid pathways.

The coffee Plant

The Coffee Plant like many other plant species has developed a number of biochemicals, which it uses to defend itself against insect feeding. The most widely known of these chemicals is the Xanthine alkaloid Caffeine.

The chemical compound caffeine is a central nervous system stimulant, which in humans reduces fatigue and increases mental alertness. It is precisely due to this chemical that the coffee plant has been cultivated by humans. At high doses the pharmacological function of caffeine is more pronounced causing disorientation, appetite suppression and diarrhea. Since the amount of caffeine to size ratio in humans is very high these symptoms are far less pronounced. However, in case of insects feeding on young coffee leaves and beans these effects are far more evident causing the insect to stop feeding and become more venerable to predation by insect predators.

Caffeine synthesis regulation in coffee plants

Coffee plants produce caffeine constantly, however, the concentration are highest in young leaves and beans in order to protect them from insect feeding. Caffeine synthesis can also be increased by the plant when it is under attack by insects feeding on the young flush and beans.

In coffee plants tissues damaged due to insect feeding produce signaling chemicals which alerts the rest of the plant that it is under attack. These plant chemicals are known as elicitors, which travel through the plant causing the plant to increase production of its defensive chemicals. The ability of plants to recognize injury and to increase their defensive responses is known as Systemic Acquired Resistance (SAR) and is ubiquitus in the plant kingdom.

Studies on coffee plants have shown that if the plant is sprayed with elicitors that mimic insect feeding the plant will respond by increasing caffeine production even in the absence of insect feeding. This ability to increase caffeine production in healthy coffee plant is of special interest to coffee growers. Since the amount of caffeine and the other phytochemicals, such as antioxidants, increases the flavor of the coffee beans and produces premium beans with a higher market value.

The KeyPlex Factor

KeyPlexDP line of products are foliar applied plant nutritional products that have been specifically formulated to provide for optimal plant growth. The micronutrients in

KeyPlex products have been designed to be readily absorbed through the plant leaves. This is achieved through chelating the micronutrients with Glucoheptonate, an aliphatic (straight chain) seven carbon organic acid. Glucoheptonate chelated compounds are readily dissociated from the molecule, without the need to expend energy and Glucoheptonate itself is readily used by the plant as a building block for the synthesis of other compounds specifically sugars. The foliar application of micronutrients has many advantages

a. It allows for ready absorption of the nutrients to the leaves where they are most needed.
b. It eliminates the problem of transport of certain micronutrients that are not readily translocated within the plant (Table 1).
c. It reduces soil effect, since most micronutrient can become bound to soil particles and remain unavailable to the plant, since they can not be absorbed through the roots.

The various KeyPlex products have been designed to provide the appropriate ratio of micronutrients need for the optimal growth of different plant species.

Table 3. Nutritional Composition of KeyPlex Products

	KeyPlex Products									
Micronutrient	**250**	**350**	**445**	**Poly Start**	**ByPass**	**Jump Start**	**Iron Plex**	**Calcium Plus**	**Cal-Mag-Boron Plus**	**Blossom**
	Concentration % (Weight per Volume)									
Nitrogen	2.5		4.0	8.0	1.0	5.0				
Phosphorous				30	3.0	20.0				
Potassium				5.0	1.0	4.0				
Sulfur	4.0	4.0								
Iron	2.0	3.5	0.5			0.05	6.25			
Magnesium		1.5				0.05			2.25	2.0
Manganese	1.14	0.75	4.0			0.2				
Zinc	1.0	0.75	4.0			0.03				
Calcium								9.0	4.5	4.0
Molybdenum	0.003	0.003				0.003				
Boron	0.02	0.16				0.02			0.5	1.0

KeyPlex as SAR Elicitors

All KeyPlex products contain the unique preparation of Yeast Hydrolysate, an EPA approved elicitor of the SAR response. The proprietary preparation of yeast hydrolysate in KeyPlex Products is unique in that it produces Alpha Keto Acids, which are the necessary components of the important metabolic pathways in plants. The Alpha Keto Acids are prepared in such a way that they are readily absorbed by the plant leaves and

can be used by the plant without expending energy to translocate or modify before use. The Yeast Hydrolysate preparation used in KeyPlex products has also been shown to act as an elicitor of the SAR response in plants. This unique property causes the plants to activate their defensive responses before pathogens and insects attack them. The induction of the plant's SAR response by the application of KeyPlex products causes the plants to be more resistant to infections.

KeyPlex products have been used in commercial agriculture for the past twenty years. During this time the efficacy of these products has been studied on a number of crops by independent university and governmental researchers.

Conclusion

The regular application of KeyPlexDP products not only will provide the coffee plants with the optimum micro-nutritional requirements necessary for optimal plant growth and yields, they will also allow the grower to increase the caffeine and antioxidant concentrations in the beans to produce a premium produce with high market value.