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Managing Plant Nutrition for Resistance to Pests and Diseases

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Summary

Advancing Eco Agriculture (AEA) is a global leader in regenerative agriculture. The mission is to provide farmers and growers with innovative, science-backed solutions to regenerate and revitalize agriculture and food systems. We need to rethink what causes plant disease and pest outbreaks. It is the health of a plant! A nutritionally unfit plant lacks resistance to disease and pests. This paper covers plant immunity – and integrating the plant health pyramid into more sustainable farm management. The plant health pyramid model demonstrates how plant health/immunity progresses through different levels with greater resistance to pests (microbes to animals – disease & insects) via the plant's ability to produce more complex proteins, carbohydrates and phytonutrients. Healthier plants reach the top of the pyramid and have great immunity/resistance to pests.

INTRODUCTION

The Hidden Resilience of Healthy Plants. The presence of pests and diseases is often a symptom of deeper problems in plant health. While agricultural practices have traditionally responded to these issues with pesticides, fungicides, and other interventions, a growing body of evidence supports a different approach: building plant health to prevent susceptibility. At Advancing Eco Agriculture (AEA), we have seen that healthy plants - with the right nutrition - have natural defenses against many pests and diseases. This concept is more than theoretical—it has practical applications on the farm, allowing growers to foster robust, resilient crops.

UNDERSTANDING PLANT IMMUNITY

Plant immunity can be understood as a progressive journey through four distinct levels, each tied to specific physiological processes and nutrient requirements. This progression was effectively captured by John Kempf's "Plant Health Pyramid," which provides a framework for understanding how plants can incrementally achieve pest and disease resistance https://advancingecoag.com/plant-health-pyramid/ . As plants ascend each level, they gain new immunity, beginning with soil-borne fungal pathogens and advancing toward resilience against more complex threats, including insects and even viruses.

LEVEL 1: Complete photosynthesis

The foundation of plant health begins with complete photosynthesis (**Fig. 1**). This stage is critical, as it enhances the plant's capacity to produce sugars—vital energy sources that power growth and immune functions. A plant photosynthesizing at full capacity can boost its carbohydrate production by as much as 3-4 times, a shift that can be easily monitored in the field with a refractometer to measure Brix levels. When plants photosynthesize efficiently, their Brix readings can leap from an average of 3-5 up to 12-15 or higher, indicating healthier, more robust energy production.

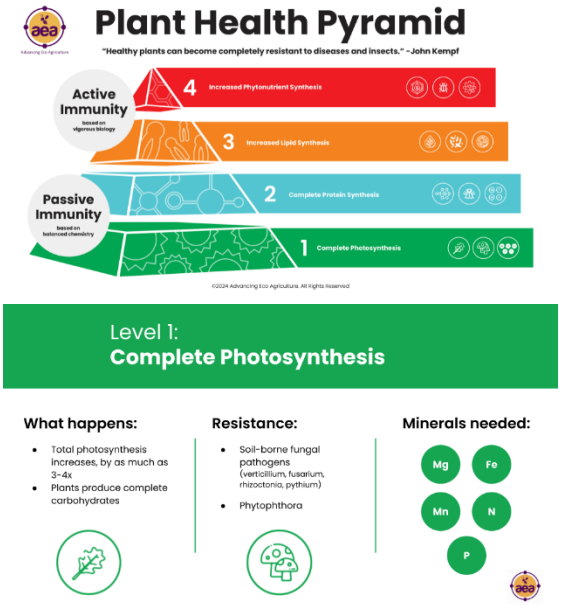

Figure 1. Level 1 on the plant health pyramid with increased photosynthesis and passive immunity to soil-borne fungal pathogens.

This increase in sugar quantity goes hand-in-hand with improved sugar quality. Plants at this stage produce complex carbohydrates instead of simple, non-reducing sugars, which changes the profile of carbohydrates in the plant's root exudates. This shift has significant implications for soil health, as complex carbohydrates support a microbial community in the rhizosphere

that actively suppresses soil-borne fungal pathogens. At this level, plants become naturally resistant to soil-borne fungal diseases, such as verticillium, fusarium, and rhizoctonia.

To achieve Level 1, plants need five critical minerals involved in photosynthesis: magnesium, nitrogen, iron, manganese, and phosphorus. While magnesium and nitrogen are essential to chlorophyll synthesis, iron is crucial for chlorophyll assembly, and manganese is needed for water hydrolysis in photosynthesis. Phosphorus supports ATP production, which is essential for metabolizing the sugars generated. AEA products like MacroPak and MicroPak can supply these minerals - with MacroPak providing nitrogen, phosphorus, and magnesium and MicroPak offering iron and manganese.

LEVEL 2: Complete protein synthesis

The second level of plant health centers on the synthesis of complete proteins (**Fig. 2**). Plants at this stage efficiently convert nitrogen into complete proteins. At this point, plants become more resistant to pests with simple digestive systems, such as larval insects and aphids, as these pests do not have the digestive capacity to handle complete proteins. Growers can monitor a plant's protein synthesis through plant sap analysis, observing nitrate and ammonium levels, which should be close to zero if the plant is actively synthesizing proteins.

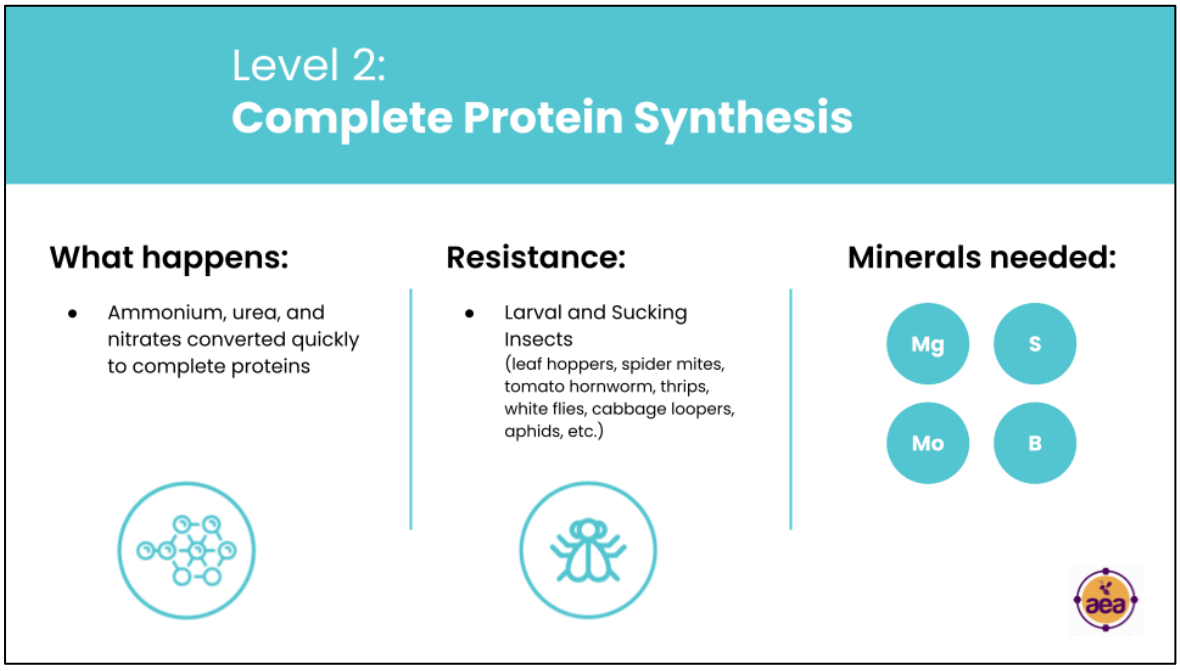

Figure 2. Level 2 on the plant health pyramid with with ammonium, urea and nitrates converting to complete proteins.

To advance to this level, plants need four essential minerals: magnesium, sulfur, molybdenum, and boron. Magnesium, sulfur, and molybdenum directly support nitrogen synthesis, while boron strengthens pest resistance by stabilizing cell walls. AEA's PhotoMag™ delivers this combination, or growers can use MacroPak and MicroPak together to cover these nutrient needs.

LEVELS 1 AND 2: Passive immunity through balanced chemistry

Levels 1 and 2 provide passive immunity to pests and diseases. In these stages, plants create metabolic conditions so that they are no longer a food source, deterring infestations before they begin. This type of immunity relies on balanced plant chemistry and can often be achieved quickly with targeted nutrient applications. Growers aiming to reach these levels can apply the required minerals through well-formulated foliar applications to address common nutrient imbalances.

LEVEL 3: Increased lipid synthesis

At Level 3, plants reach a state of energy surplus, allowing them to produce lipids, which they store as a waxy layer on their leaves (**Fig. 3).** This layer becomes a physical shield, preventing airborne pathogens from penetrating plant tissues. Plants at this stage develop resilience against fungal and bacterial pathogens, including powdery mildew, downy mildew, and rust.

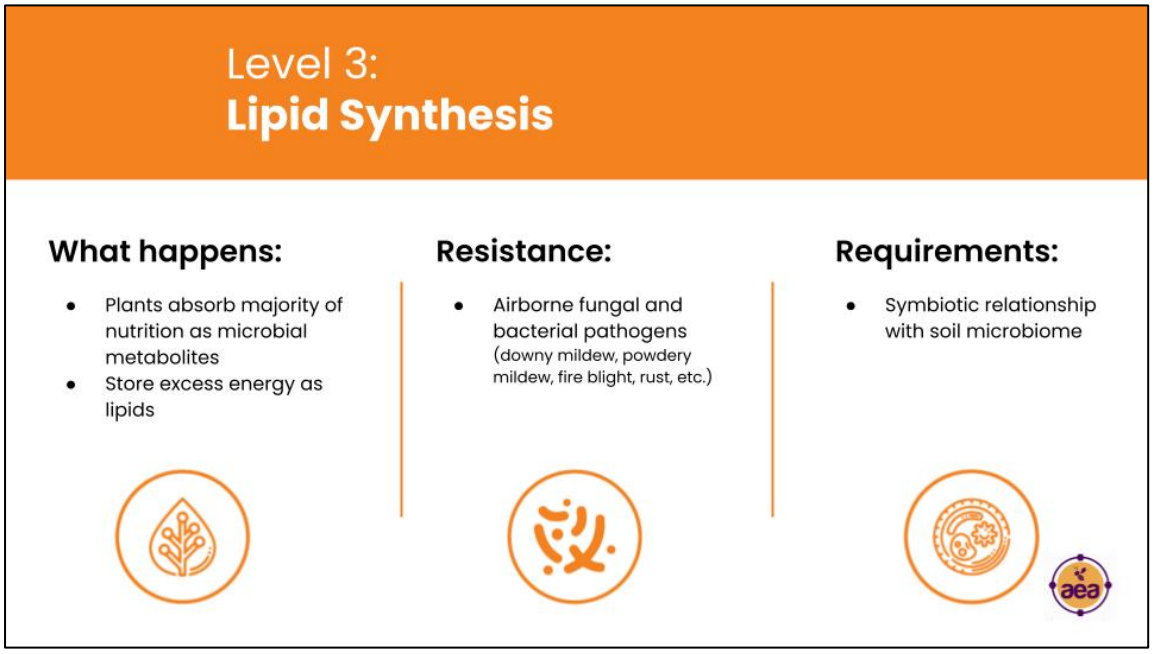

Figure 3. Level 3 on the plant health pyramid with plants storing excess energy as lipids.

Unlike Levels 1 and 2, which are largely chemistry-driven, Level 3 is influenced by the microbiome. As plants interact with soil microbes, they absorb complex nutrients, conserving energy that would otherwise go toward nutrient processing. This "prefabricated" nutrition enables sufficient energy reserves for lipid synthesis, creating the physical barriers essential for Level 3 immunity.

LEVEL 4: Elevated phytonutrient synthesis

The pinnacle of plant health, Level 4, is marked by the production of plant secondary metabolites—compounds such as flavonoids, terpenoids, and alkaloids (**Fig. 4**). These phytonutrients act as potent defenses against a broad spectrum of threats, including chewing insects like beetles and, potentially, viruses. At this level, plants shift to

active immunity, using biochemical defenses to repel pests and pathogens. To sustain this level of resistance, plants depend on a diverse and abundant microbiome, which stimulates systemic acquired resistance (SAR) and induced systemic resistance (ISR) within the plant.

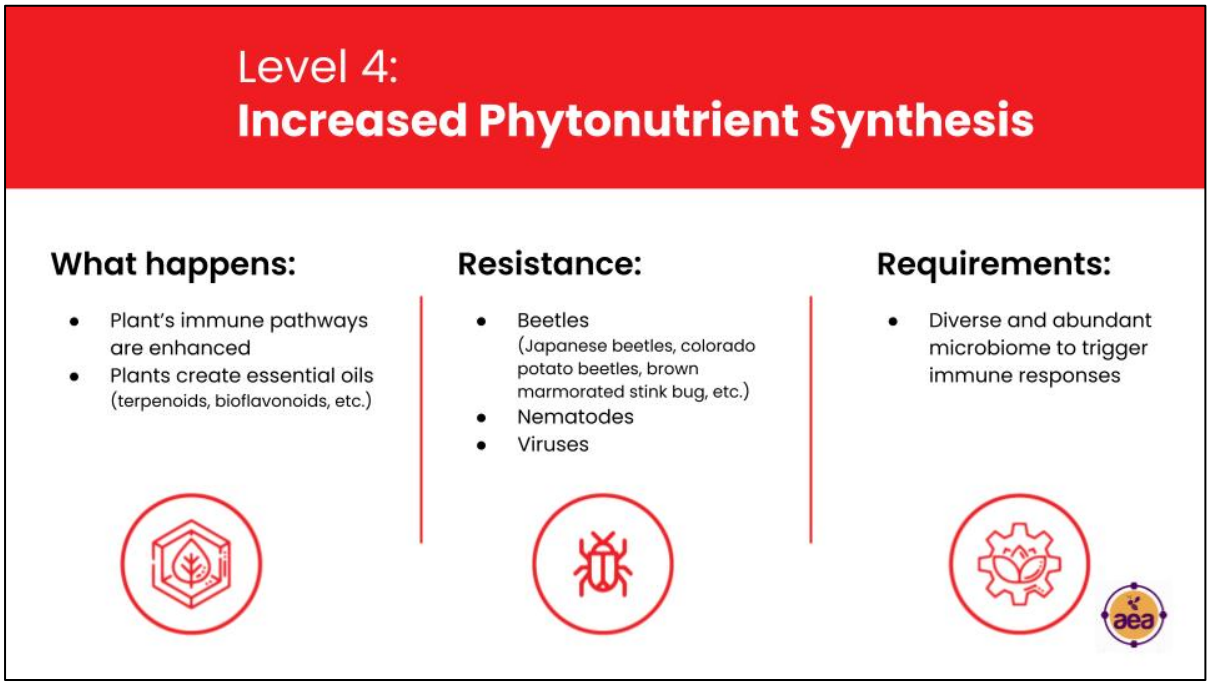

Figure 4. Level 4 on the plant health pyramid with increased phytonutrient synthesis.

INTEGRATING THE PLANT HEALTH PYRAMID INTO FARM MANAGEMENT

The Plant Health Pyramid provides a roadmap for growers to enhance crop resilience through balanced nutrition and microbiome management. By systematically progressing through each level, growers can support their plants in achieving new levels of health and immunity, reducing reliance on chemical interventions while producing healthier crops and contributing to a more sustainable agricultural ecosystem.

As growers strive to manage plant nutrition and microbiome health, they move beyond symptom treatment and embrace a holistic approach that supports plant resilience. This approach not only strengthens crop productivity but also promotes regenerative agriculture, where healthy plants, ecosystems, and communities thrive together (**Fig. 5**).

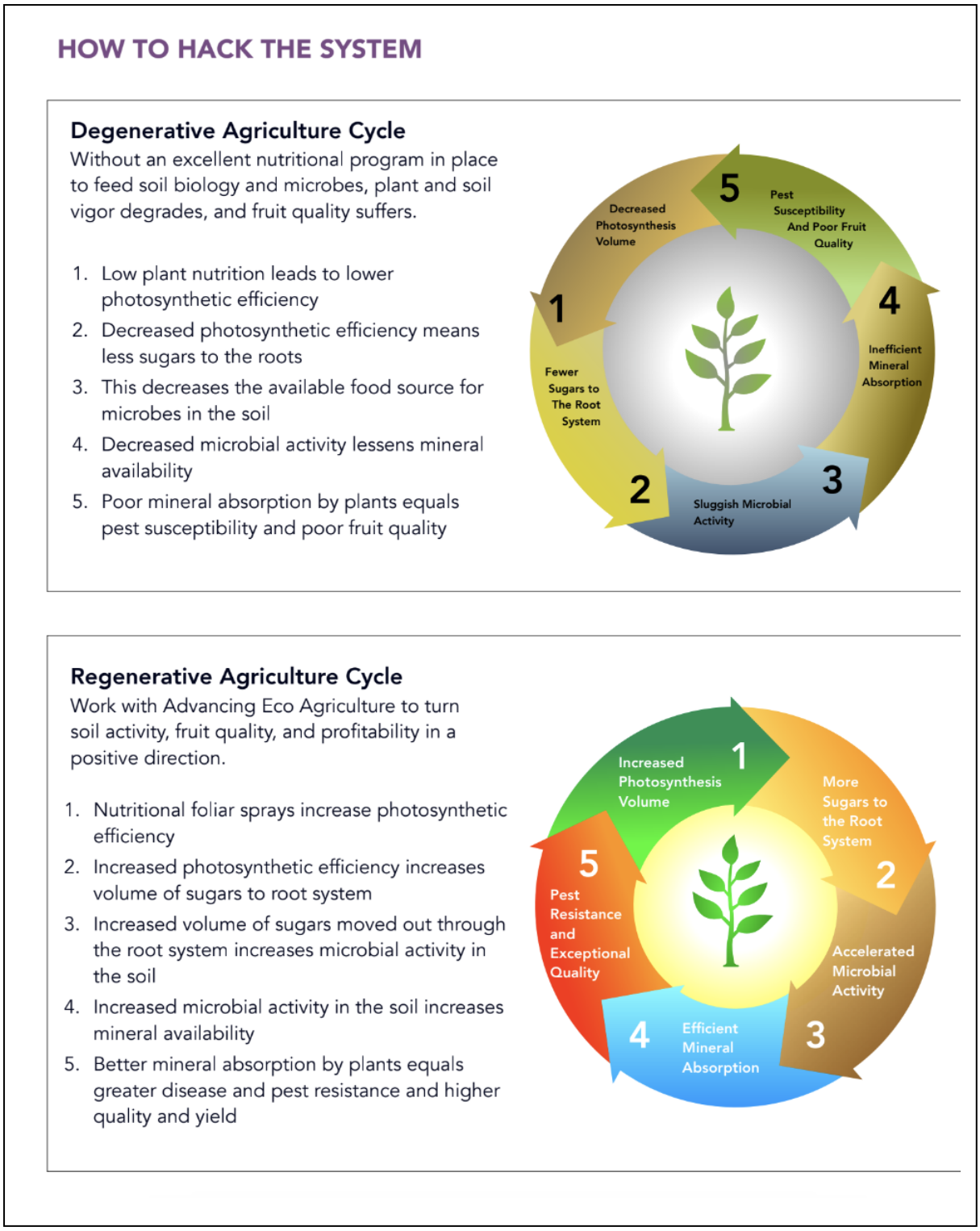

Figure 5. How to hack the system: (top) a degenerative agriculture cycle compared to (bottom) a more sustainable, regenerative agriculture cycle.