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Screening Techniques for Major Pests and Diseases

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Agriculture has long been threatened by pests and diseases, greatly affecting global food availability and economic viability. Phenotype signaling screening is an effective tool for identifying pests and diseases and providing solutions to those problems because it provides a way to see how a plant looks physiologically. This paper will describe the significance of using phenotype signaling screening in identifying pests and diseases, and the role that phenotype signaling screening plays in early identification of pests and diseases; how phenotype signaling screening is applied to breeding programs; and how phenotype signaling screening will help create sustainable agriculture. This paper will also discuss the techniques that can be used for screening for pest and disease insects; the importance of understanding plant/pathogen interactions when breeding plants that resist pest and disease attacks; and how phenotype signaling screening can change the world food supply by providing producers with better pest and disease protection for their crops.

Keyword: Biotic stress, screening techniques, breeding, measurement

Introduction

Pests and diseases present a significant threat to agricultural productivity throughout the world. Repeated attacks by and growing numbers of pests and diseases create considerable agricultural yield loss, severely jeopardizing food security. Therefore, finding new, effective techniques to limit these losses and protect plant health is becoming increasingly urgent. As an alternative to traditional methods that primarily entail the use of molecular or genetic tools, phenotypic screening methods represent a viable solution by allowing for a proactive evaluation of the major pests and diseases that affect plants by assessing the observable traits or characteristics of the plants themselves. Due to wide-scale agricultural loss due to pests and diseases, there is a critical need for innovative solutions. According to recent estimates, crop yield losses can range between 20% and 40% depending on how severely an infestation or infection occurs. In addition to adversely affecting farmers' livelihoods, these yield losses also increase the prevalence of food shortages and create economic burdens. The development of resistant crop varieties is therefore a key strategy to solve this major problem. Researchers are using genetic diversity among plant species to create plant varieties that are naturally able to resist common pests and diseases. This method reduces the need for chemical pesticides, is environmentally friendly, improves agricultural sustainability, and improves crop yields, which contributes to global food security. This paper discusses the importance of phenotypic screening methods to help eliminate major pests and diseases affecting plants. We will examine the principles, applications, and potential impact of phenotypic screening, and how it is used as a foundation to understand new advances in agriculture today. We will describe how phenotypic screening techniques work together with the production of resistant crop varieties and demonstrate how they can help strengthen worldwide food systems against the detrimental effects of pests and diseases.

Importance & Objectives of Phenotypic screening

Phenotypic screening will have a major effect on the effective management of the major diseases and pests of plants as well as being critical to the success of agriculture and sustainability of agricultural production for many significant objectives. Basically, phenotypic screening is done to evaluate phenotypic characteristics that demonstrate whether a plant is resistant or susceptible, or the likelihood of being either, to disease/crop pest/pathogens. In working with farmers, here are five reasons why phenotypic screening is important.

1. Detection of Resistance Phenotypes Early - Early Detection allows for breeders and farmers to identify resistant or susceptible phenotypes for disease early to make coinciding management decisions that will promote the development of plant varieties that are resistant.
2. Breeding Programs - In order to develop disease/pest resistant plant varieties, it's necessary to use the phenotypic evaluation of the plant material for all of the desirable phenotypic traits required to successfully produce resistant varieties.
3. The Selection of Resistant Varieties - When combining the use of phenotypic selection of pest/disease resistant plant varieties with integrated practices like using reduced amounts of chemical pesticides, maintaining a sustainable agriculture system can be accomplished.
4. High Throughput Phenotyping for Damage/Insect Behavior - High Throughput Phenotyping (HTP) systems allow for non-destructive, large scale analysis of insect feeding/damage and plant growth behaviors. HTP systems can quickly and reliably perform the analysis of many plant accessions to provide critical data for the management of plant health and crop productivity.
5. Understanding the Coevolution of Plants and Insects - Knowledge of the co-evolution of plants and insects through phenotypic screening is very important as it provides growers with evidence of how plant-insect co-evolution has occurred, leading to pest management strategies that are beneficial to both the grower and consumer..

Screening Techniques for Insects

1. **Field Resistance**: - Field screening for resistance to pests involves raising test varieties or populations in natural field conditions where pests are prevalent. Various techniques are employed to encourage pest infestation, such as closer spacing, increased nitrogen application, and irrigation to create favorable microclimates. Early planting before pest emergence or releasing artificially reared insects onto test plots ensures uniform infestation. Susceptible plants may be interplanted to facilitate pest spread, while attractants like fish meal can enhance pest density. The goal is to accurately assess resistance levels and identify resistant varieties for further breeding or cultivation**.**
2. **Greenhouse screening**: **-** This method for pest resistance is faster and more reliable than field screening. This method involves growing plants under greenhouse conditions where the environment can be manipulated to ensure that it is suitable for infestations by target pests. Insects are reared using unique methods designed to help increase insect population densities for purposes of conducting effective screening. Insects that are reared in cages will be released on to the plants that are grown in the seed boxes that are all contained in fiberglass screen cages in the greenhouse. The timing of insect release, growth stages of the insect, and quantity of insects can vary depending on both the crop type and type of pest species. When damage has been observed on the host plants, resistant and susceptible varieties can be differentiated from each other.
3. **Laboratory screening**: **-** Laboratory screening in phenotypic testing for pest resistance involves controlled experiments conducted in a laboratory setting. This method offers precise control over environmental conditions and allows for detailed observations of plant responses to pest exposure. Various techniques are employed to introduce pests to the test plants, such as infestation chambers or direct application of pest larvae or eggs. Researchers closely monitor plant reactions, including growth inhibition, leaf damage, or

other visible symptoms, to assess resistance levels. Laboratory screening enables efficient evaluation of large numbers of plant samples and provides valuable insights into the mechanisms of pest resistance.

4. **Bioassay techniques**: - The bioassay technique for phenotypic screening of pest resistance involves using living organisms, typically pests, to evaluate the efficacy of treatments or plant varieties.

Screening Techniques for Disease

1. **Artificial inoculation: -** Artificial inoculation is essential for creating uniform disease conditions for testing genotypes and facilitating comparisons. Three main methods are typically used:

a.) **Spraying**: Spore suspension is sprayed onto test genotypes, often using high-pressure spraying for efficiency.

b.) **Injection**: Spore suspension is injected into the plant surface or leaf intercellular spaces using a hypodermic needle.

c.) **Immersion**: Seedlings are immersed in a spore suspension before transplanting, making them susceptible to disease due to water absorption.

While sterile water is commonly used for spore suspension, some pathogens require dry spores to be effective, as wet spores quickly deteriorate. The choice of method depends on convenience and crop characteristics, but all aim to create consistent disease conditions for testing.

2. **Artificial Epiphytotics**

Establishing artificial epiphytotics eliminates the need for manual inoculation, vital due to the unpredictability of natural disease occurrences. This is achieved by seeding spores into the soil, either through cultivating highly susceptible genotypes over multiple years or incorporating infected debris into the soil. Maintaining proper humidity is crucial for effectiveness.

a.) **International Collaboration**: Initiating intense epiphytotics at national and international levels is crucial. The international wheat rust nursery in Mexico, established in 1957, exemplifies successful international collaboration.

b.) **Frequency of Exposure**:

Polycyclic Tests: Mimic natural disease occurrences with recurrent infection cycles. Sick nurseries created artificial are ideal for such tests, although repeated artificial inoculations can yield similar results.

Monocyclic Tests: Single exposure through artificial inoculation, preferably in controlled environments like greenhouses. However, breeders typically employ a continuous monocyclic test, particularly for moderately resistant cultures.

c.) **Measurement of Disease Intensity**:

Horsfall-Barratt Scale	% Damage in Range	Size of Interval	Interval Midpoint (%)
1	0	0	0
2	0-3	3	1.5
3	3-6	3	4.5
4	6-12	6	9.0
5	12-25	13	18.5
6	25-50	25	37.5
7	50-75	25	62.5
8	75-87	13	81.5
9	87-94	6	91.0
10	94-97	3	96.5
11	97-100	3	98.5
12	100	0	100.0

[z]Adapted from Horsfall and Barratt (1945) and Bock et al. (2010).

Qualitative Method: Classifies responses without quantifying magnitudes, suitable for monogenic disease control. Quantitative Method: Quantifies infection degree using grades, percentages, or indices. Common methods include simple usual scoring and the grading system by Horsfall and Barratt, which emphasizes assessing disease tissues versus disease-free tissues.

Some Other Scale are:

- The **Ullstrip (1944)** Diagrammatic Standard is a method used for assessing the severity of fungus infection in plants. It provides a scale to measure the extent of infection by categorizing it into different levels based on the number of lesions and their distribution on the plant leaves.

  A rating of (2.0) is generally a satisfactory lead for breeding purposes.
- The **Infection Index** developed by Villarreal and Lantican in **1965** provides a way to assess the severity of infection in plants

This standard helps in the rapid screening of plants for disease resistance and is particularly useful in research and breeding programs for crop improvement1. It's a valuable tool for agronomists and plant pathologists in diagnosing and managing fungal diseases in crops.

Conclusion

Phenotypic screening methods play a crucial role in identifying and managing plant diseases and pests. Integrating diverse approaches enhances our understanding of plant-pathogen interactions and facilitates the development of resilient crop varieties.

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