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SILENT YIELD KILLERS: NON-PEST, NON-DISEASE FACTORS LIMITING CROP PRODUCTIVITY

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Abstract

Pests, diseases and weeds are often blamed for declining crop yields, leading to increased pesticide use and rising production costs. However, in many cropping systems, yield losses persist due to silent, non-pest and non-disease factors operating within the production environment. These silent yield killers include: nutritional imbalances i.e., excessive nitrogen application, deficiencies of potassium and micronutrients, soil compaction, poor root development, improper plant population, water stress triggered by both drought and waterlogging, extremes of climate and untimely agronomic practices. Individually and collectively, these stresses impair photosynthesis, restrict water and nutrient uptake, weaken stem and root strength and increase susceptibility to lodging and environmental stress, resulting in yield losses ranging from 10–50% even in apparently healthy crops. Reducing these constraints by balancing nutrition, maintaining healthy soil structure, efficient water management and timely field operations is essential for ensuring stable, resilient and sustainable crop productivity, given the increasing climate variability.

Keywords: Silent yield loss, abiotic stress, nutrient imbalance, soil health, crop lodging, climate variability

Introduction

Food security is the major constraint in this current scenario. The factors that regulate crop productivity involve complex interactions between biology, environment and management. Although biotic stresses of pests, diseases and weeds have long been recognized as important yield-controlling factors, actual yield loss comes from abiotic and management-related stresses that occur largely out of sight throughout crop development. Silent stresses do not build up quickly or manifest visible damage but work stealthily to weaken crops through reduced root development, stem support, nutrient supply, photosynthesis and assimilate allocation (Passioura, 2006; Lobell *et al*., 2008). This makes crops look lush but fails to realize their genetic yield potential. Stresses like lodging, nutrient deficiencies, soil compaction, water deficiency, climate change, plant population mistakes and timing mistakes often come together to cumulate yield loss. The knowledge and management of silent killers of crop yield, therefore, present major challenges for enhancing yield stability under variable climate conditions for crop production. The major non-pest, non-disease factors that silently limit crop productivity and their interrelationships are illustrated in Figure 1.

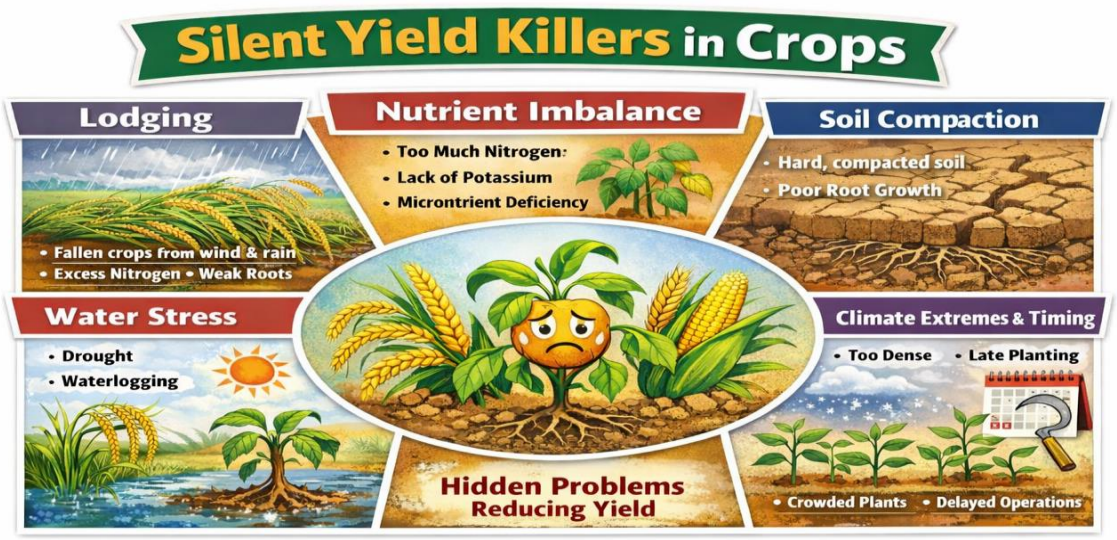

Figure 1. Silent non-pest, non-disease yield killers in crops

Lodging: When Standing Crops Collapse

Crop lodging, which refers to the permanent displacement of crop plants from their upright position caused by bending of the stem, breaking of the stem, or root rupture, is an important yet underrated factor that limits crop yields in several crop species, including rice, wheat, maize and sorghum. Excess nitrogen applications lead to increased internode elongation, which results in taller crop plants with slender walls and non-lignified regions, making them particularly prone to lodging (Zhai *et al.*, 2025; Berry *et al.*, 2004). Lack of potassium, calcium and silicon and boron particularly, makes the crop stem weaker due to poor development of cell walls and poor strength (Wu *et al.*, 2024; Bhatt *et al.*, 2019). Lack of root support due to waterlogged soils and soil compaction increases susceptibility to lodging, particularly during flowering and grain filling periods and during precipitation and high winds (Berry *et al.*, 2012). Lodging results in reduced light interception and affects vascular movement, resulting in poor grain filling, reduced test weight, harvestability, loss of grain due to shattering and poor grain quality (Berry *et al.*, 2012).

Nutrient Imbalance: Feeding Crops the Wrong Way

Nutrient imbalance can be an important, yet overlooked, cause of yield variability. Although the emphasis is placed on an excess of N, an imbalance in the application of excessive N without potassium and micronutrients causes a lack of strength in plant tissue and improper assimilate partitioning (Marschner, 2011). A deficiency in potassium limits the activities involved in cell wall thickening, enzyme activators and stress protection, making the plant more susceptible to lodging and drought (Zörb *et al.*, 2014). Other micronutrients, including Zn, B, Cu and Fe, cause a deficiency in enzymes, hormonal functions and reproduction, resulting in a low grain fill, poor and uneven grain filling (Lilay *et al.*, 2024). These imbalances rarely cause immediate crop failure, where the plant is essentially green and inefficient, performing poorly at harvest.

Soil Compaction: The Invisible Root Restriction

Soil compaction is a hidden physical constraint to crop productivity without obvious symptoms on the soil surface. It generally results

from repeated machinery traffic, heavy equipment and field operations conducted under wet soil conditions. Compacted soil layers limit root penetration, reduce soil aeration and restrict access to water and nutrients in deeper horizons. Shallow root systems increase susceptibility to drought stress, nutrient deficiency and lodging, even under adequate fertilizer and irrigation inputs. Compaction suppresses soil microbial activity, hence limiting nutrient availability. Farmers misinterpret poor crop performance as nutrient deficiency and apply additional fertilizers, increasing costs with no yield benefit. For maintaining root health and yield stability, it is very important to prevent compaction by controlled traffic, timely tillage and addition of organic matter.

Water Stress: Damage from Both Scarcity and Excess

Water stress affects crop yield under both moisture deficit and waterlogged conditions. Inadequate water supply during key stages such as tillering, flowering and grain filling will lead to reduced leaf growth, pollen sterility and poor fertilization and reduced grain capacity (Farooq *et al*., 2014). However, waterlogged situations will result in a lack of oxygen supply to the roots, reduced uptake, reduced root support and lodging in rice crops (Setter & Waters, 2003). Stagnation of water will cause yellowing, slow growth and reduced photosynthesis. Usually, in most situations, yield reduction is often not due to total water scarcity but improper irrigation timing, which is a result of improper irrigation timing and drainage.

Climate Stress: Short Events, Lasting Yield Loss

Climate-related stress has recently appeared in the list of major "silent killers of crop yields," especially due to rising levels of weather variability. Brief exposure to heat stress during flowering causes pollen sterility and drastically lowers grain formation, while cold stress during the early stages of crop development restricts tillering and biomass production (Jagadish *et al*., 2016). Abrupt and unseasonal rainfall at the cropping stage leads to lodging, sprouting and adverse effects on grain quality. The impacts of such conditions can barely be distinguishable, but they result in irrevocable loss of crop productivity due to affected photosynthesis and grain filling (Lobell *et al*., 2011).

Plant Population and Timing: Small Mistakes, Big Losses

Inefficient plant population and inaccurate field operations silently degrade productivity. Overly close plant populations lead to competition for light, nutrient and water, hence elongated and mechanically weak stems that easily lodge, while too sparse plant populations fail to utilize available resources efficiently. In the same way, sowing, application of fertilizer, irrigation, or harvesting done at the wrong time will lead to reduced growth period, nitrogen misuse and shattering of crops. Mistakes in plant population and field operations not only lead to complete crop failure but also degrades productivity.

How Farmers Can Control Silent Yield Killers

An integrated management framework for minimizing non-pest, non-disease yield losses is presented in Figure 2.

Silent yield killers must be dealt with through a holistic crop management strategy and a preventive attitude rather than a corrective one. Nutrient management through soil testing helps prevent hidden deficiencies as well as toxicities. Preventing damage to soil physical structure by avoiding field operations on wet soil helps avoid compaction and ensures root function. Careful management of water through drainage and irrigation at appropriate stages helps avoid stresses from drought as well as waterlogged

conditions. Use of varieties that are tolerant to lodging, appropriate plant population, timely application of nutrients, water and management of plant growth regulators helps improve crop architecture.

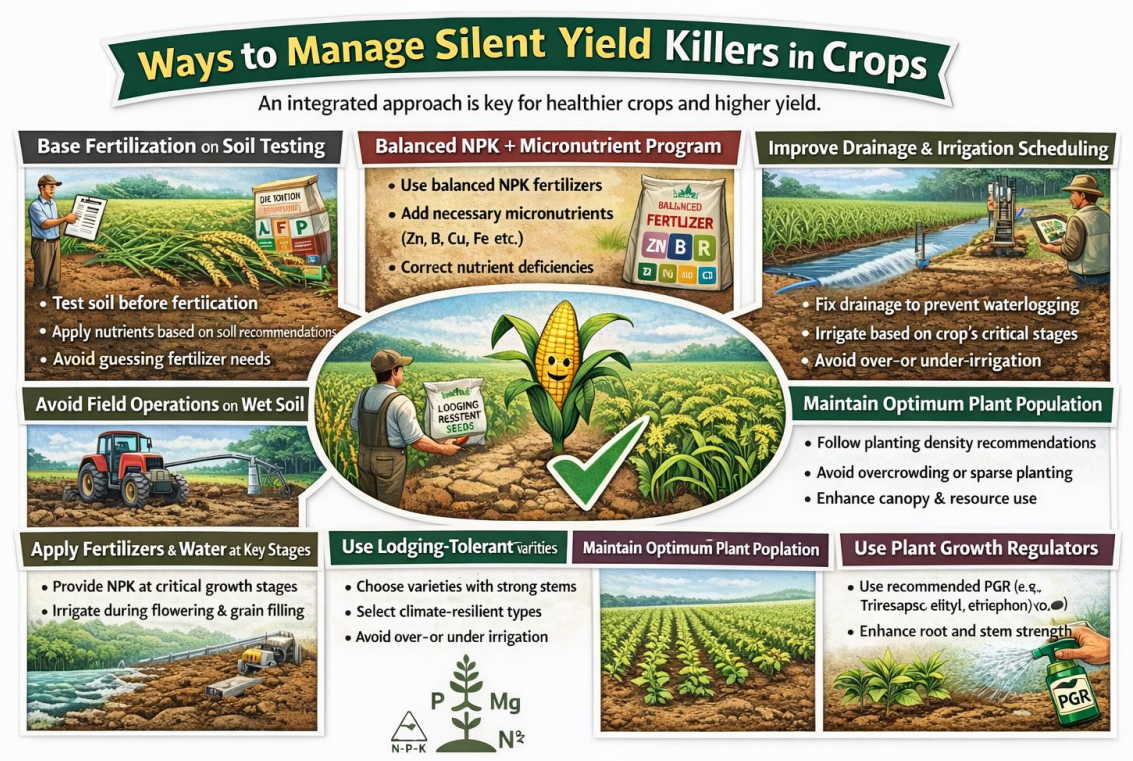

Figure 2. Integrated management of silent yield killers in crops

Conclusion

Yield losses are not always caused by pests, diseases and weeds; many yield-damaging effects occur silently because of non-pest, non-disease factors within crops. Nutritional imbalances, limitations in soil characteristics, water stress, lodging, inappropriate population density and climate affect yields without observable effects. Chemical control measures will not be sufficient to eliminate such hidden limitations. Balanced nutrition, healthy soils, timely agronomic practices and climate-smart crop management practices can contribute to sustainable yield improvement. Identifying and managing silent yield threats can greatly influence stable and profitable crop yield management.

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