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Climate - Smart Pest Control in Sustainable Agriculture Opportunities and Difficulties

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Abstract

Sustainable development has become crucial in regional and global contexts to prevent potential adverse environmental effects of human activity. Despite the fact that agriculture is the main source of pollution and ecological degradation, one of the main barriers to agricultural output is climate change. The term "climate-smart agriculture" describes farming methods and strategies intended to identify and alleviate climate-related issues early on. Changing climatic conditions have an impact on biotic and abiotic factors that affect a wide range of disease situations on crops, ultimately affecting plant health. Therefore, disease control is viewed as the main element of sustainable agriculture in light of worries about climate change.Thus, in light of climate change concerns, disease management is seen as the primary component of sustainable agriculture. This article reviews the idea of climate-smart pest management (CSPM) and how it might help promote sustainable agricultural development, especially when it comes to the impact of weather variations on phytosanitary problems. Among the primary obstacles that CSPM must overcome are implementation issues and decision-making concerns. It still has deficiencies in technology and coordination.

Key words:CSPM, Sustainable development, Smart-climate Agriculture, Pest resistance

Introduction:

Climate change is defined by the United Nations (UN) as the ongoing alteration of weather patterns and temperatures. Notwithstanding the potential for natural events like variations in the solar cycle to cause these changes, human activity remains the main cause of climate change. This is mostly due to their role in fuel emissions, including those of methane and carbon dioxide. According to the IPCC's (Intergovernmental Panel on Climate change) most recent assessment, greenhouse gas emissions have caused an approximate 1.1 ℃ increase in global temperatures. This rise is measured against the preindustrial temperature approximation, which covers the years 1850–1900. It is expected that the global temperature would rise by 1.5 ◦C within the next several decades, hitting every corner of the earth (IPCC 2021). The effects of global warming include extreme heat waves, increasing sea levels, receding glaciers and ice sheets, droughts, wildfires, heavy rainfall, alterations to freshwater and marine species, and more. There have also been more instances of crop output losses linked to climate change. For example, some crops have output losses of -16.7% and -10.8%, respectively, and are the most badly affected by climate change. Climate change may therefore pose a risk to both the quality and quantity of food security worldwide. To meet the world's population's expanding requirements and shifting dietary habits by 2050, there will need to be a 70% increase in food production worldwide. Pests are responsible for 20% to 40% of losses in the world's food supply, according to Savary et al. While the previous few decades have seen a steady advancement in agricultural techniques to increase productivity, current farming systems that rely heavily on new technologies, mechanisation, and excessive chemical use have major drawbacks on many fronts. Some of the primary environmental issues imposed by current farming techniques include soil degradation, hazards to human health, depletion of biodiversity, and contamination of soil, air, and surface and ground water in ecosystems.The Food and Agriculture Organisation of the United Nations (FAO) coined the term "climate-smart agriculture" (CSA) to refer to a cutting-edge farming methodology that aims to ensure food security by developing policies, directing entire agricultural systems for sustainable development, resilient practices, and climate-adaptive strategies (Lipper et al 2018). The climate-smart pest management (CSPM) panel, which offers numerous benefits for maintaining agricultural systems by reducing chemical usage, is a crucial part of the CSA strategy. Since CSPM still has certain drawbacks, this evaluation focuses on the idea of CSPM and phytosanitary problems associated with climate change in order to identify the areas that require more effective interventions.

Conceptual overview:

A. Climate Smart Agriculture: The idea of CSA was first presented in 2009 when talks were held on how to create more sustainable agriculture systems by highlighting the connections between preventing climate change and ensuring food security. In a study titled "ClimateSmart Agriculture, Policies, Practices and Financing for Food Security, Adaptation and Mitigation," the FAO first formally presented the CSA concept. Since then, a number of parties involved in the creation and application of the CSA concept have expanded upon it. In light of climate change, CSA is in favour of setting up internationally applicable agricultural management concepts to attain food security. Adapting and strengthening household resilience to address climate change, decreasing greenhouse gas emissions, and sustaining increases in agricultural output and household incomes are the three strategic management pillars that underpin CSA (Sekabiraet al 2022). Put differently, CSA gathers different sustainable approaches to help an agricultural community adjust to climate change by reducing its effects.

B. Climate Smart Pest Management (CSPM): The FAO does a fantastic job of explaining and promoting CSA, but academic publications rarely use the term "CSPM". The CSA's climate-smart pest control technique is known as integrated pest management, or IPM. "The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment" according to the Food and Agricultural Organisation (FAO). In order to lessen chemical pesticides' harmful impacts on the environment and public health, IPM-related agricultural practices are predicated on their sparing and prudent application (Eganet al 2021). The control of crop diseases in connection to climate change is still done so using different nomenclature. For example, Richard et al. looked at crop disease management to develop climate-smart farming systems that use integrated crop management (ICM) to produce crops with low and high input.

Climate Change-Related Phytosanitary Problems: Unexpected climate change indirectly affects rain-fed crops and feed through decreased water availability, drought and salt stress, decreased nutrient uptake

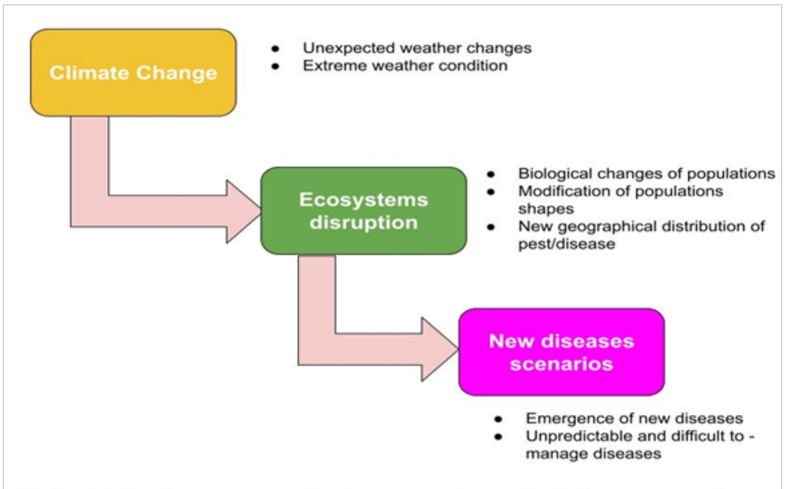

Fig.1. Relation between climate changes and new plant disease scenarios

from the soil, and land degradation. Rising sea levels, temperature increases, freshwater shortages, ecosystem instability, and biodiversity loss are other repercussions. By affecting how vulnerable crops are to diseases involving stressful conditions that affect normal growth and plant tolerance to pathogen presence, abiotic environmental factors play a crucial part in the disease triangle. Plants are being physically harmed by extreme weather, which increases their vulnerability to pest infestations. Consequently, compared to steady settings, disease manifestation or infestation may be significantly more severe. These events can include anything from too much or too little water to strong. Environmental factors may also induce favourable conditions for the formation of infections; hence, the magnitude and speed of climate change are involved in the creation of new disease and pest scenarios that can directly affect crop health. Numerous microbe and insect species experience changes in their distribution, biology, and population structure as a result of ecological shifts brought on by global warming. As a result, phytosanitary issues are probably going to get harder to diagnose and treat (Newbery et al., 2016).

Climate-Smart Pest Control's Contribution to Sustainability:Climate change is influencing disease scenarios thus pest control plans need to be adjusted for variations in the weather. Three primary processes comprise the CSPM pyramid: early diagnosis, effective interventions, and risk assessment and forecasting. However, to improve each process's effectiveness, preventive measures for pest control are always necessary. Because they keep pest and plant disease levels below the threshold for management, preventive methods are crucial for protecting plants. Using the right plant materials (certified seeds, cultivars with high tolerance/ resistance to diseases), encouraging natural enemies, etc., are all part of preventive crop protection. The greatest strategy to safeguard cultures is to begin crop production with seeds that are free of pathogens. Crop rotation may also aid in interrupting the infection cycle. Steep soils are unsuitable for crops that are susceptible to soil-borne diseases because they enable the diseases to linger for several years. Breeding plants with disease-resistant genes is another method of preventing disease. Plant breeding can be used with natural enemy or biocontrol agent breeding to obtain synergistic effects and select biocontrol organisms appropriate to the crop they should protect (Swart et al., 2018).Predicting how the chosen plants or the biocontrol agents will react to climate change can be problematic when breeding in the context of CSPM. For example, stress resulting from abrupt changes in the abiotic environment could affect how plants respond to pests they encounter today.

A. Forecasting and Risk Assessment:It is essential for risk forecasting and analysis to comprehend how pest biology and epidemiology are impacted by climate change. In order to attain suitable pest management, CSPM programmes are overseen to avert pests' emergence and growth while keeping an eye out for anticipated

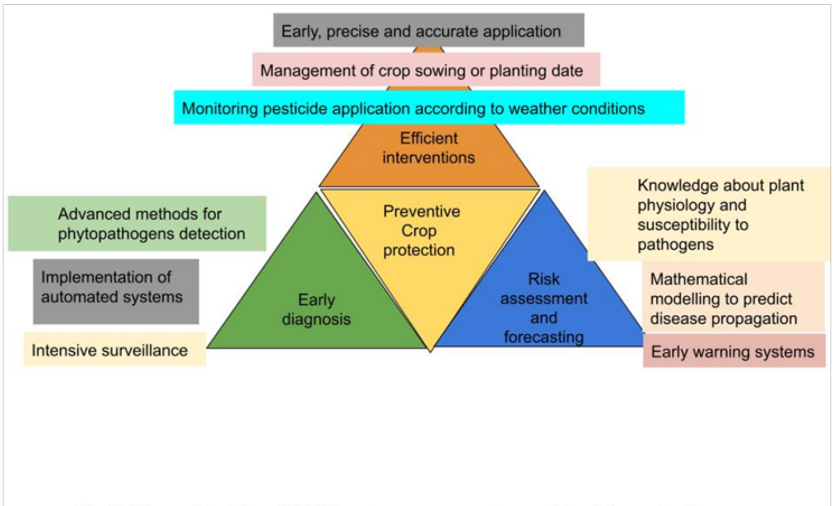

Fig.2. Pyramid of the CSPM main processes in sustainable agriculture

outbreaks. Early warning systems that offer data on illness prevalence, appearance, and progression in relation to weather data are used in risk assessment and forecasting. Determining the periods during which plants are most vulnerable to infections can be aided by knowledge about plant physiology and sensitivity to diseases. The goal of mathematical models is to forecast the spread of disease. Understanding metrological characteristics is essential for predicting changes in pest populations as well as determining places with ideal climates, visualising maps to estimate possible disease establishment zones, and supporting outbreak response initiatives.According, to certain sources, citizen science (vigilance) and passive surveillance programmes can help the public identify and report new hazards to plant health in a timely manner (Thompsonet al., 2021). All the same, we believe that in order to successfully build these new programmes based on public observations and reports, more work needs to be done on well-thought-out analytical procedures that are practical instruments for managing apparent uncertainties and evaluating this unstructured data.

B. Early diagnosis: Disease diagnosis, which begins with pest identification and continues with surveillance, is a crucial phase of CSPM. Ongoing surveillance efforts are crucial to identify newly introduced pests and/or illnesses, allowing for adequate disease management operations with less harm to the environment and public health. Furthermore, a critical classification utilised in trade certification is the declaration of areas free of pests and/or diseases or areas with low frequency of pests and/or diseases, and monitoring plays a major role in this process (Lopian et al., 2018). Early and precise interventions for disease control are made possible by the advancement of phytopathogen diagnosis techniques, which are becoming more and more accurate in the detection, quantification, and identification of plant diseases down to the strain level.

C. Efficient Interventions: Ecologically and economically sound considerations should guide any decisions about CSPM actions. Therefore, the main objectives of pest management programmes that employ environmentally friendly approaches are to improve food safety and reduce the use of chemicals in favour of more sustainable agricultural systems. Preventive actions and alternative control methods with successful and low-risk results are prioritised in CSPM. Eco-friendly treatments include biological compounds, mechanical trapping techniques, pheromones, and antagonistic organisms as well as targeted and biocontrol alternatives. The biocontrol agents associated with weather changes are new strains of climate-resilient bacteria that have the highly competitive abilities needed to flourish in the introduced environment. Additionally, strains particular to a crop or region are used into the CSPM approach. Dates for sowing crops can also be changed in response to recently anticipated disease scenarios.

Challenges of climate smart pest managements/controls: As CSPM is a component of CSA, it is subject to the same regulations, norms for updating and upgrading of knowledge, adaptability to local situations, and issues regarding decision making. Although CSPM promotes ecologically friendly farming methods, human health, and food security, there are actually very few CSPM acts that are limited to laws and policies. Because operators and data collection and handling tools must continuously update their meteorological databases, the decision-making process in CSPM is highly dynamic and sophisticated. Although sophisticated models exist for major crops and pathogens, little is known about the geographical and temporal dynamics of plant diseases in response to climate change (Jeger et al 2022). Since multifactorial models constitute the foundation of plant disease simulations, it is challenging to forecast how climate variability will impact the onset and treatment of illness. Even though climate models have been successfully constructed for over 40 years to predict how agricultural production would be affected by the weather, present knowledge regarding weather-related pests may not hold true in the future due to unpredictable extreme weather occurrences. Many agricultural decision support systems (DSS) were never fully implemented, which prevented them from moving from being validated by science to being used in real-world settings. Information and communications technology (ICT) has advanced and spread over the past few decades, but DSS still has certain drawbacks.

Conclusion:

To attain global food security and safety, CSPM is seen as an innovative strategy that can assist in transforming and re-inventing sustainable agricultural systems. Through rigorous surveillance and forecasting systems, CSPM techniques seek to anticipate changes in pest scenarios brought on by climate change in order to provide early diagnosis and effective risk monitoring solutions. In order to secure better farm outputs for people and ecosystems, environmentally friendly management practices are the cornerstone of effective CSPM interventions.However, increased coordination and cooperation within multi-sectoral consortia is necessary for the global implementation of CSPM in order to improve our understanding of how plant diseases are affected by climate change, streamline the decision-making process, and ensure that policies are aligned.The developing world may be the weakest link in this chain, hence more needs to be done by the international community to put the CSPM into practice there. Since there are insufficient effective pest management strategies and technologies in these countries, climate change-related constraints have a greater damaging influence on agricultural resources.

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