Emergency Response Strategies for New Pest Incursions

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ABSTRACT

Incursions of highly destructive pest's causes damage which have catastrophic effects to the agriculture crops, plants and native ecosystem. It explores various aspects of pest management and plant biosecurity focusing upon different response strategies for early detection, rapid response and risk assessment based upon advanced technologies like remote sensing and geographic information system (GIS). Pest Risk Analysis includes Pest Risk Area (PRA) and cost-benefit analysis (CBA) which guides decision making and resource allocation accurately. Biosecurity frameworks at national and international levels makes easy to co-ordinate responses among different areas. Rapid responses imply different strategies like containment (quarantine) and control (chemical/biological, prioritizing Integrated Pest Management – IPM) and timely communication between locals, regional, state and central government agencies, academia is crucial to protect ecosystem in plant health emergency situations. All these emergency pest response strategies certainly face challenges which include interagency coordination gaps, pesticide resistance, and climate change impacts. Future directions involve genetic pest control, advanced detection methods (AI, molecular diagnostics) and strengthened international cooperation for more effective, sustainable, and resilient pest management.

INTRODUCTION

The introduction of Invasive Alien pests surge due to several reasons like trade between countries, tourism, globalization etc. Where they cause serious economic damage after establishment in order to stop their spread early detection and constant monitoring stops IAP's spread to a non-native area. These rapid responses are crucial to eradicate invasive alien pest threats before they enter and establish. Here, we assess the worth of emergency response strategies for new pest incursions and their effectiveness.

Early Detection and Surveillance:

Early detection and surveillance have a pivotal role in managing pest incursions by enabling swift pest management strategies before infestation become widespread and severe. Advanced technologies like **remote sensing and geographic information system (GIS)** which provides real time data on pest movements. A study in srilanka explored using remote sensing to monitor fall armyworm (*Spodoptera frugiperda*) incidence in maize crops and addressing the challenges with advanced field surveys. Earths observation satellite sentinel-2 multi spectral images were analysed to map the spatial distribution of maize and fall armyworm incidence in moneragala district using spectral vegetation indices (NDVI, SAVI, NDRE). This study found Normalised Difference Red Edge Index (NDRE) to be most accurate measurement for detecting fall armyworm incidence with significant differences in disease severity observed ($p<0.005$) where Image classification achieved an 89.78% accuracy. Therefore, study revealed that remote sensing is an effective tool for mapping. This approach significantly enhanced monitoring pest movement which allowed researches and biosecurity officials to track changes in vegetation and scale of pest infestation. By combined analysis of satellite imagery and geospatial analysis authorities deployed targeted control measures which protected a large area of maize fields and successfully controlled fall armyworm infestation. (Aruni *et al*., 2023).

Another essential surveillance method involves the use of **traps** whether it may be pheromone traps, light traps or any other kind which serve as early warning mechanisms for detecting invasive insect species at farmer field level. Pheromone traps exploit chemical attractants to lure specific pests, while light traps take advantage of insect's photo tactic behaviour, capturing those drawn to artificial illumination. These tools are particularly effective for monitoring agricultural and forestry pests, helps experts identify threats before they reach damaging levels.

Above all these efforts and technologies, awareness among farmers and public participation plays a crucial role in early detection and constant watch on the pest which helps in early detection. At the grass root levels farmers and public have an opportunity to identify and to report any pests they come across through digital tools and mobile applications like plantix, picture insect and many other applications. Recently ministry of agriculture and farmers welfare in India launched the **National Pest Surveillance System (NPSS)**, an Artificial intelligence (AI)-driven platform aimed at connecting farmers, agriculture scientists and experts this empowers communities to contribute valuable data that enhances pest monitoring efforts. These robust early detection and surveillance systems, combining cutting edge technologies with community involvement, strengthens biosecurity defences and minimizes the risks associated with pest incursions which preserves ecological and agricultural stability (Ministry of Agriculture and Farmers Welfare, 2022).

Risk assessment and decision-making:

Particularly in pest management and phyto-biosecurity a structured risk assessment process ensures that threats are identified assessed and managed effectively. One of the key components in pest detection and decision making is the process of **Pest Risk Analysis (PRA)** it is a technical tool used to identify organisms which are previously not known as pests, this process consists of three stages 1. Initiation 2. Pest Risk Assessment and 3. Pest Risk Management which determines the possible environmental, economic, and social impacts of invasive alien species. By analysing factors such and potential of introduction, establishment, spread and the severity of consequences. Pest Risk Analysis aids policymakers and stakeholders to make informed decisions and required control measures (ISPM 2, IPPC).

Furthermore, **Biosecurity framework** provides national and international guidelines (NSPM'S and ISPM'S) to facilitate a rapid and co-ordinate response to looming threats. These frameworks outline protocols for surveillance, quarantine, management and eradication ensuring the best measures are to be followed to minimize the risks associated with the pest. By adhering to these structured guidelines, authorities can prevent the escalation of biosecurity threats and safeguard ecosystems, agricultural sector, and trade.

Moreover, a **cost-benefit analysis** is integral part of pest risk assessment, as it helps balance the financial implications of eradication strategies against the potential economic and environmental damage that a pest outbreak could cause. This approach ensures that resources are allocated efficiently, prioritizing actions that yield the greatest long-term benefits. By weighing the costs of intervention against the projected impact of an unchecked threat, decision-makers can implement strategies that are both economically viable and environmentally responsible. Incorporating these key elements into risk assessment strengthens emergency response mechanisms, enhancing preparedness and resilience in the face of biological threats.

Rapid Response Strategies:

A well-structured rapid response strategy is essential in preventing pests from establishing themselves in new environments. These rapid response strategies are crucial in controlling and mitigating the effect of newly detected pest incursions, which ensures the infestations are controlled before they rapidly escalate into widespread outbreaks. The primitive and most important response in this process is the implementation of containment and quarantine measures, which aims at restricting the movement of affected plants, plant products or other commodities. By executing strict regulations, we can control the spread of these pests from one area to other area, these may involve in setting up buffer zones, imposing temporary trade restrictions on transportation of potentially contaminated goods and conducting thorough inspections at the point of entries and borders to limit the risk of further transmission.

One's containment measures are defined and are in place, control measures should be deployed. Control mechanisms include chemical and biological methods aiming at reducing the pest population effectively. Chemical control measure involves the application of pesticides and insecticides to eradicate pests in high-risk areas, ensuring that infestations are supressed swiftly. However, excessive reliance on chemical treatments can lead to environmental concerns, to counteract these challenges, biological control or classical biological methods are also employed by introducing natural predators and parasitoids introducing natural predators, parasitoids, or pathogens that target invasive alien species while maintaining natural biodiversity unaffected and maintaining ecological balance (Srivatsava, *et al*., 2016). By acting decisively

and combining these mechanisms authorities can protect agriculture, ecosystem and economies from devastating consequences of invasive species.

Challenges and Future Directions in Pest Response:

A successful pest management program comes with numerous challenges that can interfere with rapid response efforts. One of the crucial problems is **lack of synchrony among agencies,** where the lagging of decision-making and instability weakens containment efforts. Without the information exchange between the locals, nationals, and international organizations pest incursions will escalate. In addition, a limited amount of capital and resources hampers response strategies in implementing necessary measures like surveillance, eradication and public awareness campaigns. This problem can be solved by establishing communication between different institutions and having a unified response framework.

Another pressing challenge is pesticide resistance, which occurs when pests adapt to repeated chemical treatments, rendering traditional control methods ineffective. Over-reliance on synthetic chemical pesticides not only increases resistance but also disrupts ecosystems by harming beneficial insects, soil biodiversity and health. This necessitates the adoption of **integrated pest management strategies (IPM)**, incorporating biological control agents, crop rotation, and habitat management which will reduce farmer's dependence on synthetic chemical pesticides (Bachev, 2015). Moreover, climate change has exacerbated pest-related threats by expanding their geographical range and altering breeding patterns. Environmental factors like warmer temperatures, shifting precipitation patterns, and extreme weather events create favourable conditions for the survival and spread of invasive species, all these factors require adaptive and proactive pest management strategies to mitigate their impact.

Furthermore, research and innovation in the future should focus on sterile insect techniques and gene editing, which have the potential for targeted and environmentally friendly solutions to manage pest incursions. Developments in early detection methods involve AI-driven monitoring system and molecular diagnostics that will improve response times and prevent widespread infestations. Besides, strengthening International Cooperation in phyto-biosecurity is important to address the Trans boundary pest threats. Building an international surveillance network and sharing research data in all the aspects of pest risk assessment including response strategies will definitely strengthen collective preparedness.

CONCLUSION:

Invasive alien pests are a major risk to global food security. Therefore, swift and well-coordinated emergency response strategies are important for effective management of new pest incursions. Synchronized efforts from all the policymakers, researches and pest management agencies are crucial to develop science-based and sustainable approaches for successful pest management programme.

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