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An Analysis and Methods to Minimize Utilizing Chemical Pesticides in Agro-Ecosystems

Arpan Kumar Tripathi[1], Sanjay kumar[2], Nallapaty Srilakshmi[3], Deepak Prashar[4], G.Nageswara Rao[5] , Rupesh Soni[6], Shekhar Verma[7]

[1]Faculty of Pharmaceutical Sciences, Shri Shankaracharya Technical Campus, Shri Shankaracharya Group of Institutions, Bhilai Chhattisgarh, India

[2]Deptt. Of Economics, Govt. College Multhan, Distt. Kangra (H.P.)

[3]Department of Pharmaceutical Chemistry, KL College of Pharmacy, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, AP, 522 502, India

[4]Shanti Niketan College of Pharmacy, Ratti Mandi Himachal Pradesh, India

[5]Professor, Electrical and Electronics Engineering Department, Lakireddy Bali Reddy College of Engineering, JNTUK Kakinada, Mylavaram-521 230, Krishna Dt, Andhra Pradesh

[6] Department of Pharmacy, Mandsaur University, Mandsaur - 458001 (MP) INDIA

[7]University College of Pharmacy, Chhattisgarh Swami Vivekanand Technical University, Bhilai, Chhattisgarh, India

ABSTRACT

Reducing the use of pesticides is a top concern for governments throughout Europe due to the negative impact they have on human health and the natural environment. Unfortunately, this is a challenging challenge to overcome since pesticides are so integral to the agri-food industries in these countries. We argue that agricultural research is crucial here and that, to have any real impact on pesticide use, it must move to a pesticide-free paradigm. In this essay, we explain the rationale for this paradigm shift and the types of research that will benefit from using it. Supporting the development of public policies but instead private initiatives for both the transition towards pisciculture; redesigning crop growth system is a system to strengthen prophylaxis; diversifying biocontrol strategies as well as associated business models; broadening the context of plant breeding to have included functional biodiversity but also evolutionary ecology concepts; establishing new objectives for agricultural machinery and digital technologies; these are the five research fronts related to these five strategies. In order to create the systemic and connected innovations necessary to drastically cut down on pesticide usage, the appropriate research initiatives must be coordinated with one another. We thus underline the necessity for interdisciplinary research programmers and present examples of cross-cutting goals that integrate multiple fronts. This allows us to give a broad framework for future studies aimed at achieving environmentally sound farming practices.

Corresponding Author e-mail: arpan260387@gmail.com

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INTRODUCTION

Pesticides have evolved into an indispensable component of the majority of agricultural practices used today. In 2018, the total amount of pesticides sold inside the European Union (EU) hit 370 million kg. Fungicides account for 46% of total sales of pesticides, followed by herbicides (35%), and then insecticides (11%). Farmers were able to significantly boost crop yields and nations were able to enhance their level of food security as a direct result of the use of pesticides and other technical improvements brought about by the Green Revolution. (2018)As the adverse effects of pesticides on both the environment and human health have been shown beyond a reasonable doubt, the reduction of pesticide usage has emerged as a priority for a number of nations and a significant topic of discussion in the realm of public policy. To begin, the exposure of non-target species to pesticides in agricultural regions is regarded to be one of the primary causes of the loss of biodiversity. This is owing to the fact that pesticides are widely used. Second, over the course of time, non-intended movement of pesticides has resulted in the contamination of both the soil and the water. Third, pesticide residues, which have been found in a wide variety of food products and are also present in the air, pose a significant threat to human health. This is especially important considering that the "cocktail effect," which refers to prolonged exposure to multiple substances, including those that disrupt hormones, is not yet fully understood.

OBJECTIVE

The research aimed to fulfill the following objectives:
- To study the pesticide-free agriculture
- To study methods for lowering pesticide use in Agronomic
- Pesticide reduction tactics' limits

METHODOLOGY

Reducing the number of pesticides used in agriculture has been demonstrated to have very little effects on the economy, despite the fact that certain stakeholders may see this as a less-than-viable method for maintaining crop earnings. Current research carried out in France has concentrated on this topic, in particular as a result of the country's commitment to organic farming methods. According to the findings of one research that was conducted in 2014 on the wheat output in France, reducing the amount of pesticides used by 50% might result in a maximum 15% decline in wheat yield. In addition, a study conducted in 2017 found that over sixty percent of agricultural operations in France had the potential to cut their usage of pesticides by as much as forty-two percent without suffering any drop in their profit margin. Our data suggest that farmers are now in a position to reduce their reliance on pesticides in the vast majority of agricultural settings. However, it is essential to keep in mind that the findings could be dependent on the context, and there is a pressing need to gain a better understanding of how the effects of reducing pesticide use could vary according to the resiliency of crops, the demand for them, and the socioeconomic context. Future research might be able to take these factors into account.

pesticide-free agriculture

Pesticides dominate the agri-food chain

Pesticides are used in all aspects of Western agriculture, from farms to marketing. Following 1945, automation, fertilizers, and pesticides intensified agriculture to enhance productivity. High-yielding cultivars, insecticides, and fertilizers enabled farmers to plant less crops at greater densities, which frequently increased pests (used hereafter to refer to all undesirable insects, fungi, weeds, and pathogens). Pesticides protected crops from pests and helped revolutionize agricultural systems. Pesticides, fertilizers, and automation have boosted farm size and production per hectare and worker, reducing biodiversity. Specialized and simplified farming practices reduced natural restrictions and increased chemical usage to manage pests. These systems now rely more on chemicals.

The increasing use of persistent and systemic pesticides has decreased ecosystem services and natural pest control, which encourages additional pesticide usage. Pesticide usage has increased due to pesticide resistance. These two developments have created a "pesticide treadmill". Pesticides are the major instrument for reducing production losses due to cropping system simplification. During the previous several decades, farm size has increased and family labor has decreased compared to land and capital, leading to more reliance on outside labor. Pesticide usage increases with contract employment and low family labor share. High pesticide usage might also result from the non-economic goal of yield maximization. As farmers' pesticide reduction seems to be substantially impacted by whether other farms reduce, peer judgement, or norms, also affects it. (Azpiazu Segovia)

Upstream and downstream businesses have united to support and profit from agricultural development, locking in pesticide usage technology. Agricultural equipment and plant-breeding industries have concentrated on intense production methods and species. Variety selection and sales are based on processing technology optimization, not disease sensitivity. Pesticide corporations advise farmers on pesticide usage; therefore, their marketing and distribution techniques boost pesticide use. Extension services often priorities single-problem solutions above systemic methods that address several issues or recommend multiple adjustments. The absence of value chains for new crops to diversify crops is another major barrier to agroecological transition and pesticide reduction. Pesticide-free practices are primarily hindered by the absence of added value across all industries. Farmers don't use these methods since they don't make more money. Pesticide-free farming might also be hindered by market demands for undamaged produce. The market seldom considers pesticides' health and environmental effects. (Micha & Chavez, 2020)

Pesticide reduction tactics' limits

IPM and organic agriculture are the primary pesticide reduction solutions. IPM underpins EU pesticide reduction policies. IPM combines “all possible plant protection technologies and subsequent integration of relevant measures that inhibit the establishment of populations of dangerous organisms” and “encourage natural pest control mechanisms,” according to the EU. The EU has sponsored IPM research and implementation via National Action Plans, believing that large-scale IPM can decrease pesticide usage. This has led to research on alternate pest management strategies and pesticide dosage optimization. This method failed since EU pesticide consumption has not dropped. Numerous variables explain this strategy's minimal effect. Secondly, IPM-implemented sectors don't add value to farmers' produce. Second, IPM-based methods vary from "low IPM" to "strong IPM," and farmers generally use just sections of the spectrum. IPM methods have only partial impacts, therefore to reduce pests, they must be combined and optimized.(2018)The dominant food system has used "weak" ecological modernization in agriculture until now. Yet, to feed the world and substantially reduce agriculture's environmental consequences, ago-ecological techniques should need a "strong" drive towards a new regionally integrated agri-food eco-economy, involving disruptive technology advances in agriculture.

Organic agriculture maintains soil fertility and closes nutrient cycles without synthetic fertilizers or pesticides. EU organic farming expanded by 74% from 2008 to 2018, yet it still accounts for just 8% of total cropland. Despite higher pricing for certified organic goods, reduced input consumption, and ago-environmental premiums in certain countries, organic systems nevertheless have lower yields than conventional systems. Technical difficulties, particularly weed control, remain unsolved. Organic systems may have more variable yields, increasing hazards. Lastly, copper, utilized in arboriculture and vineyards, is an organic substance that harms the environment. To boost productivity and decrease dangers, organic farming procedures must be improved. (Johanna et al., 2020)

As a result, we advocate a third approach: agriculture devoid of synthetic insecticides (including synthetic and natural pesticides that have negative impacts on the environment and human health). The use of IPM and other methods to lessen insect damage and increase natural control is essential in pesticide-free farming. (2018) Therefore, eliminating pesticides fully demands going beyond IPM by profoundly restructuring systems and breakthrough breakthroughs at numerous value chain levels. Pesticide-free agriculture with synthetic fertilizers may lose less production than organic agriculture. Yet, nitrogen fertilizer's environmental implications need rethinking and maybe reducing fertilization techniques in existing cropping systems. Nitrogen availability influences plant both primary and secondary metabolites, which in turn affects plant defence and crop nutrient content for pests, hence it is important to keep an eye on fertilisation in pesticide-free settings.

Redesigning farming systems and implementing technological breakthroughs to phase out pesticides may lower yields. Cropping system overhaul should no longer priorities yield maximization. While natural restrictions may minimize productivity loss, yields will remain low and erratic. IPM must transition to priorities profitability, resilience, and environmental services above production. Yet, markets may need certification and/or state policy to assist changeover. (2019)

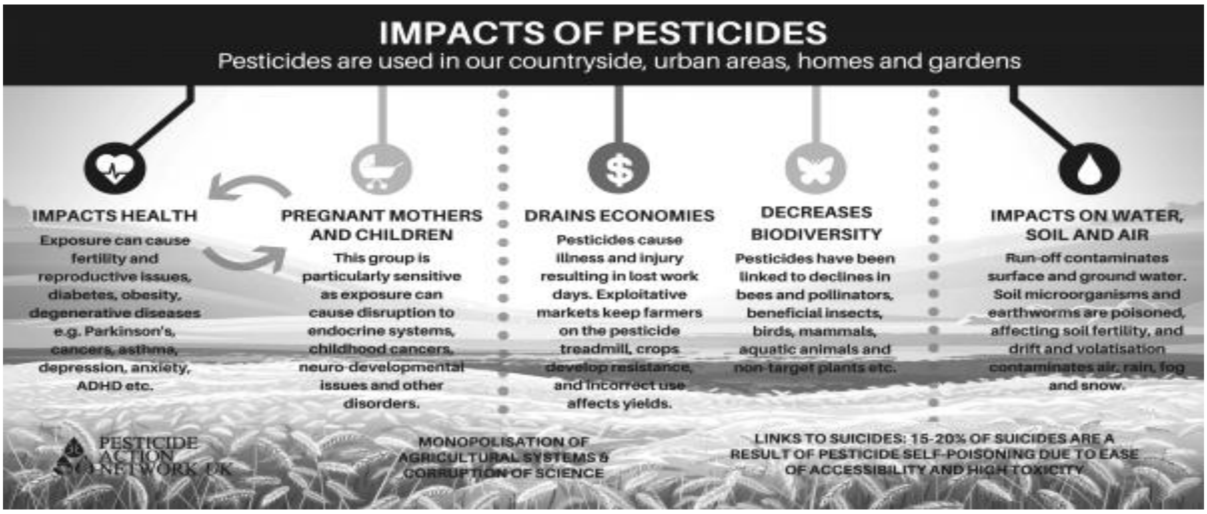

Figure 1: impacts of pesticides

The methods for lowering pesticide use in Agronomic

Using pesticides to protect crops is a delicate process because of the potential for adverse effects on both the environment and human health. Even while the annual usage of pesticides has increased to 3.5 billion kg of active ingredients, a sizeable proportion of the chemicals used have been found to be excessive, uneconomical, or unneeded.

Nowadays, there is widespread agreement that pesticide usage must be progressively lowered to the minimum amount needed to successfully guarantee crop production, and that dangers associated with pesticide application must be minimized to the greatest extent practicable. (2019)

Agronomic methods

- It is impossible to have healthy crops and forestall the buildup of pest, disease, and weed pressure without using appropriate agronomic methods. Important, in particular, are the following routines:
- Proper management of plant nutrients and soil fertility; Crop rotation; Appropriate irrigation management; Appropriate timing of sowing or planting and of intercultural activities to decrease insect populations;
- Reduced weed growth and enhanced crop nutrition through timely shallow tillage.
- Spraying just the most urgent areas and detecting weeds using optical sensors are examples of precision agriculture;
- Both intercropping (where feasible) and using a range of varieties can slow the spread of disease and pests by providing food and cover for predatory insects;

Crops that are resistant to the problem

Different crops and crop types have varying degrees of pest and disease resistance and weed competition. Preventative pest control relies heavily on growing crops adapted to local circumstances and choosing appropriate crop kinds. The population of pests in a field may be greatly reduced by the adoption of resistant cultivars and crop rotations that include non-susceptible crops. (Ancillotto et al., 2023)

Natural pesticides and biological pest control

Pheromones, insect traps, predatory insects, fungal and bacterial diseases, and viral pathogens are all used in bio-control strategies to reduce pest populations. (2018)

Eliminating an entire insect population by the use of synthetic pesticides would cut off food for natural predators, weakening the system as a whole. That's why it's important to control insect numbers to the point where there's a healthy balance of predators and pests, and crop damage is maintained to a minimum.

Methods for Coordinated Pest Control (IPM)

Rather of trying to get rid of pests entirely, IPM takes an ecological perspective and focuses on controlling them. It is based on the principle that a robust ago-ecosystem, one that safeguards, promotes, and enhances the biological processes that underlie production, is the best protection against pests and diseases in farming.

Although while it does not just concentrate on pest avoidance, the widely used GlobalG.A.P. methodology comes rather near to these concepts. The vast majority of stores now demand proof of adherence to standards for safe and sustainable farming practices before they'll even consider stocking a product.

With real IPM, the primary emphasis is on preventing pests from occurring in the first place via the use of resistant cultivars and sound agronomic practices, as well as on identifying and monitoring pests and using biological controls. Chemical pest management is profitable once the economic threshold is crossed, defined as the point at which the cost of treatment equals the cost of predicted loss in crop. Step four is to take what you've learned about IPM and apply it to the following growing season. (Ancillotto et al., 2023)

Fifth, Agroecology

Sustainable agroecosystems are the focus of agroecology, which is the study of agricultural systems, their classification according to ecological and socioeconomic criteria, and the application of ecological ideas and principles to their design and management. It's an approach to farming that takes into account the interdependencies among crops, livestock, people, and the natural world. The goal of Agroecological pest management is to promote mutually beneficial interactions between pests and their natural antagonists. The goal of agroecology is to maximize agricultural production systems via the use of biodiversity-based ecological processes, however there is no consensus on what methods and inputs are compatible with it.

Organic Farming

Soil, environment, and human health all benefit from the production methods used in organic agriculture. Rather of using inputs that might have unfavorable consequences, it makes advantage of natural processes, local biodiversity, and cycles that are tailored to the area. The use of chemical fertilizers and pesticides is absolutely forbidden under organic standards. (2018) Good agronomic techniques including crop rotation and intercropping, the use of organic manures, the adoption of resistant cultivars, and bio-control are the foundation of organic agriculture's crop protection strategy, which aims to minimize the negative effects of pests, diseases, and weeds.

Integrated Pest Management and agroecology are two of the methods utilized in organic farming; the main distinction is that synthetic chemicals are not allowed to be employed, even as a last option.

Rather, if preventative measures are insufficient, organic farmers may resort to using some natural compounds approved by organic standards to combat pests and illnesses. Yet, some of them also have unintended consequences for species that aren't the intended targets. Copper's buildup in soils makes it particularly difficult for use as a fungal disease control agent. (Azpiazu Segovia)

The switch to herbicides with lower risk

Several scales have been developed to rank pesticides according to their potential danger to people and ecosystems. So, the most apparent strategy to lessen the harmful side effects of pesticides is to gradually phase out the usage of extremely dangerous pesticides and replace them with less hazardous ones.

To reduce harm to humans and ecosystems, this method must be paired with careful pesticide application. The two most crucial precautions are the use of protective gear and the observance of waiting times before harvest.

Nonetheless, poor adoption rates are seen in many regions due to a lack of knowledge, a lack of protective equipment, and the impracticality of the practice in hot and humid weather. (Naseri, 2019)

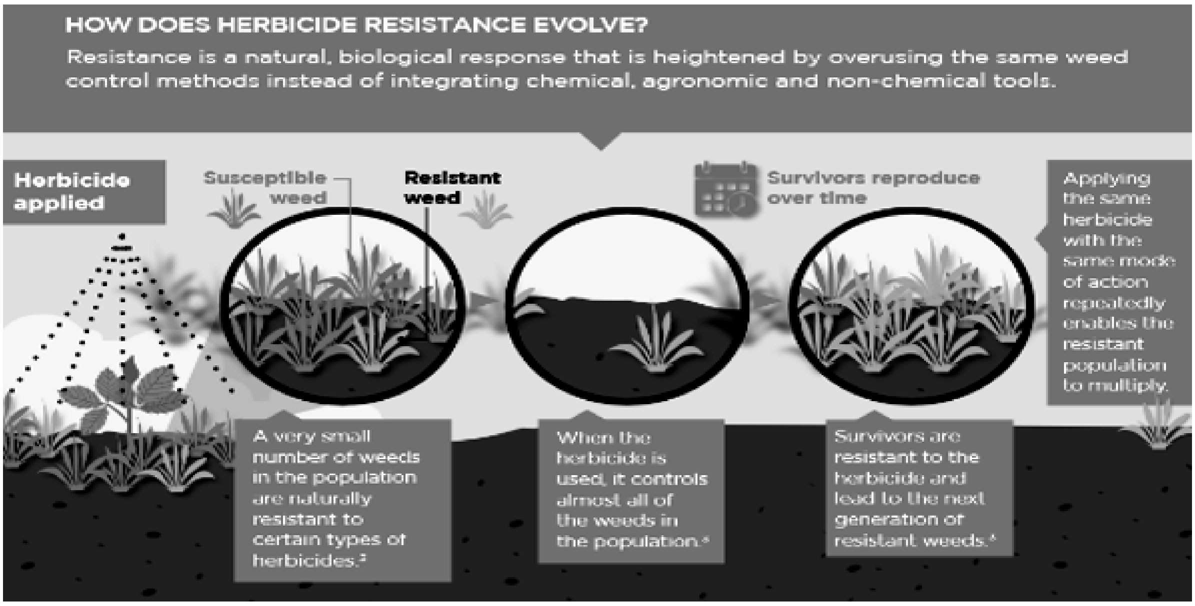

Figure 2: Evolution Of Pesticides Resistance

CONCLUSION

Pesticide-free agriculture is an ambitious goal that is intertwined with other global concerns, such as maintaining healthy ecosystems and safeguarding biodiversity, as outlined by the United Nations' Sustainable Development Goals. Substantial reductions in pesticide usage are necessary, but this is a difficult problem to solve since the whole agri-food industry has been built on pesticides for decades. The use of pesticides in agriculture is a major focus of scientific study, with many ongoing research projects yielding insights and new technologies that may be used without altering our present agricultural practices. We contend that a shift in focus is required now in order to identify viable options for the future. The development of novel, cutting-edge agricultural research within the same pesticide-free paradigm plays a crucial role. We pinpointed the areas of study that need to be expanded upon in order to develop methods for pesticide-free farming. Several lines of inquiry must be coordinated in order to establish pesticide-free agricultural systems that rely on enhanced natural controls, are based on individualised instead than generic solutions, are implemented there at landscape scale, and are made possible by reworking value chains. But, academics won't be able to go into these uncharted territories unless the industry as a whole undergoes a radical rethinking of its structure, incentives, and funding in light of clearly articulated goals. Investment in both basic research issues including participatory research that involves farmers and the whole agri-food chain, which requires long-term project finance, should be encouraged. Reforming the research and development system also entails updating extension and training programmes.

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