Original Research Paper

Volume-7 | Issue-11 | November-2017 | ISSN - 2249-555X | IF : 4.894 | IC Value : 79.96

Agricultural Science

TECHNOLOGICAL INTERVENTION FOR ENVIRONMENTALLY SAFE PLANT PROTECTION

Dr Kavya Dashora Assistant Professor Indian Institute of Technology, New Delhi

ABSTRACT Crop protection largely focuses on the curative control of biotic stress on plants like pests, diseases and weeds. Most of the studies related to plant protection were based on the host parasite interaction and the solutions often equaled the development, transfer and adoption of single component technologies such as new crop varieties or agrochemicals1. The use of synthetic agrochemicals can be largely credited for managing pest on food crops and thereby increasing yields in agricultural production. Although it has significantly reduced the crop losses, the extensive and unguarded use of agrochemicals opened a new dimension of environmental toxicity hazards. In due course, these pesticides started contaminating drinking water sources, soil and air affecting food-safety, public health and the environment2 and the development of herbicide resistant weed populations in crop production systems3.To meet the growing demand of safe food for world's population in present and future; the global agricultural production has to undergo rapid transformation. Much research is being conducted to develop more holistic and integrated approach for pest management avoiding the use of hazardous chemicals. The greater impact will be seen when the technology based greener approaches to crop protection will be adapted by the growers.

KEYWORDS :

1 Introduction:

The goal of addressing hunger and achieving food security becomes more challenging looking to the present world population of 7.3 billion, which is projected to reach 9.7 billion by 2050 and 11.2 billion by 2100[4]. In addition, global life expectancy is projected to increase due to better availability of healthcare and food. This growing global population also sees a direct consequence as increased urbanization, reduced land holdings, climate change and water scarcity. Recent estimates indicate that up to 34% of the world's land surface could be used for agriculture, although approximately 20% has been deemed marginal and unsuitable for rainfed agriculture. Therefore, careful management and protection of the most productive agricultural lands will be required, along with novel approaches to achieving increased production on marginal lands.

To increase the productivity of crop per acre, the use of agrochemicals for increasing was a good move but only for a limited term. considering the hazardous effects of chemical use on soil, water and food toxicity, it is essential that we explore more sustainable, safe and environment friendly options shifting from complete chemical approaches to eco-friendly technology-oriented approaches and integrated systems-oriented approaches that consider innovation as a combination of technological and non-technological advances across different levels (plot, farm, region)[5].

With increasing population and a warming climate, additional factors will also influence the global availability of food, possibly leading to water scarcity and decreased water quality. Approximately 70% of global freshwater consumed is used in agriculture[6]. Increased production on the reduced land resources will likely require more water for irrigation leading to increased water scarcity. The present review aims to examine recent and emerging technological trends for the crop protection, the role of regulation in new technology development for increased production and improved sustainability in agriculture.

Developments and Emerging Trends in the Crop Protection:

Farming being one of the oldest human activities since the dawn of civilization, has undergone gradual transformations identifying locally suitable crops, cropping patterns and production practices both by farmers and researchers. To attain food self-reliance for the increasing trend of population, India initiated technology led research for integrated crop production packages including high yielding varieties, use of agrochemicals and integrated pest management to have a sustainable agriculture production. As a result of these efforts, the country became not only self-reliant but an exporter in agro-produces also.

Emerging Technologies:

Biotechnology has, to date, delivered specific agronomic traits designed to overcome production constraints for perhaps 12 million of the world's farmers [7]. This technology support to the crop production has drastically improved productivity and profitability of a large number of farmers and has made important, positive socio-economic and environmental contributions. Till now, very limited agronomic traits have been successfully commercialized so far in certain crops, yet the research conveys a hope for further augmentation in crop production through technology. The gains from the insect resistant traits and herbicide tolerant traits have largely helped farmers to cut down costs and save environment from unwanted chemicals in farming systems. This has also increased the profit margins and more harvest.

Genetic Engineering:

This technology has led to the production of Genetically Modified Organisms (GMOs) by recombinant DNA technique, gene editing and RNA interference (RNAi). With these advanced GMOs, insecticide applications is being reduced and need based herbicide applications is getting popularity among the farmers in many parts of the world. Adoption of GMO crops has also led to increased adoption of technology based farming, conservation tillage practices, reducing the unwanted contamination of agrochemicals in soil, air and water. Apart from benefits at input levels, the output traits which have proved beneficial to the farmers are enhanced yield and reduced weed interference. This technology is looking forward to develop fortified food to address malnutrition and deficiencies. The “golden rice” is genetically engineered to produce β-carotene, the precursor to vitamin A, as well as an increased level of absorbable iron[8]. Similarly, other potential developments from genetic engineering technology include improved food safety for addressing microbial contamination and allergen detection, edible vaccines and therapeutic monoclonal antibodies produced from plants [9].

Very recently, targeted technologies like 'zinc-finger nucleases (ZFNs), CRISPR-Cas9 and transcription activator-like (TAL)-effector nucleases (TALENs)' have been developed for site-specific gene modification. An alternative technology is RNAi, whereby RNA molecules used to down regulate the expression of genes can be incorporated and expressed in the plant as well as can be sprayed directly onto the plant as a biological agent [10].

Microbial and Botanical Technologies:

Use of microbes in enhancing agricultural production have been well known now. Generally, the common microbe or plant based agricultural products are sourced from naturally occurring micro-organisms, plant extracts or other organic matter. With the help of new technologies, the gut bacteria of various macro-organisms such as beneficial insects, mites and nematodes are being used for pest management and soil productivity enhancement. They are classified as bio pesticides and bio stimulants. Bio-pesticides include plant extracts, organic acids and semio-chemicals and can also include secondary metabolites of many plants. It also includes bacteria and fungi having antagonistic properties. Biological products generally are a part of most successful integrated pest management technologies and are often used in conjunction with conventional crop protection products to reduce residues while maximizing yields. Bio-stimulants are used to increase the vigor of the crop by modifying plant physiology for managing abiotic stress, improving root establishment, facilitating the uptake of nutrients and the likes.

Organic Agriculture:

There is a strong coherence between organic agriculture and biological agents used for crop production. The non-chemical technologies using botanical, biological and organic products like organic manure, compost, vermiculture and the likes are essential for organic cultivation. Technological advances allow increased efficiency of soil nutrient management and non-chemical weed control in organic systems. The holistic system of organic crop production can cover all aspects of self-sustaining farm from animal rearing to post harvest. These technologies aim at meeting challenges like economically justifiable operating costs, recurring source of renewable energy, high energy efficiency, time economy , labor inputs, animal welfare and ecological sustainability. Studies suggested eco-friendly weeding methods, including destroying weeds by heat (torching or steaming), by blocking off-light (covering the plants), mechanical weeding, and solarization to kill off plant seeds in the soil [11].

Seed Treatments:

The use of seed treatments for healthier crops has been helping farmers to address soil borne diseases. A major advantage of seed treatment compared to broadcast application of chemicals is that the treated seed is typically located below the soil surface, significantly reducing *runoff* losses of crop protection coatings [12]. There are numerous additional benefits and uses of this technology. It has been witnessed that systemic activity can be positive for a soil-applied compound since it has no effect on insects that do not consume the leaves or other portions of a plant, leaving most beneficial insects unharmed [13].

Precision Agriculture:

Precision agriculture uses the high-end technologies like geospatial information and sensors to increase the yield and manage the resources optimally. Such an approach help the farmers in reducing the cost of agriculture by investing in need based options for production and protection of crops. Other technological tools widely used for precision agriculture include digital farming which utilizes high-resolution geo-positioning systems (GPS) and geographic information systems (GIS) in addition to real-time data with precise information of the crop in the field area. Satellite mounted sensors, drones or UAVs are very commonly used to generate high-resolution images of large plantations and the results are analyzed to automate nutrient and pesticide applications by planters. Such an approach of minimizing inputs also reduces loss of nutrients and crop protection products in runoff. There is a tremendous development in technology based advances in farming and many are expected to be developed in near future also.

No and Low Tillage:

No-tillage farming systems are actively promoted by National and International research and development organizations to conserve soils and through soil conservation ensure food security, biodiversity and water conservation. Instead of tilling before seeding, seeds are deposited directly into untilled soil by opening a narrow slot trench or band. Today, it is also seen as a measure to be supported under the United Nations Framework Convention on Climate Change [14]. The lack of tillage helps promote infiltration of water (and nutrients and crop protection chemicals present in the water) reducing runoff as well as soil erosion. Globally, adoption rates of no-till technology vary by region to region, with the largest percentages found in South America (47%), North America (38%) , Australia and New Zealand (12%) , and much lower rates in other regions of the world [15] .

Regulations in Technology Development:

The key challenge being faced by modern agricultural technologists is to develop low cost, sustainable and innovative approaches by integrating multiple technologies to minimize environmental impact while avoiding resistance development, ecological imbalance and inadaptability by the users. Since their introduction, there has been tremendous progress in reducing the potential risk that synthetic chemicals pose. Improved screening processes, identification of taxa-specific modes of action and extended and better validated testing protocols have all contributed in managing the risk in using chemical [16]. The rate of use of agrochemicals have fallen significantly as well as their environmental detections are also tending downwards [17], indicating an increase in overall safety but at the same time, the public concern towards GM crops have increased significantly. For a risk free technology development, it is very important to regulate the development of both engineering and biological technologies, because these technologies are either close to biological processes like developing biocontrol agents or their functioning impacts the environment. It is equally important to understand, assess and plan for management of risks posed by the new technologies being introduced into the system. Any technology to be developed, should quantify the risks and benefits while at the same time working on the potential alternatives.

The agricultural production and protection industry is evolving at a very fast pace. Research and development programs have now been more responsible of the impact on both ecology as well as environment. The technologies should address the people, environment and their profit requirements. To develop more efficient, user friendly and eco-friendly technologies, more interactions and collaborations are required among academic, government, industry and regulatory scientists for designing, developing and facilitating the adoption of innovative technologies to enable farmers to increase production of safe food.

References:

1. M.J. Kropff, J. Bouma, J.W. Jones. Systems approaches for the design of sustainable agro-ecosystems *Agric. Syst., 70 (2001),* pp. 369-393
2. R.P. Richards, J.W. Kramer, D.B. Baker, K.A. Krieger. Pesticides in rainwater in the northeastern United States, *Nature,* 327 (1987), pp. 129-131
3. S.R. Moss. Herbicide resistance in weeds: current status in Europe and guidelines for management *Pesticide Outlook, 14 (2003),* pp. 164-167
4. *World Population Prospects: The 2015 Revision: Key Findings and Advance Tables*, ESA/P/WP.241, United Nations, 2015.
5. C. Leeuwis. *Communication for Rural Innovation. Rethinking Agricultural Extension* (with Contributions of Anne van den Ban). Blackwell Science, Oxford (2004)
6. *Coping with Water Scarcity: An Action Framework for Agriculture and Food Security, FAO Water Reports 38*. FAO, Rome, 2012.
7. Graham Brookes and Barfood, Peter, GM Crops: Global Socio-economic and Environmental Impacts, 1996- 2007, *PG Economics* Ltd, UK, 2009
8. X. Ye, S. Al-Babili, A. Klöti, J. Zhang, P. Lucca, P. Beyer and I. Potrykus, *Science*, 2000, 287, 303–305
9. J. M. Van Emon, *J. Agric. Food Chem.*, 2016, 64, 36–44
10. A. Regalado, *MIT Technol. Review,* August 11, 2015, 540136, https://www.technologyreview.com/s/540136/the-next-great-gmo-debate.
11. Parish, S. A Review of Non-Chemical Weed Control Techniques. *Biological Agriculture and Horticulture,* 1990.7, 117-137
12. *The Role of Seed Treatment in Modern U.S. Crop Production*, Crop Life Foundation, 2013.
13. *The Value of Neonicotinoids in North American Agriculture*, Agroinfomatics, 2014.
14. Andreas Gattinger, Julia Jawtusch, Adrian Muller, Paul Mäder. *No-till agriculture – a climate smart solution?* Edts: Nicole Piepenbrink, Anika Schroeder, MISEREOR. Published by: Bischöfl iches Hilfswerk MISEREOR e.V. Mozartstrabe 9, 52064 Aachen, Germany(2011).
15. R. Derpsch and T. Friedrich, Proc. 4th World Congress on Conservation Agriculture, New Delhi, India, February 4–7, 2009.
16. I. D. Kelly and R. Allen, in *The Politics of Weeds. Topics in Canadian Weed Science*, ed. K. N. Harker, Canadian Weed Science Society – *Société Canadienne de Malherbologie*, Pinawa, Manitoba, 2011, vol. 7, 3–12.
17. R. J. Gilliom, J. E. Barbash, C. G. Crawford, P. A. Hamilton, J. D. Martin, N. Nakagaki, L. H. Nowell, J. C. Scott, P. E. Stackelberg, G. P. Thelin, and D. M. Wolock *The Quality of Our Nations Waters – Pesticides in the Nation's Streams and Ground Water, 1992 – 2001, U.S. Geological Survey Circular 1291*, 2006, 172.