Chapter 18
Artificial Intelligence in Integrated Pest Management

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ABSTRACT

Climate change, the increase in the international exchange of infested materials, and pest control problems cause unpredictable pest outbreaks faced by farmers. To overcome these problems, a sustainable pest control tactic, integrated pest management (IPM), which is providing the effective use of natural resources, is needed. IPM is an ecologically based control management strategy that considers all factors (i.e., natural enemies, economic thresholds, plant susceptibility and breeding factors, pest biology, and climatic conditions). In IPM, expert staff constitutes the essential element. The expert plays a role in system design, monitoring ecological factors, and decision-making mechanisms. For sustainable pest management, it is possible to perform the routine processes such as monitoring biological and environmental components and choosing the appropriate time and method through artificial intelligence. In this chapter, the use of artificial intelligence in IPM and information about algorithms, tools, methods used in artificial intelligence will be explained.

INTRODUCTION

Today, modern agriculture is facing great difficulties. Agricultural manufacturing has now become a competitive and globalized industry where farmers and other actors providing input into agriculture have to consider climatic and geographical differences as well as global economic and political factors. In order to ensure nutrition demand of the growing world population, food production needs to be increased from year to year, but the world's arable areas are limited (FAO, 2014; Quarcoo et al., 2014). While the use of

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agricultural products for bioenergy creates additional pressures on the world's food requirement, housing as well as transportation problems narrow down the world's arable lands considerably (Boserup, 2017). In recent decades, the changes in global climate has led to an increase in unexpected precipitations, global warming, droughts and the frequency of extreme weather events (Piao et al, 2010). These unfavorable conditions lead to endangering traditional production areas and bringing new risks and uncertainties for world agriculture. Because of climate change, the outbreaks of existing pests are increasing or they become the main pests in areas where they did not cause problems before (Scherm, 2004). An increase in the international exchanges of infested material (seed, plant and soil) is caused by unpredictable pest problems faced by farmers (Dent et al., 1995). In addition to all these global problems, issues related to pests such as pesticide resistance, secondary pest outbreaks and breakdown in host plant resistance, have increased the magnitude of the agricultural production problem (Weller et al., 2014). To cope with these challenges, a continuous and sustainable increase in productivity in all agricultural production areas is needed, while water, energy, pesticides and fertilizers, etc. should be used diligently and efficiently.

Consequently, agriculture needs help to eliminate these problems and uncertainties and requires new solutions for all aspects of agricultural production, from better and predictable product planning to precision agriculture and optimized resource implementation. Nowadays, the most popular and sustainable approach to controlling pests is Integrated Pest Management (IPM) (Flint and Bosh, 1981). However, this approach is quite sophisticated and requires a lot of knowledge, expertise, and observation. In practice, it is necessary to monitor the pest in the field, determine the most sensitive stage of pests, decide on the most appropriate control tactic (pesticide or other alternative methods) and apply it in the best time (Flint and Bosh, 1981). Consequently, IPM requires intensive field observation, trained staff, and data mining. In this context, it has emerged that the use of artificial intelligence (AI) algorithms is a necessity for controlling, tracking, and using these agricultural inputs at the optimal times (Azfar et al., 2015). In this chapter, we will examine the impact and the historical development of Industry 4.0 on modern agriculture and the innovations in IPM in concerning information technologies.

BACKGROUND

Industry 4.0 in Agriculture

Industry 4.0 is defined as the intelligent production period in which all live and inanimate objects with a particular economic value can communicate and interact with other objects through internet connection along with developments in many fields of technology (e.g., AI, 3D printers, robotics, biotechnology, and nanotechnology) (Lasi et al., 2014). In order to increase the added value of economic production, developed countries are preparing for a new industrial revolution in almost every sector, including agricultural production, and many businesses have been or are being integrated into this new industrial revolution. In this period of digitalization in production, virtual and physical systems are being integrated and the objects connected to the internet will, therefore, become intelligent in the production system (Aksoy, 2017).

One of the important places where the transformation has been realized under Industry 4.0 is the factories equipped with "smart" technology. These factories are called dark (lights out) factories because no people work there (Alkan, 2016). These smart systems, which are used extensively in industry, have even entered our daily lives (such as electricity, water, fire alarm and intervention systems in smart