



Precision Agriculture Techniques for Effective Weed Management in Field Crops

(*Kashish Singh¹, Arti Chaudhary¹, Khushi Chaudhary¹ and Shani Gulaiya²)

¹M.Sc. Research Scholar, SOAG, Galgotias University, Greater Noida (U.P.)

²Assistant Professor, Galgotias University, Greater Noida (U.P.)

*Corresponding Author's email: kukki9363@gmail.com

Precision agriculture is a farming method that uses technology and data analysis to improve crop yields and reduce environmental impact. Precision agriculture techniques for weed management use advanced tools to reduce herbicide use and soil disturbance. These techniques can increase crop yields and health, while also being more environmentally friendly. Precision Agriculture is a progressive farming practice that uses technology and data analysis to enhance agricultural productivity and sustainability. It is an important aspect of modern farming practices which is gaining popularity nowadays. Precision Agriculture includes the utilization of tools such as GPS, remote sensing, Internet of Things (IoT) devices and data analytics. Precision Agriculture facilitates real-time monitoring and management of crops. Precision Agriculture practices support optimum utilization of resources such as water, fertilizers and pesticides while minimizing wastage and environmental impacts. Weeds are unwanted plants that interfere with crop growth and production or a plant which is a pest and damages human property. Weeds cause more yield loss across the world than insect pests and diseases combined thus making their management extremely necessary. At present time due to extensive use of chemical herbicides there is adverse harm to the environment or ecosystems and weeds have also developed more resistance to herbicides which led to the need of management practices which can effectively control weeds and also reduce environmental impacts. Precision Agriculture which optimizes the use of resources while also reducing the environmental degradation is an excellent solution to this problem.

Keywords: Precision agriculture, remote sensing, site-specific weed management, robotic weeders and variable rate technology.

Introduction

Precision agriculture (PA) is a scientific approach to farming that uses sensors and analysis tools to improve crop yields and manage resources. It helps farmers make better decisions about when and how to apply fertilizers and water. Precision Agriculture is a farm management concept that revolves around the process of observing, measuring, and responding to various inter-and intra-field variability inputs for modern agriculture. According to a study conducted by the Federation of Seed Industry of India (FSII), Weeds are causing ₹92000 crore (\$11 billion) worth loss in crop productivity each year. FSII stated in its report that weeds are responsible for approximately 25-26% of yield losses in kharif crops and 18-25% in rabi across India. The report also revealed that the average cost of weed control per acre is around Rs. 3700 to Rs. 7900. Precision Agriculture offers several methods or techniques to effectively manage the weed population while reducing environmental impact and reducing management costs. These methods rely on use of advanced technologies to identify, monitor and control weeds with high accuracy. The data-driven approach in precision agriculture enables site-specific weed identification and treatment and thus reduce

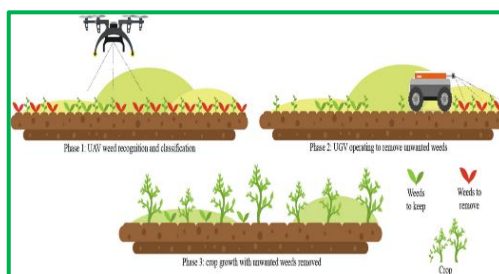
herbicide use, lower expenses and minimize environmental impact. This article explores the principles and applications of precision agriculture in weed management and emphasizes its potential in weed management practices.

Some techniques used in precision agriculture include:

Remote Sensing: Remote sensing is the process of gathering information about an object or area from a distance. It's a science that uses cameras and other sensors to detect and record energy that's reflected or emitted from the Earth's surface. Remote sensing uses satellite imagery, drones or sensors mounted on tractors to detect weeds and map them in crops. The technologies in remote include multispectral and hyperspectral imaging and thermal sensors. It differentiates between weeds and crops based on spectral signature which allows targeted treatments. It uses the imagery to collect data of a field over time which allows farmers to properly observe conditions and takes measures to manage weeds. Remote sensing provides instantaneous data which can help to generate weed maps within hours and thus allows quicker and targeted interventions.



Site-Specific Weed Management (SSWM): Site-specific weed management (SSWM) is a method of weed control that targets specific weeds or patches of weeds in agricultural fields. It uses technology to detect weeds and then applies weed control methods based on the needs of the field. Site-specific weed management focuses on managing weeds only where they are present. It includes use of technologies like GPS-enabled equipment, geographic information systems (GIS). The goal of this method is to apply the required amount of herbicide at the right place. This reduces herbicide application by up to 80%. Site-specific weed management is quite helpful in promoting biodiversity, reducing expenses and minimizing the environmental impact on agriculture.



Benefits

SSWM can reduce the amount of herbicide used.

SSWM can help to prevent the buildup of weeds and pests.

SSWM can help to maximize the chances of successfully controlling weeds.

Machine Vision and Artificial Intelligence (AI): This particular practice identifies weed species in real-time using cameras and AI algorithms. It uses deep learning models and image processing systems to facilitate automated weed control and differentiate even similar looking weeds and crops. Machine vision uses cameras and sensors to analyze plant and weed attributes. AI on the other hand uses algorithms to examine high-resolution images of the field to differentiate between weeds and crop plants. With the use of computer vision farmers can pinpoint weed locations and target them with high accuracy. This technology reduces herbicide use, enhances crop yields and reduces environmental damage.



Robotics and Automated Weeders: Robotic weeders are automated vehicles that use AI and sensors to identify and remove weeds from crops. They can be used to reduce the need for herbicides and manual labor, and are a more environmentally friendly option for farming. In precision agriculture, automated vehicles, robotic or mechanical weeders



and laser weeders are used to physically remove or treat weeds. Robotic weeders use sensors to identify weed location in real-time and create weed maps. An example of robotic weeder is IC weeder which uses a camera to determine crop and weed position and hose around them. These weeders are helpful in reducing the need of herbicides which minimizes environmental pollution and improves sustainability. This method also decreases the need for manual labour which can be helpful in areas with labour shortage.

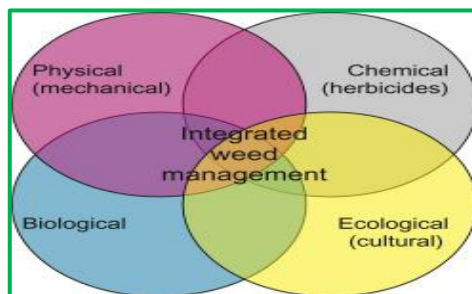
Variable Rate Technology (VRT): Variable rate technology (VRT) is a tool that helps farmers apply the right amount of inputs to their fields, such as water, fertilizer, and chemicals. VRT is a key part of precision agriculture, which helps farmers increase productivity and minimize waste. This technology comprises the use of precision sprayers and VRT-enabled machinery for weed management.

Under this method herbicide is applied at variable rate based on weed density and location. VRT Technology either uses map-based historical data on weed invasion to determine herbicide application rates or uses sensor-based real-time data to modify herbicide dose. Map-based systems are best for pre-emergence weed control while sensor-based systems are more useful for post-emergence weed control. Best use of VRT Technology include initial small-scale use, using expert advice,



investing in good quality sensors and collaborating with other farmers. This technology helps to optimize herbicide use, increasing cost efficiency and reducing chemical/herbicide use.

Integrated Weed Management (IWM): Integrated Weed Management (IWM) is a strategy that uses a variety of methods to control weeds in a way that is economical and environmentally responsible. IWM aims to improve crop yield by reducing the number of weeds in a field. Integrated Weed Management is an aspect of Precision Agriculture which includes combined use of cultural, mechanical, biological and chemical control methods where chemical control methods are used as last resort when other methods fail at effectively managing weed population. IWM provides a broad approach to weed management by maintaining balance between sustainability and effectiveness. Use of precision agriculture technologies like GPS, GIS, automated weeders and remote sensing can help farmers in reducing herbicide use by enabling targeted applications which follows the concept of IWM of reducing environmental harm, enhancing crop yields while efficiently managing weed population.



Benefits of Precision Weed Management

Precision agriculture practices for weed management provide a lot of benefits. The targeted or site-specific approach in precision agriculture helps to reduce herbicide expenses and environmental harm along with much better weed control efficiency. Precision weed management leads to optimum use of inputs which minimizes the wasteful use of inputs. Precision techniques also decrease the accumulation of toxic residues of herbicides in water, soil and ecosystem, it may also reduce herbicide toxins retention in crop plants. These benefits show exactly how advantageous and necessary these precision agriculture techniques are at present time and also for our future.

Challenges and Future Aspects

Precision Agriculture despite being proven an excellent solution to weed management problems nowadays faces several challenges in its adoption such as high technology costs, lack of time and resources for data management, lack of technical knowledge and farmers lack of confidence in new techniques. Machine vision and robotic or automated technology

have shown positive results in weed identification and distinguishing between weed and crop plants. Precision agriculture technologies such as robotic and automated weeders have shown high efficiency in weed control and reducing weed populations in various field conditions significantly.

Conclusion

Precision agriculture techniques for weed management in field crops can help to increase crop yields, reduce environmental impact, and lower production costs. The various technologies and methods used in Precision Agriculture leads to a targeted approach which helps to reduce expenses, minimizing environmental harm and improving overall health of agro-ecosystem by reducing herbicide usage or decreasing chemical inputs. However, the adoption of these techniques is still slow due to its high complexity to use. As pollution and environmental degradation is a serious problem at present time precision agriculture practices are needed to counter these problems.