



Laser Weed Control: Empowering Conservation Agriculture through Precision Technology

*Anisha Dalai¹, Dr. Akshaya Kumar Sethy² and Dr. Ipsita Kar³

¹M. Sc. (Ag.) Scholar, Department of Agronomy, College of Agriculture, OUAT

²Sr. Scientist, AICRP on Groundnut, Odisha University of Agriculture and Technology

³Assistant Professor, Odisha University of Agriculture Technology, India

*Corresponding Author's email: anishadalai271@gmail.com

Since the onset of agriculture, managing weeds have always been a tedious, time consuming and concerned part of agricultural ecosystem. While moving from days old conventional agriculture towards soil sustaining conservational agriculture we must eliminate the weeds and the use of chemical herbicides for a sustainable future of agriculture. In order to do so, we need a technology that can manage the weeds in the field without damaging the crops, soil health and creation of weed variants that are resistant to chemicals. In this context laser weed technology, a technology of high precision can act as a soil-friendly, non-chemical and crop- protective alternative method for weed management. By using artificial intelligence, robotics, high analysis computers and laser beam; it detects and damage the growing part of weeds selectively without disturbing soil and crop. Reducing dependence on herbicides on one side and maintaining the principles of conservation agriculture on the other, laser weed control holds the potential of a precise and sustainable method of weed control in conservation agriculture.

Keywords: Conservation agriculture, laser weed control, weed management, artificial intelligence, sustainability

Introduction

Weeds are the crop plants that grow out of place and out of time. When these weeds grow in agricultural field they compete with the crop plants for nutrient, water, sunlight, space and in return spread and host a number of plant pathogens that affect the crop. So, weeds have always been one of the biggest hurdles in agriculture causing yield loss in one way or the other. Initially, farmers were dependent on manual weeding practices to get rid of these unwanted plants in the field. Discovery of herbicide during world war II paved way for a less labourious method of weed control. Herbicide decreased the loss due to weed, with a much lower cost and effort than the manual weeding. But, gradually the side effects of the chemical herbicides came out that led the scientists to search for a better alternative to the herbicides. At the same time, the continuous degradation of land, decreasing nutrient levels and soil health raised concerns regarding the practices of conventional agriculture. To protect the soil and environment from continuous degradation, to preserve the fertility and structure of soil and to continue the practice of agriculture in a sustainable manner, we need to shift from conventional agricultural practices to follow the practices of conservation agriculture. But, the practice of conservation agriculture is dependent on use of herbicides for weed control, without disturbing the soil via physical or mechanical methods. Here comes the need of a technology that will help to get rid of the weeds in the field without damaging or eroding the soil structure and without affecting human health by using chemicals. One such technology is the laser system for controlling the weeds without disturbing the soil.

What is laser weed control?

Laser weed control is a method of controlling or destroying the weeds without using any chemical or disturbing the soil structure and the crop plants that are present in the field. The laser beam is used to target the specific weeds in the field. This laser beam uses intense heat to target the growing tissues or any part of the weed and destroy them and thereby preventing further weed growth. As compared to traditional methods where spraying of chemical is done over the entire field, affecting the crop alongside the weeds, laser weed control do not cause any harm to plants other than weeds. Also, it do not require heavy labour to operate the machine and these machines are fully or partially automated. Thus standing out as an efficient method among all the alternatives, laser weed control proves it to be an emerging technology for the benefit of mankind.

How does the technology works?

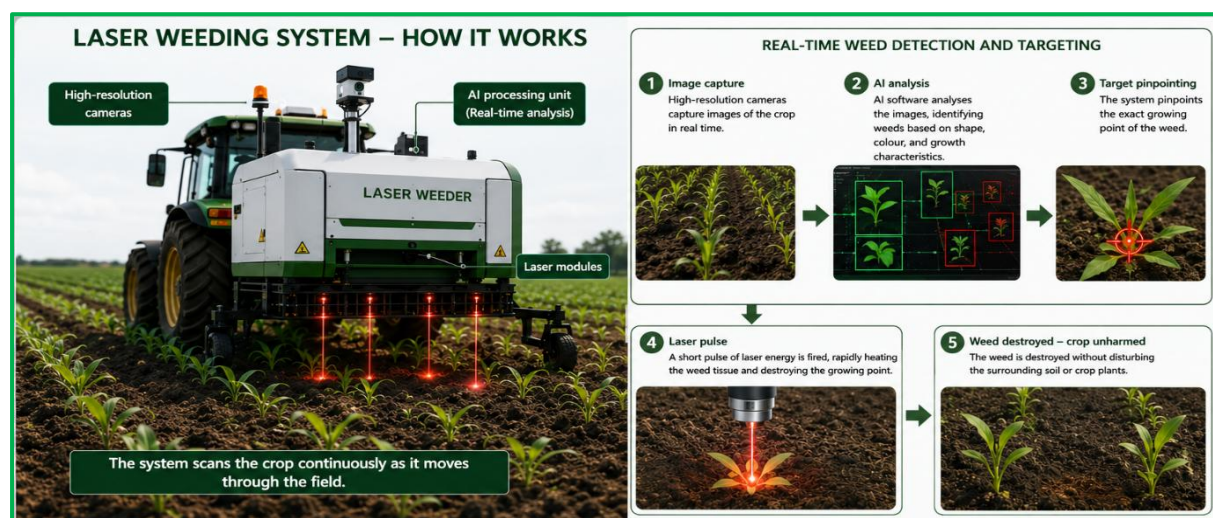


Fig 1. Demonstration of the procedure of laser weeding

The machine used for laser weed control consists high resolution or multispectral cameras, artificial intelligence, detection model, and a device producing laser beam. The laser weeding system works by:

1. Taking pictures of the plants in the field with the help of high-resolution cameras
2. The pictures captured were then analysed by the artificial intelligence present in the system and it then detects and differentiates the weed from the crop plant
3. The weed plant identified by the system is then targeted at the growing point of the meristem
4. The laser beams of short duration containing high energy is then fired at the target resulting in the destruction of its growing point

Thus, restricting further growth and development of the weed.

Role of laser weed technology in conservation agriculture

Practices under conservation agriculture (CA) are based on its three core principles:

1. Minimum mechanical soil disturbance
2. Permanent organic soil cover
3. Diversification of crop

All the principles mentioned, helps in restoring lost fertility and health of soil, conserving soil moisture, improving soil structure and reducing erosion. But in doing so, the least cultivation of soil lead to less exposure of weed seeds present in soil to sunlight, thereby decreasing the efficiency of weed control via cultural method. As soil is least disturbed other heavy machineries such as rotavators are also not used, leaving only the use of chemicals to control the weeds. Here comes the role of laser weeding system that perfectly works according to the principle of less soil disturbance and kills the weeds without destroying the soil structure, its microhabitats and the build-up crop residues.

Advantages of laser weed control in conservation agriculture

- Less or no dependency on chemical herbicides
- Helps in reducing the emerging of herbicide resistant weeds
- Reduces soil disturbance, soil degradation and microhabitat loss
- Destroying weeds with high precision and reducing crop damage
- Reducing environmental contamination
- It provides a way forward for conservation agriculture to produce organic foods



Fig 2. Advantages of laser weed control

Comparison with conventional method of weed control

Feature	Laser weed control	Chemical herbicides	Mechanical weeding
Uses chemicals	no	yes	no
Soil disturbance	none	none	high
Selectivity	very high	moderate	low-moderate
Herbicide resistance issue	no	yes	no
Environmental impact	very low	moderate-high	moderate
Suitable for conservation agriculture	excellent	good	limited

Limitations of laser weed control

- It demands high initial investment
- For building the laser weeding system it need high resolution camera, AI softwares, laser systems and advanced robotics
- Require advanced power supply and sensors for working in field condition
- Small and fragmented farmlands make the use of laser systems unviable in terms of expenditure
- Accuracy of the systems depends on accurate detection and get affected by rain, dust or thick crop canopies
- The laser beam is effective mostly on young weeds than those of mature ones, thereby restricting the time of use to initial days of weed growth

Conclusion

Laser weed control is not only a new advance technology but also signify an important step towards sustainable and conservation-oriented agriculture. It uses AI-guided lasers to target individual weed and reduce the need for herbicide application and prevent soil disturbance. This protect soil structure, conserve soil moisture, support beneficial soil organisms, and maintain the long-term health of agricultural ecosystem, making it an ideal for conservation agriculture. While the technologies are still advancing, challenges such as high initial costs and their large-scale adoption still persist. The ongoing advances in robotics, artificial intelligence, and precision farming are making laser weed control more functional and feasible. As agriculture is progressing towards climate-smart, resource-efficient, and environmentally friendly production system, laser weed control has the potential to become an important tool for sustainable weed management and the wider adoption of conservation agriculture.

References

1. Slaughter, D. C., Giles, D. K., & Downey, D. (2008). Autonomous robotic weed control systems: A review. *Computers and electronics in agriculture*, 61(1), 63-78.
2. Yaseen, M. U., & Long, J. M. (2024). Laser weeding technology in cropping systems: A comprehensive review. *Agronomy*, 14(10), 2253.
3. Zhang, H., Cao, D., Zhou, W., & Currie, K. (2024). Laser and optical radiation weed control: a critical review. *Precision agriculture*, 25(4), 2033-2057.
4. Lu, R., Zhang, D., Wang, S., & Hu, X. (2025). Progress and challenges in research on key technologies for laser weed control robot-to-target system. *Agronomy*, 15(5), 1015.
5. Cárceles Rodríguez, B., Durán-Zuazo, V. H., Soriano Rodríguez, M., García-Tejero, I. F., Gálvez Ruiz, B., & Cuadros Tavira, S. (2022). Conservation agriculture as a sustainable system for soil health: A review. *Soil Systems*, 6(4), 87.
6. FAO (Food and Agriculture Organization). (2017). Conservation Agriculture. <https://www.fao.org/conservation-agriculture> (Explains the principles and benefits of conservation agriculture.)
7. Bajwa, A. A. (2014). Sustainable weed management in conservation agriculture. *Crop protection*, 65, 105-113.
8. Andreasen, C., Vlassi, E., Salehan, N., Johannsen, K. S., & Jensen, S. M. (2024). Laser weed seed control: Challenges and opportunities. *Frontiers in agronomy*, 6, 1342372.
9. Das, T. K., Saha, P., Roy, A., & Raj, R. (2023). Technologies for Automation of Weed Control in Conservation Agriculture. *Souvenir*, 59.