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CARBON ROBOTICS LASER WEEDER: AI BASED SOLUTION FOR AGRICULTURE

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Abstract: The Carbon Robotics LaserWeeder represents a significant improvement in precise weed management for specialty crops at a large scale. This advanced tool uses modern cameras and technology to rapidly differentiate weeds from crops. No matter the weather or time of day, it uses a variety of strong lasers to specifically aim and remove weeds. The LaserWeeder provides a sustainable solution for modern farming by increasing crop yield and reducing farming costs, addressing the long-standing issue of weed management that has troubled farmers for centuries. Manual weeding, machines, and herbicides have influenced the techniques used for weed management. Nevertheless, every method has its own drawbacks. Despite their effectiveness, herbicides can have negative effects on crop health and lead to environmental concerns. There is a danger of damaging plants while using mechanical weeding, and it is still difficult and costly to hire manual workers. With the progress of agriculture, there is a growing urgency for creative solutions. Farmers around the globe encounter a complicated network of difficulties in terms of controlling weeds. As weeds compete with crops for resources, they can significantly reduce the overall productivity of agricultural systems. Additionally, the increase in herbicide-resistant weeds has led to a decrease in the efficiency of conventional chemical treatments. The issue is worsening due to a lack of skilled workers willing to engage in manual weeding. It is still a challenging task for farmers to balance productivity, cost-effectiveness, and environmental impacts.By introducing the Carbon Robotics LaserWeeder, a cutting-edge device designed to fight against weeds. This autonomous robot operates 24/7 with great accuracy, utilizing artificial intelligence, sophisticated cameras, and 30 powerful lasers. It is effective on over 100 different types of crops and can be used on all soil types, including certified organic fields. offers a more environment-friendly alternative.

Index Terms **- Herbicide Resistant, Precision Weed Management,Sustainability, Weed Control Technology**

I. INTRODUCTION

The Carbon Robotics Laser Weeder is a significant breakthrough in the field of precise weed control, providing a sustainable answer to the traditional issue of managing weeds in farming. Originally created as a self-operating laser weeding device in 2021, this groundbreaking technology has since been upgraded and improved, leading to its widespread recognition and praise among farmers. In 2022, the system was upgraded significantly, utilizing state-of-the-art autonomous features and advanced laser technology for highly precise weed removal. The Carbon Robotics Laser Weeder has received prestigious awards for its role in promoting agricultural sustainability, leading to widespread recognition of these technological advancements. By skipping ahead to 2024, we find the track laser weeder standing out as the top choice for precise weed control technology. With cutting-edge sensors and advanced algorithms, this state-of-the-art device functions independently to detect and eradicate weeds with unmatched precision. By utilizing lasers, it accurately focuses on unwanted plants with minimal harm to crops, soil, and nearby ecosystems. The Carbon Robotics Laser Weeder is highly valuable for farmers looking to increase crop yields and reduce environmental impact, thanks to its precise field navigation and targeted weed control capabilities. This paper explores the development of the Carbon Robotics Laser Weeder from its beginning to its present state in 2024. We investigate the functioning of this

groundbreaking technology, emphasizing its autonomous features, and progress in identifying and removing weeds.

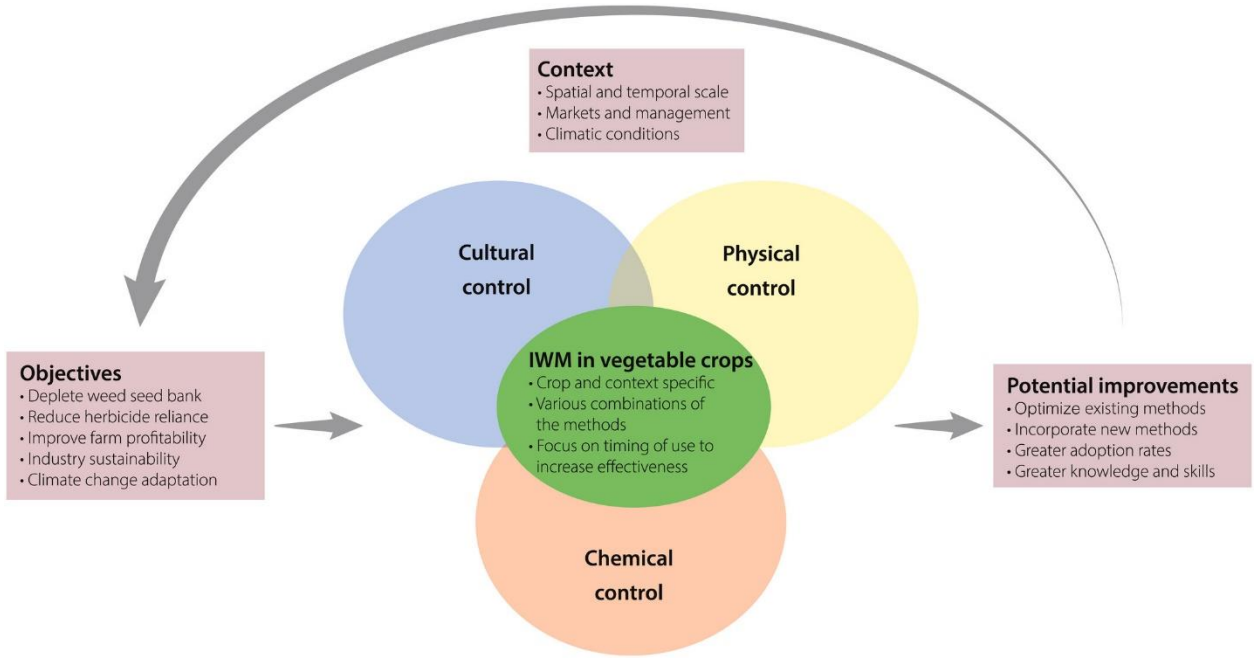

Fig1.Conceptual Diagram Of Integrated Weed Management In Vegetable Production Systems

1.1 The Autonomous Laser Weeder

In the field of weed control, Carbon Robotics unveiled the Autonomous LaserWeeder in 2021, a groundbreaking advancement. This self-driving robot marked a major progression in farming technology, providing farmers with an effective method for controlling weeds and reducing environmental harm.The main characteristics of the 2021 Autonomous LaserWeeder were:

The Autonomous LaserWeeder utilized advanced AI deep learning technology to independently explore farmland and accurately detect weeds. This technology empowered the robot to differentiate crops from weeds, enabling precise weed control measures.With advanced computer vision technology, the Autonomous LaserWeeder is able to identify weeds among crop plants with precision, even in challenging and changing conditions. This ability enabled the robot to adjust its weed control methods instantly, improving its efficiency.The Autonomous LaserWeeder used industrial CO2 lasers to send accurate bursts of energy to remove weeds effectively. These lasers effectively destroyed weeds while minimizing harm to nearby plants and crops.Advanced technology and precision targeting allow the Autonomous LaserWeeder to silently eliminate more than 100,000 weeds every hour, making it a highly effective tool for weed control in agricultural fields.Addressing environmental concerns related to traditional weed control methods, the Autonomous LaserWeeder reduces herbicide usage by up to 90%. Its accurate aim and low ecological footprint made it a viable choice for farmers interested in implementing environmentally friendly farming methods.In general, the 2021 Autonomous LaserWeeder was a major advancement in weed management technology, providing farmers with a dependable and effective way to control weeds in their fields. The cutting-edge AI features, computer vision technology, and industrial CO2 lasers transformed it into a groundbreaking tool for modern agriculture, leading to the adoption of more sustainable and eco-friendly farming methods.

1.2 2022 Laser Weeder

In 2022, Carbon Robotics revealed an improved edition of their LaserWeeder, with numerous notable upgrades and enhancements compared to the previous model. This advanced version, known as the 2022 LaserWeeder, represented another significant achievement in the development of weed control technology, providing farmers with increased effectiveness, accuracy, and flexibility in weed eradication.The 2022 LaserWeeder comes with important features and improvements.

Enhanced Laser Capability: One of the key improvements in the 2022 LaserWeeder was the integration of 30 industrial CO2 lasers, greatly boosting its weeding efficiency from the prior version. This larger laser system enabled quicker and more comprehensive weed removal, increasing the efficiency of the LaserWeeder in big farming operations.

Improved Coverage and Faster Speed: Thanks to its upgraded laser capacity, the 2022 LaserWeeder has the ability to cover two acres per hour, revolutionizing farming practices for those with large specialty row crop fields. The LaserWeeder's increased speed and coverage features boosted operational efficiency and productivity for farmers, allowing them to address weed infestations more efficiently and quickly.

Seamless Incorporation: The 2022 LaserWeeder smoothly blended into current agricultural systems, tackling issues related to spraying, hand weeding, and mechanical weeding. The versatile design and easy-to-use interface of the LaserWeeder made it simple for farmers to integrate it into their weed control routines, reducing interruptions to their activities.

AI-Powered Technology: Expanding on the AI deep learning and computer vision features of the previous model, the 2022 LaserWeeder utilized advanced technology for accurate weed detection and removal. The LaserWeeder used AI technology to detect and remove weeds by using thermal energy, working 24/7 regardless of the weather.

1.3 Recognition and Awards

In June 2023, Carbon Robotics was awarded the AI Breakthrough Award for their LaserWeeder technology, which was recognized as the Best AI-based Solution for Agriculture due to its significant impact and innovation. This award illustrated how the LaserWeeder has transformed weed management and supported sustainable farming practicesThe AI Breakthrough Awards program recognizes outstanding achievement and creativity in the artificial intelligence sector in different fields, such as agriculture. The recognition honors companies and products that show exceptional performance, innovation, and success in utilizing AI technology to tackle real-world problems and enhance business results.Carbon Robotics was awarded the Best AI-based Solution for Agriculture for their LaserWeeder, showcasing its ability to revolutionize weed control for farmers. Through the utilization of advanced AI deep learning, computer vision, and industrial CO2 lasers, the LaserWeeder provided a more effective and environmentally-friendly option compared to conventional weed control techniques.Carbon Robotics' LaserWeeder technology has been heavily praised and acknowledged for its significance and influence in the agricultural industry. Carbon Robotics has shown leadership and innovation in the field of weed management by eliminating over one billion weeds and providing farmers with reliable and sustainable tools.

1.4 Track Laser Weeder

In 2024, Carbon Robotics unveiled the Track LaserWeeder, showcasing the newest advancement in their LaserWeeder technology. This new solution, with advanced features and improvements, increased the efficiency, accuracy, and effectiveness of weed control in agriculture.Some of the main characteristics and improvements of the 2024 Track LaserWeeder are:

Improved tracking capabilities: The Track LaserWeeder utilized advanced tracking technology to navigate agricultural fields accurately and target weeds with unparalleled precision. This improved tracking ability guaranteed comprehensive field coverage and optimized weed control efforts, leading to better weed elimination results.

High-Speed Performance: Expanding on the quickness and effectiveness of earlier versions, the 2024 Track LaserWeeder featured high-speed operation, allowing it to efficiently and rapidly cover extensive The increased speed resulted in improved weed management efficiency, reducing labor expenses and productivity for farmers agricultural areas..The Track LaserWeeder was created to be flexible on all types of terrain, such as rough or inclined surfaces, ensuring uniform efficiency in different boosting farming settings. Its capacity to easily maneuver difficult terrain made it a flexible instrument for farmers overseeing various landscapes and crop varieties.

Advanced Sensor Technology: With advanced sensor technology, the Track LaserWeeder is able to precisely pinpoint and distinguish weeds among crop plants, even in intricate and changing surroundings. This ability allowed the robot to adapt its weed control methods immediately, maximizing its efficiency and reducing harm to crops.

Incorporating Precision Weed Management Systems: The Track LaserWeeder smoothly merged with precision weed management systems, enabling well-coordinated and synchronized weed control activities. This incorporation allowed farmers to enhance their weed control methods, increasing crop production while reducing environmental harm and resource consumption.

II. LITERATURE SURVEY

2.1 Current Robotics Methods For Precision Weed Control

This involves researching how applications in this area have been used in the last 5 years, finding out the main technical areas limiting wider adoption, and determining which key subjects will lead future advancement and usage. The integration of computer vision with conventional machine learning and deep learning is advancing weed detection and robotic methods for weed control. Autonomous weeding robots are rapidly advancing by integrating essential technologies for perception, decision-making, and control. This review evaluates various weed detection methods and weeder robots utilized in precise weed management, which efficiently save labor and decrease environmental pollution from pesticide usage, outlining recent trends in this field. The constraints of existing systems are examined, and suggestions for future research paths are put forward.

2.2 Role of Precision Weed Management

The growth of the global population has led to a demand for increased food production, resulting in higher stress on agricultural resources. Furthermore, issues regarding climate change, water scarcity, and diminishing arable land quantities profoundly impact the sustainability of agriculture. Weeds have the potential to impact agricultural systems by reducing both the quality and quantity of food production through competition for natural resources. Alternatively, weeds can be seen as important signs of biodiversity due to their function in offering ecosystem services. There is a requirement for implementing a successful and enduring weed control system by combining different control techniques (e.g., cultural, mechanical, and chemical) in a balanced manner, without causing harm to the overall agricultural ecosystem. Therefore, it is important to steer clear of heavy mechanization and excessive herbicide usage. Dealing with herbicide resistance in certain weed biotypes is a significant current concern that needs to be addressed. However, advancements in weed control technologies have the potential to increase food production, decrease input requirements, and mitigate environmental harm, ultimately moving us toward more sustainable agricultural practices. This article examines the most typical traditional and non-traditional methods of weed control from a sustainability standpoint, emphasizing the use of precision and automated technologies linked to precision weed management (PWM).

2.3 Weed Management in Herbaceous Field Crops

Gives an outline of how weeds affect crop yield and discusses the current research on managing weeds in herbaceous crops in the field. The primary focus of physical weed control is on thermal methods like flame and laser weed control, which effectively eliminate weeds with precision. Mechanical weed control accuracy is enhanced through the use of sensor technologies, machine vision technology, and high-precision navigation. The use of plant extracts and pathogens to create herbicides is common in biological weed control, however, it can be expensive and may pose risks to mammals due to toxicity. Chemical weed management is frequently used, leading to both environmental contamination and the development of weed resistance. Scholars suggest using integrated weed management strategies, combining biological control, seed bank control, and enhancing crop competitiveness, in order to decrease the reliance on chemical herbicides. Integrated weed management strategies are seen as the future path for weed control. To summarize, physical, mechanical, biological, and chemical strategies are frequently employed to manage weeds. The implementation of integrated weed management strategies can enhance weed control, ultimately improving crop yield and quality in specific situations. The primary goal of this review is to categorize the advancements in research regarding weed control methods for herbaceous crops in the field and offer a guide for the agricultural industry to create weed management plans. In particular, this article divides weed control techniques into four categories, examines the pros and cons of these methods, and explores potential areas for future research.

III. OBJECTIVE

Carbon Robotics aims to offer a new and environmentally friendly way to control weeds in agriculture with their laser weeder.The Carbon Robotics laser weeder seeks to provide farmers with a more efficient and eco-friendly option compared to conventional herbicides and manual labor, through the use of cutting-edge robotics and laser technology.
Primary goals of the Carbon Robotics laser weeder could consist of:

1) Weed management: Precisely addressing and eradicating weeds in farm fields without relying on chemicals or excessive hand labor.
2) Precision: it involves accurately targeting and eliminating weeds with minimal harm to nearby crops or soil.
3) Efficiency: Enhanced efficiency through decreased time and labor needed for weed management tasks in comparison to traditional approaches.
4) Sustainability: Advocating for sustainable farming methods through decreased use of herbicides and lessening environmental effects.
5) Scalability: it involves creating a solution that can be expanded to cater to the requirements of various kinds and scales of farms, thus enhancing weed management practices in the agricultural industry.
6) Ease of Use: Creating a user-friendly interface and operational system to simplify the deployment and operation of the laser weeder for farmers in their fields.
7) Cost-Efficiency: Offering a more economical option for weed control compared to traditional methods, potentially lowering expenses for farmers in the long run.

In general, the aim of the Carbon Robotics laser weeder is to help improve sustainability, efficiency, and productivity in agriculture by providing an advanced remedy for weed control.

IV. RESEARCH METHODOLOGY

Carbon Robotics laser weeder uses robotics, advanced sensors, and precision laser technology to detect and eradicate weeds in farming areas. The general process of using a laser weeder usually includes the following steps, although the methodology may differ depending on the design and implementation.

- Detection and Recognition: The laser weeder uses sensors like cameras and/or infrared sensors to identify weeds in the field. Sophisticated imaging technology and machine learning algorithms can be used to precisely detect weeds among crop plants and soil.
- Navigation and Positioning: The robot moves independently or with some assistance in navigating across the area using GPS, LiDAR, or similar positioning technologies. Accurate placement guarantees that the laser effectively targets weeds without harming crops or beneficial plants.
- Aiming for Accuracy: After spotting and recognizing weeds, the laser weeder accurately aims a high-energy laser beam at them. Laser energy is focused on the leaves of the weed, leading to quick heating and vaporization of the plant tissue, ultimately resulting in the weed's death.
- Real-Time Monitoring and Adjustement: Continuous monitoring and adjustment in real time by the laser weeder ensures that field conditions are optimized for weed targeting while minimizing damage to surrounding plants.
- Data collection and analysis: While in operation, the laser weeder can gather information like maps showing weed density, environmental factors, and performance measurements. Analyzing this data can help enhance the efficiency and effectiveness of weed management tactics in the long run.
- Safety Features: The laser weeder is provided with safety measures to guarantee secure operation in the field. This can involve sensors for detecting humans or animals, emergency stop devices, and fail-safe systems to avoid accidental harm or damage.

V. FUTURE SCOPE

The future path of Carbon Robotics laser weeder has the potential to revolutionize agriculture by utilizing advancements in robotics, AI, and laser technology to redefine weed control methods. Although it currently mainly targets row crops, the technology's versatility suggests potential for wider use in various agricultural settings, such as specialty crops and orchards. This flexibility shows its ability to help with a variety of farming difficulties and needs, hence increasing its usefulness and influence.A smooth incorporation into current farming methods is essential for the broad acceptance of the laser weeder. By seamlessly blending with existing equipment and methods, the technology boosts operational efficiency and promotes its adoption by farmers. Ongoing advancements in interoperability and compatibility standards are expected to help facilitate this integration. Customization and scalability play a crucial role in enabling farmers of various sizes to effectively utilize the advantages of the laser weeder. Being able to customize weed management techniques for individual requirements and circumstances guarantees its effectiveness and importance in diverse farming activities.This flexibility allows the technology to meet the various requirements of farmers globally, no matter the size of their farm or the type of crops they grow.The eco-friendly laser weeder aligns well with the increasing demand for sustainable farming practices by minimizing herbicide use and reducing environmental impact. This not only helps the environment, but also meets consumer demand for eco-friendly products, boosting farmers' marketability and profitability.Additionally, utilizing data analytics and machine learning can support ongoing enhancement and advancement of weed management practices. Through the analysis of operational data and the identification of patterns, the laser weeder can improve its performance, increase efficiency in weed control, and ultimately enhance crop production.

VI. CONCLUSION

To sum up, the laser weeder from Carbon Robotics stands out as a symbol of creativity in the agricultural sector, ready to transform weed control methods. Its incorporation of advanced technologies such as robotics, AI, and laser systems is set to revolutionize how farmers manage weed control, providing a sustainable, effective, and accurate option to traditional approaches. By being able to work with different types of crops and farming conditions, the laser weeder meets the varied requirements of farmers, enabling them to increase

efficiency while reducing harm to the environment. Furthermore, its smooth incorporation into current agricultural practices guarantees convenience and simplicity in implementation, promoting its extensive utilization in various farming activities. The laser weeder fits into the worldwide movement towards sustainable agriculture by decreasing herbicide use and advocating for eco-friendly methods, satisfying consumer desire for environmentally friendly farming practices. In the future, with further improvements from Carbon Robotics, the laser weeder has the possibility to enhance weed control and also drive larger changes in agriculture. Therefore, it serves as evidence of how innovation can effectively tackle the modern farming challenges, providing a preview of a future where efficiency, sustainability, and productivity come together to shape a stronger and more successful agricultural environment.

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