International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-14 Issue-1, October 2024

Fabrication of Remotely Controllable Robotic Weed-Ejector Vehicle

K. Girishma Yadav, B. Druga Prasad

***Abstract:** Weed is an unwanted plant in an agriculture field that keeps the crop plants deprived of sunlight, fertilisers and water. If not removed, weed reduces the crop output to a larger extent i.e., endangering the farmer's interests. There are three main reasons for leaving weed to grow in fields and substantial loss of crop output 1) non-availability of agricultural labour, 2) fear of snake bites and 3) higher amounts of time required for weed injection. As of there are no successful ROVs (Remotely operating vehicles) to get to the weed and capable of pulling off the weed without the farmer physically entering into the agricultural fields. The Proposed model reduces farmers getting exposed to snake bites during weed ejection and reduces the time and labour requirement for weed ejection. The project involves the study of different mechanisms required for weed pull-off from the agricultural fields and remote-control systems, modelling of components, fabrication of components, assembly and testing of the Remotely Controllable Robotic Weed-Ejector Vehicle.*

***Keyword:** Weed Mechanism, Testing of Remotely Controllable Vehicle, Remote Control System, Fabrication Components.*

I. INTRODUCTION

Weed removal in agricultural fields poses a myriad of challenges that significantly impact the efficiency, cost-effectiveness, and overall success of weed control efforts. Primarily, the labour-intensive nature of weed removal demands substantial human effort, rendering the process time-consuming and costly, particularly in expansive fields. Acquiring skilled labourers, especially during peak seasons, becomes a hurdle, resulting in delayed weed removal and allowing unchecked weed growth, competing with crops for crucial resources. Additionally, manual weed removal proves to be inefficient compared to alternative control methods due to the resilience of weeds. The deep roots and various propagation methods, such as rhizomes or seeds, make complete eradication a challenging feat. Incomplete removal leads to weed remnants regenerating over time, necessitating repeated efforts to maintain fields. This inefficiency is coupled with risks to desirable crops, as workers may unintentionally uproot or harm cultivated plants during the removal process, causing yield losses and compromising overall productivity.

Manuscript received on 30 July 2024 | Revised Manuscript received on 27 August 2024 | Manuscript Accepted on 15 October 2024 | Manuscript published on 30 October 2024.
*Correspondence Author(s)
K Girishma Yadav*, Department of Mechanical Engineering, JNTUA College of Engineering, Anantapur (Andhra Pradesh), India. Email ID: girishmayadav123@gmail.com, ORCID ID: 0009-0000-9679-1000
Prof. B. Durga Prasad, Department of Mechanical Engineering, JNTUA College of Engineering, Anantapur (Andhra Pradesh), India. Email ID: durga.mech@jntua.ac.in

The persistence of certain weed species further complicates the situation, with underground structures enabling regeneration even after visible parts are manually removed. Timely weed removal is critical to prevent competition for vital resources, adding complexity to the process. The scale and size of agricultural fields present practical challenges, making manual removal impractical in larger areas. In such cases, alternative methods like mechanical cultivation or chemical weed control may prove more efficient and effective. Weather dependency poses yet another obstacle, particularly in regions with unfavourable climates. Adverse weather conditions, such as rain or extreme heat, can impede or delay weed removal activities, reducing their effectiveness. Wet or muddy conditions make manoeuvring in fields challenging for labourers, and excessive heat poses health risks. To address these challenges, farmers employ a combination of weed control methods and strategies. Mechanical cultivation, including the use of tillage equipment like cultivators, helps mitigate the labour-intensive nature of weed removal. However, careful implementation is essential to avoid soil disturbance and damage to crop root systems. The exploration of alternative methods, such as chemical weed control, provides options for efficient, large-scale weed management. In essence, a holistic and adaptive approach, considering factors like timing, scale, and weather conditions, is indispensable for successful weed control in agriculture.

II. LITERATURE SURVEY

Bhagirath S. Chauhan et al. [1] (2017) In response to evolving challenges in modern agriculture, this review explores nonconventional weed management strategies. Labour shortages render manual control ineffective, while chemical options face ecological and resistance concerns. Alternative approaches include improved tillage, harvest seed control, allelopathy, biotechnology for herbicide resistance, bioherbicides, and thermal management. Precision techniques integrating remote sensing and robotics show promise. Integrated strategies are advocated for optimal results. Future research should focus on technological and cultural optimization for sustainable cropping systems. These methods offer the potential for enhancing agricultural efficiency and conservation practices.

Graham Brodie et al. [2][11][12][13][14][15] (2007) Microwave heating has long been explored in agricultural contexts, with soil pasteurization emerging as a promising weed control method. This paper examines the efficacy of using a pyramidal horn antenna as a microwave applicator for soil pasteurization, targeting both seed germination suppression and established weed control. A laboratory system, powered by a modified microwave oven operating at 2.45 GHz, was developed for experiments. Results indicate effective suppression of Malva parviflora seedlings and wheat seeds to a depth of approximately 6 cm, highlighting the potential of microwave technology in agricultural weed management.

Bhagirath S. Chauhan et al. [3] (2017) Rice serves as a staple for billions, predominantly in Asia. Transitioning to dry-seeded rice (DSR) addresses labour and water concerns but exacerbates weed issues. Herbicides, while effective, face resistance challenges. Integrating diverse tactics like tillage, crop residue, and cultivar selection is essential for sustainable weed control. Adjusting agronomic practices and incorporating manual/mechanical weeding alongside strategic herbicide use enhances efficacy. This review synthesizes existing knowledge to outline comprehensive strategies for optimizing weed management in DSR. By amalgamating various approaches, we can mitigate weed pressures, ensuring resilient and productive rice cultivation systems.

Bhagirath S. Chauhan et al. [4] (2013) The study examined the impact of fertilizer placement methods on weed growth and grain yield in dry-seeded rice (DSR) systems. Results revealed that herbicide application significantly reduced weed biomass, with fertilizer placement influencing weed biomass in untreated plots. Surface broadcast of fertilizer led to increased weed biomass compared to subsurface placement. While grain yield remained unaffected by fertilizer placement in herbicide-treated plots, surface broadcast resulted in lower yields compared to subsurface placement. Overall, the study highlights the importance of appropriate fertilizer placement to mitigate weed pressure and optimize grain yield in DSR systems.

Stephen O Duke et al. [5] (2012) Despite the urgent need for new herbicides to combat weed resistance, the introduction of novel modes of action has stagnated for two decades. Factors contributing to this include market dominance by glyphosate-resistant crops, diminished research efforts, industry consolidations, and the perception that all viable molecular targets have been identified. However, evidence suggests untapped target sites exist. While modern discovery methods lack public dissemination, the economic imperative posed by herbicide-resistant weeds, particularly glyphosate-resistant strains, may drive innovation. The complex interplay of these factors underscores the uncertain landscape of herbicide development, yet hints at potential breakthroughs on the horizon.

ALBERT FRANCIS A et al. [6] (2017) The dual negative effects of crop damage and pollution caused by diesel-powered weed removal machines highlight their limitations as viable solutions for weed control in agriculture. Their inability to protect surrounding crops, as well as their contribution to pollution, make them impractical and unsustainable. Instead, farmers are encouraged to look into alternative methods that prioritise crop protection, reduce environmental impact, and promote sustainable agricultural practices. This review emphasises the importance of transitioning to cleaner, more environmentally friendly agricultural technologies to ensure long-term sustainability and environmental stewardship.

MARUTHI G V et al. [7] (2019) The difficulty of detecting and removing cut weeds left by weed removal machines significantly reduces their potential benefits and effectiveness. Farmers are burdened with manually searching for and extracting scattered weed remnants, which negates any perceived advantages provided by the machine. Given these limitations, there is an obvious need for alternative weed control methods that provide more efficient and comprehensive solutions to the challenges of agricultural weed management.

MADHULESH K S et al. [8] (2020) The environmental impact of petrol-powered weed-removal machines highlights the critical need for sustainable agricultural alternatives. Electric-powered machines and biofuels provide promising solutions for reducing air pollution and greenhouse gas emissions associated with weed control. However, effective implementation of government regulations and incentives is critical in encouraging the widespread adoption of cleaner technologies, thereby promoting environmental sustainability in the agricultural sector.

III. MODELLING

To create the chassis in CATIA V5, begin by selecting the appropriate workbench and using the "Rectangle" command to draw two 25mm squares, positioning them 450mm apart. Utilize the "Pad" command to extrude a 25-mm square sketch into a 100-mm-long square pipe. Draw a 25-mm square on one face of the pipe and "pad" it to 400mm. Then, draw two 25mm squares on this face, each 150mm from the centre, and "pad" to form two pipes of 400mm length. Create motor support plates by drawing 40mm x 70mm rectangles on chassis edges, adding 13mm diameter circles, and "padding for 2mm thickness. Cut features by adding a 13mm hole and a 25mm x 60mm rectangle "Pocket" to 23mm depth. Lastly, draw two 20-mm squares on the centre beam and "Pad" for a 300-mm-long chassis. Review and validate the assembly following figure (3. 1)

Retrieval Number: 100.1/ijeat.A453714011024
DOI: 10.35940/ijeat.A4537.14011024
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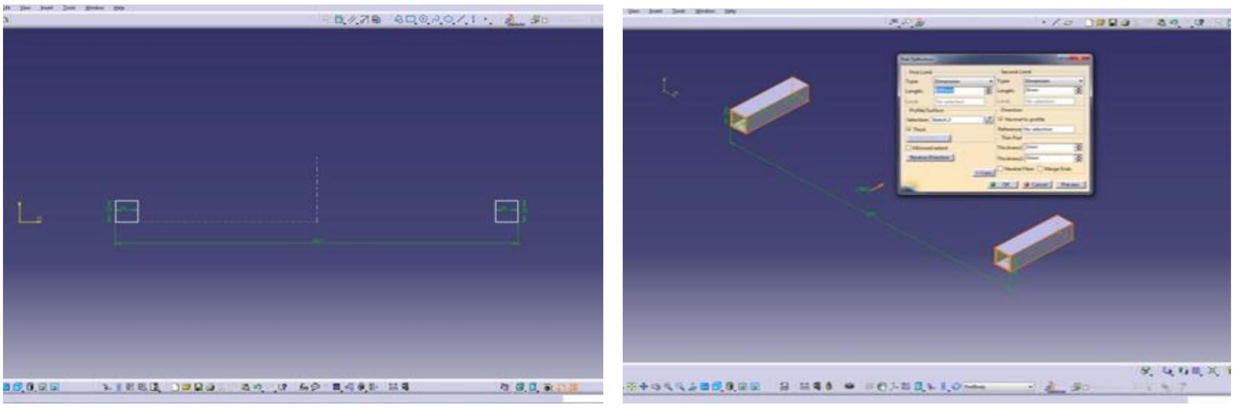

Fig (3. 1) Weed Ejection Component Design

A. Weed-Removal Mechanism

In CATIA software, we crafted a weed-removal mechanism using fundamental commands like line, rectangle, pad, and pocket. The line command shaped the overall structure; rectangles represented structural components; pad-extruded sketches into 3D parts; and pocket-added functional elements. The meticulous application of dimensions and alignments optimized performance, and through iterative refinement, we achieved a final 3D model with structural integrity, efficient weed removal capabilities, and seamless integration with our project. CATIA's tools facilitated visualization and evaluation, resulting in a practical and functional weed-removal mechanism.

B. Weed-Holding Mechanism

We developed a weed-holding mechanism in CATIA using commands such as line, rectangle, pad, and pocket. This mechanism, designed for secure weed containment in agricultural or gardening contexts, utilized lines and rectangles to define the structure and holding components. The pad command extruded sketches into solid 3D parts, while the pocket command created recessed areas for secure weed containment. Precise attention to dimensions and alignments, coupled with iterative refinement, led to a practical and effective weed-holding mechanism compatible with our project. CATIA's 3D tools provided an accurate environment for visualization and evaluation, ensuring the design met the desired specifications [9][10].

C. Parts Assembly

In CATIA's assembly workbench, we successfully integrated all designed components, including the chassis, weed-removal mechanism, slider, and weed-holding mechanism. Meticulous alignment and mating of individual parts resulted in a comprehensive assembly for our project. The assembly workbench facilitated accurate positioning and connections, ensuring proper fit and functionality. Rigorous verification for interferences or clashes led to necessary adjustments. The culmination is a fully assembled project, harmoniously integrating all designed parts into a cohesive and functional system.

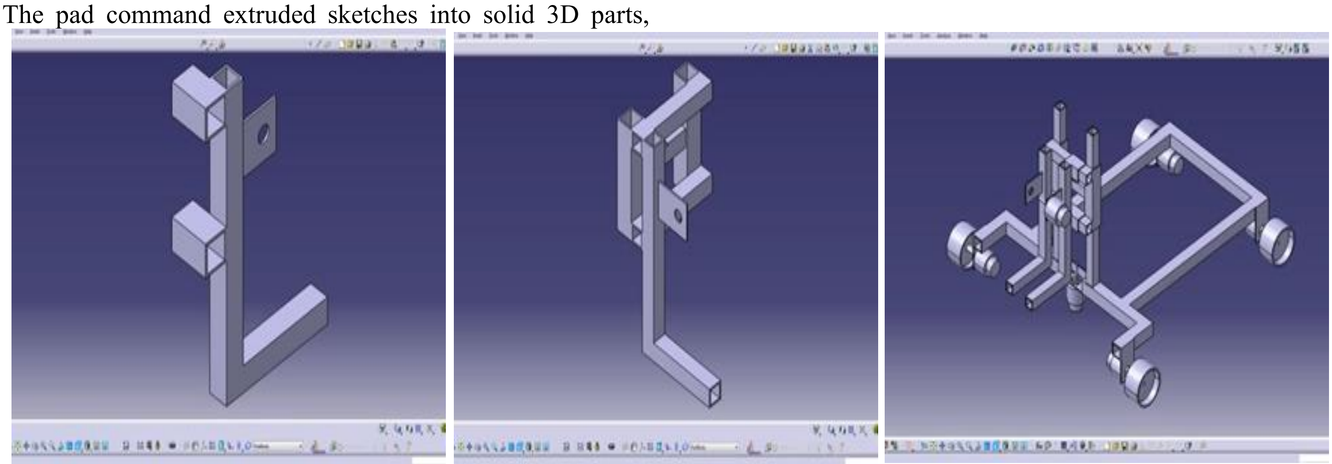

Figure (3.1.1), (3.2.2) and (3.3.3) Design Assembly of Weed Ejector

IV. FABRICATION ASSEMBLY

A. Procedure

- Chassis: The robotic weed ejector vehicle is supported and structured by its chassis. usually composed of lightweight.
- Wheel: The wheels enable the vehicle to move and navigate various terrains. They are usually designed with traction and stability in mind to ensure smooth operation.
- Motor: Motors are responsible for powering the vehicle's movement. They provide the necessary torque and speed to drive the wheel.
- Weed locking and weed pulling arrangement: The weed locking and lifting arrangement is a system designed to effectively control and remove weeds. This arrangement provides a solution for managing and eliminating unwanted plants.

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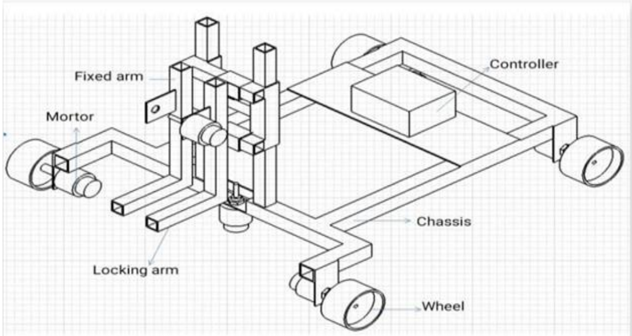

Fig (4.1.1) Fabrication Assembly Part

B. Electrical Circuit Board

An important component of the vehicle that houses and connects the electrical circuits

Fig (4.2.1) Electrical Circuit

C. Working Principal

The finalized project operates on a robust working principle that integrates various components and circuits to efficiently control two distinct remotes, each serving different functions.

i. Weed Ejector Remote (Transmitter and Receiver)

- The weed ejector remote utilizes a transmitter-receiver pair.
- The transmitter sends control signals to the receiver, which interprets these signals.
- The receiver then interfaces with the motor, which controls the weed ejector mechanism.
- The motor operates at 10 RPM (rotations per minute) and requires 12 volts for optimal performance.
- This motor is designed for high torque, allowing it to efficiently lift and lock the weed ejector arrangement in place.
- The transmitter's commands are translated into actions by the receiver, ensuring precise control over the weed ejector's operations.

ii. Amplifier Remote (Transmitter, Receiver, and Amplifier)

- The amplifier remote comprises a transmitter, receiver, and amplifier.
- Similar to the weed ejector remote, the transmitter communicates with the receiver.
- The receiver, in turn, interfaces with the amplifier, which consists of a four-wheel motor system.
- Each wheel motor operates at 10 RPM and requires 12 volts.
- These motors are optimized for both high speed and high torque, enabling efficient movement and manoeuvrability.
- The receiver ensures that commands from the transmitter are accurately translated into actions by the amplifier, facilitating precise control over the four-wheel motor system.

iii. Power Supply and Connectivity

- Both remotes are powered by a 12-volt battery, providing the necessary voltage for operation.
- Electrical circuits connect the various components, ensuring seamless communication and functionality.
- The weed ejector remote's motor is directly connected to its receiver, while the amplifier remote's receiver interfaces with the amplifier controlling the four-wheel motor system.
- Additionally, power management is ensured through adaptors, such as stepping down the voltage from 12 volts to 5 volts for camera operation.

iv. Overall Working Principle

- The system's working principle revolves around effective communication between transmitters and receivers, translating commands into actions via motorized mechanisms.
- Each remote serves a specific function: the weed ejector remote lifts and locks the weed ejector arrangement, while the amplifier remote controls the movement of a four-wheel motor system.
- High-torque motors are employed where lifting and locking mechanisms are required, whereas high-speed, high-torque motors are utilized for swift and precise movement of the four-wheel system.
- The power supply ensures consistent voltage delivery to all components, while electrical circuits facilitate connectivity and signal transmission, culminating in a fully functional and efficient remote-controlled setup for weed ejection and movement tasks as shown in Figure (4.3.4.1).

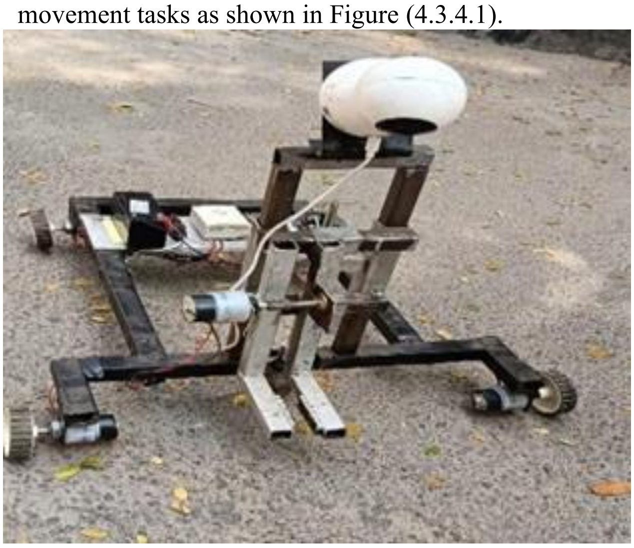

Fig (4.3.4.1) Fabrication of Weed Ejector

Retrieval Number: 100.1/ijeat.A453714011024
DOI: [10.35940/ijeat.A4537.14011024](https://doi.org/10.35940/ijeat.A4537.14011024)
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V. CALCULATION

Holding Torque (T_h) = (F_u x dm/2) x ((L+Л x μ x dm)/ (Л x dm - μ x L)=0.214 N-m

Power required for holding (P_h) = 2 Л N T_{Ru}/ 60=0.224 Watts

Lifting Torque (T_l) = (F_l x dm/2) x ((L+Л x μ x dm)/ (Л x dm - μ x L)=0.239 N-m

Power required for Lifting (P_l) = 2 Л N T_{Ru} / 60=0.25 Watts

Weed Ejector travelling speed (V)=2 x 3.14 x N x D/60=0.0366 m/s

Weed Ejector Travel Power (P_g) = F x V=2.156 Watts

Power Consumption of each weed ejector motor = P/4=0.539

VI. RESULT

The design of weed ejector components, including the chassis and holding and lifting mechanisms, was meticulously executed using CATIA V5 software, as illustrated. The assembly of these components was seamlessly integrated using the same software, resulting in a comprehensive design assembly. Following the design phase, the weed ejector components were fabricated according to the specifications outlined in the design, and each part was meticulously finished to meet the operational requirements, as depicted in Figure (6. 1). The assembly of the weed ejector includes essential elements such as the chassis, motors, lead screws, and wheels, aligning precisely with the assembly design. In terms of power requirements, the calculations for lifting while uprooting plants with diameters ranging from 2 to 6mm indicated a power need of 0.25 watts. To address this, a 12-watt motor was incorporated into the project for lifting. It is noteworthy that the motor's capacity exceeds the calculated requirement, ensuring ample power for the lifting operation. Similarly, the power needed to hold plants within the 2– 6 mm diameter range was calculated at 0.224 watts. To meet this requirement, a 12-watt motor was employed for holding, surpassing the calculated capacity and guaranteeing sufficient power for the holding operation. Ultimately, the weed ejector model demonstrated its efficacy by successfully uprooting weeds and plants with diameters ranging from 2mm to 6mm. The integration of robust design, appropriate motor capacities, and precise fabrication has resulted in a functional and efficient weed ejector system.

Fig (6.1) Assembly Image of The Project

VII. CONCLUSION

A weed is an unwanted plant in an agriculture field that keeps the crop plants deprived of sunlight, fertilizer, and water. If not removed, weed reduces crop output to a greater extent, i.e., endangering farmers' interests. Hence, it is very important to eject the weed from the fields to get good farm outputs. As of now, there are no remotely operable vehicles or machines available on the market that can eject weed from the fields. Due to the non-availability of such ROVs (remotely operable vehicles), farmers had to enter the fields for the ejection of weeds, which exposed them to snake bites. The situation demands a dedicated "remotely operable weed ejection vehicle" that can remove weed from the fields. The present project can eject weed from the flat fields using jaw locking, lifting, and 4-wheel drive mechanisms to travel. While testing, the remotely operable weed ejection vehicle was able to uproot the unwanted plants, ranging from 2mm to 6 mm in stem diameter.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

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AUTHORS PROFILE

K Girishma Yadav, M.Tech Degrees from JNTUA College of Engineering (Autonomous) in Ananthapuramu in Product Design, B.Tech specialised in Mechanical Engineering. My academic journey reflects a deep passion for mechanical engineering and a commitment to advancing the field. showing my skills in both design and hands-on fabrication. I did the project on the fabrication of a remotely controllable robotic weed-ejector vehicle. The model minimises farmers' exposure to snake bites and reduces labour in weed ejection. It involves studying mechanisms, remote control, fabrication, assembly, and testing. Expert in problem-solving and analysis. My goals contribute meaningfully to improving safety and minimising snake bite risks during weed ejection. Reduce the time and labour involved in weed management.

Prof. B. Durga Prasad, M.Tech, PhD, Professor & Head of the Mechanical Engineering Department, brings 20 years of expertise in teaching and placement excellence. Known for his dedication and passion, he motivates students to achieve both academic and personal growth. He has supervised 50 M.Tech dissertations and PhD research at Sathyabama University and JNTUA, with 14 PhD students currently under his guidance. Additionally, he serves on doctoral committees at several universities, consistently exceeding expectations for his position.