A Next-Generation Weed Management Platform: Engineering of a Modular Weed Management System Integrating a Multi-Mode Bioherbicide Formulation and Precision Spraying Tool to Reduce Agricultural Chemical Inputs

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Weed infestations are considered as the most prominent biotic stressors threatening crop yields globally, contributing to 25-40% of annual crop losses. Currently, synthetic herbicides are mostly commonly used to manage weeds; however, they pose numerous shortcomings due to adverse effects on the environment, risk of exposure-linked Cancers, and, importantly, Herbicide Resistance. This investigation aimed to discover a sustainable, eco-friendly alternative to synthetic herbicides for effective weed management and to reduce chemical inputs in agriculture by selectively applying novel bio-herbicides using an AI-embedded sprayer. To accomplish this, an end-to-end modular weed management system was developed, comprising 1) Development of an Eco-Friendly, Novel Bioherbicide Formulation with Multiple Modes of Action 2) Development of a YOLOv11(Computer Vision Algorithm)-based Application for In-Field Detection of 40 Weed Species and 3) Engineering of a Low-Cost, AI-Guided Precision Sprayer for Selective Application of Bioherbicides. Greenhouse studies were conducted to screen 15 compounds and test 3 novel formulations across 10 weed species, with Glyphosate used as an industry standard. Field trials were conducted for testing efficacy of both formulations and sprayer. The novel formulation achieved a 97% weed management efficacy, outperforming industry standard Glyphosate. Weed management efficacy was improved by 17% with AI guided sprayer, reducing the total herbicide volume by 21%. This integrated approach emerges as a cost-effective, accessible, and eco-friendly method for weed management. This project presents widespread implications to significantly reduce synthetic herbicide use, combat herbicide resistance in weed species and improve global crop production.

Awards Won:

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