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Next-Generation Weed Control: A Game Changer for Summer Mungbean Cultivation

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Summer mungbean (*Vigna radiata* L.) is a vital short-duration pulse crop that fits well into intensive cropping systems of India, particularly during the summer season after rabi harvest, contributing significantly to nutritional security and soil fertility through biological nitrogen fixation (Willey, 1979). Weed competition remains one of the most serious constraints in summer mungbean cultivation, causing substantial yield reductions due to severe crop–weed competition during early growth stages (Rao, 2000). Conventional weed management practices such as hand weeding and repeated use of single herbicide molecules are becoming less effective because of labour scarcity, rising costs, and increasing herbicide resistance in weeds (Meena *et al*., 2015). In this context, next-generation weed control approaches—comprising advanced herbicides, ready-mix formulations, precision application technologies, and integrated weed management—offer sustainable solutions for improving productivity and profitability of summer mungbean.

Keywords: Summer mungbean, weed competition, integrated weed management, herbicide resistance, precision spraying

Introduction

Pulses play an essential role in Indian agriculture by providing affordable protein, enhancing soil fertility, and supporting sustainable cropping systems (Willey, 1979). Mungbean is widely cultivated due to its short growth duration, low water requirement, and adaptability to diverse agro-climatic conditions (Meena *et al*., 2015). Expansion of summer mungbean cultivation in irrigated rice-based systems has improved land use efficiency and soil nitrogen status; however, its productivity remains low mainly due to heavy weed infestation during early growth stages (Rao, 2000).

Weed Infestation: A Major Yield Constraint

Mungbean is a poor competitor with weeds during its initial growth period because of slow early growth and shallow root system (Singh *et al*., 2017). The critical period of crop–weed competition in summer mungbean generally occurs between 15 and 30 days after sowing, during which uncontrolled weeds can drastically reduce yield (Rao, 2000). Common weed flora includes grasses such as *Echinochloa colona* and *Cynodon dactylon*, sedges like *Cyperus rotundus*, and broad-leaved weeds including *Amaranthus viridis* and *Trianthema portulacastrum*, which compete with the crop for nutrients, moisture, light, and space (Meena *et al*., 2015). Yield losses due to unchecked weed growth in mungbean have been reported to range from 30 to 70 per cent (Singh *et al*., 2017).

Limitations of Conventional Weed Control Practices

Hand weeding and mechanical interculture are commonly practiced for weed management in mungbean, but their effectiveness is limited by labour scarcity and high operational costs (Rao, 2000). Continuous and indiscriminate use of the same herbicides has resulted in reduced efficacy and the development of herbicide-resistant weed species, posing a serious threat to sustainable crop production (Meena *et al*., 2015). In addition, improper application of herbicides may cause crop injury and environmental pollution (Singh *et al*., 2017).

Understanding Next-Generation Weed Control

Next-generation weed management emphasizes an integrated approach combining chemical, mechanical, and cultural methods to achieve effective weed suppression with minimal environmental impact (Kumar *et al*., 2008). Instead of relying on a single control method, this approach promotes diversified weed management strategies that ensure long-term sustainability of mungbean-based cropping systems (Willey, 1979).

Advanced Herbicide Technologies in Mungbean

Recent advancements in herbicide chemistry have led to the development of low-dose and crop-selective herbicides suitable for pulse crops, enabling efficient weed control at reduced chemical load (Meena *et al*., 2015). Pre-emergence herbicides help suppress early weed emergence, thereby reducing competition during critical crop establishment stages, while post-emergence herbicides effectively control emerged weeds when applied at appropriate crop growth stages (Singh *et al*., 2017).

Role of Ready-Mix and Sequential Herbicide Application

Ready-mix herbicide formulations containing multiple active ingredients provide broad-spectrum weed control and reduce the risk of herbicide resistance development (Meena *et al*., 2015). Sequential application of pre-emergence followed by post-emergence herbicides has been found effective in maintaining weed-free conditions throughout the critical competition period in mungbean (Singh *et al*., 2017).

Precision Application Technologies

Precision application of herbicides using improved spraying equipment such as flat-fan nozzles and battery-operated knapsack sprayers ensures uniform spray coverage and enhances herbicide efficiency while reducing chemical losses (Rao, 2000). Emerging technologies like drone-assisted spraying further improve timeliness and reduce labour dependency in weed management operations (Kumar *et al*., 2008).

Integrated Weed Management: A Sustainable Approach

Integrated Weed Management (IWM) combines cultural practices such as optimum sowing time, appropriate seed rate, and narrow row spacing with mechanical and chemical methods to suppress weed growth effectively (Willey, 1979). Integration of these practices enhances weed control efficiency and improves crop productivity while reducing dependence on herbicides alone (Meena *et al*., 2015).

Herbicide Rotation and Resistance Management

Repeated use of herbicides with the same mode of action acceler ensuring the selection of resistant weed biotypes, which is now a major challenge in modern agriculture (Rao, 2000). Rotation of herbicides with different modes of action and adoption of integrated weed management strategies help delay resistance development and sustain herbicide effectiveness (Singh *et al*., 2017).

Economic and Environmental Benefits

Implementing advanced weed management techniques provides numerous advantages for farmers. Efficient weed management at key growth phases contributes to superior crop establishment, increased nodulation, and better nutrient utilization. This leads to greater yield and enhanced grain quality. Decreasing reliance on manual labor reduces production

expenses and guarantees timely interventions. Precision application along with low-dose herbicides lessens environmental hazards and encourages sustainable pulse farming. In summary, advanced weed management boosts profitability while endorsing sustainable agricultural practices.

Conclusion

Weed infestation continues to be a significant obstacle in summer mungbean farming, severely impacting both yield and profitability. Traditional weed control methods alone are insufficient to tackle the intricate and evolving weed issues that farmers encounter. Advanced weed management techniques, utilizing innovative herbicide technologies, precise application methods, and integrated strategies, present effective and sustainable solutions

By implementing these contemporary methods, farmers can effectively manage weed populations, lower production expenses, and achieve higher and more consistent yields. Raising awareness and enhancing the skills of farmers and extension workers regarding next-generation weed control will be essential for bolstering mungbean production and ensuring the long-term viability of pulse-based farming systems.

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