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A Review of the Role of Integrated Weed Management in the Conservation Agriculture System

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ABSTRACT: Tillage equipment is typically used by farmers to improve soil structure and manage weeds. However, by repeating this process, they destroy the soil structure and reduce soil fertility. Tillage is minimized or removed entirely in conservation agriculture systems. Conservation agriculture (CA) is becoming more popular around the world as a result of various benefits, including the conservation of soil and water resources, the reconstruction of soil fertility, the protection of soil from erosion, and the reduction of labour requirements. The various approach of integrated weed management is met by applying any acceptable physical, biological, or chemical weed management technique to the existing cultural weed management of conservation agriculture (IWM). IWM is beneficial to conservation agriculture since it aids in the management of weed issues and the lack of certain weed control solutions. The main limitation of CA-based systems is weeds. By uprooting, severing, and burying weeds deeply enough to prevent emergence, transferring weed seeds both vertically and horizontally, and altering the soil environment, tillage influences weed emergence and seed germination. Therefore, any decrease in tillage frequency or intensity may have an impact on the weed invasion. Herbicide usage done carefully can minimize soil tillage and increase soil biodiversity. Last but not least, IWM promotes improved yield per area unit and more effective crop growing. As a result, the topic of integrated weed control in connection to conservation agriculture and environmental sustainability is discussed in this review paper.

Keywords: Integrated weed management, Conservation Agriculture, Environment.

INTRODUCTION

The need to manage weed infestation has been justified by the reduction in crop productivity caused by the presence of weeds. Several weed management tactics have been tried and tested throughout the years. Tillage, whose primary goal is to generate suitable soil conditions for crops, also serves as a mechanical weed control strategy because weeds are uprooted and buried in the soil. More specifically, repeated tillage operations have been proven to be effective in managing perennial weeds because they can deplete the energy reserve of perennial crops by destroying their storage organs and propagules. Tillage is the process of mechanically manipulating soil and plant waste. It is inextricably linked to conventional agricultural production methods (Farooq & Siddique 2015). Intensive tillage loosens the soil, promotes the release of soil nutrients for crop growth, and changes the circulation of water and air inside the soil, in addition to weed management (Hosseini *et al.,* 2016).

Tillage has an impact on soil parameters like temperature, moisture content, bulk density, porosity, and infiltration, all of which have an impact on crop performance (Adebisi *et al.,* 2016).

Tillage, on the other hand, is a cause of land deterioration. Intensive tillage can degrade soil quality by causing carbon loss and erosion due to the excessive breakdown of soil aggregates. Tillage reduces the soil's water holding capacity, resulting in dryness in soils with little or no plasticity (Singh *et al.,* 2016). Tillage with heavy machinery frequently emits greenhouse gases into the atmosphere and can compact the soil. Conservation agriculture, which emphasises minimal soil disturbance among other components, has arisen as a popular approach in various countries to address the environmental difficulties associated with traditional tillage. Conservation agriculture is practiced on 154 million hectares in the twenty-first century, with an annual expansion of roughly 7 million hectares (Friedrich *et al.,* 2012). Chemical weed management has been the primary technique in developed countries since the introduction of herbicides. Herbicide use has yielded benefits for many years, but the consequences have just recently become apparent. In developed countries, this is the scenario. The herbicides were expensive due to the higher prices of crude oil that had always been imported into these countries, as well as the knowledge and skill required to use them. As a result, the main strategy in these countries is to combine non-chemical treatments with herbicides that are already available. It has been observed that a minor weed today gradually gains importance and becomes a major weed of minor regional or national concern tomorrow. The truth is that it was diverted towards it. The proposed control strategies are primarily for one weed in a stand-alone manner, neglecting the entire system. This is clearly a treatment for that weed, but it is not a cure-all. It inadvertently stimulates the growth and spread of other lesser weeds in the coming years. Once again, the world, the possibilities of discovering a new weed control method, persistence, and residual risks are all factors to consider (Chittapur *et al.,* 1997).

1. Integrated weed management component contributes to

— To prevent agricultural interference, increase the abundance of weed species.

— Dominance of a species in the existing weed flora makeup. The introduction of a new species into the current weed flora.

— Profitability has improved.

— Species succession is changing.

— At the farm level, there is an improvement in overall pest management.

— Acceptance of practices that are beneficial to stakeholders on a social level.

Table 1: The methods of weed control compared (Singh *et al.,* 2015).

Methods	Usual duration of effect	Energy requirement	Impact
Quarantine	Long	Very low	Prevents future weed problems
Habitat management	Medium to long	Varies	Improves crop growth
Farm hygiene	Medium to long	Varies	Reduces need for and cost of other weed control method
Mulches	Shorts	High	Reduces germination of weeds.
Cultivation	Short	High	Rapid knockdown of weeds
Mowing	Short	High	Reduce height of weeds

Methods of IWM

(i) Preventive weed management method. Weed seed mingling with crop is one of the most important factors in weed spread. Preventive measures include the use of weed-free crop seeds and equipment, the isolation of imported animals, the scouting for new weeds, and the prevention of weed seed development on the field (Monaco *et al.,* 2002). The major goal of this indirect weed control strategy is to limit the number of weed plants emerging with the crop.

Use clean wheat seed free from weed seeds: Weed seed mingling with crop is one of the most important factors in weed spread. Many of the farmer's wheat seeds include weed seeds, particularly Phalaris minor, according to drill box studies. Farmers should utilise seed that has been cleansed or that has been certified.

Cultural weed control method: The adjustment of farm techniques to benefit crop development at the expense of weeds is known as cultural weed control. Tillage, sowing time, sowing methods, competitive crop cultivars, increased crop density, closer spacing, irrigation, fertilization, and crop rotation are some of the agronomic measures used in cultural weed management.

Sowing time: Weed seed germination should be discouraged by adjusting the sowing method. In comparison to late sowing, early wheat sowing (final week of October) reduces Phalaris minor infestation. The temperature in early sown wheat is inhospitable to Phalaris minor.

Crop rotation: Crop rotation is a key part of weed management in general. Weed invasion is more common in monocultures. Weeds' life cycle can be broken by planting crops with distinct seeding and maturity times. Rotating crops is primarily used to reduce the weed seed bank in the soil. Crop rotation has been discovered to be a very successful cultural approach in breaking the relationship of troublesome weeds such as P. minor with wheat. According to a survey, Isoproturon resistance in Phalaris minor was found in 67 percent of rice-wheat rotation farms. Phalaris minor populations can be reduced by rotating wheat fields with crops such as sunflower, sugarcane, or berseem.

Mulching: Mulching is used to cover the soil when there is no crop present or during the planting season. Mulching blocks light from reaching the soil surface, preventing weeds from germinating. Although nonliving mulch materials such as plastic are frequently employed in many cropping systems, organic mulch (live/green mulch or crop/plant residue) is preferred.

Physical weed control method: Physical weed control entails breaking, cutting, destroying, burning, or severely injuring weeds with force, heat, or other physical forms of energy (Swarbrick & Mercado, 1987). Physical methods of weed control include hand weeding and mechanical weeding. Grazing, mowing, mulching, tilling, and burning are all part of the process.

Biological weed control method: The employment of natural enemies to lessen the impact of weeds and weed count is known as biological control. It refers to the usage of living beings and biologically derived products (Ehi- Eromosele *et al.,* 2013). Phytopathogenic bio-herbicides, microorganisms, or microbial phytotoxins are used in the same way as conventional herbicides (Boyetchko & Peng 2004).

Chemical weed control method: Chemical weed control refers to the application of a synthetic chemical to kill or inhibit the growth of weeds. Herbicides are classified as systemic or non-systemic (contact) based on how they pass through plants. Herbicides are classified as pre-emergence or post-emergence depending on when they are applied. Herbicide selectivity is determined by crop compatibility and the type of weed they control. Herbicides can be a valuable and effective part of any weed-control strategy. Herbicide resistance, on the other hand, is a problem with some species. Increased pesticide use has the potential to harm the environment. The availability of herbicides and the cost of herbicides, however, make chemical weed management difficult to implement (2012, Kughur).

Integrated Weed Management: Under CA, no single weed management strategy, such as cultural, mechanical, or chemical, could offer the requisite degree of weed control efficiency because to the multiplicity of weed problems. As a result, a variety of weed management options should be studied in order to broaden the weed control range and efficacy for long-term crop production.

The term " Integrated weed management system" refers to a collection of cost-effective, dependable, and practicable weed management strategies that can be employed by farmers as part of a competent farm management system. This strategy considers the need to maximize agricultural productivity while reducing economic losses, human health risks, and potential damage to flora and fauna, as well as increasing environmental safety and quality. The integrated weed management system is not intended to replace selective, safe, and effective herbicides; rather, it is a sensible approach for encouraging the prudent use of herbicides in conjunction with other safe, effective, cost-effective, and environmentally friendly control strategies. For efficient weed management, clean crop seeds and seeders should be combined with field sanitation (weed-free irrigation canals and bunds). The weed control efficiency of sprayed herbicides and competitiveness against weeds are improved by combining appropriate agronomic practices, timeliness of operations, fertilizer and water management, and crop residues remaining on the soil surface. To develop sustainable and effective weed management strategies under CA systems, practices such as stale seedbed practice, uniform and dense crop establishment, use of cover crops and crop residues as mulch, crop rotations, and practices for enhanced crop competitiveness with a combination of pre and postemergence herbicides should be integrated (Singh *et al.,* 2015).

Advantages of IWM

— IWM is regarded as a more practical and long-term technique, as a combination of treatments will take care of weeds in their whole, preventing weed seed development and soil seed bank replenishment.

— It will lower the likelihood of weed flora shift, herbicide resistance weeds, and other ecological problems.

— It could be used in conjunction with integrated pest management to eliminate weeds, which serve as a breeding ground for a variety of insect pests and illnesses.

— In the long run, it will yield a higher net return, especially when cropping intensity is increased.

— It's especially beneficial when there's a lot of cropping going on.

Disadvantages of IWM

— It's not easy to find IWM that are mutually compatible, supportive of one another, and that match the diversity of weed species.

— An IWM will not apply consistently to all crops in all locations.

— Based on a variety of parameters including soil, crops, climate, and production practices, IWM is very site-specific and cropping system-specific.

— It's more of an idea than a method of weed control in the traditional sense. Its effectiveness may fluctuate over time and space due to changes in the efficacy of weed control strategies combined.

CONCLUSION

It is permissible to advance interventions such as CA that avoid human-induced soil degradation. The use of CA reduces erosion and some of the other issues that come with tillage. However, the advent of various weed difficulties in California necessitates the incorporation of its inbred weed control component (cover crop, crop residue mulching, and crop rotation) with other weed management tactics without compromising its principles. Acceptance of any compatible physical, biological, or chemical weed management method to the existing cultural weed management of CA satisfies the IWM's many strategies. Reduced weed management options in California tend to increase herbicide use, which can result in water contamination, weed resistance, weed flora shift, and pesticide carryover. The IWM monitors herbicide overuse. As a result, incorporating IWM within CA helps to ensure its long-term viability and strengthens its environmental protection focus.

Acknowledgment. Weed management research is limited in conservation agriculture. Long-term research should be conducted to get a comprehensive understanding of weed, disease, and insect responses to no-till soil and microclimate conditions. Under Conservation agriculture, soil biological characteristics and the rhizosphere environment should be examined in various soils and crops, with a focus on optimizing fertilizer technique. Because herbicides cannot be completely eliminated from crop management and no tillage, herbicide breakdown pathways, adsorption-desorption, and transport processes continue to be important research themes. There is a need to investigate the factors influencing farmer adoption and acceptance of no-tillage agriculture. In conservation agriculture systems, the development of integrated weed, disease, and pest control solutions is crucial.

Conflict of Interest. None.

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