ISBN: 978-81-970675-6-3

8. Integrated Weed Management

Puneet Kumar Chhokar, Vishnu Sharma, Preeti Yadav, Ramzan Mohammed

Department of Agronomy,
Naini Agricultural Institute SHUATS,
Prayagraj, UP.

Abstract:

This chapter explores the principles, strategies, and practical applications of Integrated Weed Management (IWM) in contemporary agriculture. Beginning with an overview of IWM, the chapter delves into the multifaceted components that make up this holistic approach, including cultural, mechanical, biological, and chemical control methods.

Highlighting the importance of a diverse and integrated approach, the chapter examines the synergistic effects of combining these methods to effectively manage weed populations while minimizing environmental impact. The chapter also discusses the challenges associated with the adoption of IWM and explores potential technologies, such as precision farming and digital solutions, to enhance its efficacy.

By presenting a comprehensive overview, this chapter aims to contribute to the understanding and promotion of Integrated Weed Management as a sustainable and resilient strategy for weed control in modern agriculture.

8.1 Introduction:

A weed may be defined as the plant growing at a place where it is not wanted (**FAO, 2002**), of all the biotic factors weeds causes maximum losses in the crop that is around 38% of the total productivity loss is caused by the weed, by competing with the main crop for space, nutrients, light and water (**Das, 2015**).

Thus, we can say that, weeds pose a perennial challenge to agricultural production, by competing with the crops for resources, hence impacting the overall productivity.

Integrated Weed Management (IWM) is a holistic and sustainable approach that combines various methods of weed control effectively while minimizing the environmental pollution through reduced reliance on chemical herbicides.

This chapter endeavour to provide detailed description on the topic "*Integrated Weed Management (IWM) and climate change*", with major focus on the need for adaptive strategies to sustainably address weed-related challenges in a changing climate and at the same time exploring the principles, components, benefits of Integrated Weed Management and studying the principle of effective spray technology.

8.1.1 Principles of Integrated Weed Management:

Integrated Weed Management (IWM) is based on the following 6 pillars, and these are as follows: -

a. Diverse methods of control: IWM employs diverse weed control methods, including cultural, mechanical, biological, and chemical approaches. By using a range of control methods, further development of resistant weed populations can be prevented at the same time it reduces the dependence on any single method of control.
b. Timing and Precision: Effective and efficient IWM requires high precision and careful timings in the application of control measures. Hence having and understanding of the life cycle of weeds and implementing control measures at critical growth stages can exponentially improve the weed control efficiency.
c. Traditional/Cultural Practices: These include crop rotation, cover cropping, inter-cropping etc. These practices help to disrupt the weed population growth, reduce weed competition and enhance soil health at the same time, as a result they have become the integral part of IWM.
d. Physical/Mechanical Control: This method include tillage, mulching, and mowing etc. These usually include the utilization of labour and are time and energy consuming when compared to the chemical mode of control however they reduce the selection pressure on the weeds, thus preventing the development of herbicide resistant weeds, physically disrupt weed growth, prevent seed germination, and provide an immediate solution to weed problems.
e. Biological Control: Using biological agents that act as predators, parasites etc to the target weed can be used as an eco-friendly approach to manage the target weed population, these methods contribute to the long-term and sustainable weed control. For example, *Zygrogramma* beetle has been one of the most important bio-control agent of carrot grass (*Parthenium* sps.) for the past 4 decades (**Sahoo *et al*, 2023**).
f. Chemical Control to be used only as a Last Resort: Now although chemical control is cost effective, time, energy and labour saving (**Chhokar *et al*, 2012**). However, it can lead to development of herbicide resistance in weeds, furthermore it also leaves behind chemical residues in certain cases thereby affecting the growth and productivity of the succeeding crop.

A. Components of Integrated Weed Management: Basically, IWM is composed of 3 broad components which are also part of its principles and these are cultural methods, mechanical methods and biological method. IWM is imploring combination these methods for effective and efficient weed control. For example, According to Rai *et al.*, 2018 atrazine application at a rate of 1.00 kg per hectare, coupled with hand weeding (HW) and two sessions of hand weeding, as well as paddy straw mulching, gave higher yield than the un-weeded plots (68.30 g), which was noted to be 203.48 g, 188.34 g, and 186.82 g, respectively.

B. Cultural Methods: It can also be termed as preventative weed control measures, this method focuses on boosting crop competitiveness and hindering the growth and development of weed populations. Practices such as land preparation, adjusting sowing time and depth are encompassed within this category. However, employing these methods in isolation may not yield satisfactory weed control. To achieve optimal results, a combination of these practices with other methods is necessary, as emphasized by Chhokar et al. in 2012. It is noted that these preventative measures are time-consuming and exhibit lower efficiency compared to chemical weed control methods.

The method comprises the following practices.

a. **Early Planting: -** altering the planting time helps to reduce the critical period of weed competition and hence reducing the weed competition as if weed is done effectively then yield comparable to weed free conditions can be obtained (Reddy and Reddy, 2023). Singh, 2007 claimed that *Phalaris* was more prominent at low temperature in the range of 15 to 20 °C which is usually prevalent during the month of November to December in North-India, hence going for early planting in October gives advantage to the wheat.
b. **Cropping System: -** Employing diverse cropping systems can be another effective strategy for weed control. For instance, cultivating intercrop between the main crop rows creates limited space for weed growth, thereby reducing weed populations. As demonstrated by Xu *et al*. in 2019, cultivating mustard as an intercrop in wheat in areas where rice-wheat cropping system is prevalent, will significantly suppresses the emergence and germination of *Phalaris minor*.
c. **Crop rotation**: - Rotating crops disrupts the life cycle of specific weeds, preventing them from establishing persistent populations. Diversifying crops in a rotation also confounds weed adaptation.
d. **Deep Ploughing:** Conducting deep ploughing in the summer following the rabi season exposes weed seeds to sunlight, leading to their destruction. This practice, known as Khurra-Bakhroni, is effective in weed management. Similarly, cultivating lowland rice has been identified as another method to decrease weed abundance, as indicated by Shakrawar *et al*. in 2018.

C. Mechanical Methods:

The mechanical or physical method involves the manual or tool-based removal of weeds during inter-cultural operations.

According to Dawood, 1994 and Sekhon et al. 1993, hand weeding is considered equally effective as herbicide application, with the caveat that multiple hand-weeding sessions are required for optimal results.

However, this method has been criticized for being time-consuming and costly by some.

As a result, its widespread use is more prevalent in regions or countries with lower labor costs or in areas where organic farming is practiced, minimizing the use of chemical herbicides.

Brand *et al*, 2007 demonstrated that inter-cultural practices using implements like chissler can yield a comparable grain yield to the herbicide treated plots, however a wider row spacing is a prerequisite for the effective mechanical weed control.

Following is some of the commonly used mechanical weed control: -

a. **Chissling:** Brand *et al*. in 2007, illustrated that employing inter-cultural practices with tools such as a chiseler can produce a grain yield similar to that of plots treated with herbicides. Nevertheless, to achieve effective mechanical weed control, it is essential to have wider row spacing.
b. **Flaming:** it is one of the most common methods to control aquatic weeds, but it can also be used to destroy weed seed banks and control terrestrial weeds. (Brand *et al*, 2007).
c. **Hand Hoeing:** It can define as the physical removal of weeds using a hand hoe, According to Dhiman *et al.* (1985) hand hoeing at 20 and 40 DAS was found to effective against *Phalaris* population and at the same time also helped in increasing grain yield of wheat by 26% against 41% obtained by chemical weed control method.
d. **Conservation agriculture:** Adoption modern concepts of tillage involving minimum tillage, zero tillage etc helps in reducing the weed biomass in wheat. (Chhokar *et al*, 2012)

D. Chemical Method:

The advent of chemical weed control in India gained prominence during the post-green revolution era, coinciding with the introduction of high-yielding varieties. This marked a shift towards an intensive agricultural system. The rising costs of fuel and labor have rendered traditional weed control methods inefficient, paving the way for mechanized chemical weed control, which is considered cost-effective and less time-consuming. However, the success of chemical weed control hinges on factors like the method and timing of application, the susceptibility of the cultivar, and prevailing soil conditions. Notably, the effectiveness ultimately relies on effective spray technology, underscoring the importance of precision and careful application. It's crucial to highlight that inadequate spray technology can contribute to the development of herbicide-resistant weeds, emphasizing the need for responsible and strategic use of chemical weed control methods.

Following methods can be adopted for effective chemical weed control.

a. **Herbicide rotation and Mixture application**: - Herbicides having same mode of action should not be used year after year as this is the reason for induction of the resistance in the weed population. Hence, the herbicides can wither be substituted with a herbicide of another MOA group or can also be applied in mixer with other herbicide to increase its efficacy. This will in turn prevent the development of a herbicide resistance in weeds. Example: - Using pyroxasulphone, flumioxazine, metribuzine etc in place of Isoproturon to control *Phalaris minor*, which is otherwise found ineffective against it. (Chhokar *et al*, 2007).
b. **Raising Herbicide resistant crops: -** Farmers should consider utilizing genetically modified crop seeds designed to withstand various herbicides or exhibit resistance. Alternatively, they can also use cultivars with specific allelopathic traits, which exert detrimental effects on weed populations, thereby creating an unfavorable environment for weed growth. As an illustration, research initiatives should be directed towards the development of wheat cultivars tolerant to herbicides.

c. **Susceptible MOA**: A survey conducted by Valverde in 2003 indicated that herbicides categorized under the ACCase and ALS groups are susceptible to the development of resistance, particularly in developing countries. Therefore, it is recommended to use them cautiously, taking this susceptibility into consideration.

d. **Use of integrated weed management: -**Under the circumstances when grassy weeds particularly *Phalaris minor* is causing serious threat to the wheat productivity, the only option left is to adopt integrated approach for the control of weeds. This can be achieved by judicious use of chemicals, diversification of rice-wheat sequence, adopting proper tillage practices including closer spacing and using suitable wheat varieties. Example atrazine @ 1.00 kg ha-1 + HW, 2 HW and paddy straw mulching, producing grain yield of (203.48 g, 188.34 g and 186.82 g) respectively, as compared to un-weeded plot (68.30 g) (Rai *et al.* 2018).

E. Spray Technology:

Spray technology represents a critical facet of modern agriculture, offering precise and efficient methods for applying herbicides to crop field. From pesticides and fertilizers to herbicides and plant growth regulators, the proper application of these substances significantly influences crop health and yields, as over application can cause photo-toxicity in crops reducing its growth and under application might not be able to suppress the weed growth.

Hence the knowledge of proper spray technology must be disseminated among the farmers, this includes the key components of a sprayer, calculation of the dose required, calibration of the sprayer (involving walking speed of the individual doing the spray etc) Innovations in spray technology have revolutionized agricultural practices, ensuring targeted and controlled delivery of agrochemicals. Key components include:

a. Nozzles: Precision-engineered nozzles play a crucial role in determining droplet size and distribution. Properly selected nozzles enhance efficacy while minimizing drift, optimizing the use of agrochemicals.
b. Spray Equipment: Advances in spray equipment, including boom sprayers, aerial systems, and handheld devices, contribute to efficient and uniform application across various crop sizes and terrains.
c. Adjuvants: Surfactants and adjuvants enhance the performance of sprays by improving the spread, penetration, and retention of droplets on plant surfaces, maximizing the effectiveness of agrochemicals.
d. Variable Rate Technology (VRT): VRT allows for the adjustment of spray rates based on specific field conditions, optimizing resource utilization and reducing environmental impact.
e. Drift Reduction Technology: To mitigate the environmental impact of over spray, technologies that minimize drift, such as drift-reducing nozzles and formulations, are integral to responsible spray application.
f. Digital Farming Integration: The integration of spray technology with precision agriculture and digital farming systems enables data-driven decision-making. Sensors, GPS, and automation contribute to the creation of tailored spray prescriptions for optimized results.

F. Calibration:

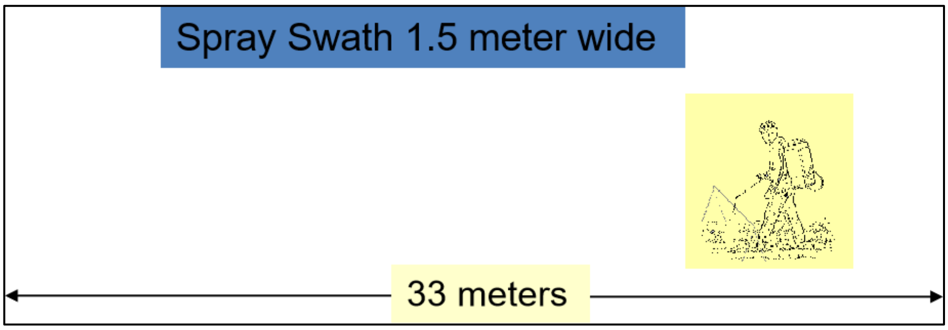

Figure 8.1: Shows an Individual with A Knapsack Sprayer Carrying Out Calibration.

For calibrating a knapsack spray put a mark at 33 meters length from the starting, now since we are using 2 nozzle boom then the swath area (effect spray area) will be 1.5m, hence total area covered from the starting to finish then again to the starting point is around 100 metre square (33 x 1.5 x 2 (covered the length of 33 meters 2 times)), now suppose tank had a total of 4 liters at the starting point and at the finish it had 1 litre then we can say that at the speed maintained by the sprayer around 3 liters of water is needed to cover an area of 100 m^2 that is 300 L/ha, now according the dose of herbicide can be prepared.

Calibration is mainly done to determine the speed of the individual while spraying and the quantity of the water needed to complete the spray

G. Calculation of herbicide dose:

Following formulae can be employed to calculate the herbicide dose for a particular area:

$$\text{Haerbicide dose} = \frac{100}{\text{Concentration of herbicide in chemical}} \times \text{Recommended dose} \times \frac{\text{Target area}}{10{,}000}$$

8.2 Conclusion:

Integrated Weed Management represents a holistic and sustainable approach to weed control, acknowledging the multifaceted nature of weed problems in agriculture.

By combining cultural, mechanical, biological, and chemical strategies in a coordinated manner, farmers can effectively manage weed populations while fostering environmental sustainability and long-term agricultural resilience.

As agriculture continues to evolve, the principles of Integrated Weed Management will play a crucial role in shaping weed control strategies for a more sustainable future.

8.3 References:

1. Brand, J., Yaduraju, N. T., Shivakumar, B. G., & Murray, L. (n.d.). Weed Management. Lentil, 159–172. doi:10.1007/978-1-4020-6313-8_10.
2. Chhokar R.S, Sharma R.K and Sharma I (2012). Weed Management strategies in wheat - A review. *Journal of Wheat Research* **4(**2**)**:1-21.
3. DAS T.K, 2015. Weed Science Basics and Applications; Chapter: Weed evolution, concept, definition, nomenclature and distribution. Jain Brothers: P:1-22.
4. Dawood, R.A. Hand weeding in lentil (Lens culinaris Med.) grown on beds at various growth stages under different phosphorus levels. Assiut Journal of Agricultural Sciences. 1994. 25(3): 131–142.
5. Dhiman, S.D., Mohan, D.S.R., Sharma, H.C. (1985). Studies on cultural methods of weed control in wheat. Indian J. Agron. 1985. 30, 10—14.
6. FAO. (2002). Procedure for post border weed risk management. Assessed on 10-12-2023.
7. Rai, A., Mahata, D., Lepcha, E., Nandi, K., & Mukherjee, P. K. (2018). A Review on Management of Weeds in Maize (Zea mays L.). *International Journal of Current Microbiology and Applied Sciences*, *7*, 2906-2922.
8. Reddy Y.T, and Sankara Reddy G.H (2023). Weed Management: *Principles of Agronomy*. Kalyani Publishers, Ludhiana: 384-424.
9. Sahoo R.K, Manu S, Chandrakumaran N.K and Vasudevan K. (2023). Nuclear and Mitochondrial Genome Assemblies of the Beetle, Zygogramma bicolorata, a Globally Important Biocontrol Agent of Invasive Weed Parthenium hysterophorus, *Genome Biology and Evolution.* Vol - 15 (10), doi.org/10.1093/gbe/evad188.
10. Sekhon, H.S., Guriqbal Singh and Brar, J.S. Effect of chemical, mechanical and cultural manipulations on weed growth and grain yield of various pulse crops. Integrated weed management for sustainable agriculture Proceedings of an Indian Society of Weed Science. International Symposium, Hisar, India, 18–20 November 1993. III: 141–146.
11. Shakrawar, M., Naberia, S., & Pande, A. (2018). Indigenous technical knowledge for pest, disease and weed management in agriculture. *International Journal of Chemical Studies*, 497-498.
12. Singh, S. (2007). Role of Management Practices on Control of Isoproturon-resistant Littleseed Canarygrass (Phalaris Minor) in India. Weed Technology, 21(2), 339–346. doi:10.1614/wt-06-150.1.
13. Valverde B.E (2003). Herbicide-resistance management in developing countries: In Labrada R. (ed.) *Weed management for developing Countries Appendium 1*. Food and Agricultural Organisation of United Nations, Rome, Assesed on 10-December-2023.
14. Xu, G., Shen, S., Zhang, Y., Clements, D. R., Yang, S., Li, J., … Gao, Y. (2019). Designing Cropping Systems to Improve the Management of the Invasive Weed Phalaris minor Retz. Agronomy, 9(12), 809. doi:10.3390/agronomy9120809.