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own set of problems and risks; its use must be minimized to account for the desired economic and environmental effects [8-10]. The problem associated with weed control is amplified due to herbicide resistance that some of the weed species have developed over the course of time due to the overuse of herbicides or their evolution (process of natural selection) toward favorable conditions [11]. Weeds may be resistant to specific herbicides (selective) or may be resistant to a broad spectrum of herbicides (nonselective) [11-13]. These inherent features have evolved based upon the various mechanisms such as absorption, metabolism, translocation, detoxification, and site of action, which confer resistance to the weeds [14-16].

In order for a successful weed elimination and control strategy to be effective, all of the above conditions must be met. Most of the herbicides, as described in this chapter, interact and interfere with the metabolic machinery and other biochemical pathways of weeds and cause irreversible damage, tissue injury, leading to the eventual death and elimination of the weeds [17]. Herbicides may vary based upon their complex chemical structures, characteristics, and properties with other members of their family, and are grouped according to their mode of action and target specificity [18-20]. The mode of action of herbicides includes inhibition, interruption, disruption, or mitigation of the regular plant growth [21-23].

Herbicides are classified based upon different aspects, such as mode of action, site of action, chemical families, time of application, selectivity, translocation, etc. [24-26]. It is important to note here that even a particular herbicide-resistant weed could be susceptible to a specific herbicide provided the amount and the rate of application are appropriate. On the other hand, excessive use of herbicides could damage the crop and also impart resistance to the same weeds which were intended for control or elimination. Therefore, it is important to strike a balance between these strategies and find the optimum medium for the best and maximum effect.

Based upon the time of application, herbicides are classified as preemergence or postemergence [27] as shown in Figure 1. When applied preemergent, they may be effective against grassy weeds or broad-leaf weeds [28,29]. On the other hand, when applied postemergent, they may be selective (specific target) or nonselective (broad target) [28]. At the preemergent stage, the herbicide may be applied to the soil or even the seeds may be treated with them. With postemergent applications, the seedlings are sprayed with specific herbicides so as to eliminate weeds. Selectivity is defined as the capacity of a herbicide to kill a target plant without harming or killing the nontarget plants [30]. Selective herbicides are highly specific and are best suited for the control of a specific weed associated with a specific crop; most of the herbicides used in agriculture and related industries are highly selective. Upon contact, they act by getting absorbed and translocated into the xylem or the phloem of the weeds, by inhibiting or disrupting the metabolic machinery or other biosynthetic pathways, and by injuring or killing the weeds [31]. Nonselective herbicides, on the other hand, have a limited use in agriculture and other related industries, but they are effective in land-reclamation projects where the land needs to be cleared of all vegetation or where the weeds may be localized, away from the plants of interest. Glyphosate, however, has been used worldwide as a nonselective herbicide, but it acts more selectively when used in association with genetically engineered crops, which have been developed for resistance against glyphosate [21,32,33]. The selectivity or nonselectivity of herbicides depends upon various factors, such as plant physiology, environment, and the nature of the weeds.
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ology, soil topography, environment, timing of application, rate of application, and application technique [26]. The classification of herbicides is equally important for managing and understanding herbicide resistance, which continues to be a problem in sustainable agricultural management [24,25]. The overuse of herbicides, just like other pesticides such as insecticides, may lead to increased development of resistance among plants, causing injury and destruction of useful plants in both agriculture and land management [6]. Understanding the reasons for classifying the herbicides based upon their modes of action, instead of the chemical family or the site of action, will help to understand the reasons behind the development of resistance due to their overuse.

Plants interact differently with different herbicides based upon their absorption, translocation, metabolism, and physiological response. The mode of action may be prevalent at the tissue or cellular levels and the tissue-injury symptoms are similar for a specific group. Herbicides are also selective in their mode of action, crop/weed favorability, and soil topology. Herbicides may either be applied directly to the foliage or be added to the soil during plowing/tilling [34]. Herbicides may have a vertical or horizontal translocation movement of the chemicals representing different groups [35-37]. There are other herbicides that kill upon contact on the foliage and are potent enough such that they do not require translocation either way. Plants are intact systems that consist of organs, tissues, cells, and molecules, which are reservoirs of organized biochemical processes that take place uninterrupted. Herbicides may be absorbed by the plants via the roots (soil-based herbicides) or the shoots (spray-based herbicides) [38]. The metabolic activity requires the movement of sap through the xylem (translocation of water and nutrients) and phloem (translocation of sugars) [39,40]. When the herbicides penetrate the cell walls of the weeds, they cause tissue injury and permeate the sap, in the process, interrupting various biochemical pathways. Upon interaction with the herbicides, weeds are killed by the dysfunction of their biochemical processes.

Traditionally, herbicides were mixed with the soils, but at present, the trend is leaning toward spraying herbicides and also developing herbicide-resistant crop varieties [6,41]. Given the environmental concerns associated with aerosols, soil pollution, and water-system contamination, developing environment-friendly herbicides has become a priority [42,43]. The United States Environmental Protection Agency (US EPA) has many regulations and guidelines in place for the proper manufacturing, sale, and use of herbicides (www.epa.com). The rate of application of herbicides and their strategic placement are of prime importance and depend upon the kind of weeds that need to be killed. Herbicides with higher rates of absorption and retention (during spraying) require a less volume and a less potency as compared to their counterparts. The weather/temperature conditions (mild, temperate, or tropical) determine the effectiveness of herbicides on a specific crop. Along with the temperature, the humidity and the plant vigor also play important roles in designing the herbicide application strategy [44,45]. An understanding of the leaf-surface coverage area, leaf-surface properties, and the chemical properties of the herbicide is essential for maximum success [46-48].

Herbicides are grouped based upon their chemical structures, which consist of a base-specific molecule surrounded by a side chain or a group(s) [49]. A modification of a functional group leads to a modification in the activity, selectivity, and persistence of herbicide and also