Weeds in Agricultural and Nonagricultural Systems: Impacts and Trends for a better Systematic Control against Alternate and Collateral Hosts of Crop Pests

Bitaisha Nakishuka Shukuru*, Meenakshi Rana

Department of Plant Pathology, School of Agriculture, Lovely Professional University (LPU), PO Box 144411 Phagwara, Punjab, India

* Corresponding Author : nakishuka.12111882@lpu.in

Author ORCID iD: https://orcid.org/0000-0002-3037-261X

Abstract

Weeds compete with the desired vegetation, reducing yield and product quality in both agricultural areas and in the forest. Unwanted vegetation is also flourishing in aquatic systems and nonagricultural zones such as industrial sites, roadsides, railway lines, water pipes, airports, and sports fields. The interest of this endeavor is that it seeks to shed light on the right measures for the integral and systematic control of weeds in general, especially those that play the role of alternative hosts of pests. The estimation of total losses caused by different pests can reach up to 45% for weeds, 30% for insects, 20% for diseases and 5% for other plagues, including disorders, flooding, drought, landslide, wind, storm, and other environmental disasters. For example, in a research station, a new variety of cassava is 40 t/ha with 8 times weeding, but in the fields, it will produce an average of 10 t/ha once the number of weed control is reduced at 3-4 times the season. In this chapter we demonstrate aspects relating to the inventory of weeds, their biology and ecology, the problems and damage they cause both to agricultural crops and in nonagricultural areas and finally the effective approaches to control them, including herbicides and cultural techniques.

Keywords: weed, field, nonagricultural areas, integrated management, alternative hosts.

1. Introduction

Weed is any undesirable and unwanted plant that interferes with the use of edaphic, water resources with a cultivated plant and/or man. It is therefore a plant that is where it should not be, a plant that is present and growing where we rather want to have another instead or no plants at all. Weeds are therefore an important factor in the management of edaphic and water resources and their effective impact on agriculture is high.

There are no global studies yet to show their impact. However, it is widely known that the annual production losses caused by weeds (Pimentel et al., 2005; Llewellyn et al., 2016; Gharde et al., 2018) far exceed those caused by any other categories of agricultural pests such as insects, nematodes, pathogens, mites, birds, rodents, and abiotic stresses (Oerke, 2006; Chauhan et al., 2017; Schonbeck, 2022). Accordingly, yields and incomes registered in agricultural production are low (Bajwa, 2015; Fahad et al., 2015; Shukuru and Archana, 2021; Shukuru, 2022), despite lots of efforts (Kraehmer et al., 2016; Shukuru, 2022) in management for reaching expected yield.

2. Adverse effects of weeds

2.1. Reduction or loss of crop yields

Weeds compete with crops for nutrients (especially nitrogen), light, water, moisture, and space (Krupinsky et al., 2006; Santín-Montanyá et al., 2015; Swanton et al., 2015; Guglielmini et al., 2017; Ramesh et al., 2017; Korres, 2018; Chauhan, 2020). The intensity of the competition depends on the species of weed, the severity of its infestation, the duration of the ability of the cultivated plant to withstand the competition and finally the climatic conditions that influence the growth of the weed and the cultivated plant.

There is a direct correlation between yield loss and competition due to weeds. Generally, the 1kg increase on weed growth corresponds to a 1kg reduction in the yield of the cultivated plant. Weeds make better use of soil nutrients than cultivated plants, many of which grow even faster than the cultivated plant (Radosevich et al., 2007; Kaur et al., 2018). Undisturbed, they can go so far as to inhibit crop tillering and branch production, affect photosynthesis and plant production.

Depending on the degree of competition, yield losses can range from 10-70%; sometimes it can reach even 100% (Chauhan, 2020). In India, for example, total weed control can add about US$5 trillion to its economy; in the United States, weed control exceeds more than US$20 billion (McWhorter, 1984; Bridges, 1994). Yield losses due to weeds are higher in the tropics. In Asia, for example, weed control can increase yield by about 70% in irrigated areas (Rao et al., 2017). Under extreme conditions, effective weed control can triple rice yield.

2.2. Reduction in the market value of land

A strong infestation by perennial weeds can affect the possibilities of using a piece of land for agricultural purposes, thus reducing its monetary value. Millions of hectares of Asian rice perimeters have been abandoned due to severe infestations of *Cyperus rotundus, Cynodon* *dactylon*, and *Imperata cylindrica* (Garrity et al., 1996; MacDonald, 2004; Rodenburg and Johnson, 2009).

2.3. Limit of choice of culture

Cultures differ in their ability to withstand competition (Shukuru et al., 2022; Shukuru et al., 2023). In many cases, the presence of a weed species will dictate the choice of cultivated species. A strong presence of weeds makes some economic crops less profitable (especially legumes, vegetables, cotton).

2.4. Deterioration of product quality

Most vegetable crops suffer from the presence of biotic stresses (Pimentel et al., 2005; Shukuru et al., 2021; Brown et al., 2022; Shukuru et al., 2022; Wong et al., 2022) like weeds. The presence of seeds and weed debris in harvested products significantly reduces its quality and market price.

2.5. Increased costs of controlling diseases and pests

Weeds serve as alternate or collateral hosts for many insects, nematodes, and pathogens. Insects such as aphids, thrips, mealybugs, whiteflies, weevils, and drillers survive on spontaneous grasses (the same is true especially for maize, rice, sorghum, sugarcane ...). In the following season, the crops are invaded by these insects and pathogens, which increases the cost of control.

2.6. Interference with human life

For example, reduced comfort, allergy related to irritating plants, thorns that may be present and so on.

2.7. Aquatic weeds pose major problems for water

Weeds remarkably reduce the flow of water into canals and other pipes during irrigation and drainage (obstruction of pipes) with all the difficulties that this implies for the delivery of water to plots located at a great distance from the source, plus pipe maintenance work.

Weeds cause too much water loss through transpiration, clogging all the structures for regulating water regimes in hydro-agricultural devices. In addition, they cause the decrease in navigability, the penetration of light into the water, reduction, or disruption of flow and so on.

Some species of aquatic weeds include: *Eichornia crassipes, Typha angustifolia, Hydrilla verticillata, Potamogeton* spp.*, Salvinia molesta, Ipomea aquatica, Nymphea* spp., and *Pistia* spp.

3. Biology and weed propagation

Understanding weed species in relation to their geographic distribution, growing habitat and population dynamics of weed species and their community is of great importance (Chauhan and Johnson, 2010; Ghersa, 2013). The development of an effective and adapted management program depends on knowledge of the biology of the species present in the environment.

Distinct from their lifespan, annual and biennial weeds generally depend on their seed production as the only means of propagation and survival. The abundant production of small seeds represents their adaptation which gives them a high probability of dispersal and re-infestation. A single Plant of *Bidens pilosa* can produce more than 500,000 seeds. Many weeds can produce enough viable seeds even when they have been cut shortly after flowering. Perennial weeds are usually propagated vegetatively (rhizome, stolon, tubers, bulbs, cuttings, etc.), but most also produce seeds in abundance.

4. Weed ecology

Understanding the interrelationship between an organism and its environment (Chauhan and Johnson, 2010; Matloob et al., 2015), i.e., the characteristics of weed growth and adaptations that allow them to survive changes in the environment, is one of the best paths to good weed management.

4.1. Persistence and survival mechanism

It refers to the measurement of the adaptive potential of a weed that allows it to grow in any environment. It is largely influenced by climatic factors such as temperature (variation, max and min), precipitation (quantity and distribution), insolation (light intensity, duration of sunshine) and wind (speed and direction), edaphic factors such as soil structure, texture, and temperature, field capacity, aeration, soil pH, soil fertility, and biotic factors including plants and animals that play a diverse role in weed growth (Zhou et al., 2005; Travlos et al., 2020;

Shrestha et al., 2022; http://ecoursesonline.iasri.res.in/mod/page/view.php?id=101855; https://agriinfo.in/persistence-of-weeds-2147/).

Weed survival mechanisms include abundant seed production, survival of vegetative reproductive organs during adverse conditions, seed spread and dormancy, and their ability to withstand environmental changes; the dissemination of seeds, weed seeds are great travelers to be transported by various agents (wind, water, animals, man ...); germination and dormancy of seeds: not all seeds from even a single plant germinate at the same time. Many weeds persist from their long-dormant seeds; vegetative multiplication which is due mainly to deep rooting, and the presence of a high number of dormant vegetative organs (Singh and Singh, 2009; Qasem, 2019; Shrestha et al., 2022).

4.2. The weed-desirable plant competition

Competition here involves two or more organizations looking for a particular factor, when it is insufficiently supplied. Weeds affect the growth and yield of plants grown from competition through nutrient, water, and light. As a rule, for each unit of growth of a weed corresponds a unit of reduction of the cultivated plant (Nagashima and Hikosaka, 2011).

5. Multiple approaches to integrated weed control

In weed control, the main goal is to maintain a less weed-prone environment by using one or more methods, alone or in combination, as a preventive or curative. Reducing the effects of weeds to an acceptable level therefore means that their control does not automatically mean their eradication. The degree of undesirability of weeds will therefore depend on their harmfulness to the cultivated plant. It is tolerable up to a threshold beyond which the struggle will prove necessary.

5.1. Traditional methods

For a long time, before chemical control became the dominant force in weed management, farmers used traditional approaches such as manual (Bajwa, 2015), mechanical (Rodenburg and Johnson, 2009; Abbas et al., 2018; Hussain et al., 2018; Merfield, 2019) and cropping (Johnston et al., 2002; Korres, 2018) to control weeds for centuries. With the availability of herbicides (especially after 1940) for each weed and their spectrum of use for each herbicide, most traditional practices and weed management have been overshadowed. Among these traditional methods are the prevention of 'Weed-free crop seeds' infestation, seed certification, seed purity, legislation on pests and diseases in general and weeds and quarantine for certain weed species. All in all, time is the most important parameter (Brown et al., 2022; Catalano, 2022).

5.2. Eco-physiological approaches

Ecological components that have an impact on weed physiology include light, water stress, temperature (Santín-Montanyá et al., 2015)., soil solarization (Horowitz et al., 1983)., CO_2 atmospheric concentration (Santín-Montanyá et al., 2015; Ziska et al., 1999), mineral nutrition, and the cropping system (rotation, crop association, more competitive species and varieties, cover plants).

In the crop-weed system, light plays the role of regulating growth and development and even competition between the two. The plant response varies depending on the amount of light, duration of light, quantitative spectrum of light and its fluctuations. The amount of light intercepted by weeds is a major determinant of their growth. Manipulating the amount of light intercepted by their canopy can significantly reduce their degree of harm; water stress reduces photosynthesis by interfering with chlorophyll synthesis, electron transport, synthesis, and activity of carboxylation enzymes; temperature governs the seasonal growth of weeds and their geographical distribution. For example, at daily and night temperatures of 18°C/12°C and 24°C/12°C, respectively, maize grows faster than any weed and thus stifles its growth; soil solarization is also based on high temperatures preventing the germination of weed seeds; the concentration of CO_2 in the atmosphere affects the crop well as the weed, directly or indirectly. C_3 plants generally use more CO_2 than C_4 plants, which has an impact on plant-weed competition, as most weeds are C_4 plants, while many of the plants grown are C_3 plants (Singh and Singh, 2009; Qasem, 2019; Travlos et al., 2020; Shrestha et al., 2022).

However, in a crop-weed system, the application of nutrients is generally more beneficial to weeds than to cultivated plants, because of their ability to mobilize even small reserves available to them as quickly as possible. Strategies to reduce competition for nutrients include application methods, application time, alternative sources of nutrients as crops and weeds respond differently to different types of fertilizers (Qasem, 2019; Travlos et al., 2020). The use of more competitive crops and varieties reduces the invasion of the main crop by weeds. A vigorous, fast-growing plant takes advantage over weeds that take time to emerge. They perform better competition through nutrients, sunstroke, soil organic matter andCO_2. The most competitive plants include cereals such as maize, sorghum and soybeans. Crop rotation is so necessary because the continued exploitation of the same species can promote the proliferation of weeds associated with it. Although crop combination is practiced maximizing land use and yield, it has a significant effect in suppressing weed growth. Cover crops can also be used on heavily infested fields and thus clear the soil for food crops to be planted in subsequent seasons. In addition, there is a possibility of smothering weeds with a high density of crops. Products that stimulate the growth and germination of weed seeds can also be used to better control them, such as ethylene and nitrates.

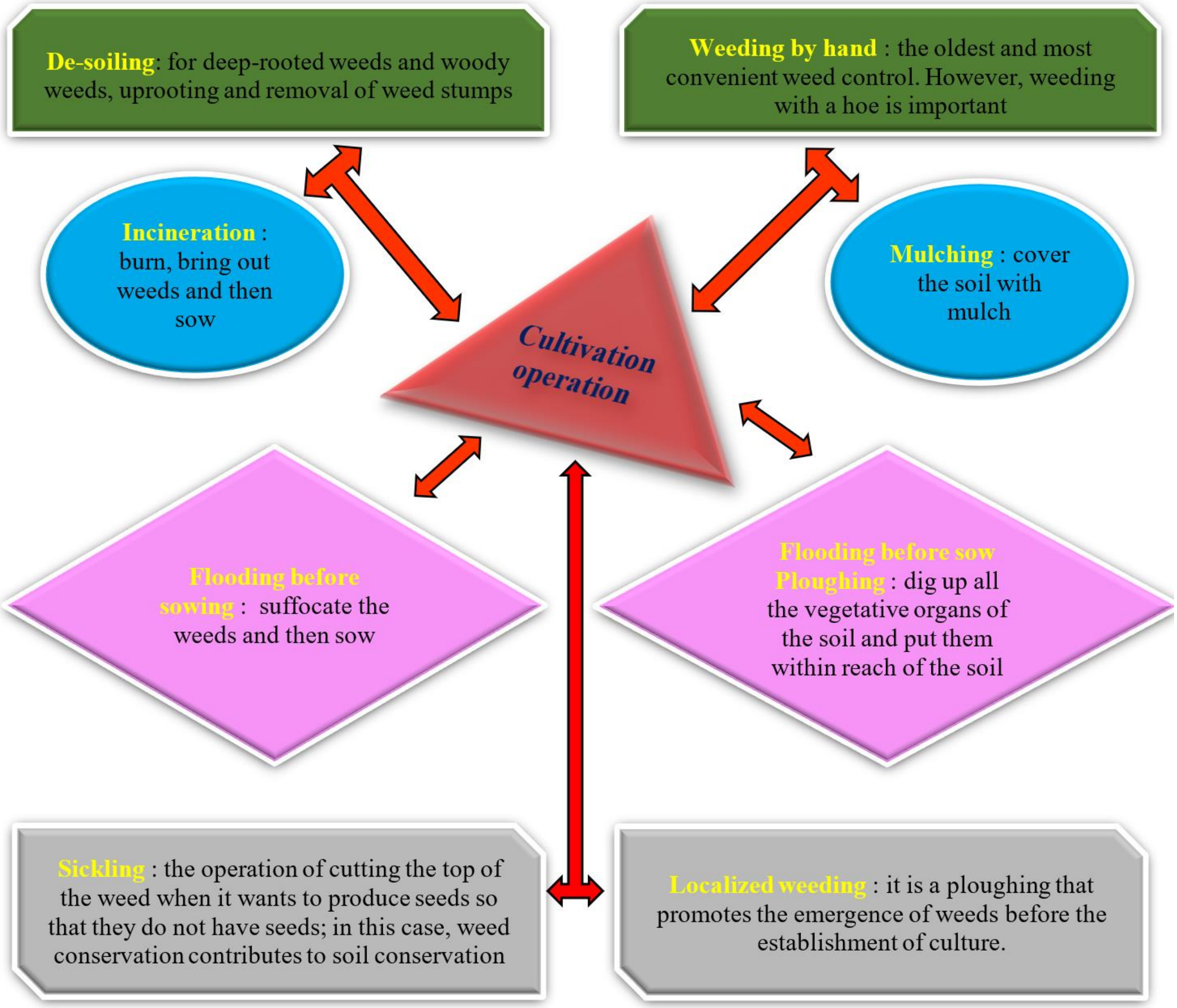

Fig. 1. Post-infestation management measures, including control and eradication measures.

5.3. Chemical method

Control is based on the use of herbicides ((Johnson et al., 2009; Chauhan and Gill, 2014)., with globally about 513 herbicide-resistant weeds reported (Heap, 2022). Total, absolute, or radical herbicides can kill all plants indiscriminately, while selective herbicides are used for the destruction of weeds while causing little or no damage to the crop plant. A total herbicide can become selective when the dose of use is lowered; similarly, a selective herbicide will become total if the normal dose of use is exceeded (Aktar et al., 2009; Marin-Morales et al., 2013). Contact or contact herbicides destroy the plants and parts of plants on which it is applied. Pre-emergence herbicides, the application of which is carried out after sowing the cultivated plant but before its emergence. Pre-emergence can be contact, that is, the product kills the weeds on which it is applied but the toxic action is of very short duration, being quickly evaporated or transformed into non-toxic substances, or residual, that is, when the product persists on the soil for a long enough time to kill the weeds at the time of their germination or emergence. Postemergence herbicides is carried out after the emergence of weeds and the cultivated plant. Thus, herbicides can be organic (petroleum and synthetic) or inorganic.

Table 1. The most encountered weed species. There are more than 250,000 species in the world of which about 250 are considered the main weeds or weeds in the agricultural and nonagricultural system. They cause enormous difficulties to human life by reducing the quality and quantity of agricultural production and by seeking solutions to the problems they cause. Most are persistent and need to be controlled.

Species	Categories	Distribution	Control means
Echinochloa spp.	Annual grasses widely distributed around the world	The most encountered anywhere in the world	Preemergence: chloramben, atrazine, simazine, diuron, liuron, metolachlor, consulfuron, imazaquine, fomezafen
Eleusine Indica	Annual grass, difficult to fight	In semi-arid areas	The best fight to fight it is pre-emergence: simazine, atrazine, liuron, diuron, oxychlorofen and monuron. Post emergence: paraquat gives good results
Euphorbia hirta	Annual grass	Tropical and subtropical areas in old environments, many crops, roads...	Methods such as weeding with hoeing, weeding effectively give good results: atrazine, urea derivatives.
Imperata cylindrica	Indian grass, one of the most dangerous herbs in the world, rhizome reaching a great depth	It can be found in several countries of the world: itis difficult to eradicate in a culture environment	Postemergence: paraquat with a lot of repetitions. Systematic herbicides such as glyphosate, dalapon.
Lantana camara	Perennial grass	Tropical, subtropical, and temperate, very dangerous in the world	Foliar sprays are less effective because there is a possibility of emergence; hence the use of the systemic herbicide.
Oxalis corimboza	Perennial grass	Miscellaneous environment	Mechanical destruction cannot eradicate the species, but deep ploughing can eradicate the species. Need for herbicides in pre-emergence: diuron, oxyfluorfen, oxadiazon.
Ageratum conyzoides	Tropical annual grass	Tous les environnements (routes, champs)	Manual methods, treatment with simazine, atrazine and diuron in pre-emergence; post-emergence: 2,4-D.
Amaranthus viridis, A. spinosis	Annual herbs	Field of cereals, peanuts, cotton, and different other crops	Simazine, atrazine, oxyfluorfen, oxadiazon, alachlor (preemergence); Imazaquin, paraquat, imazethapyr (in postemergence).
Bidens piloza	Annual grass	In tropical environments	Preemergence: Simazine, atrazine, diuron; in postemergence: 2,4-D.
Chenopodium sp.	Annual grass	Widely distributed	Preemergence: metolachlor, propachlor, chlorbromuron, chloramben, alachlor. Postemergence: paraquat, diclofop, dinozeb, betazone.
Commelina bughalensis, C. diffusa	Perennial grass. It reproduces by seed and rhizome with deep rooting	Grasses of a strongly humid environment with waterlogged organs, in the fields of legume crops, banana plantations, etc.	It is a species resistant to many herbicides. Soil-level treatment gives better results than foliar sprays; the most widely used herbicide is glyphosate.
Cyonodon dactylon	Perennial grass	Tropical, subtropical, semi-arid regions	Preemergence: the diuron Postemergence: dalapon, glyphosate
Cyperus rotundus	Very persistent perennial grass	Found in 52 crops in 92 countries, in the tropical and subtropical zone	Soil treatment with imazaquine, or chlorimuron in preemergence; Post emergence: chlorumuron and imazethapyr.
Digitania vestida	Annual grass	It is found in tropical and temperate climates; it produces many of the seeds with the possibility of spreading vegetatively	Preemergence: butylate + atrazine; alachlor + diuron; alachlor + chloramben; Postemergence: nicosulfuron, bromoxynil
Panicum sp.	Perennial grass very aggressive and difficult to fight because of the production of rhizomes	In tropical environments	Difficulty also to eradicate it as *Imperata*, we need systemic herbicides
Paspalum notatum, Pennisetum purpureum	Grass with vegetative production difficult to control by mechanical methods	Everywhere in the world	The application of paraquat gives good results but it faces the problem of re-emergence, hence the use of systemic herbicides or the mixture of two.
Solanum nigrum	Nightshade	In cultural regions	Glyphosate
Striga lutea	Parasite of cereal crops	Can grow in any environment	Pre-emergence: simazine, atrazine, linuron, diuron, monolinuron; Post emergence: paraquat

6. Field weed management

All plants grown in the field are subject to competition due to weeds.

The weed problem varies from one crop to another, from one region to another, from one farm to another or even from one corner of the field to another. Weeds grow intensely in wet, rainy, and dry regions. However, they adapt to extreme climatic conditions as they are always in competition with plants grown in any situation. Weeds and their control are as old as agriculture itself. Manual and mechanical methods have always been the most widely used (Mishra, 2016; Matloob et al., 2020), and the oldest (Mehdizadeh and Mushtaq, 2020), particularly in developing countries.

With the introduction of herbicides, weed management has become more efficient, and more economical in terms of time and financial means. However, the use of herbicides should not exclude the use of mechanical and/or manual methods and cultivation practices (Ali et al., 2017) in weed control. Note that competition due to weeds is maximum during the first stage of growth of the plant. However, the critical period varies from culture to culture. A few of the crops below serve as examples in weed management in the open field. Currently, the use of herbicides and tillage to remove weeds are two most combined practices, unfortunately presenting significant negative environmental impacts (MacLaren, 2020).

6.1. Cases of cereals and oilseeds

Competition due to weeds is usually more pronounced for the direct sowing case than for transplants. Yield losses from weeds for cereal crops (especially rice, maize, wheat, sorghum, millet) often range from 30-65% (Milberg and Hallgren, 2004; Oad et al., 2007). The most common weed species are grouped in the genera like *Echinochloa*, *Commelina*, *Cyperus*, *Panicum*, *Ageratum*, *Euphorbia*, *Setaria*, *Digitaria*, and *Crotalaria*.

Fig. 2. Maize field full (A) and free (B) of weeds

In crop control, manual, mechanical and cultural methods give good results but are economically profitable only on small areas. On large areas, this previous approach becomes difficult, hence the use of herbicides.

Yield losses due to weeds in a groundnut field can be as high as 80% (Ghosh et al., 2000). Manual weeding is effective for weed control. In rainy conditions, weeding is not a satisfactory method because it requires a certain regularity. For soybeans, leave the field one month free of weeds; a month later, sowing significantly gives the same yield as if it were kept throughout the season. Mechanical and manual methods are excellent control measures (Kumar and Ladha, 2011; Zimdahl, 2018). Unfortunately, they are only applicable when weeds are not already established, and their damage may already be noticeable; hence the need for pre-emergence struggle (**table 2**).

Table 2. Control of cereal and oilseed weeds through chemical control

Crop	**Preemergence**	**Postemergence**
Rice	Thiobencarb (1-2 kg/ha); Butachlor (1-2 kg/ha); Oxadiazinon (1-1. 5 kg/ha); Pretilachlor (0.5-1 kg/ha); Bensulfuron	Acifluorfen (0. 5-1. 5 kg/ha); Bifenox (1. 5-2 kg/ha); Trichlorpyr (0. 2-0. 4 kg/ha); Quinclorac (0.2-0.4 kg/ha)
Wheat	Linuron; Diuron. 2,4-D should be avoided at the young stage of wheat.	2,4-D; Picloram (0. 25-0. 5 kg/ha); Fluazifop (0. 25-1 kg/ha); Tribenuron (10-20 g/ha)
Maize	Atrazin (1-2 kg/ha); Simazin (1-2 kg/ha); Alachlor (2-3 kg/ha); Acetochlor; Dimethylamide; Metholachlor; Oxyfluorfen; Imazaquin	Primisulfuron; Prosulfuron (50-60 g/ha); Imazaquin (can also be used in postmergence)
Sorghum	Propazin; Atrazin; Alachlor; Isoproturon; Metolachlor	Prosulfuron (15-30 g/ha); Trifluralin

		(0.8-1.2 kg/ha)
Peanut	Metolachlor (1.5-3 kg/ha); Pronamide (1.5-3 kg/ha); Thiazopyr; Imazethapur (50-70 g/ha)	Acifluorfen; Imazaquin; Fluazifop (50-100 g/ha); Imazethapur (30-50 g/ha); Chlorimuron
Sunflower	Bifenox (0.5-1 kg/ha); Bronamide (1.5-3 kg/ha); Thiazopyr (0.5-1.5 kg/ha)	Imazaquin
Soybean	Metolachlor (1.5-3 kg/ha); Pronamide (1.5-3 kg/ha); Thiazopyr (0.5-1.5 kg/ha); Imazethapyr (50-70 g/ha).	

6.2. Case of sugar cane, tobacco, banana, potato, and sweet potato

For sugar cane, the critical moment of the competition is between the 4th and 5th month during tillering and the elongation phase. This has a direct impact on the yield and sugar content of the juice. In pre-emergence, control is effective for 8 to 12 weeks. There is a direct negative correlation between weed population and machinable cane, yield and sugar content. From time-to-time mechanical control can offer moderate efficiency, hence the use of the combination of mechanical method + herbicide. Weed competition affects both the yield and quality of tobacco. The orobranchial species is the most predominant. Tobacco is sensitive to many post-emergence herbicides, hence the need to use a lot of pre-emergence herbicides. Potatoes are grown on fertile soils rich in organic matter, hence the permanent presence of weeds that cause serious problems. It emerges even before the establishment of culture. Their competition affects the number of tubers, their size and can introduce yield losses of up to 50%. When a potato field is kept weed free for the first 4 weeks after planting, there is no significant reduction in yield. Fast-growing sweet potato varieties suffer very little from competition due to weeds. However, the critical period is 8 to 12 weeks after planting; thus, the best control is obtained by a pre-emergence treatment. As the afterglow takes 8 weeks, there is no post-emergence application because, the cover of the crop inhibits the growth of weeds (Fongod et al., 2010; Bailey, 2013; Yano et al., 2016; Monks et al., 2018; El-Metwally & El-Wakeel, 2019; Girolamo-Neto, et al., 2019; https://agritech.tnau.ac.in/agriculture/agri_weedmgt_sugarcane.html; https://burleytobaccoextension.ca.uky.edu/common-weeds-burley-tobacco-fields).

Herbicides that give good results in pre- and post-emergence are listed below (**Table 3**).

Table 3. Herbicide control of weeds in sugar cane, tobacco, bananas, potatoes, and sweet potatoes

Crop	**Preemergence**	**Postemergence**
Sugar cane	Atrazine (2-3 kg/ha); Ametrine (2-3 kg/ha);	Prosulfuron (15-40 g/ha); Halosulfuron (30-

	Alachlor (1.5-2.5 kg/ha); Metoxuron (4-6 kg/ha); Diuron (1.5-2.5 kg/ha); Metribuzin (1-1.5 kg/ha); Imazapyr (4-10 kg/ha); Fluometuron; Thiazopyr (1-2 kg/ha)	50 g/ha); Glyphosate (0.8-1.6 kg/ha) very effectively controls many perennial weeds; Paraquat (0.4-0.8 kg/ha) vs . *Cynodon dactylon*, *Cyperus rotundus*
Tobacco	Imazapyr; Diphenamide (2-3 kg/ha); Trifucaline	Glyphosate
Banana	Atrazine; Simazine; Diuron Linuron; Thiazopyr, Fluome, Turon	Paraquat; Dalapon; Glyphosate; 2,4-D. The Diuron or simazine mixture with paraquat makes it possible to extend the period or duration of control.
Potato	Linuron; Methabenz & Thiazuron (0.75-1.25 kg/ha); Butachlor (1.5-2.5 kg/ha), Oxyfluorfen (0.1-0.3 kg/ha), Amilophos (0.4-0.8 kg/ha); Diphenamide (3-4 kg/ha)	Paraquat (0.4-0.8 kg/ha) ; Propanil (1-1.5 kg/ha) ; Glyphosate (0.8-1.6 kg/ha)
Sweet potato	Vernolate; Diphenamide	

6.3. Case of vegetables

Generally, vegetables are weak competitors to weeds. The slightest competition has a significant effect on the yield and quality of the product at any stage of growth. Manual weeding is widely practiced in vegetable cultivation especially in developing countries. Vegetables represent a varied group of species where the use of herbicides may not have a prominent place. In pre-emergence, substances such as napronamide (1-2 kg/ha), pronamide (1.5-3 kg/ha), dephenamine (2-3 kg kg/ha), oxyfluorfen (0.25-1 kg/ha) and thiazopy (0.5-1.5 kg/ha) give a good result for a wide range of weeds. In post-emergence, the product as fluazifop (50-100 g / ha) is highly effective. Even though these herbicides are all usable for all vegetables in general, the selectivity for each vegetable has yet to be determined (Singh et al., 2019; Chacko et al., 2021).

7. Weed control in nonagricultural systems

7.1. Aquatic systems

Aquatic weeds are plants that grow on the surface of waters where they are undesirable. It is the algae with around 100 families of hydrophytic species that can live on water surfaces. Some frequently encountered species are the species of the genus *Nenuphar, Myriophillum, Polygonum, Pistia, Eichornia* and *Nymphea*. The means of control consist either of a decrease in the population of weeds, or of eradication according to the degree of undesirability of the effects they cause.

Other means of control include mechanical methods such as the use of ropes attached to boats, biological methods such as the use of fish or other animals, and the application of herbicides which are faster and more accessible economic means. However, herbicides pose residue problems in nonagricultural areas (Spliid et al., 2004)., including the aquatic environment. As a result, the use of herbicides with low toxicity and short duration of action. In aquatic environments, few herbicides can be used (Gordon et al., 2013; Zimdahl, 2018), such as acrolein, amitrole, bensulfuron, 2,4-D, dalapon, diquat, paraquat, fluoridone, glyphosate, simazine and diuron may be recommended.

7.2. Other miscellaneous noncrop habitats

For the control of weeds in forests (Vasic et al., 2012), near roads, railways, and other conservation systems (Singh et al., 2015), the use of triazine, urea derivatives and uracil can work well. Also, paraquat, picloram, glyphosate, and dicamba can be used. Furthermore, industrial sites, airports, open spaces in villages, sites and cities can sometimes be invaded by weeds that need to be controlled. The choice of one or the other herbicide, of the products already mentioned will depend on the specificity of the weeds to be controlled.

Concluding remarks

With the environmental and biological problems created by some herbicides and the speed with which herbicide resistance is being created, especially around the last two decades, it has proved necessary to use traditional measures, in combination with other existing methods, especially biological, and chemical of course. Since any plant can become a weed in special situations, we recommend the development of an integrated weed management program.

Declaration of Competing Interest

Both authors declare that they have no known competing personal relationships that could have appeared to influence this chapter.

Authors' contributions

This paper was carried out in collaboration between both authors. The conceptualization of the chapter, artwork, writing, original draft preparation, and resources, by Shukuru, B.N. The validation and supervision of the work, by Rana, M. Both authors have read and agreed to publish the present version of the manuscript.

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