Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 2264-2270
Received: 18-07-2020
Accepted: 23-10-2020

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Weed management

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Abstract
India has a wide range of agro climates and soil types. The highly diverse agriculture and fanning systems are beset with different types of weed problems. Weeds cause 10-80% crop yield losses besides impairing product quality and causing health and environmental hazards. Invasive alien weeds are a major constraint to agriculture, forestry and aquatic environment. Crop-specific problematic weeds (weedy rice in rice) are emerging as a threat to cultivation, affecting crop production, quality of product and income of farmers. Traditionally, weed control in India has been. largely dependent on manual weeding. However, increased labour scarcity and costs are encouraging farmers to adopt labour and cost-saving options. These include herbicides whose market grew at an annual rate of 15%. Integrated weed management (IWM) is being practiced by Indian farmers, with the level of adoption varying from one farm to the other. The continuous application of isoproturon coupled with mono-cropping rotation of rice-wheat has led to the evolution of resistance in Phalaris minor Retz. In the northern part of India. Efforts to manage herbicide resistance have led to the adoption of conservation agriculture in the rice-wheat cropping system, as a component of IWM. Research on weed management in India is mostly centred on herbicide efficacy. Herbicides, applied alone or in combinations, have been regarded as essential tools in the effective management of weeds in different-ecosystems. IWM, which includes preventative, mechanical, cultural, chemical and biological methods, is advocated in crop production systems as well as aquatic and forest ecosystems. Herbicide-resistant (HR) transgenic crops have the potential to improve the weed management efficiency and facilitate adoption of CA in India, provided the risks associated with such crops are examined in detail, prior to their adoption and commercialization. Newer weed management approaches must be developed considering the threat of HR weeds appearance in addition to the recurrence and persistence of weeds and the need to bring down weed management costs to enhance profit for farmers while protecting the environment. Understanding weed-ecology and-biology_ and. using_ infoimatiox L technoiogy, should be part of developing and disseminating effective, economical and ecologically advantageous IWM strategies in India. Detailed review of weeds and weed management' options of the past, present and future in India is made in this chapter.

Keywords: Weed, Biological, Identification and Control

Introduction
Weeds are unwanted and undesirable plants. They are also the plants out of place. When a plant grows in a place where it is not needed, then it is called as weed. Weed does not refer to any particular plant. A plant can be undesirable at one place and desirable in another place. For example Bermuda grass is a valuable plant in pastures, but the same plant in crop fields is a trouble some weed. An economically useful plant may be called as weed under situations where its presence is not desired. E.g. Groundnut in maize field. Ameena *et al.* 2006.

Why is it difficult to control weeds?
Weed seeds germinate earlier; their seedlings grow faster; they flower earlier and form seeds in large numbers and mature earlier than the crop they infest. Weeds are difficult to control because of their characteristics. Some of the characteristics of weeds which make them difficult to control are:

1. Weeds produce large number of seeds.
2. Weeds can also reproduce by vegetative methods.
3. Weeds are resistant and persistent to control.
4. Weeds have wide adaptability.
5. Weeds are hardy and resist adverse climatic and soil conditions.
6. Weeds have deep root system.
7. Weeds have smaller seeds which help in their easy dispersal.
8. Weeds have long periods of dormancy. For example lotus has 20 years of dormancy.

Why should we control weeds?
Weeds have always been a bottleneck for crop production and successful agriculture. The major harmful effects of weeds are Baneijee *et al* 2012 [2].

1. Weeds reduce the crop yields
Weeds compete with crop plants for space, sunlight, soil nutrients and moisture. Because of this competition for various resources, weeds affect the growth of crop plants and finally reduce the crop yield. The yield loss may vary from 10 to 100 per cent depending on the intensity of weeds and the degree of management. On an average, weeds reduce crop yields by 45 per cent.

2. Weeds reduce the quality of agricultural produce
Weeds not only reduce the yield but also the quality of agricultural produce. The grains (crop seeds) mixed with weed seeds fetch a lower market price.

3. Weeds increase the irrigation water requirement
Weeds use a greater share of applied irrigation water and thus reduce the water use efficiency of crops.

4. Weeds remove the available nutrients from soil
Weeds because of their deep and effective root system absorb more nutrients than crop plants.Thus, the overall uptake of nutrients by the crop is reduced and the fertilizer use efficiency is reduced.

5. Weeds also reduce the quality of animal produce
Weeds not only affect the quality of field crops but also affect the quality of animal produce.For example wool quality, milk quality.

Types of weeds
There are several types of weeds. Weeds are grouped into different categories on the basis of certain common features among them. Understanding the classification of weeds helps in managing them in a better way. Chadha *et al*.1996 [3].

Based on the relative position of occurrence, weeds may be
Absolute weeds: Plants which do not have any economic value or less economic value and are present in cropped fields or other places where their presence is not desired. e.g. Echinochloa (in rice fields); Gomphrena (in maize fields).

Relative weeds
Crop plants/ economically useful plants when present in another crop field. e.g. Ground nut in maize field or Maize in sorghum field.

- **Based on origin weeds are grouped into two types. They are**

1. **Indigenous weeds / Local weeds:** Those weeds which are native of a region/country are known as Indigenous weeds. e.g. purple nutsedge
2. **Alien weeds / foreign weeds:** Those weeds which are from foreign countries are called alien weeds. e.g. Parthenium.

- **Based on plant morphology, weeds are classified into two types. They are**

1. Monocot weeds: Those weeds which have only one cotyledon (true leaf). These are further classified into
1. **Grasses:** e.g. Bermuda grass
2. **Sedges:** e.g. Purple nutsedge
3. **Dicot weeds:** Those weeds which have two cotyledons (true leaves) are called as dicot weeds. These are also called as Broadleaved weeds (BLWs). e.g. Parthenium.

- **Based on lifecycle, weeds are grouped into three types. They are**

1. **Annual weeds:** Those weeds which complete their life cycle within one season or year are called as annual weeds. The annual weeds propagate through seeds. e.g. Amaranthus

2. **Biennial weeds:** Those weeds which complete their life cycle in two seasons or two years are called as biennial weeds. e.g. wild carrot

3. **Perennial weeds:** Those weeds which live for three or more seasons or years are called as perennial weeds. They produce seeds more than once in their life cycle. Based on the ecological affinity to water, weeds are broadly classified into four groups.

4. **Wetland weeds:** Those weeds which are mostly found in wetland or moist areas are called as wetland weeds. E.g. Echinochloa

5. **Gardenland weeds:** Those weeds which are found in gardenland situations are called as gardenland weeds. They require more soil moisture but do not normally tolerate water logged situations. E.g. Parthenium.

6. **Dryland weeds:** Those weeds which are commonly found in dry land areas are called as dryland weeds. E.g.Euphorbia.

7. **Aquatic weeds:** Those weeds which are found in the water bodies are called as aquatic weeds. They have special adaptations to survive under water logged situations. e.g.Eichhornia, lotus, hydrilla, typha Based on the dependence on other plants weeds can be classified into two major groups. They are

8. **Non-parasitic weeds**: Those weeds which can live on their own without any dependence on other plants are called as non-parasitic weeds. These weeds can prepare their own food. E.g. Amarantus.

9. **Parasitic weeds:** Those weeds which depend on other plants either partly or completely for their food are called as parasitic weeds. The parasitic weeds either partially or totally on other plants for their food. The plants on which the parasites depend for their food are called as host plants.

If the parasite is partially depending on its host then it is known as partial or semi parasite. They are green in colour. They draw water and nutrients from the host and synthesize their food material.
If the parasite is totally depending on its host for its host then it is known as complete or total parasite. The total parasites are not in green colour. They directly draw the food from the hosts.
Some parasites are attached to root of the host plants. Such parasites are called as root parasites. Whereas some parasites are attached to the stem of the host plants. These are called as stem parasites.

Thus, there are four groups of parasitic weeds.
Partial root parasite: e.g. Striaga
Partial stem parasite: e.g. Loranthus, Viscum
Total root parasite: e.g. Orabanche
Total stem parasite: e.g. Cuscuta

Integrated weed management
Weeds can be controlled by several methods. Continuous use of the same method leads to build up of tolerant weeds. Therefore, it is necessary to combine two or more methods to achieve better control of weeds. Integrated weed management (IWM) is a weed management system that uses all suitable techniques in a compatible manner to reduce weed population. The IWM includes cultural, physical, biological and chemical methods. By using two or more of these methods, weeds can be controlled effectively and economically.

Advantages of IWM
- ✓ Higher weed control efficiency.
- ✓ Shifts crop-weed competition in favour of crops.
- ✓ Prevents the weed shift towards perennial nature.
- ✓ Prevents the resistance of weeds to herbicides.
- ✓ No danger of herbicide residue in the plant or soil
- ✓ No environmental pollution
- ✓ Higher net returns
- ✓ Suitable for higher cropping intensity

Mechanical Methods of Weed Control
Mechanical methods of weed control involve the use of either implements or hands for physical removal or destruction of weeds. Mechanically weeds can be controlled by hand pulling (e.g. hand weeding), using weeding tools (e.g. hand hoeing) and passing implements (e.g. Inter-tillage implements). Some of the mechanical methods of weed control are given below.

1. **Stale seed-bed technique**
   This is the method of weed control wherein one or two flushes of weeds are induced and destroyed before taking up sowing. In stale seed-bed technique, the land is ploughed once or twice using a cultivator before the receipt of rainfall to provide favourable conditions for germination of weed seeds. Later, these weed seedlings are destroyed by tillage operation. The implements like country plough, blade harrow, peg toothed harrow or cultivators may be used for this purpose. This method mainly aims at reducing the intensity of weed seeds in soil.

2. **Summer ploughing**
   Immediately after the receipt of the summer rain, the land is ploughed. This controls the weeds by Killing the weeds which have already emerged. Burying a part of weed seeds deep into the soil. Exposing a part of weed seeds to sunlight and birds Any tillage implement can be used for summer ploughing. Apart from controlling weeds, summer ploughing also has the other advantages such as control of soil borne insect pests and pathogens, in-situ conservation of rain water and reducing erosion.

3. **Hand pulling**
   The emerged weed seedlings are pulled out and thrown out of the field or pushed into the field. This method is mostly used in wetlands. This is the most efficient method of controlling weeds but time consuming and labour intensive.

4. **Hoeing**
   Hoeing is working with hand tools or implements drawn by bullock in the inter-rows. The implements used for this purpose are

Table 1

Cultivators	Junior hoe
Peg toothed harrow	Rotary weeder
Blade harrow (Guntaka)	Cono-weeder
Danties	Dryland weeders

5. **Hand weeding**
   In this method the weeds are removed using hand tools. Usually women folk are employed for hand weeding. Hand weeding is usually carried out with weeding tools called hand-hoe in arable crops and by spades in plantation crops. This method of weed control is more tiresome, time consuming and costlier. Hand weeding should be done at 3-4 weeks after sowing.

6. **Submergence**
   Flooding is common in wetlands. Continuous submergence of rice field is found to control weeds to a great extent. In rice, submergence of water to a depth of 5 cm is found to be adequate to control most of the weeds.

7. **Mulching**
   Mulch refers to a protective covering of material on soil surface. Act of applying mulch is called mulching. Mulching is an important and effective method of weed control in gardens and horticultural crops. Materials used as mulch include crop residues, straw, leaves, paper, plastic films, gravel and dry soil. Weeds are controlled by mulching due to higher soil temperature and shading.

8. **Digging**
   Weeds are removed by digging upto deeper layers so as to remove undergrounds storage organs. It is very useful in the case of perennial weeds and it is practiced with the help of pick axes or crow bars.

9. **Burning**
   Burning is the cheapest method of controlling mature unwanted vegetation in non-cropped areas likefield bunds, road sides, ditch banks etc. It is also used to dispose off heaped weeds.

Cultural Methods of Weed Control
Several cultural practices like tillage, planting, fertilizer application, irrigation etc., are employed for creating favour-able condition for the crop. Cultural methods alone cannot control weeds completely, but help in reducing weed population. Hence, they should be used in combination with other methods Das *et al.* 2012 [7].

1. Sowing/Planting method
Sowing of clean seeds without weed seeds should be done. Transplanting is another operation which reduces weed population since the crop has an additional advantage due to its age. The clean field preparation for transplanting helps in reducing weed germination.

2. Crop rotation
The chances of some weeds occurring is higher, if the same crop is grown year after year. Crop rotation can eliminate or atleast reduce difficult weed problems. e.g. obnoxious weeds like *Cyperus rotundus* can be controlled effectively by including lowland rice in crop rotation. Cotton-Sorghum crop rotation effectively controls striga. Chauhan *et al.* 2012 [5]

3. Intercropping
Intercropping is growing two or more crops simultaneously on the same piece i .e. along with the main crops intercrops are grown in definite rows .e.g. Cotton + Blackgram.

Chemical Weed Control
The chemical weed control includes the use of chemicals known as herbicides for controlling weeds.

Advantages of chemical weed control
- Many (pre-emergence) herbicides give early weed control.
- Very high control can be obtained, particularly in case of perennial and obnoxious weeds.
- Large area can be covered in a short time.
- Reduces the cost of pre-planting tillage.
- Possible in areas where the availability of labour is scarce/costly.
- Can be used for weed control in areas where inter-cultivation is not possible.
- Economically cheaper.

Limitations of chemical weed control
1. Herbicides kill only selected species of weeds and all weeds are not controlled with one chemical.
2. Excess dose may injure the crop plants.
3. The lower doses result in poor weed control
4. The soil should be wet at the time of application of herbicides.
5. Indiscriminate and improper use may pollute the environment.

Table 2: Herbicide Formulations

Herbicide Formulations		
1.	Soluble Powders(SP)	Sodium salts of 2,4 – D,TCA
2.	Water Soluble Concentrates (WSC)	Diquat, Paraquat.
3.	Wettable Powers(WP)	Atrazine 80% WP, Diuron 80% WP
4.	Emulsifiable Concentrate(EC)	2,4 – Dester, Alachlor, Pendimethalin
5.	Granules (G)	Granules of Butachlor, Anilofos.

Herbicide Label Information
Several symbols are printed on the label. There are four categories of toxicity and each of which is indicated by an appropriate symbol as under:

Table 3: Herbicide Label Information

Sl. No.	Toxicity Category	Colour of triangle	Signal word on label	Warning symbol on the label
1.	Extremely toxic	Bright red	POISON (Printed in red)	Skull and cross bones
2.	Highly toxic	Bright yellow	POISON (Printed in red)	-
3.	Moderately toxic	Bright blue	DANGER	-
4.	Slightly toxic	Bright green	CAUTION	-

Biological Weed Control
Biological control is the control of a weed by using another living organism. The organism which is used for control is known as bio-agent. The bio-agent for controlling the weed may be (1) Insects (Predators / parasites), (2) Pathogens (Fungi, bacteria, virus), (3) Animals (Fish, duck, geese, snails, pigs, etc) or (4) Plants

Advantages of biological control
1. Environmental friendly
2. Economical in long-run
3. Self-multiplying
4. Effective in areas not reachable to man
5. Effective in non-cropped areas
6. No development of resistance
7. No residual effect as in case of chemical weed control

Limitations of biological control
- High initial cost
- Small / narrow span of activity. Therefore has less use
- Very slow action
- Adaptability of bio-agent to released environment is a must.
- Bio-agents are not available for all weeds.

Bioagents for control of few important weeds

A. Insects

Table 4: weed and Bio-agent

Weed	Bio-agent
Opuntia (Pricly pear)	*Cactoblastis cactorum* (Cactus moth)
	Dactylopius opuntiae (cochineal insect)
	D. tomentosus
Lantana	*Crocidosema lantana* (Tortricid moth)
	Agromyza lantanae (Seed fly)
	Thecla echion and *T. bazochi* (Lycaenid butterfly)
Parthenium	*Zygogramma bicolorata* (Mexican beetle)
	Epiblema strenuana (Gall insect)
Eichhornia (water hyacinth)	*Neochetina eichhorniae*
	Neochetina bruchii

B. Plants

Marigold has potential to control parthenium. *Cassia serratia* can be used to control parthenium.

C. Fish

Certain fresh water Carp fish consume large quantities of aquatic weed control. The common carp can also be used to aquatic weeds. Chinese grass carp is a promising fish for control submerged aquatic weeds.

Weeds commonly noticed in fields

Fig 1: Country mallow **Fig 2:** Prickly chaff flower **Fig 3:** Amaranthus

Fig 4: Mexican poppy **Fig 5:** Water fire wort **Fig 6:** Calotropis

Fig 7: Centella **Fig 8:** White Cock's comb **Fig 9:** Wild mustard

Fig 10: Commelina **Fig 11:** Field bind weed **Fig 12:** Cyanotis

Fig 13: Thorn apple

Fig 14: Eclipta

Fig 15: Water hyacinth

Fig 16: Gramaphone flower

Fig 17: Lantana

Fig 18: The water fern

Fig 19: Touch me not

Fig 20: Opuntia

Fig 21: Parthenium

Fig 22: Common purslane

Fig 23: Garden night shade

Fig 24: Striga

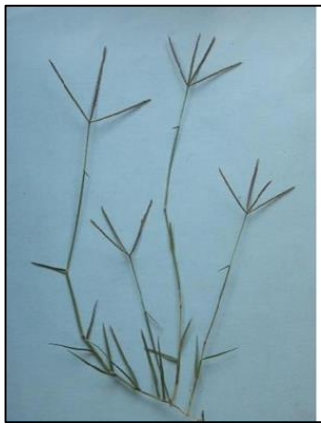

Fig 25: Bermuda grass

Fig 26: Crow's foot grass

Fig 27: Echinochloa

Fig 28: Zinger grass

Fig 29: Purple nut sedge

Fig 30: Fimbristylis

Fig 31: Puncture wine

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