Major Weeds of Rapeseed-Mustard in India

All India Coordinated Research Project on Rapeseed-Mustard
(Indian Council of Agricultural Research)
Directorate of Rapeseed-Mustard Research
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Foreword

Rapeseed-Mustard is an important group of edible oilseed crops in India. Technological advancement in rapeseed-mustard production has resulted in increased productivity. But many biotic stresses such as weeds cause severe yield losses up to 40% in rapeseed-mustard. They reduce crop productivity and quality by competing with crop plants for available nutrients, water, land and light resources and also influence the agro-ecosystem. The losses due to weeds are through indirect action and many a times, the farmers fail to perceive the potential losses. Sustainable natural resource management in crop production largely depends on weeds. Some weeds are specific to the crops. The sound knowledge of weeds should lead to their effective management through cultural, physical, biological and chemical approaches and also prevents them from further spreading. DRMR has been serving the stakeholders by providing timely access to information on different aspects of the crop, rapeseed-mustard, since its inception and fulfilling the mandate of supporting the rapeseed-mustard production system in the country. This publication, **Major Weeds of Rapeseed-Mustard in India**, describing their systematic position, salient characteristics and management is timely and well conceived.

I am sure this bulletin will help the rapeseed-mustard growers, academicians and researchers alike to address weed problem and its effective management to enhance crop productivity. I compliment the efforts of Dr J. S. Chauhan, Director, DRMR and Drs S. S. Rathore, Kapila Shekhawat, O. P. Premi and B. K. Kandpal for compiling the available information and bringing out this important publication.

(Swapan K. Datta)

New Delhi
July 23, 2012

Preface

Rapeseed-mustard is an important group of oilseed crops occupying premier position in oilseed economy of India. It ranks 2nd after soybean and contributed 22.4% and 22.6% to oilseed acreage and production, respectively, in India during 2011-12. Of the several major biotic stresses influencing rapeseed-mustard production systems, weeds cause substantial loss to crop yield and quality. A variety of weeds affects these crops but the extent of damage in terms of yield and resources is location specific. Many of the weeds are specific to crop and/or location, for example *Orobanche aegytptica* is becoming great menace in rainfed areas of Rajasthan, Madhya Pradesh and Haryana, whereas, *Chenopodium, Asphodelus, Melilotus* and *Trianthema* spp. cause serious yield losses in other areas. Weed flora is also influenced by cropping systems, management practices and environment. It is of utmost importance to have information on weed biology and identification to plan a sound management strategy. We therefore, felt it imperative to document the major weeds of rapeseed-mustard in India. The present publication attempts to provide information on biology, characteristics and management of weeds.

We place on record our sincere thanks to Dr A. R. Sharma, Director and Dr V.S.G.R. Naidu, Sr. Scientist (Eco. Botany), Directorate of Weed Science Research, Jabalpur for reviewing the manuscript and offering critical comments for its improvement. We are also grateful to Prof. S. K. Datta, Deputy Director General (Crop Sciences), ICAR, New Delhi for guidance and accepting our request to write foreword. We expect this publication will help crop production researchers, extension personnel and academicians in proper identification of weeds and their effective management. The suggestion and comments for its improvement are welcome.

DRMR, Bharatpur **S S Rathore**
July 24, 2012 **J S Chauhan**

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- *Sonchus oleraceus* : Common sowthistle
- *Spergula arvensis* : Corn spurrey
- *Trianthema monogyna* : Carpet weed
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1

Introduction

Weeds are unwanted plants grown out of place, whose undesirable qualities outweigh its good points. Jethro Tull (1731) in his book, Horse-Hoing Husbandry was the first who used the word weed with present spelling and meaning. Weeds are no stranger to human beings; they have been in existence ever since the start of cultivation of crops and have been recognized as a problem since inception of civilization (Hay, 1974). Prof. Beal defined weeds precisely as "a plant out of place". Weed is defined as an honest independent competitor for food materials in struggle for existence (Campbell, 1923). Many authors have described weeds as colonizers or pioneers species in a disturbed field (Bridges, 1995) as ruderals. Navas (1991) defined a weed as "a plant that forms populations that are able to enter habitats cultivated, markedly disturbed or occupied by man and potentially depress or displace the resident plant populations which are deliberately cultivated or are of ecological and/ or aesthetic interest".

Salient features of weed

A plant to be considered as weed must possess special characteristics, for easy invasion, easy establishment and long persistence. These ideal characteristics are well described by Baker (1974) and mentioned as under:

- Seeds germinate under wide varieties of environment
- Discontinuous germination (internally controlled) and great longevity of seeds
- Rapid growth from vegetative phase to flowering
- Continuous seed production till growing conditions prevails
- Self compatibility but not complete autogamy or apomixy
- Cross pollination even by unspecialized factors or wind
- Very high seed output in favorable environment
- Seed production in wide range of environmental conditions
- Adaptation for short and long distance dispersal
- Vigorous vegetative reproduction or regeneration from fragments in perennials
- Ability to compete inter-specifically by special means (rosette, choking growth and allele-chemicals).

Weed menace in rapeseed-mustard

The area and production of rapeseed-mustard were 5.92 million ha and 6.78 million tonnes during 2011-12 (Anonymous 2012). The potential yield of Indian mustard is 2500-3000 kg/ha but due to different biotic and abiotic stresses, the present average national productivity is only 1145 kg/ha. The low rapeseed-mustard productivity is mainly attributed to the pests such as weeds, pathogens and insects. *Phalaris* weed ecosystem reduces yield significantly under irrigated rapeseed-mustard grown either in rotation as sole crop or inter cropped with wheat (Saraswat *et al.*, 2003). In this bulletin the compilation of weed flora in mustard growing areas is documented for their exact identification which will help in planning suitable management strategies.

Effects of weeds

Weeds are troublesome in many ways. They reduce crop yield by robbing water, light, space and soil nutrients. Weeds can produce allelopathic substances that are toxic to crop plants. Weeds often serve as hosts for crop diseases; they may also provide shelter for insects and diseases for hibernation. The potential yield losses due to weeds can be as high as about 65 per cent depending on the crop, degree of weed infestation, weed species and management practices (Yaduraju *et al.*, 2006). Directorate of Weed Science Research, Jabalpur estimated an additional income of Rs. 1,05,036 crores per annum, if proper weed management technologies are adopted, besides, approximately Rs. 100 billion is spent on weed management annually in India, in arable agriculture alone (NRCWS, 2007). Weeds cause damage in the form of yield loss, degradation of land value, negative impact on product quality and health of human being and animals which can be understood as below:

- **Nutrient removal:** The competition for nutrients constitutes important aspects of weed-crop interaction. Weeds remove large quantities of plant nutrients from the soil and deprived the crop plants. *Amaranthus* species is nitrophils and often accumulates over 3% N in their dry matter, *Digitaria* on the other hand is phosphorus accumulator, contain 3.36% P_2O_5 and *Chenopodium* and *Portulaca* species are potassium lovers

with over 4 % K_2O in dry matter. This shows that the weeds are very exhaustive in nutrient demands and badly deprive the crop plants from soil nutrient.

- **Yield losses:** Of the total losses caused in crop yield by the agricultural pests, weeds contribute as high as 37%. The crop yield losses were 22.7% and 36.5% in *rabi* and *kharif* season, respectively (Anonymous 2011). In rapeseed-mustard, the mean yield loss was reported up to 37.7% (Saraswat *et. al.* 2003). However, under All India Coordinated Project on Rapeseed-Mustard, from various locations 18.1% (Ludhiana) to 41.7% (Varanasi) mustard yield loss has been reported (AICRP-RM 2011).
- **Weed menace to human health:** Weeds cause serious allergies and skin diseases. Carrot grass (*Parthenium hysterophorus*) is responsible for asthma and dermal allergies. Pollens of *Ambrosia* and *Franseria* cause hay fever.
- **Weeds as alternate host:** Weeds harbor many insect-pests and pathogens during crop season and also during off-season. *Amaranthus* give shelter to many caterpillars, likewise pathogens of various diseases rest on *Trianthema* sp. The spores of Alternaria blight of Indian mustard survive on *Anagallis arvensis*, *Convolvulus arvensis* and *Chenopodium album*.
- **Allelopathy:** Many weeds release root exudates in the form of secondary metabolites which suppresses the growth and development of crop plants. Plant weed species, as many as 90 interfere with plant growth through allelopathic mechanism (Putnam and Tang, 1986). Rice (1984) described these chemicals in to 14 categories that were either secondary compounds produced by the plants or associated with the shikimic acid and acetate pathways. The allelopathic effects of the weeds on crop plants have been reported by preparing their hydro-leachates and irrigating the test plants with them. Allelopathic effect for inhibition in seed germination of various crops has been recently reported through *Cyperous rotundus* and *Prathenium* sp. leachates

- **Effect of weeds on moisture use pattern**

  Weeds absorb soil moisture voraciously and cause water stress for the crop plants. The effects of weeds on soil moisture were more devastating under water deficit and rainfed conditions. In general, for producing equal dry matter, weeds transpired more water than crop plants. From weedy field, most of the available soil moisture was exhausted by weeds, which debars the crop plant to attain full pod development stage. It is also reported that weeds remove moisture from up to 100 cm soil depth.

Classification of weed flora

The classification of weeds on the basis of morphology, ontogeny and levels of association is useful for better understanding of weed problem and devising effective weed prevention and management strategies. On the basis of morphology, the weeds in the rapeseed-mustard field could be classified as:

- **Broad leaf weeds:** These are mostly dicotyledonous possess broad leaf with reticulate venation in the leaves. The stem has true cambium and vascular cylinder, *viz*, *Chenopodium album, C. murale, Melilotus spp., etc.*
- **Grasses:** These are *graminacious,* monocotyledonous, narrow leaved, parallel venation, possess fibrous shallow roots and no cambium for secondary growth. They produce small sized seed but prolific in number, *viz, Cynodon, Avena fatua,* etc.
- **Sedges:** Sedges are narrow leaved, but deep rooted with rhizome and nut sedges. They produce small sized large number of seeds, *viz, Cyperus rotendus,* etc.

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Description of weeds

The effective weed management requires proper identification of weeds, weed biology and their relative competitiveness. The infestation of various kinds of weed has been observed in rapseed-mustard field; these include annuals, biennials, perennials, monocot, dicot, leguminous and parasitic weeds. The common weeds of rapseed-mustard, their systematic position, floral biology and morphology is described herein:

Ageratum conyzoides

Common name: Goatweed, Billygoat-weed, Chick weed, Whiteweed, Jangli pudina

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Ageratum*
Species	*conyzoides*

Salient characteristics

Goat weed is an annual erect softly hairy herbaceous weed and grows up to 90-100 cm. The leaves are oppositely arranged ovate to lance-like, coarsely rounded and have saw-like margin. Numerous pale blue or whitish flower heads are 6 mm across, often forming dense domed to flat-topped clusters in leaf axils or end of branches. The stem is often red and has long

white hairs. The unpleasant smelling leaves are also covered with fine hair. Each flower head consists of 60-75 flowers. The dark seeds have scales and ends in a needle-like shape. This weed reproduces mainly by seed which are dispersed through livestock, clothes and agricultural machinery. It complete its lifecycle in less than two months. The seeds germinate in response to light and are not viable beyond 12 months.

Amaranthus spinosus

Common name: Spiny Amaranthus, Janglai chailai

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Chenopodiales
Family	Amaranthacaea
Genus	*Amaranthus*
Species	*spinosus*

Salient characteristics

The plants are herb/shrubs, the leaves are opposite or alternate, simple, usually covered with hairs. It is an annual herb normally branched with red tinged erect stems, sometimes ascending, 50-150 cm long. The plants are succulent, leaves ovate to rhombic-ovate, elliptic, lanceolate-oblong. The inflorescence is racemose type, mostly the minute flowers are being arranged in dense fascicles. Flowers are bracteates,

hermaprodite green, in axillary clusters in the lower part of the plant and in unbranched or branched spikes in the upper part. The lower clusters are entirely without stamens and the upper flowers in the spikes staminate. Nearly 2.0 lakhs seeds are produced per plant. The seeds are endospermic usually have a rough or polished testa. Some *Amaranthus* species have prolonged seed dormancy of six years. The small seeds weed are dispersed though the wind, air, irrigation water, etc. Animals can also disperse seed.

Anagallis arvensis

Common name: Blue pimpernel, Krishaneel

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Ericales
Family	Primulaceae
Genus	*Anagallis*
Species	*arvensis*

Salient characteristics

It is an annual or biennial herb, 10-30 cm tall. The stem is quadrangular, short winged on ridges, usually branched from base. Leaves are opposite, occasionally in whorls of 3, sessile, ovate to narrowly ovate, minutely glandular punctate mainly abaxially, base subrounded, margin entire, apex obtuse or acute. Pedicel is recurved in fruit. Corolla is blue or red, rotate, 4-6 mm, parted nearly to base; lobes obovate-elliptic. Dispersal of this weed is through seeds.

Argemone mexicana

Common name: Mexican prickly poppy, Satyanashi

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Ranunculales
Family	Papaveraceae
Genus	*Argemone*
Species	*mexicana*

Salient characteristics

It is commonly grown in wasteland but also found in mustard field. It is a prickly, glabrous, branching herb with yellow juice and yellow flowers. Leaves are thistle like. Stem clasping, oblong, sinuately pinnatifid, spinous and viens are white. Flowers are terminal, yellow. The allelochemicals cinnamic and benzoic acid of *Argemone mexicana* inhibit the germination and seedling vigour of mustard. The seeds resemble the seeds of *Brassica nigra*. As a result, mustard can be adulterated by argemone seeds and rendering it poisonous. The fruit is prickly oblong or egg-shaped (ovoid) capsule. Seeds are numerous, nearly spherical, covered in a fine network of veins, brownish black and about 1 mm in diameter. It reproduces by seed. The seeds fall nearby the parent plant but also dispersed by water, farm machinery, livestock and by birds.

Asphodelus tenuifolius

Common name: Wild onion, Pyazi

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Liliopsida
Order	Liliales
Family	Liliaceae
Genus	*Asphodelus*
Species	*tenuifolius*

Salient characteristics

It is an annual erect weed in *rabi* crops in Northern India. It also occurs in wheat, barley, etc. It attains full maturity in 40 days after flowering, under stress conditions this period may reduce even up to 15 days. It is highly moisture responsive weed and hence is more prevalent in irrigated conditions. The roots are adventitious and fibrous. The stem is underground, bulb/ rhizomes. The leaves are large in number, basal, slender, simple and hollow. The inflorescence is racemose type, develops on a special aerial stem known as scape. The flowers are white and pinkish in colour. Its germination starts from last week of October to second fortnight of December. It prefers to grow on light textured soils. The propagation takes place through seeds, which are furrowed with firm seed coat and are blackish in colour. A single plant can produce about 500-2000 seeds. The seed remain dormant to avoid unfavorable environmental conditions. Dispersal of weed is through seeds only.

Avena fatua

Common name: Wild oats, Jangali jai

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Liliopsida
Order	Poales
Family	Poaceae
Genus	*Avena*
Species	*fatua*

Salient characteristics

It is a winter season annual. Wheat, barley and rapeseed-mustard crops are widely affected by wild oat and cause serious problem. Root system is fibrillose, well-developed. Stem reaches 50-120 cm in height, straight-stalked, glabrous. Leaves are linear wide, with leaf sheath at the base, ciliated along edge, with uvula but unlobed. Inflorescence is a long, sprawling or compressed panicle. One plant bears up to 500 seeds. Top part of each panicle forms small grains (about 30% of total amount), which immediately fall to soil when ripe. Seeds germinate after hibernation. The seeds remain viable over 15 years. Dispersal by seeds only.

Brassica kaber

Common name: Jangali sarson, wild sarson

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Brassicales
Family	Brassicaceae
Genus	*Brassica*
Species	*kaber*

Salient characteristics

The morphological features of jangali sarson are similar to the *Brassica juncea*. The plants are erect, annual or perennial herbs, with alternate, estipulate leaves, pubescent, some with forked, stellate, or malpighian (pickaxe-like) hairs. It is the flowers that make the Brassicaceae one of our easier families to recognize. The flowers are radially symmetric, with 4 sepals, 4 petals, 6 stamens (2 short and 4 long) and a single bilocular pistil having parietal placentation. Fruits are siliqua and endospermic weeds. Seeds are very small with long viability. Dispersal of this weed is through seeds.

Capsella bursa-pastoris

Common name: Shepherd's purse

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Capparales
Family	Brassicaceae
Genus	*Capsella*
Species	*bursa-pastoris*

Salient characteristics

It is known by its common name shepherd's-purse because of its triangular, purse-like pods. It is a small and annual ruderal. From the base emerges a stem about 0.2 to 0.5 meters tall, which bears a few pointed leaves which partly grasp the stem. Lower leaves, whole to pinnatipartite, are in rosette. Inflorescence is loose raceme with tetramerous actinomorphic flowers, petals are white. The flowers are white and small, in loose racemes and produce seed pods which are heart-shaped. Fruit is inversely-triangular, heart-shaped silicle with narrow cross wall. Unlike most flowering plants, it flowers almost all year round. It produces nearly 70000 seeds per plant. Seeds germinate from a depth of less than 2-3 cm. Seed viability is up to 10-11 years. It reproduces entirely from seed, has a long soil seed bank and short generation time and is capable of producing several generations each year. Seed dispersal is through air, farm machinery and water.

Chenopodium album

Common name: Lamb's-quarters, Bathua

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Chenopodiales
Family	Chenopodiaceae
Genus	*Chenopodium*
Species	*album*

Salient characteristics

It is a winter annual and extremely polymorphic species. It is also a major weed of wheat, barley and chickpea in northern India. Stem is highly branched and grooved. Lower leaves are triangular with wedge-shaped base, middle leaves are rhomboid,

unequally dentate along the edge and upper leaves are lanceolate. The base of leafstalks often has purple spots. Flowers are numerous, small, spike-shaped inflorescence, which are aggregated into paniculate or racemose inflorescence.

It produces up to 75,000 seeds per plant. Seeds are heterospermous, one plant produces three types of seeds, larger-quickly germinated, smaller-germinating in the second year after ripening and very small seeds-germinating in the third year after ripening. Seeds remain viable even under adverse condition of submergence and pass unharmed through the digestive system of animals. Seeds remain viable up to 10 years. Seeds spread mainly by irrigation water, wind, birds and manure.

Chenopodium murale

Common name: Khartua, goosefoot

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Chenopodiales
Family	Chenopodiaceae
Genus	*Chenopodium*
Species	*murale*

Salient characteristics

It is widespread, particularly in tropical and subtropical areas, commonly found in all winter season crops. This is an

annual herb reaching 50-80 cm height with redish or red-streaked green stem. The leaves are simple and alternate; the roots are branched tap type. The flowers are small, greenish, arranged in dense cymose inflorescence. The stem is usually erect, herbaceous, branched, cylindrical solid, hairy and green. The buds do not open into typical flower blossoms but remain with the sepals covering the ovary as the fruit develops. The pollination takes place through insects. It spreads through seeds. The seeds are albuminous with a curved or twisted embryo. The seeds are dispersed by air, birds, irrigation water and through farm machines.

Convolvulus arvensis

Common name: Hiran khuri, field bindweed

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Solanales
Family	Convolvulaceae
Genus	*Convolvulus*
Species	*arvensis*

Salient characteristics

It is a climbing or creeping herbaceous perennial plant growing to 0.5-2 m tall. It reproduces by seeds and creeping roots. The seeds have long dormancy. It binds with the mustard plant and makes harvesting extremely cumbersome. Main stalk root develops plenty of lateral roots (offshoots) that bear buds. The

leaves are spirally arranged, linear to arrowhead-shaped, and alternate, with 1-3 cm petiole. The sepals are 4-6 mm long, oblong, emarginated at top, having small pointed apex, glabrous and ciliated along margins. Corolla is 15-26 mm long, funnel-shaped, with five longitudinal folds, pink, seldom white, glabrous or with two rows of hair in upper part. The flowers are, white or pale pink, with five slightly darker pink radial petal. Reproduction occurs by root shoots and by seeds. Seed production per plant is up to 10,000 and seed viability is up to 50 years.

Cynodon dactylon

Common name: Bermuda Grass, Dub grass

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Lilopsida
Order	Poales
Family	Poacae
Genus	*Cynodon*
Species	*dactylon*

Salient characteristics

It is a perennial weed, also known as Bermuda Grass, Doab, Dog's Tooth Grass, Bahama Grass, Indian Doab. It persists in rapeseed-mustard field for long time. It is a rhizomatous perennial weed. Stalks are 10-50 cm tall, ascending, branchy. Rhizome with long branching soboles are located in ground at depth of 20 cm.

Their length reaches 2-3 m. Leaves are linear lanceolate, rigid, 7-10 cm long, or soft, 10-15 cm long, glabrous or hairy, glaucescent. Ligule is short, ciliated; inflorescence consisting of 3-8 spiciform branchlets up to 7 cm long. Spikelets are sessile, ovoid-lanceolate, overlapping. Caryopsis is elliptic, dark-red or brown, glabrous. Each inflorescence contains 150-250 spikelets and one plant can produce 1000-2000 seeds. The weed propagates quickly by rhizomes.

Cyperus rotundus

Common name: Perple Nutsedge, Motha

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Liliopsida
Order	Cyperales
Family	Cyperaceae
Genus	*Cyperus*
Species	*rotundus*

Salient characteristics

This is a perennial weed and perpetuates in the soil in the form of rhizomes and also a major weed in rice and maize. The underground rhizomes carry numerous tuberose thickenings helping plants to breed. Leaves are glabrous, linear, 2.5 mm wide, usually short aggregated at base of stem. Inflorescence is umbel-shaped, with unequal rays of 0.3-10 cm in length bearing apical friable bunches of spikes The spike is oblong-linear, 10-20 mm in length and 1-2 mm in width; 2-3 basal

leaves considerably exceed inflorescence in length. The seeds have long period of germination (April-September) and very low germinating capacity (fresh-mature seeds 6-7%). Viability of seeds is up to 10 years. One plant is able to form about 10,000 seeds and 100 tubers during a vegetation period. Propagation is through seeds and underground tubers, which are the swollen end of its rhizomes.

Euphorbia hirta

Common name: Ashthma herb, Badi dudhi

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Malpighiales
Family	Euphorbiaceae
Genus	*Euphorbia*
Species	*hirta*

Salient characteristics

It is an annual, glabrous plant which contains white lacteal juice. The stalk has 1 to 7 axillary peduncles (1-5 cm long) above and sometimes short, non-blossoming branches below. Stem is erect, usually unbranched, herbaceous, cylindrical, solid, covered with yellow crisped hairs. Phyllotaxy is alternate. Leaves are soft, without stipules, simple, opposite, subsessile, acute, unicostate with reticulate

venation. Inflorescence is axiallry cymose with large number of cyathia densely crowned. The flowers are pedeicillate,unisexual, monoecious and greenish-yellow. The female flowers are wrapped by cup-shaped cover leaf having lobes and glands (nectaries). Glands are semi-lunar, truncated at the base, reddish, extended in long horns, without appendages. Seeds are oval, compressed, with a spherical-conic appendage, and with a rough surface having several transversal grooves. It produces 3,000 seeds per plant. Seed viability remains up to 2 years.

Fumaria parviflora

Common name: Fine leaf fumitory, Pitpara, Gajari, Ban soya

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Papaverales
Family	Fumariaceae
Genus	*Fumaria*
Species	*parviflora*

Salient characteristics

It is an annual weed. Stem is erect or ascending, branched, glabrous, somewhat canaliculate at base. Leaves are rosette; at once divided in 3 stalked segments and one vein is not very distinct. Later leaves are alternate, blue-green, 1-4-pinnate with filiform segments, sometimes 3 mm broad and mostly acuminate, channeled at base. Flowers are pink or white,

purple-blotched at the apex, 10-20 in raceme at first dense then lax at fruiting. Fruit is one-seeded about 2 mm in diameter, rounded, heavily bulged-in at the top, from straw-yellow and greenish-grey to greyish-brown and brown, dull. Seeds are ovate, reddish-brown. The number of seeds produced per plant is approximately 15,000 and viability remains up to 3-5 years. The weed spreads by seeds.

Launaea nudicaulis

Common name: Bold leaf Launea, Jangali gobhi

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Asterales
Family	Compositae
Genus	*Launaea*
Species	*nudicaulis*

Salient characteristics

It resembles cauliflower but the flowers are of entirely different type. The yellow flowers are somewhat like those of the dandelion but smaller and less dense. Sometimes the plant flowers close to the ground at about 20 cm, but usually it grows to 40 cm. The leaves are pinnate with soft white teeth at the edges. The upper stalks are slender and hardly have any leaves. When the flower withers away its place is taken by a small, puff ball composed of seeds that float away in the breeze. When broken off the stalks have yellow latex. The fluffy hairs act as a parachute and carry the seeds far and wide. The fruits are broken in to two halves, dehiscence of capsule start from apex. The parachute like structure, pappus helps in seed dispersal.

Melilotus indicus

Common name: Sweet clover, Peeli-safed senji

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Genus	*Melilotus*
Species	*indicus, parviflora*

Salient characteristics

M. indicus and *parviflora* are known as safed and peeli senji respectively. The plants are erect or ascending biennial or annual, with trifoliate leaves. The stem is well-branched. The leaves are compound with alternate, pinnately three-foliate, petioles, with a pair of stipules forming a wing at the base. The succulent stems become fibrous with age. The roots are deep tap-rooted. Inflorescences are elongated, one-sided racemes of yellow and white flowers, borne on long axillary stalks.

The small flowers, the smooth stem below the flowers and the toothed leaves make it easily recognizable. The flowers are perfumed and the leaves are sweeter when dried. It grows best on neutral or alkaline soils. It produces 14,000-35,000 seeds per plant. The seeds remain hard and contribute to the development of a large seed bank. These seeds will remain dormant until conditions are optimal for scarification, so abundance can fluctuate wildly from year to year. The water is the most important mean of seed dispersal, although wind can blow seeds up to several meters.

Orobanche aegyptica

Common name: Broomrape, Gudia, Hadda

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Lamiales
Family	Orobanchaceae
Genus	*Orobanche*
Species	*aegyptica*

Salient characteristics

Broomrape is a serious noxious root halo-parasitic weed. *Orobanche aegyptica* and *ramose* are widely reported. Genus *Orobanche* has over 200 species of parasitic herbaceous plants. It has no chlorophyll to make food through photosynthesis. It has reduced leaves, uniform inflorescences, microscopic uniform seeds and very little variation in corolla color and shape. The colour of the stem is creamy at the top in the early stages but turns brown to almost black on maturity. Leaves are reduced to small purplish scales. Flowers are light blue to violet, tubular, about 15 mm long and two-lipped with lower lip three-lobed and upper lip shallowly two-lobed.

Each plant may produce over half a million seeds in a short period of eight weeks. Seeds remain viable for up to 10 years in soil, and germination is stimulated by plant root exudates. It spreads by seed.

Parthenium hysterophorus

Common name: Carrot weed, Gajar ghas, Congress grass

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Parthenium*
Species	*hysterophorus*

Salient characteristics

It is a noxious weed now intruding in almost all crops. It is an annual herb with pale green lobed leaves, a deep taproot and an erect stem with several branches. It can grow up to 1-1.5 m, characterized by angular longitudinally groowed profusely branched hairy stem. Later leaves are deeply lobed and hairy, initially forming a rosette. Mature plants are erect. Flower heads, each containing five black seeds, are creamy-white and about 4 mm size. They are clustered on large branched stalks that arise from the leaf forks. *Parthenium* seed banks are persistent with seed viability more than 50% after more than two years in the soil. Seeds near the soil surface are rarely viable beyond two years. However, undisturbed, buried seed will stay dormant for a longer period. It reproduces by both vegetative and sexual means. It can produce large quantity of seeds, up to 1,00000 per plant. More than 340 million weed seeds per ha can be present in the surface soil. The seed is easily spread by vehicles, farm machineries, animals, stock feed and water.

Portulaca oleracea

Common name: Common parselans, Verdolaga, Little hogweed

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Caryophyllales
Family	Portulacaceae
Genus	*Portulaca*
Species	*oleracea*

Salient characteristics

It is an annual succulent weed, which may reach 40-50 cm in height. It has smooth, reddish, mostly prostrate stems and alternate leaves clustered at stem joints and ends. The inflorescence is cymose, cincinnus. The yellow flowers have five regular parts and are up to 6 mm wide. The flowers appear at anytime during the year, depending upon rainfall. Seeds are formed in a tiny pod, which opens when the seeds are mature. One plant produces approximately one million very small seeds germinating at temperatures ranging between 25-50°C. Seeds germinate on soil surface or from a depth no more than 1.5 cm; seeds remain capable of germinating in soils up to 30 years. Plants are very persistant. Propagated mainly by seeds and also propagated by portions of broken stem. Seeds are transported through air and birds.

Sisymbrium orientale

Common name: London rocket, Indian hedge mustard, wild mustard, Oriental hedge mustard

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Capparales
Family	Brassicaceae
Genus	*Sisymbrium*
Species	*orientale*

Salient characteristics

It is an erect annual weed. It is branched and grows up to 1 m. Young plants form a rosette with deeply lobed, pointed leaves. Lower leaves are petiolate, pinnatisect with ovate-oblong, irregularly dentate, slightly backward directed lateral lobes with larger, almost lanceolate upper lobe. Upper leaves are lanceolate or almost hastate, small, sessile. Flowers are small, situated on short peduncles, clustered on tips of stem and branches in narrow, almost spiciform racemes elongating at fruiting. Flowers are pale yellow and 6–10 mm long. Indian hedge mustard produces very large numbers of seeds and it causes problems at harvest. Fruits are pods gradually narrowed toward the apex, compactly enclosed with minute hairs, pressed to the inflorescence axis together with short and thick fruit stalks. Seeds are reddish-brown, roundish, angular. Maximum seeds produced per plants are 2,700 seeds. Seed is primarily dispersed by animals through ingestion and manures.

Sonchus oleraceus

Common name: Common sowthistle

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Sonchus*
Species	*oleraceus*

Salient characteristics

The name refers to its attractiveness to swine and the similarity of the leaf to the ear of a pig, while the oleraceus portion of the Latin name refers to its delectable nature (Sonchus refers to the hollow stem). Another common name Hare's thistle refers to its beneficial effects and attractiveness for hare and rabbits. Leaves are usually the part which people eat and they are useful as salad greens or cooked like spinach. Blanching or boiling removes bitter flavour. The flowers are hermaphrodite and common pollinators include bees or flies. The flowers are self-fertile. Mature seeds are formed 1 week after flowering. It prefers full sun, but can tolerate most soil conditions. The seed number per plant varies considerably with environmental conditions and ranges from 5,000 to 40,000. The seed has a pappus of hair which help in dispersal through wind under dry conditions.

Spergula arvensis

Common name: Corn spurry, Ban dhania, Satgadia

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Caryophyllales
Family	Caryophyllaceae
Genus	*Spergula*
Species	*arvensis*

Salient characteristics

It is an annual seed-propagated weed, oily-feeling with short taproot and creeping, ramified growth. The root is tap branched type. Stems are erect or ascending in groups or prostrate, jointly articulated, up to 40 cm high or long. The leaves are cauling, round, simple, opposite, linear, sessile, and fleshy, upper surface arched, underside furrowed, 2-3 cm long and sticky haired. The inflorescence is cymose, dichasial cyme with suppression of branches on one side. Flower is small, with five white petals and calyx with separate sepals, in terminal, umbellate-like inflorescence. Boll is wide ovate, opens with 5 folds. Seeds are small, black colored 1-1.8 mm in diameter. Approximately 5000-10,000 seeds per plant are produced. Seeds can remain viable in soil for at least 5 years. In dry storage seed longevity is over 15 years. The seeds are dispersed by wind, animals, farm machines and birds.

Trianthema monogyna

Common name: Carpet weed, horse parslane

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Aizoales
Family	Aizoaceae
Genus	*Trianthema*
Species	*monogyna*

Salient characteristics

It occurs in wastelands, roadsides, lawns, gardens and cultivated crops. Stems are prostrate or rising, somewhat succulent, up to 50 cm long or more, smooth or sparsely velvety. Leaves are flat, elliptic to obovate or spade-shaped, 1-2 cm long, 0.4-2 cm wide, margins entire, tip blunt, base rounded to wedge-shaped. Leaf stalks are 0.5-2.5 cm long, expanded into a sheath joined with opposing leaf base to form a cup. Pink flowers are borne solitary, stalkless, largely hidden in leaf axils. The seeds are borne in the node of stem and are blackish in colour, the seed setting started early in the life cycle and continue as the growth prolongs. Germination occurs during rainy season but infestation continues to winter season too. On drying of the plant, the seeds are dispersed and a large seed bank builds in the soil. Seeds are disseminated by wind, water, farm implements and birds.

Varnonia cinerea

Common name: Little iron weed, Phulani

Systematic position	
Kingdom	Plantae
Division	Angiospermae
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	*Vernonia*
Species	*cinerea*

Salient characteristics

It is an annual, erect herb, 15-75 cm in height. The stem is stiff, striate, pubescent in habit, erect, usually branched above, or rarely from base. The leaves are simple, alternate, variable in shape, broadly elliptic or lanceolate, irregularly toothed, or crenate-serrate. Root vertical, woody, branched with fibrous rootlets. Lower and middle leaves are with 10-20 mm petiole, leaf blade rhombic-ovate, rhombic-oblong or ovate, abaxially gray-white or yellowish puberulent, The flowers are pinkish violet, heads small, about 20 flowered in divaricate terminal corymbs, involucral bracts linear-lanceolate, awned, silky on the back, pappus white. The flowering time is January-February. Achene, oblong, clothed with white hairs on the fruits. Dispersal of weed occurs through seeds.

3

Weed management

Critical period of weed competition

The critical period of weed competition (CPWC) is the shortest time span in the ontogeny of crop when weeding will result in the highest economic returns. In mustard, CPWC is between 20-40 days after sowing. It reveals that the maximum loss in yield of mustard occurs when the weeding is not done during this period, likewise weed control during these period results in maximum yield advantage. Beyond this period, the crop becomes competitive and suppresses the weeds. The loss occurred during the critical period of weed competition can never be compensated by weed control measures adopted later. Singh *et al.* (1986) reported an increase of 70.4% in mustard yield due to weed control during CPWC over no weeding.

Integrated Weed Management

Weeds cause significant yield losses in rapeseed- mustard and noxious parasitic weeds may cause even complete crop failure. For effective weed management the foremost requirement is effective weed prevention strategies. Once seed setting in weed is over, then as truly said, one year seeding, seven years weeding, the situation becomes cumbersome. Weed prevention comprises all measures which deny the entry and establishment of weeds in an area through checking weed dissemination. The weed management in mustard is done by both cultural and herbicidal approaches. Recently, the farmers have adopted herbicides for weed control because it increases the profit, weed control efficiency, reduce time and labour requirement.

- **Cultural practices :** Cultural practices of weed management include proper crop stand and early seedling vigour, selective crop stimulation, proper planting method, optimum planting time, crop rotation, stale seed bed preparation, growing of smoother crops, deep summer ploughing, and minimum tillage. If followed properly, it discourages weed to minimum level of infestation. In the cultural treatment, hand weeding

in mustard is done at 20 days after sowing which can be followed by a hand-driven wooden plough or hand hoe between the lines at 35 days after sowing. The smoother crops like cowpea, blackgram, moth bean, sunnhemp, clusterbean and sesame acts as suppressors for broomrape and other weeds.

- **Physical :** It encompasses the mechanical operations like hand pulling, hand hoeing, tillage methods, mowing, soil solarisation, heating and burning, mulching. Tillage helps in controlling the weeds by killing the emerging seedlings, seeds, delaying germination and leaving a rough surface to hinder the weed seed germination. Most of the annual weeds like *Chenopodium* and *Asphodelus* may be controlled by removing them every year just before flowering and fruiting. However, deep-rooted perennials are eliminated by deep ploughing. Conservation tillage with mulching on surface also helps in controlling the weeds effectively. Bazaya *et al.* (2006) found that polythene mulch was effective in controlling the weeds by increasing the soil temperature and acting as a physical barrier for emergence of weeds.
- **Biological :** It involves the use of living organisms, as insects, fungus, bacteria, virus and competitive plants to limit the infestation of the weeds. In rapeseed-mustard the various bio-agents for weed control has been identified. Sharma *et al*. (2011) reported that *F. solani* infection on *Orobanche* increased the number of dead spikes of broomrape. Bio-agents insects such as *Phytomyza orobanchia* and fungi such as *Fusarium oxysporum sp orthoceras* are natural enemies of *Orobanche*. Seed production in *Orobanche* was found to be reduced significantly in many countries (Kroschel and Klein, 2003). *Zygogramma bicolorata* on *Parthenium* and *Athesapeuta cypri* on *Cyperus* rhizome are also reported effective in minimizing their population.
- **Herbicidal :** Significant reductions in weed population and its dry matter can be obtained with fluchloralin @ 1 kg/ha supplemented with hand weeding at 30 and 60 days after sowing. Isoproturon and pendimethalin (within 48 hours of sowing) supplemented with hand weeding at 30 and 60

days after sowing is also very effective against most of the weeds. The common, trade and chemical names along with time and doses of herbicides relevant for weed control in rapeseed-mustard have shown in Table 1.

Table 1. Some herbicides used for weed management

Common name	Trade name	Chemical name	Dose (a.i.) kg/ha	Time of application
Pendimethalin	Stomp	N-(1-ethyl propyl) 3,4-dimethyl-2, 6-dinitroaniline	0.75-1.0	Pre-emergence
Glyphosate	Round up	N-(phosphanomethyl) glycine	0.25-0.50	Post-emergence
Isoproturon	Tolkan, Arelon	N'-(4-isopropyl-phenyl-N,N-dimethylurea	0.75-1.0	Pre and post - emergence
Trifluralin	Treflan 4EC	N-N-dipropyl-4 (trifluromethyl)-2, 6-dinitroaniline	0.50	PE
Oxyfluorfen	Goal	2-chloro-1-(3-ethoxy -4 nitrophenoxy)-4-trifluromethyl) benzine	0.15-0.25	Pre-emergence
Clodinafop	TopiK	prop-2-ynyl (R)-2-[4-(5-chloro-3-fluoro-2-pyridyloxy)phenoxy] propionate	0.06	Post-emergence

In terms of net returns, fluchloralin and pendimethalin alone or in combination with hand weeding at 30 days after sowing recorded the highest benefit: cost ratio. In AICRP-RM trials at Bawal, weed free plot recorded 39.9% higher seed yield over weedy check. For *Orobanche* amongst herbicidal treatments, glyphosate (0.5%) recorded higher seed yield (1510 kg/ha) but was at par with fluchloralin (1-1.5 kg/ha), glyphosate (0.25%) and 2 drops of soybean oil. Use of isoproturon as pre-emergence @ 1 kg a.i./ha at Ludhiana was reported, effective for weed management in *B. napus* as compared to the two hoeing (AICRP-RM , 2008).

Precaution in handling of herbicides

Use of herbicides is becoming popular due to effective and easy weed control. Herbicides are poisons but their selectivity and controlled use reduce the weed pressure on crops. The successful use of herbicides depends on optimum dose, time, method of application, formulations, type of sprayers, their nozzles, etc. To avoid fatal risk associated with these toxic chemicals, following precautions must be taken into consideration for better results.

- Use the recommended selective herbicide only.
- The dose and time of application should be followed as per standard recommendations.
- Use only flat fan nozzles in spaying of herbicides.
- Use antidotes for neutralizes toxic effect of herbicides on human beings.
- Always follow instructions given for the use of particular herbicides.
- Sprayer should be calibrated properly to find out quantity required to cover a hectare of land.
- Always use clean water and sprayer for herbicide application.
- Prepare the solution just before spraying and do not store them for future use.
- Do not spray herbicides on windy weather to avoid drift hazard to nearby susceptible crops.
- Dispose off empty container by burning down at least 18 inch deep in an isolated area away from water supply points.
- Do not drains or flush sprayers near source of domestic irrigation water.
- The granular herbicides should be broadcasted uniformly in 4-5 cm standing water.
- Spray of herbicides should be done after draining the water from the field.

Effect of herbicide drift of 2, 4-D on mustard

2,4-D drift effect on mustard

Spraying of 2,4-D should be done on clear and sunny days only when the leaves are dry and the soil has enough moisture. The harmful effect of herbicide drift has been often reported in various crops. The herbicide 2,4-D applied to wheat often results in drift hazards in mustard (figure). To avoid drift hazard, use flat fan nozzle and high volume sprayers during windy conditions (wind speed >10 kmph). Power spray makes very small drizzle and there are more chances of herbicide drift when herbicides are applied through power spray. Various types of shields (hoods) are used to prevent or limit drift. Be selective in selecting herbicide for multiple cropping.

Sprayers

The application of herbicide is mainly done through in the form of liquid through the implement sprayers. The sprayers are of various kinds of different capacity, spray types, delivery, droplet sizes, etc. Generally any type of sprayer is made up of pump, power source, tank, pressure gauge and pressure regulator. On the basis of spray volume and pressure involved, the sprayers are of three types:

- **High volume sprayers:** These require 300-500 litres/ha of spray fluid. The size of spray droplets range between 300-500 µm. Examples are foot and knapsack sprayers.
- **Low volume sprayers:** These require 50-100 litres per ha of herbicide solution. They are normally motorized knapsack sprayers.
- **Ultra low volume:** 1-5 litres herbicide solution per ha is required. The size of droplets ranges between 60-100 µm. Example is knapsack mist blowers.

Knapsac Sprayers

These are used on the back of worker during operations. Knapsack sprayers are indispensable agricultural tools. Tanks of knapsack sprayer are made up of either plastic or metal. There are three common types of Knapsack sprayers .

- **Hydraulic:** These are manually operated and work on hydraulic pressure. Its tank capacity ranges between 15-30 liter. It is particularly good for spot treatment and band application of herbicides. Its spray volume is approximately 250 lit/ha. The main constraint is drudgery associated with the man who uses it.
- **Manual pneumatic**: They are comparatively easy to work as do not require pumping during operation / spraying. The tank is pressurized after

filling the liquid to 2/3rd capacity with a built in hand pump. Tank cleaning is difficult.

- **Motorized pneumatic**: These are low volume sprayer suitable for spraying concentrated spray liquid. A blast of air flows and air blast atomizes spray liquid to fine droplets. Air acts as carrier. Faster the air is pressured, more the atomization. These sprayers are also used as blowers. Mist blower causes considerable loss of herbicide by winds.

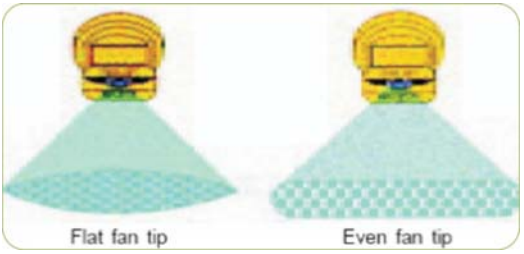
Foot sprayers

These are operated by foot as pedal pump and are popularly applied for pesticide application. It has provision of 1–2 long delivery hoses. Fitted with either lance or 2-6 nozzle booms. Its potential spray pressure is 17 to 21 kg / cm^2 output with lance is 1 ha/day. It can spray high volume spray and covers more area.

Boom Sprayers

Boom sprayers are mainly driven by mounting on tractor. These sprayers distribute herbicides using a boom with spray nozzles spaced at regular intervals. The most common example is wide horizontal booms used on field sprayers to spray field crops. Low pressure boom sprayers are often used for spraying herbicides. Available for spraying on field crop with 2 type of ground spray boom, 30-40 ft. long boom with 25 nozzles and 50 fit. long boom with 31 nozzles

Nozzles



A spray nozzle is a precision device that facilitates dispersion of herbicide into a spray on plant or soil surface. Nozzles help in uniform distribution of herbicide over an area, increase liquid surface area and create impact force on a solid surface. A wide variety of spray nozzles are in use for different kind of pesticides. For herbicide application generally flat fan nozzles are used due to better coverage of herbicide on the weeds. Flat fan nozzle tips produce a nearly flat fan in several selected angles and deposit a flat, elliptical pattern on the ground. There is less drift effect of herbicides.

4

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