DOI: 10.15740/HAS/AU/12.TECHSEAR(6)2017/1715-1723 **Agriculture Update**
Volume **12** | TECHSEAR-6 | 2017 | 1715-1723
Visit us : *www.researchjournal.co.in*

A REVIEW :

Effective weed management – A key to pests and disease management

A. RESHMA, K. USHAKUMARI AND G. RISHITHA

ARTICLE CHRONICLE :
Received :
17.07.2017;
Accepted :
01.08.2017

SUMMARY : Weed survival in the crop fields cause direct and indirect damage to the crop yield and quality.30-40% yield loss occurs due to weedsbecause they compete with crops for water, nutrients and light.In addition to the above effects, weedsact as one of the most significant sources of insect and mite pests and diseases. Crop debris can harbour a lot of pests, giving them a safe place to wait around before moving into another crop. Weeds provide shelter and food for insect and mite pests and act as a host or alternate hosts for insects. Insects will move easily from weed to crop plants and they act as vectors for various plant diseases in the field.To minimise the incidence of the pests and diseases on the crop, it is essential to keep the weeds under check by adopting the effective weed control methods which include preventive and control methods.Before adopting an appropriate method, it is essential to know about the weed seeds dispersal, mode of propagation, crop-weed competition.Crop production practices should seek to sever the taxonomic association between the crop and the weeds found within the crop, and nearby places they must be eliminated. Particularly important integrated weed management practices including crop rotation, intercropping, flooding, green manuringand reduceduse of chemical herbicides, management of weeds in non-cultivated areas should be followed.

KEY WORDS :
Weed, Crop –weed competition, Crop debris, Vectors

How to cite this article : Reshma, A., Ushakumari, K. and Rishitha, G. (2017). Effective weed management – A key to pests and disease management. *Agric. Update*, **12**(TECHSEAR-6) : 1715-1723; **DOI: 10.15740/HAS/AU/ 12. TECHSEAR(6)2017/1715-1723.**

Author for correspondence :
A. RESHMA
College of Horticulture, (Dr.Y.S.R.H.U.) West Godavari, VENKATARAMANNAGUDEM (A.P.) INDIA
Email: reshmaaluru9557 @gmail.com

BACKGROUND AND OBJECTIVES

Weeds are major components of agro-ecosystems and they affect the biology of pests and beneficial insects in several ways (Altieri *et al.*, 2009). Crop protection is one of the factors which influences crop production, eco-environment and sustainability in agricultural production. Among various pests, weeds constitute one form which affect productivity and sustainability of agricultural production. Since inception of agriculture, weeds have been recognized as potential source for pests and being removed mechanically, chemically and through cultural practices. Weeds are harmful in many ways. They cause reduction in crop yield and quality. Weeds compete with crops for water, nutrients and light. Being hardy and vigorous in growth habit, they grow faster than crops and consume large amount of water and nutrients, thus causing heavy losses in yields. Certain classes of weeds share adaptations to rural environments. That is to say: disturbed environments where soil or natural vegetative cover has been damaged or frequently gets damaged, disturbances that give the weeds advantages over desirable crops, pastures, or ornamental plants. The nature of the habitat and its disturbances will affect or even determine which types of weed communities becomedominant. Weeds in general reduce crop yields by 31.5% [22.7% in winter and 36.5% in summer and rainy (*Kharif*) season]. A challenging target in agricultural production has to beachieved with a proper management of all inputs including fertilizers and pesticides. Pest management in general and weed management in particular, will definitely playa great role in achieving and sustaining self-sufficiency in the agricultural production in future.

Losses caused by weeds:

Weeds are competitive and adaptable to all adverse environments. Of the total annual loss of agricultural produce from various pests in India, weeds account for 45%, insects 30%, diseases 20% and others 5%. It has been estimated that in general weeds cause 5% loss in agricultural production in most developed countries, 10% loss in less developed countries and 25% loss in least developing countries. Rao (1983) estimated 45% loss of agricultural produce by weeds, 30% by insects, 20% by disease and 5% by other pests. The world food loss due to weeds was estimated to be 287 million tonnes accounting 11.5% of the total food production (Parker and Fryer, 1975). Estimates showed that weeds in India cause an annual monetary loss of Rs19 800 million (Mukhopadhyay,1992).

Direct yield losses due to weeds have been estimated to range from 10 to 82%, depending on the cultivar, weed species and density, cropping season, plant spacing, fertility and moisture status of the soil and climatic and environmental conditions (Tiwari *et al.,* 1995). The losses due to weeds vary with the crop. (Singh *et al*., 1993) reviewed the losses caused by weeds in vegetable crop ranging from 6 to 82%. Besides reduction in grain yield, weeds remove large amount of nutrients fromthe soil and indirectly reduces the yield potential by serving as alternate host to a number of crop pests and diseases.

Weed as ahosts for different insect and mite pests:

Weeds are a primary source for many phytophagous insects. Most of the insects prefer to feed on weeds and make water, soil nutrients and sunlight more available to crop plants, thereby reducing weed competition with crops.The sesiid moth *Carmentahaematica* (Ureta) attacks only snakeweeds, *Guteirrezia* and *Grindelia* spp. in the family Asteraceae (Cordo *et al.*, 1995). But insectsmay damage crops readily in the absence of attractive weeds.This is evident in case of Colorado potato beetle (Leptinotarsa :decemlineata) which prefers to oviposit on hairy nightshade (*Solanum sarrachoides*) rather than on potato (*Solanum tuberosum* L.), and eggs are less abundant on potato in the presence of nightshade (Horton and Capinera, 1990).The insect preference for weeds has been exploited effectively through the introduction of natural predators for the biological suppression of invader weeds, with spectacular success which is a classical example for biological control (Goeden and Andres, 1999 and Myers and Bazely, 2003).

There are negative aspects associated with insect feeding on weeds.When insects have a wide host range (oligophagous to polyphagous) they sometimes move from weeds to crop plants, causing crop damage. Commonly, this follows weed destruction due to tillage or herbicides, butit also may be a more natural process, following weed senescence or consumption of the weed by the insects. Thus, a common recommendation in many crop production systems is to keep weed populations at a low level, not only within the crop field, but also in adjacent areas such as irrigation ditches and fence rows, as these sites are a common source of insect inoculum for the crop field (Capinera, 2001 and Metcalf and Metcalf, 1993).

The exotic cotton mealy bug *Phenacocus solenopsis* Tinsley (Hemiptera: Pseudococcidae) invaded India during 2006 and caused wide spread infestation across all cotton growing states. *P. solenopsis* also infested weeds that aided its faster spread and increased severity across the cotton fields. A total of 108 weed species from 32 different families served as hosts for *P. solenopsis* in India which was higher than those recorded (65) from Pakisthan by (Arif *et al*., 2009). Monga *et al.* (2009) reported the spread of *P. solenopsis* from border rows to inside of cotton fields and the need for early detection and initiation of insecticide interventions. Host range analysis clearly indicated that the continuos monoculture of cotton increases the *P. solenopsis* preference for Malvaceous hosts and it is one of the reason for increased incidence and severity on the crop. Weed hosts *viz., Portulacagrandiflora and Xanthium strumarium* are the major weed hosts that have been infested by *P. solenopsis* (Abbas *et al.*, 2010).

There are some common weeds which are infected by root-knot nematodes on farms and in bioassay pot soil which includes slender amaranth, old world diamond-flower, tropic ageratum, sicklepod, mimbra, balsamapple, purple bushbean, little ironweed, ivy gourd and cut leaf ground cherry. The presence of egg masses on the weed hosts indicated their ability to sustain root-knot nematode populations and thus, their potential to act as reservoir hosts (Sunil *et al.*, 2010).

Sting nematode is one of the major devastating pests especially in field crops and mostly agronomic, fruit and vegetable crops are hosts for this nematode. The hosts

Crops	Forages	Weeds	Others
Corn	Pearl millet	Morning glory	Bent grass
Sorghum	Fescue	Crab grass	Tomato
Soyabean	White clover	Johnson grass	Potato
Wheat	Crimson clover	Sorrel	Peppers
Oats	Ladino clover	Wild carrot	Peach
Barley	Kobe Iespedeza	Rag weed	Elm

http://ianrwww.unl.edu/ianr/plntpath/nematode/stingnem.htm

plants for sting nematode are:

In the cultivation of Maize, the weed species *Cynodondactylon* and *Digitariasanguinalis* are hosted by the nematodes *Meladogyne incognita* and *Pratylenchussps.* Similarly in Potato culture five of the major 12 weeds are listed among the worlds worst weeds.The weed species *Digitariasanguinalis* acts as a hosts for *Meladogyne incognita.* In Cassava there are six major weed species which are hosted by the nematodes *Meladogyne*and Pratylenchussps (Leo, 1998).

Weed hosts for diseases:

Weeds harbourdiseases that can be transferred to crop plants by insect feeding first on weeds and then on the crop (Chellemi *et al.*, 1994). Most of theplant diseases are caused by viruses and mollicutes and to a lesser degree by fungi and bacteria, are commonly transmitted by insects from weeds. Aphids, whiteflies, leafhoppers, and thrips are the most common vectors of plant disease because they have piercing-sucking mouthparts and in some casesthey secrete the diseasepropagules as they feed (Hunter, 2004). Weedy areas around crop fields are often the over-wintering site for grasshoppers (as eggs in the soil), which initially feed (weeds may be the only source of food early in the growing season) and roost there (preferring the taller weeds for thermoregulation and possibly for nutrition. In case of some diseases of grasshoppers, caused by the fungus *Entomophagagrylli*, such weeds are sometimes heavily populated by dying grasshoppers that cling to elevated perches even after death (Carruthers *et al.,* 1997). The high grasshopper densities at such sites serve as foci of disease infection and faster the spread of the insect pathogen in the insect population.

The diseases may be introduced into a crop by only a few insects, followed by rapid secondary transmission within the crop. It is difficult to prevent the inoculation of a disease, through secondary transmission and can be reduced through the effective insect suppression. This insect suppression is usually achieved primarily by spraying of insecticides and secondarily by weed control. Elimination of the source of the disease and vectors is often the most effective approach to management and this often means weed control (Agrios, 1997 and 2004).

Several insects transmit different viruses in different crops, but aphids and whiteflies are among the most important virus *vectors* (carriers of viruses).The insect vectors feed on various parts of weeds that are infected by a virus and acquire the virus in the process. They then can feed on uninfected agricultural crops and transmit the virus to them. Insects are often attracted to weeds and survive on them because weeds can provide food for insects when preferred food is scarce, or weeds can provide shelter from adverse conditions such as bad weather or pesticide applications. Several weeds have been reported as virus hosts by Kucharek and Purcifull (2001). Some viruses, such as *Tomato mosaic virus*, are not transmitted by vectors. Others, such as *Bean common mosaic virus*, can be transmitted by vectors or through seed (Adams and Antonie, 2011). Removal of weeds that act as virus sources may be helpful in reducing the initial infestation by a virus of the main crop in the same field as well as other fields that are near the weeds. Removal of volunteer plants from field borders may also help in management of viral diseases (Momol and Pernezny, 2006). Recognizing the common virus host plants is important because they may be reservoirs for viruses, allowing them to survive during the off-season when the main vegetable crops are not grown.

Weed hosts of some vegetable crops:		
Weed host	Virus	Reference
Alyceclover	*Watermelon mosaic virus*	Mossler and Nesheim (2011)
American burnweed	*Bidens mottle virus*	Pernezny and Raid (2008)
American pokeweed	*Cucumber mosaic virus*	Ferreira and Boley (1992)
Balsam apple	*Cucurbit leaf crumple virus*	Webb *et al.* (2010) and Webb *et al.* (2011)
Balsam apple	*Papaya ringspot virus*Type W	Kucharek and Purcifull (2001) and Larson *et al.* (2011)
Balsam apple	*Squash vein yellowing virus*	Baker *et al.* (2008), Adkins *et al.* (2008) and Adkins *et al.* (2010)
Balsam pear	*Zucchini yellow mosaic virus*	Fukumoto *et al*. (1993)
Beggarticks	*Bidens mottle virus*	Pernezny and Raid (2008)
Beggarticks	*Tomato spotted wilt virus*	Zitter and Daughtrey (1989)
Big chickweed	*Tomato spotted wilt virus*	Groves *et al*. (2002)
Bull thistle	*Lettuce mosaic virus*	Koike and Davis (2009)
Burr clover	*Lettuce mosaic virus*	Koike and Davis (2009)
Butterweed	*Bidens mottle virus*	Pernezny and Raid (2008)

Insect-weed -crop plant interaction:

The army cutworm, *Euxoaauxiliaris* (Grote), will serve as a classical example for insect-weed-crop plant interaction. Army cutworm is a common lepidopteran pest in the western Great Plains region of North America in which wheat (*Triticum aestivum* L.) is grown. Predominantly it is a pest of small grains, but it also feeds on a large number of plants, including many weeds in preference to grain crops.The larval stage of this insect feeds aboveground at night and spends the daylight hours hiding in the soil.The army cutworm feeds on a weed known Tansy mustard [*Descurainiapinnata* (Walt) Britt.] by completely consuming the foliage and only the base of the plant remains.In this case, the army cutworms are beneficial insects, serving to reduce competition by the weeds with the young wheat by killing or severely inhibiting the growth of the tansy mustard plants. If the tansy mustard plants (or other weeds) are completely consumed by the larvae before it reaches the maturity, the cutworms are forced to feed on the wheat. In this case it serves as a pest to the main crop. (John, 2014).

Presence of weeds maybe beneficial to wheat cultivation, because it lures cutworms from the wheat.If the herbicides are applied before the cutworms mature, they deprive the larvae of food, forcing them onto the wheat. So it is advisable to delay herbicide application until after the larvaeare matured and thereby reducing or eliminating the herbivory of wheat.

Weeds affect host-finding by insect herbivores:

Weeds can modify the attractiveness of crops to the insect herbivore, thereby affecting the rate of colonization. Both vision and odour play an important role in host location by most insects (Stanton,1983). In the case of vision-based host finding, it is the spectral profile (nonvisible to humans as well as visible) to which the insect responds.J. S. Kennedy and collaborators postulated that during the dispersal phase, insects (aphids, for example) were attracted to short-wavelength UV light, and this tends to take insects upward towards the sky. After a period of flight, they were no longer attracted to UVlight, instead they preferlong-wavelength light (Kennedy *et al.*, 1961). Vegetation (weeds vs. bare soil, or weeds plus crop plants vs. crops plus bare soil) could influence the spectral reflectance pattern of a site, thereby affecting the propensity of flying insects to alight. Weeds can also modify the attractiveness of crops to insects by affecting the hue (colour) of the foliage; as first demonstrated conclusively by V. Moericke (Kennedy,1976), many herbivorous insects areattracted to yellow or yellowish green during the host-seeking phase, relative to dark green or other colours (Kostal and Finch, 1996 and Moericke, 1969). Thus, light green weeds interspread among darker green crops could be relatively more attractive to alighting insects. Mulching the crop with silver plastic mulch to increase the amount of ultraviolet light being reflected, effectively disorienting flying insects and reducing the rate of alighting by airborne insects (Rhainds *et al.,* 2001; Stapleton and

Summers, 2002; Stavinsky *et al.*, 2002 and Summers and Stapleton, 2002).

Many of the insects depends on vision only to identify an appropriate habitat and then use odour to identify a suitable host (Judd and Borden 1992a and b). Insects using odour for host location tend to be more selective in their feeding habits than insects depending mostly depending on vision. Chemicals play an important role in the evolution of specific host-herbivore relations than vision. When resources are concentrated, as in agricultural monocultures, presumably insects can readily find their host plant due to the concentrated host-produced odours.

Finch and Collier (2000) proposed that host-location behaviour resulting from visual and chemical orientation was modified by the retention time and behaviour of insects in a crop.If the insects are continuously stimulated by the appropriate stimuli they would oviposit and begin an infestation. If an unacceptable host was encountered during the investigatory phase, or chemical stimuli were inadequate, the insect would be more likely to move on, thereby reducing the likelihood that a crop would be infested (Herzog and Funderburk, 1986).

Many chemical compounds found in plants are common to a group of plants, often most, or all of, the members of a plant family. Some examples of insect herbivores and the plants on which they feed, are (e.g., the silkworm moth, *Bombyxmori* [L on white mulberry, *Morus alba* (L.); or the rosemary grasshopper, *Schistocercaceratiola*, on Florida rosemary, *Ceratiolaericoides* Michx.)] or more broadly (e.g, Japanese beetle, *Popilliajaponica* Newman, with about 400 species from many plant families recorded as hosts; or green peach aphid, *Myzuspersicae* (Sulzer), which feeds on plants from 40 plant families).

Weeds affect beneficial insects:

Weeds can directly affect the abundance of beneficial insects, including predators, parasitoids and pollinators (AlDoghairi and Cranshaw, 2004; Alteiri, 1988 and Showler and Greenberg, 2003). Some predators and parasitoids also feed on weeds. Many predatory insects with piercing-sucking mouthparts are facultative predators, imbibe plant sap when necessary to sustain their existence. The presence of certain weeds (those with accessible nectar from flowers or extra floral nectaries) enhances the survival of beneficial insects and assists in biological suppression of pests (Russel, 1989 and Southwood, 1986). The presence of phytophagous insects on weeds may support populations of beneficial insects, elevated populations of generalist beneficial insects will spill over onto crops and help suppress pests.In

Common weed name	Pest / disease	Scientific name of pest or disease	Damage caused to healthy plants
Ragwort	Flea Beetle	*Longitarsusflavicornis*	Destroys roots
	Flea Beetle	*Longitarsusjacobaeae*	Destroys roots
	Crown Boring Moth	*Cochylisatricapitana*	Bores into root crown
	Cinnabar Moth	*Tyriajacobaeae*	Defoliates plant
Slender thistles	Rust Fungus	*Pucciniacarduipycnocephali*	Infects leaves and stems
Spear thistle	Receptacle Weevil strain	*Rhinocyllusconicus*	Destroys developing seeds
	Gall Fly	*Urophorastylata*	Galls flower heads
Variegated Thistle	Receptacle Weevil strain	*Rhinocyllusconicus*	Destroys developing seeds
Scotch/Illyrian/ Stemless Thistles	Onopordum Seed Weevil	*Larinuslatus*	Destroys developing seeds
Paterson's Curse	Crown Boring Weevil	*Moguloneslarvatus*	Destroys crowns
	Root Boring Weevil	*Mogulonesgeographicus*	Destroys roots
Boneseed/Bitou Bush	Bitou Tip Moth	*Comostolopsisgermana*	Feeds on growing tips
	Black Boneseed Beetle	*Chrysolinaprogressa*	Defoliates plants
	Tortoise Beetle		Defoliates plants
Horehound	Plume moth	*Pterophorusspilodactylus*	Defoliates plants
St. John's Wort	Mite	*Aculushyperici*	Stunts growth
English Broom	Twig Mining Moth	*Leucopteraspartifoliella*	Destroys new growth
Common Prickly Pear	Cochyneal	*Dactylopiusopuntiae*	Destroys all aerial parts

https://www.dlsweb.rmit.edu.au

some cropping situations, weeds or other noncrop plants (called refugia or banker plants) are deliberately planted to faster development of beneficial insects that will affect pest populations on crop plants (John and Capenaria, 2005).

Common weeds that harbour pests and diseases:

Wees control methods:

Good agronomic practices (GAP) is an efficient and excellent tool for effective weed management and in turn pests and disease management in general. GAPs include crop rotation, fallow, flooding, deep ploughing, soil solarisation-which involves a combination of physical and biological process, adjusting planting dates, irrigation, fertilization, sanitation tillage etc. (Anil Kumar *et al*., 2012). Mechanical weed management includes tillage, mulching, flooding, draining, heating, cutting, pulling, dragging and hand-weeding. Kumar *et al.* (l993) found that mulching by polyethylene sheets for 32 days decreased the emergence of *Dactylocteniuaegyptium, Achrachneracemosa. Trianthemaportulacastrum* and *Cyperusrotundus* by more than 90% and the solarization effect was restricted to the 0-5 cm layer of soil.

Crop rotation:

Banga *et al.* (1997) found drastic change in the population of *Phalaris minor* in cropping sequence other than rice-wheat. Bhan and Sushilkumar (1997) reviewed the causes of heavy incidence of *P.minor* in rice-wheat cropping sequence in Punjab, Haryana and Uttar Pradesh and strongly suggested the change in the rice-wheat cropping sequence.

Intercropping:

When two or more crops are grown together as intercrops, the total weeds suppressing ability of a system will be higher than the sole cropping. Intercropping suppresses weeds better than sole cropping and thus provides an opportunity to utilize crops themselves as a tool of weed management (Rao and Shetty, 1976). Intercropping of sorghum with cowpea and green gram smothered weeds and reduced hand-weeding cost (Rao and Shetty, 1981).

Cover cropping:

The cultivation of shortvegetation plants can reduce the development of weeds, pests and diseases and protect soil against direct environmental impacts for alonger post-harvest period and incorporate the nutrients remaining in soil into a biological metabolism cycle (Kassam and Brammer, 2013). The use of cover crops for controlling summer weeds can contribute to reducing the number of herbicide treatments (Alcantara *et al.*, 2011).

Biological weed management:

Biological control of weeds by insects and other fauna and by pathogens in India was reviewed by Sushilkumar (1993) and Kauraw (1996), respectively. Biological agents may be integrated with chemical herbicides or other practices to control the complex of weed flora in water bodies (Bhan and Sushilkumar, 1998). Thakur *et al.* (1992) recommended 3 indigenous insects as potential bio-control agents for *Lantana. viz.*, a flower feeder *Asphondyliaalantanae,*flower and leaf defoliator *Hypenalaceratalis*, and a borer of'ripe fruits, *Homonamicaceana*. Mexican beetle *(Zygogramma bicolorata)* caused severe impact in suppressing of parthenium in and around Bangalore (Jayanth *et al.*, 1987 and Jayanth,1993). But recently this beetle was found feeding on sunflower crop and xanthium (Sridhar, 1991, Kumar *et al.*, 1993 and Sushilkumar and Bhan,1996).

Chemical weed control:

Herbicides can display taxonomic discrimination, favouring survival of weed populations that are related to the crop plant. Continuous cropping of the same crop in the same field and repeated application of the same herbicides can lead to shifts in weed populations and weeds may develop resistance against the herbicides. For example, use of 2,4-D for control of broadleaf weeds increases frequency of grass weeds in corn (*Zea mays* L.) and wheat. Therefore, crop rotation can help to reduce the herbicide-based selection for weeds that are related to the crop (John, 2005).

Conclusion :

– Weed management varies with the agro-climatic and ecological situations. Hence, weed management strategies should be highly location-specific.

– Much emphasis should be placed on the areas of research which can give sustainability in improving the production programmes, plant protection and more so weed management.

– Most of the parasitic weed problems are highly specific to cropping systems in an area. Therefore, there is a need to develop the strategies need for cropping systems as an approach, for example agronomic practices including water management for control of perennial weeds, and developing practices for changing the microclimate with the use of various practices in a particular cropping system.

– Researches should focus mainly on developing models for weed crop association factors influencing the weed growth and strengthening the effect of biotic and abiotic stresses on floristic distribution of weeds and developing cost-effective technologies for sustained use and improving production.

– There is a strong need to develop an approach and practice for eco-friendly systems for weed management. Our future programmes of research on the role of herbicides in an environment purity should be considered.

– Feasible programmes are to be taken on biological control using pathogens, insects, micro-organisms and developing botanicals from various plants and using allelo chemicals.

– Herbicides shall remain one of the main methods tor weed management. No doubt, there is great change in the evolution of herbicides since fifties. Reduction of active materials in herbicides to 5-10 g/ha level itself is going to be one of the important factorin improving the eco-friendly behaviour of herbicides, but feasibility of their use has to be developed specially for the farmers in the developing countries.

– With the continuous use of herbicides, the problem of resistance of weeds to herbicide has been observed. There is need to develop appropriate research programmes in molecularbiology to work on genetic resistance and the metabolism of herbicide related with it.

– Management of weeds in non-cultivated areas should be adopted which includes management of weeds on roads, highways, airports, industrial installations, railways and places of aesthetic beauty. Not much work has been done in this direction. Efforts are needed as number of questions are coming up when the society is getting enlightened on weed problems in this area.

Authors' affiliations :

K.USHAKUMARI AND G. RISHITHA, College of Horticulture, (Dr.Y.S.R.H.U.) West Godavari, VENKATARAMANNAGUDEM (A.P.) INDIA

REFERENCES

Abbas, G., Arif, M. J., Ashfaq, M., Aslam, M. and Saeed, S. (2010). Host plants, distribution and overwintering of cotton mealy bug (Phenococussolenopsis : Hemiptera : Pseudococcidae). *Internat. J. Agric. Biol.,* **12** : 421-425.

Adams, M.J. and Antoniw, J.F. (2011). Descriptions of plant viruses. *Association of Applied Biologists,* Rothamsted Research, Harpenden, UK.

Agrios, G.N. (1997). *Plant pathology,* 4th Ed. San Diego: Academic Press. 635 p.

Agrios, G. N. (2004). Transmission of plant disease by insects. Pages 2290- 2317 In: Capinera, J.L. Ed. *Encyclopedia of Entomology. D*ordrecht: Kluwer Academic.

Alcantara, C., Pujadas, A. and Savedra, M . (2011). Management of Sinapis alba sub sp. mairei winter cover crops residues for summer wee control in southern spain. *Crop prot.,* **30** :1239-1244.

Al-Doghairi, M.A. and Cranshaw, W.S. (2004). The effect of interplanting of nectariferous plants on the population density and parasitism of cabbage plants. *Southwest. Entomol.,* **29** : 61-68.

Altieri, M. A. (1988). The dynamics of insect populations in crop systems subject to weed interference. pp. 433-451 *in E. A. Heinrichs, ed. Plant stress-insect interactions*. Wiley-Interscience, NEW YORK, U.S.A.

Altieri, M.A.,Vanschoonhoven, A. and Doll, J. (2009). The ecological role of weeds in insect pest management systems: *A Review Illustrated by Bean (Phaseolus vulgaris Cropping Systems,* pp. 195-205.

Anil Kumar, S., Bhatt, B. P., Deepak, S., Gade, R.M., Ajay Kumar, S. and Sangle, U. R. (2012). Good agronomic practices (*gap*) - An efficient and eco-friendly tool for sustainable management of plant diseases under changing climate scenario. *J. Plant Disease Sci.,* **7** : 1.

Arif , M. I., Rafiq, M. and Gaffar, A. (2009). Host plants of cotton mealy bug (Phenococussolenopsis): A new menace to cotton agroecosystems of Punjab, Pakisthan. *Internat. J. Agric. Biol.,***2** :163-167.

Banga, R. S., Yadav, A. and Malik, R. K. (1997). Crop rotation—an effective mean to control resistant *Phalaris minor* in wheat. *Farmer& Parliament,* **33**(3) : 16 -7.

Bhan, V. M. and Sushilkumar (1997). Integrated management of *Phalaris minor*in rice-wheat ecosystems in India. In : *Proceedings International Conference on Ecological Agriculture, 15-17* November 1997, at Chandigarh, India.

Bhan, V. M. and Sushilkumar (1998). Integrated management of *Phalaris minor* in rice-wheat ecosystems in India. In: *Proceedings International Conference on Ecological Agriculture,* 15-17 November, 1998.

Capinera, J. L. (2001). *Handbook of vegetable pests*. San Diego: Academic. 729 p.

Carruthers, R.I., Ramos, M.E., Larkin, T.S., Hostetter, D.L. and Soper, R.S. (1997). The Entomophagagrylli (Fresenius) Batko species complex: its biology, ecology, and use for biological control of pest grass-hoppers. *Mem. Entomol. Soc. Can.,* **171** : 329-353.

Chellemi, D. O., Funderburk, J. E. and Hall, D. W. (1994). Seasonal abun-dance of flower-inhabiting Frankliniella species (Thysanoptera: Thri-pidae) on wild food plant species. *Environ. Entomol.,* **23** : 337-342.

Cordo, H. A., DeLoach, C. J. and Ferrer, R. (1995). Host range of the Argentine root borer *Carmentahaematica* (Ureta) (Lepidoptera: Sesiidae), a potential biocontrol agent for snakeweeds (*Gutierrezia* spp.) in the United States. *Biol. Control,* **5** : 1-10.

Finch, S. and Collier, R. H. (2000). Host plant selection by insects-a theory based on 'appropriate inappropriate landings' by insects of cruciferous plants. *Entomol. Exp. Appl.,* **96** : 91-102.

Goeden, R.D. and Andres,L. A. (1999). Biological control of weeds in terrestrial and aquatic environments. Pages 871-890 in T. S. Bellows and T. W. Fisher, eds. *Handbook of biological control. San Diego: Academic.*

Hatcher, P.E. and Melander, B. (2003).Combining physical, cultural and biological methods: prospects for integrated non-chemical weed management strategies.*Weed Res.* ,**43** : 303-322.

Herzog, D. C. and Funderburk, J. E. (1986). Ecological bases for habitat management and pest cultural control. Pages 217-250 In: M. Kogan, Ed. *Ecological theory and integrated pest management practice.* Wiley-Interscience, NEW YORK, U.S.A.

Horton, D.R. and Capinera, J.L. (1990). Host utilization by Colorado potato beetle (Coleoptera: Chrysomelidae) in a potato/weed (*Solanumsarrachoidesendt*) system. *Can. Entomol.,* **122** : 113-121.

Hunter, W.B. (2004). Plant viruses and insects. Pages 1762-1768 In: Capinera, J.L. Ed. *Encyclopedia of Entomology*. Dordrecht: Kluwer Academic.

Jayanth, K. P., Visalakshi, P. N. G., Ghosh, S. K. and Choudhary, M. (1987). Feasibility of biological control *of Parthenium hysterophorus* by *Zygogramma bicolorata* in the light of controversy due to its feeding on sunflower. In : *Proceedings of First lnternational conference on Parthenium hysterophorus.* pp. 45- 50.

Jayanth, K.P. (1993). Ecological impact of insects introduced for biological control of weeds - Conflicting interests. *Curr. Sci.,* **65**: 901-4.

John, L.Capenaria (2005). Relationship between insect pests and weeds : An evolutionary perceptive. *Weed Sci.*,**53** : 892-901.

Judd, G.J.R. and Borden, J.H. (1992a). Influence of different habitats and mating on olfactory behaviour of onion flies seeking ovipositional hosts. *J. Chem. Ecol.,* **18** : 605-620.

Judd, G.J.R. and Borden, J. H. (1992b). Aggregatedoviposition in Delia antiqua (Meigen): A case for mediation by semiochemicals. *J. Chem. Ecol.,* **18** : 621-635.

Kauraw, L. P. (1996). Biological control of weed with pathogen. In: *Weed management:an important tool in imlproving the crop production. Training course Manual,* National Research Centre on Weed Science, 8-15 January 1996, Compendium: pp. 42-54.

Kennedy, J.S., Booth, C. O. and Kershaw, W.J.S. (1961). Host finding by aphids in the field. III. Visual attraction. *Ann. Appl. Biol.,* **49** : 1-21.

Kennedy, J. S. (1976). Host-plant finding by flying insects. Pages 121-123 In: *T. Jermy,* Ed. *The host-plant in relation to insect behaviour and reproduction. Plenum,* NEW YORK, U.S.A.

Kostal, V. and Finch, S. (1996). Preference of the cabbage root fly, *Delia radicum* (L.), for coloured traps: influence of sex and physiological status of the flies, trap background and experimental design. *Physiol. Entomol.,* **21** : 123-130.

Kucharek, T., Purcifull, D. and Hiebert, E. (1996). Viruses that have occurred naturally in agronomic and vegetable crops in Florida. Extension Plant Pathology Report no. 7, Plant Protection Pointers, University of Florida, Gainesville, FL. Available: *(http://edis.ifas.ufl.edu/pdffiles/PG/PG10100.pdf* **.**

Kumar, A.R.V. (1992). Is the Mexican beetle *Zygogramma bicolorata* (Coleoptera :Chrysomelidae) expanding its host range? *Curr. Sci.,* **63**(2) : 29-30.

Kumar, B., Yaduraju, N.T., Ahuja, K.N. and Prasad, D. (1993). Effect of silsolarization on weeds and nematodes under tropical Indian conditions. *Weed Res.*,**33** : 423-429.

Leo, E. Bendixen (1998). *Major weed hosts of Nematodes in crop production.* Special Circular, pp. 119.

MacRae, A. W. (2010). American black nightshade biology and control in fruiting vegetables, cucurbits, and small fruits. *Horticultural Sciences Department HS 1176*. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: *(http://edis.ifas.ufl.edu/hs1176).*

Metcalf, R.L. and Metcalf, R.A. (1993). *Destructive and useful insects; their habits and control*.5th Ed. McGraw-Hill, NEW YORK, U.S.A.

Moericke, V. (1969). Hostplant specific colour behaviour by *Hyalopterouspruni* (Aphididae) .*Entomol. Exp. Appl.,* **12** : 524-534.

Momol, T. and Pernezny, K. (2006). Florida plant disease management guide: Tomato. Plant Pathology Department PDMG-V3-53. *Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences*, University of Florida. Available: *http://edis.ifas.ufl.edu/pg059.*

Monga, D., Rishi kumar, V., Pal, V. and Jat, M.C. (2009). Mealy bug, a new pest of cotton crop in Haryana: A survey. *J. Insect Sci.,* **22** :100-103.

Mukhopadhyay, S. K. (1992). Emerging problems and advances in weed management. Presidential Address, Agriculture Section. *Indian Science Congress,* held at Baroda.

Myers, J.H. and Bazely, D.R. (2003). Ecology and control of introduced plants. Cambridge, Great Britain: *Cambridge University Press.* 313 pp.

Parker, C. and Fryer, J. D. (1975). Weed control problems causing major reduction in world food supplies. *FAO Plant Protection Bulletin*,23, Food and Agriculture Organisation, Rome.

Rao, A.N. and Shetty, S.V.R. (1976). Some biological aspects of intercropping system on crop weed balance. *Indian J. Weed Sci.,* **8** : 32-34.

Rao, A.N. and Shetty, S.V.R. (1981). Investigation on weed suppressing ability of smother cropping systems in relation to canopy development and light interception. In : *Proceedings of theEighth Asian Pacific Weed Science Society Conference,* held at Bangalore, during 22-29 November 1981, pp. 357-364.

Rao, V.S. (1983). *Principles of weed science.* Oxford & IBH Publishing Co., NEW DELHI, INDIA.

Rhainds, M., Kovach, J. , Dosa, E.L. and English-Loeb, G. (2001). Impact of reflective mulch on yield of strawberry plants and incidence of damage by tarnished plant bug (Heteroptera: Miridae). *J. Econ. Entomol.,* **94** :1477-1484.

Russell, E.P. (1989). Enemies' hypothesis: a review of the effect of vegeta-tional diversity on predatory insects and its parasitoids. *Environ. Entomol.,* **18** : 590-599.

Showler, A.T. and Greenberg, S. M. (2003). Effects of weeds on selected arthropod herbivore and natural enemy populations, and on cotton growth and yield. *Environ. Entomol.,* **32** : 39-50.

Singh, K., Pandita, M. L. and Thakral, K. K. (1993). Integrated weed management in vegetable crops. *In: Proceedings of Intemational Symposium on Integrated Weed Management for Sustainable Agriculture*. held at Hisar, during 18-20 November, 1993, **1** : 365-368.

Southwood, T.R.E. (1986). Plant surfaces and insects-An overview. Pages 1-22 In: B. Juniper and T.R.E. Southwood, Eds. *Insects and the plant surface*. Edward Arnold, LONDON, UNITED KINGDOM.

Sridhar, S. (1991). *A cure no more, under attack the sunflower crop.* Frontline, Madras, 9-22 November.

Stapleton, J. J. and Summers, C. G. (2002). Reflective mulches for manage-ment of aphids and aphid-borne virus diseases in late-season canta-loupe [*Cucumismelo* (L.) var. cantalupensis]. *Crop Prot.*, **21** : 891-898.

Stavinsky, J., Funderburk, J., Brodbeck, B. V., Olson, S. M. and An-dersen, P. C. (2002). Population dynamics of Frankliniella spp. and tomato spotted wilt incidence as influenced by cultural management tactics in tomato. *J. Econ. Entomol.,* **95**:1216-1221.

Summers, C.G. and Stapleton, J. J. (2002). Use of UV reflective mulch to delay the colonization and reduce the severity of Bemisiaargentifolii (Homoptera: Aleyrodidae) infestations in cucurbits. *Biol. Control,* **21**: 921-928.

Sunil, K., Singh, Uma, R. Khurma and Peter, J. Lockhart (2010). Weed hosts of root knot nematodes and their distribution in Fiji.Weed Technology pp. 607.

Sushilkumar (1993). Biological control of problematic weeds of forests and waste lands in India. *Annl Entomol.,***11**(2):77-97.

Sushilkumar and Bhan, V. M. (1996). Development and damage potential of *Zygogrammabicolorata,* introduced for parthenium control on another weed *Xanthium strumarium. J. Appl. Zoological Res.,* **6** (2): 120-121.

Thakur, M. L., Ahmad, M. and Thakur, R. K. (1992). Lantana weed. (*Lantana camaravar. aculeata* Linn.) and its possible management through natural insect pests in India. *Indian Forester,* **118** (7) : 466-88.

Tiwari, J. P., Kurchania, S. P. and Paradakar, N. R. (1995). Impact of· small canary grass dominated weed eco-system on wheat and effect of isoproturon on sustainable yield. In : *Proceedings of Biennial Conference Indian Society of Weed Science,* held at Annamalai during 9-10 February, Indian Society of Weed Science, pp. 34-45.