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WEED DYNAMICS IN RICE-WHEAT CROPPING SYSTEM

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Abstract

The rice-wheat cropping system is the most important agricultural production system in Indo Gangetic Plains in India. The productivity of this system is declining after 1990's. The weeds are the major problem in the productivity of this system. In rice-wheat cropping system, the menace of *Phalaris minor* in wheat has threatened the productivity of wheat crop. Yield losses especially from *Phalaris minor* alone are estimated from 25 to 50 per cent and, under very severe infestations, the losses may go up to 80 per cent. Rice crop management system supports the survival of *Phalaris. minor* seed in rice-wheat system. The major weeds in rice are *Echnichola* spp., *Digitaria sanguinalis*, *Commelina benghalensis*, *Celosia argentia*, *Cyperus rotundus*, *Cyperus iria* and *Cyperus rotundus* . Weeds in wheat show resistance to isoproturon and cross resistance to the other herbicides. The rate of resistance evolution depends on the soil seed bank dynamics and selection intensity, with selection intensity having the greatest impact. The study of the weed dynamic in rice-wheat cropping system helps the researchers and farmers to formulate the strategies for the control of weeds. In this chapter has discussed the impact of weeds, weed seed bank, various management practices for control of weeds. Weed dynamic can be controlled effectively by the conservation tillage which includes crop rotation, cover crops and reduced tillage.

Key words: Rice-wheat cropping system, weed dynamic, resistance, conservation tillage

Introduction

The rice-wheat cropping system (RWCS) is one of the most important agricultural production systems in the world owing to the large extent of area it occupies and the vast population it feeds. This system contributes 40 per cent of the rice and wheat production in the country. The productivity of rice-wheat system is decreasing due to emergence of multi-nutrient deficiencies and building up of soil pathogens and weed flora besides increasing soil health problems.

Weed control is a limiting factor in crop production (Buhler, 1992). Weeds are probably the most ever-present class of crop pests and on the odd occasion cause massive crop failures over vast areas. They reduce the crop yield and deteriorate the quality of produce and hence reduce the market value of the turn out (Arif *et al*., 2006). They use the soil fertility, available moisture and nutrients, compete for space and light with crop plants, which result in yield reduction (Khan *et al*., 2004). If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80 per cent (Karlen *et al*., 2002). In rice-wheat system, yield reduction in rice due to weeds has been reported to the extent of 45 per cent depending upon the soil type and rainfall pattern of a particular area (De Datta, 1981). Weed seed bank dynamics regulate communities of many of our most important weed species. A better understanding of the seed bank is critical for the development of more efficient weed management systems.

Weed seed bank

The weed seed bank is the reserve of viable weed seeds present on the soil surface and scattered in the soil profile. It consists of both new weed seeds recently shed and older seeds that have persisted in the soil for several years. The weed seed bank not only serves as a physical history of the past successes and failures of cropping systems, it can also help producers predict the degree to which crop-weed competition will affect crop yield and quality (Menalled, 2008).This guide us to describes the fate of weed seeds after being shed, explains how management decisions affect the weed seed bank, discusses the importance of minimizing inputs into the seed bank and provides weed seed bank management strategies.

Weed seeds after shedding

Weed seeds can reach the soil surface and become part of the soil seed bank through several avenues. The main source of weed seeds in the seed bank is from local matured weeds that set seed. Agricultural weed seeds can also enter a field by animals, wind, water and human activities, like cultivation and harvesting. How far weed seeds can travel depends on the dispersal process and the weed species (Fig. 1).

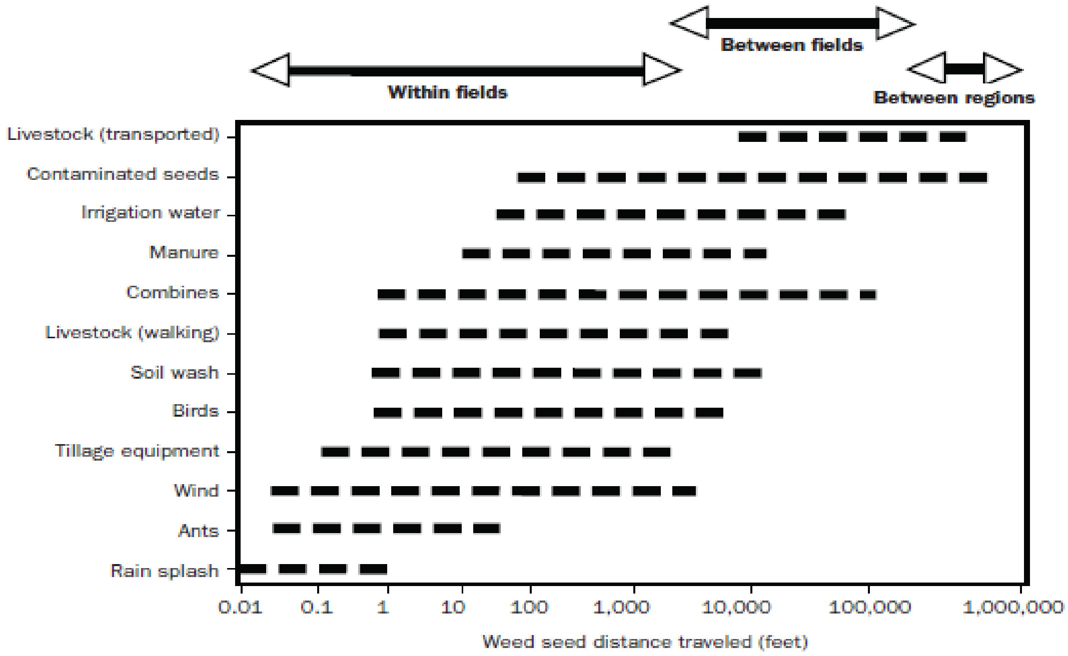
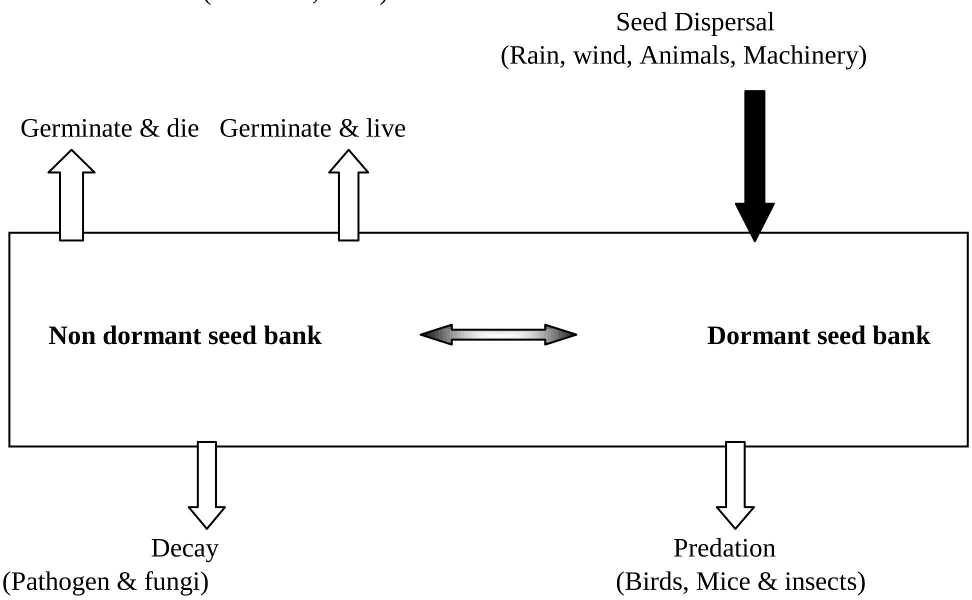


Fig1. Agricultural weeds can travel over a long distance, depending upon the method of transportation and weed species. Adapted from Mohler (2001)

Understanding the importance of these dispersal mechanisms is vital in the development of preventive weed management strategies. Weed seeds can have numerous fates after they are dispersed into a field (Fig. 2). While a few of these weed seeds will germinate, emerge, grow and produce more seeds, a large proportion of them will germinate and die (also known as fatal germination), decay in the soil, or fall to predation by insects, birds or mammals. Many weed seeds will remain dormant in the soil and not germinate under any set of environmental conditions. When a weed seed is dormant it will not germinate regardless of the environmental condition. This dormancy state is not permanent and weed seeds can change from a state of dormancy to non-dormancy, where they can germinate over a wide range of environmental conditions (Menalled, 2008).



Source: Menalled (2008)

Figure 2. Fate of weed seeds. Input in the seed bank are shown with black arrows and losses with white arrows

Affect of management practices weed seed distribution in the soil profile

Weed seeds disperse both horizontally and vertically in the soil profile. While the horizontal distribution of weed seeds in the seed bank generally follows the direction of crop rows, type of tillage is the main factor determining the vertical distribution of weed seeds within the soil profile. In plowed fields, the majority of weed seeds are buried four to six inches below the surface (Fig.3).

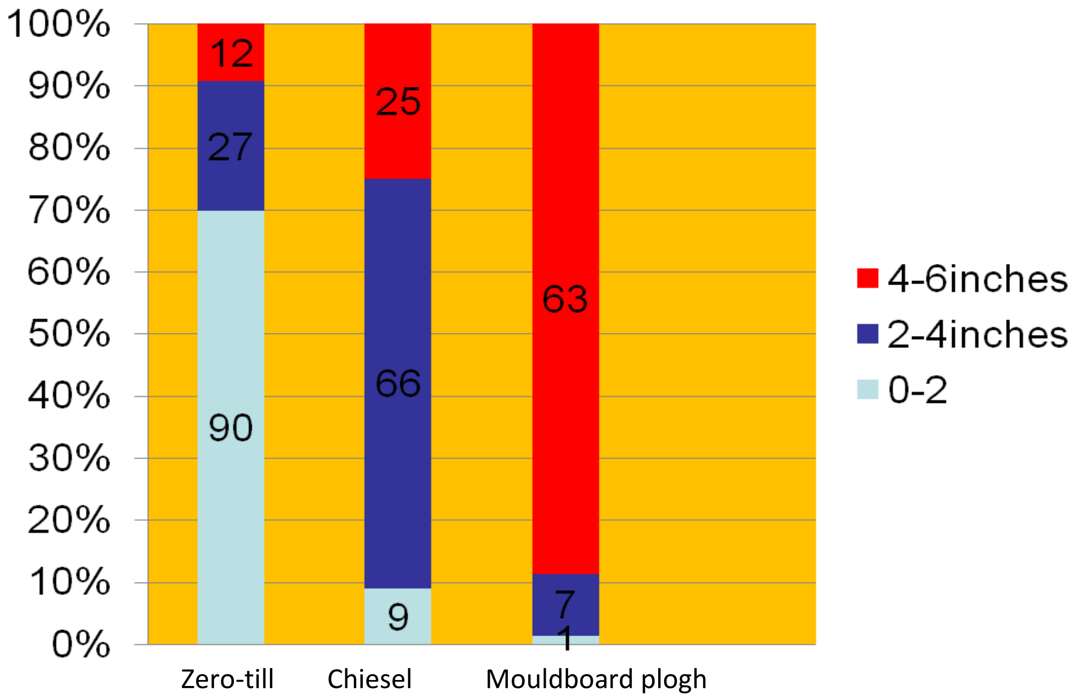


Fig 3: vertical distribution of weed seeds in different Sowing methods at different soil depths (Clements *et al.*, 1996)

Under reduced tillage systems such as chisel plowing, approximately 80 to 90 percent of the weed seeds are distributed in the top four inches of the soil profile. In no-till fields, the majority of weed seeds remain at or near the soil surface. Although very few studies have assessed the affect of tillage systems on the vertical distribution of weed seeds in different soil types, evidence exists that soil characteristics influence weed seed distribution (Clements *et al.*, 1996).

Status of rice-wheat cropping system

Rice and wheat are the staple food crops, which have become the integral part of human diet of 800 million people in South-East Asia. The system spans four countries in the Indo-Gangetic Plains (IGP) region, Bangladesh, India, Nepal, and Pakistan, and occupies about 13.5 million ha. It accounts for about one-third of the area of both rice and wheat grown in South Asia, and it produces staple grains for more than 1 billion people, or about 20 per cent of the world's population. There are both favorable irrigated areas with high productivity in the western parts and not so favorable rainfed areas with low productivity in the eastern parts (Ladha *et al.*, 2000). Sources of irrigation include both river canals and tubewells.In the northwest parts of the IGP, the RWCS is highly mechanized, input-intensive, and dependent on conjunctive use of surface water and groundwater. In contrast, in the eastern IGP, it is less mechanized, low-input based, and prone to problems of poor drainage and rainwater management .In this system, rice is grown in the *kharif* (wet) season, followed by wheat in the *rabi* (dry) season. The adoption of Green Revolution technologies in the 1960s and 1970s increased yield significantly. Thereafter, the growth rates have declined, giving rise to concern that future production increases may not keep pace with the population that will continue to expand. However, researchers started questioning the sustainability of the rice-wheat system in the light of slowing yield growth and degradation of the resource base (Ladha *et al.*, 2003).

This system provide employment, live hood and income for 700 million people of India. The rice-wheat cropping system fulfills 80 per cent of food requirement and 60 per cent of the nutrition requirement of Indian population(Gill *et al.*,2008).Indo-Gangetic plains contribute major portion in the productivity of rice and wheat. Out of total rice and wheat production in India, 42 per cent comes from IGP comprising Punjab, Haryana, Uttar Pradesh, Bihar and west Bengal. The productivity data indicates an increasing trend for the period 1958-1998, but a decreasing and stagnating trend afterward(Gupta *et al.*, 2003).However, we need to maintain the food security for 1.3 billion people by 2010 AD. In order to meet the food needs of approximately 1.3 billion people in South Asia, rice and wheat contribute nearly 70-95 per cent of calorie intake. The visible concerns in rice-wheat system which require immediate attention are the decreasing inherent fertility of the soil, depletion of water table and increasing biotic stresses.

In rice-wheat cropping system, the menace of *Phalaris minor* in wheat has threatened the productivity of wheat crop. Yield losses especially from *Phalaris minor* alone are estimated from 25 to 50 per cent and, under very severe infestations, the losses may go up to 80 per cent (Malik *et al.*, 1995). Isoproturon worked very well for many years and was used almost exclusively; however, its efficacy has fallen with the development of resistance in *Phalaris minor.* The phenomena of development of resistance in *Phalaris minor* to isoproturon have been established by many scientists in Haryana (Malik and Singh 1993) and Punjab (Walia *et al.*, 1997). The resistant biotypes of this weed required 2-8 times more of isoproturon compared to susceptible biotypes for the same level of control. *Phalaris minor*. Though alternate herbicides, namely, clodinafop, sulfosulfuron and fenoxaprop-p-ethyl are providing effective control of isoproturon resistant *Phalaris minor*, however, the increased dose requirement of diclofopmethyl (Malik and Singh, 1995) and fenoxaprop-ethyl (Yadav *et al.,* 2001) for resistant biotypes compared to susceptible biotypes has been reported. Three new herbicides (sulfosulfuron, clodinafop and fenoxaprop) have been recommended for the control of isoproturon-resistant biotypes of *Phalaris minor* in rice-wheat system. Now the cases of cross-resistance against these herbicides particularly clodinafop after its continuous use have been reported from the farmers in the rice-wheat belt. Rice crop management system supports the survival of *Phalaris. minor* seed in rice-wheat system. The major weeds in rice are *Echnichola* spp., *Digitaria sanguinalis, Commelina benghalensis, Celosia argentia, Cyperus rotundus, Cyperus iria* and *Cyperus rotundus* (Singh and Singh, 1996).

The succulent green crop with the liberal use of nitrogenous fertilizers and constant humid microenvironment in both the crops (rice and wheat) renders susceptibility to insect-pests and diseases. Generally the farmers tend to act on the advice of local dealers which adds to the complexity of the problem. Sheath blight, which was considered as a minor disease in rice, has been emerging as a major disease in both scented and non-scented varieties after 2005. Due to the increase in area under hybrids and other susceptible varieties, the incidence of false smut is on the rise. Incidence of Bakane, blast and bacterial leaf blight are other threats to the productivity of rice cultures. Earlier the incidence of stem borer was sporadic in nature which now is causing constant problem to rice growers not only in scented but other varieties also. Leaf folder and white backed plant hopper are the other major insects in rice crop which require special attention. Aphid in wheat is likely to be a regular pest in the years to come. Powdery mildew and rusts may be the yield limiting factors in wheat.

Shifting of weed flora in rice-wheat cropping system

Weed flora of this intensified cropping system is dominant with the annual weeds. Now a day's weed management has been associated with second generation problems. In the early 1990's the menace of *Phalaris minor* has increased in rice-wheat cropping system and has threatened the productivity of wheat crop. Continuous use of urea based herbicides for more than a decade has resulted in the evolution of resistant biotypes of *Phalaris minor* (Malik *et al*., 1995; Walia *et al*., 1997), now the situation is under control but the problem of cross resistance is emerging. Three new herbicides (sulfosulfuron, clodinafop and fenoxaprop) have been recommended for the control of isoproturon-resistant biotypes of *Phalaris minor* in rice-wheat system. Now the cases of cross-resistance against these herbicides particularly clodinafop after its continuous use have been reported from the farmers in the rice-wheat belt. Rice crop management system supports the survival of *P. minor* seed in rice-wheat system. New emerging weeds like *Sphenoclea zeylanica* in rice and *Rumex retroflexus* and *Malva parviflora* in wheat may be the likely menace of future in rice-wheat system.

Management practice for control of weed seed bank in rice- wheat system

Weed communities present within agricultural fields are the end results of the interaction of agronomic, environmental, and ecological selection pressures. The management of these factors and the potential for the introduction of new species are the determinants of community composition (Derksen *et al.*, 1996). Ideal weed control in sustainable agriculture will be that which can increase species diversity, yet maintain weed biomass below a critical threshold against crop growth and yield (Miyazawa *et al.,* 2004). For the resistance to evolve genetic variation for the resistance trait must exist within a population and selection events must take place. The rate of resistance evolution depends on the soil seed bank dynamics and selection intensity, with selection intensity having the greatest impact. Considering the component of selection intensity, the majority of sites where herbicide resistance to *Phalaris minor* has developed are characterized by the practices that imposed high selection pressures. These practices include:

Seed longevity

While burying weed seeds by tilling increases the longevity of the seeds in the seed bank, leaving weed seeds on the soil surface exposes them to predation, reducing their abundance in the seed bank.

Table 1: Number of years required for 50 and 99 percent reduction in seed number in the seed bank of ten common agricultural weeds

Name of weed	Years required for 50 % reduction	Years required for 99 % reduction
Common lambsquarters (*Chenopodium album*)	12	78
Field pennycress (*Thlaspi arvense*)	6	38
Common cocklebur (*Xanthium strumarium*)	6	37
Yellow foxtail (*Setaria glauca*)	5	30
Prostrate knotweed (*Polygonum aviculare*)	4	30
Shepherd's purse (*Capsella bursa-pastoris*)	3	11
Giant foxtail (*Setaria faberi*)	less than 1	5
Common sunflower (*Helianthus annuus*)	less than ½	2
Kochia (*Kochia scoparia*)	less than ½	2

Source: Davis *et al*., (2005)

Rotation

Rotation can cause a shift in weed species composition. Knowledge of theses shifts can help in changing the composition of the weed seed bank from undesirable to easy-to-manage species. Singh *et al.*, (2008) studied that when rice-wheat cropping system is changed, there is reduction in weed density and weed dry matter production. Rice-wheat-greengram sequence recorded lowest population of all the three groups of weeds followed by rice-wheat, rice-chickpea and rice-pea sequence. (Table2)

Table2: Density of grasses, sedges and broad-leaved weeds and weed dry matter accumulation in rice at 25 DAT under different crop sequence

Crop sequence	Grasses		Sedges		Broad-leaved weeds (No./m^2)		Weed dry matter production (g/m^2)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Rice-wheat	7.44 (56.5)	6.80 (6.80)	5.06 (25.5)	4.43 (20.8)	5.25 (28)	4.10 (16.8)	6.12 (37.3)	4.37 (18.7)
Rice-chickpea	5.77 (35.5)	5.13 (29.0)	4.72 (22.0)	4.17 (18.5)	4.07 (16.5)	3.03 (10.5)	5.78 (33.9)	4.08 (16.6)
Rice-wheat-green gram	3.29 (13.8)	2.18 (6.0)	2.44 (9.5)	1.97 (5.0)	1.93 (5.5)	1.14 (1.0)	3.15 (10.8)	3.09 (9.1)
Rice-wheat-*Sesbania* (GM)	4.19 (20.5)	2.93 (14.3)	3.78 (14.8)	3.36 (11.3)	3.62 (13.5)	2.01 (5.3)	4.75 (25.0)	3.77 (13.8)
Rice-mustard-green gram	4.32 (20.5)	3.04 (11.8)	3.36 (12.8)	2.44 (7.0)	3.00 (10.8)	2.00 (3.5)	4.27 (18.4)	3.72 (13.5)
Rice-Lentil-Cowpea (F)	3.75 (16.8)	3.29 (14.5)	3.06 (10.8)	2.33 (6.0)	2.58 (7.8)	1.28 (1.5)	3.80 (14.6)	3.52 (12.1)
Rice-pea	5.85 (34.8)	5.42 (29.5)	4.41 (22.0)	4.29 (19.3)	4.14 (19.8)	3.36 (13.5)	5.83 (35.0)	4.26 (17.9)
Rice-lentil-Mustard (3:1)-cowpea	4.34 (19.8)	3.12 (14.5)	3.30 (15.5)	2.79 (7.5)	2.90 (9.8)	1.76 (3.0)	4.17 (17.5)	3.60 (12.8)
Rice-Maize + pea (1:1) - cowpea	4.68 (22.0)	3.71 (16.8)	3.54 (16.3)	2.78 (8.8)	3.75 (14.8)	2.56 (7.3)	5.08 (25.7)	3.84 (14.3)
Rice-potato-green gram	3.97 (18.0)	2.38 (7.0)	3.70 (14)	2.48 (6.8)	2.84 (8.3)	1.40 (1.5)	4.08 (16.9)	3.52 (12.2)
S.Em-$^+$ LSD(p=0.05)	0.80 2.32	0.99 2.87	- NS	0.58 1.69	- NS	0.53 1.53	0.58 1.69	0.24 0.71

Source: Singh *et al.*, (2008)

Similarly in wheat crop rotation has been cited extensively as an effective method of *Phalaris minor* management because selection pressure is diversified by changing patterns of disturbances. Diversification of the area under rice-wheat cropping system will not only bring changes in weed spectrum but will also create soil conditions unfavorable for *Phalaris minor*. Replacing wheat with alternate crops like berseem, potato, sunflower, gobhi sarson for 2-3 years in rice-wheat cropping system, the population of *P. minor* was found to be reduced significantly (Table 3).

Table 3. Status of seed bank of *Phalaris minor* in different crop rotations in Kapurthala and Patiala districts.

Treatments	No. of seeds 100g of soil/plot			
	0-7.5 cm		7.5 to 15.0 cm	
	Kapurthala	Patiala	Kapurthala	Patiala
Rice-wheat	4.0	3.0	1.8	1
Rice-potato-sunflower/wheat	0.7	0	0.3	0
Rice-toria-sunflower	0	-	0	-
Rice-berseem	0	0	0	0
Rice-gobhi sarson	0.5	-	0	-
Rice-onion-wheat	-	0	-	0

Source: Brar *et al.*, (2002)

Use of new alternative herbicides

The rotation of herbicides with different modes of action may be important in avoiding the evolution of resistance. Three new herbicides, namely, clodinafop, sulfosulfuron and fenoxaprop-p-ethyl have shown promising results in controlling isoproturon resistant biotypes of *P. minor* (Table 4)

Table 4. Dry matter accumulation by different biotypes of *Phalaris minor* (g/pot)

Biotype	Average	Isoproturon	Tralkoxdim	Fenoxaprop -p-ethyl	Clodinafop	Sulfosulfuron	Control	Mean
Escape of	-	0.94kg/ha	0.35kg/ha	-	0.06kg/ha	0.025kg/ha	-	-
Clodinafop	4	6.1	3.6	2.2	1.4	1.8	6.5	3.6
Fenoxaprop -p-ethyl	4	4.3	3.2	3.8	1.4	1.5	6.2	3.4
Sulfosulfuron	13	4.6	3.2	1.9	2.0	1.4	5.9	3.2
Tralkoxdim	2	7.3	3.5	1.8	1.2	1.2	7.6	3.8
Diclofop	2	5.4	3.5	2.3	1.6	1.6	6.2	3.4
Isoproturon	5	4.2	3.3	2.0	1.4	1.0	5.5	2.9
Mean	-	5.3	3.3	2.3	1.5	1.4	6.3	-

C. D. (P=0.05) for escapes 0.32 Weed control treatments 0.32 Interaction 0.77
Source: Brar *et al.,* (2002)

Tillage levels

Tillage affects weed management, weed seed production and pattern of soil disturbances. *P. minor,* which germinates from upper soil layers, can be buried by deep ploughing. Zero tillage technique integrated with timely planting of wheat (October sowing) has shown promising results in reducing *P. minor* infestation and higher grain yields.

Crop genotypes with high smothering potential

Differences between cultivars in competitiveness with weeds have been shown to exist in different cereal species. The tall varieties have more potential to compete with weeds but these tend to produce lower yields and are susceptible to lodging. In addition to plant height, other plant attributes that improve early ground cover also contribute to competitiveness to the weeds. Long duration varieties like PBW 343, WH 542 and PBW 34 due to their fast growing habits suppress the growth and development of *P.minor.*

Increased crop density

The role of increasing crop density in reducing competitiveness and seed output by weeds has been reported in several studies. However, there is not much scope of increasing plant density than the already adopted densities (2000 plants/m2) in wheat and 33 hills per square meter in rice in India.

Sowing time

The sowing time of crop should be adjusted so that it is maximum favorable for crop growth and development and least favorable for weed germination and growth e.g. to control *P. minor* in wheat. The sowing of wheat is preferred between 25 October to 10 November, when temperature is still high for *P. minor* germination and when *P. minor* germinates the crop has established and it poses great competition to weeds. However, length of delayed sowing of improved weed management has to be offset against reduced yield due to shortened growing season.

Planting pattern

Manipulating method of sowing to get even dense canopy also helps to control weeds by causing shading effects on weeds due to overcrowding e.g. bi-directional sowing in wheat gives less weeds as compared to unidirectional sowing although seed rate is same. It has been revealed that the crops planted closely (15.0 cm) resulted in significant increase in grain yield of wheat as compared to normal spacing of 22.5 cm because of the dense canopy cover which smothered the weed growth by reducing the dry matter production of *P. minor* by 15.2 per cent.

Impact of tillage in weed management

There are several objectives of tillage, of which, the most important ones are: suitable seed-bed preparation, weed control, and soil and water conservation, improvement of soil structure, soil permeability, soil aeration, root penetration, destruction of pests, soil inversion etc. Weed control is an important object of tillage. Tillage reduces or eliminates weed competition for moisture, nutrients, light, and CO2 in the micro-environment, and thereby improves crop growth. Tillage may induce the germination of weed seeds which can then be destroyed by subsequent tillage or chemical treatment to impoverish the population of weed seeds in the soil. Tillage may also prevent weed seed germination by the burial effects on seeds. Tillage physically alters the weed relationship with the soil. It may destroy weed seedlings by uprooting, smothering, desiccating, decomposing or merely weakening weed plants through dislodging, damaging, disorienting, depleting food reserves, root pruning or other injury. Conservation agriculture includes reduced tillage, zero tillage, mulches and cover crops etc. Conservation agriculture employs all modern technologies that enhance the quality and ecological integrity of the soil, but the application of these is tempered with traditional knowledge of soil husbandry gained from generations of successful farmers. Conservation agriculture promotes minimal disturbance of the soil by tillage (zero tillage), balanced application of chemical inputs (only as required for improved soil quality and healthy crop and animal production), and careful management of residues and wastes.

Weed seed bank dynamics and CT

The tillage systems disturb the vertical distribution of weed seeds in the soil in different ways. Studies found that mould board ploughing buries most weed seeds in the tillage layer, whereas chisel ploughing leaves most of the weed seeds closer to the soil surface. Similarly in reduced or no till systems 60 to 90 per cent of the weed seeds are located in the top 2 inches of the soil. In term of the level of soil disturbance, tillage systems can be ranked as: ZT< chisel plough< mould board plough. Understanding the impact of management practices on the vertical distribution of seeds is important as it can help us predict weed emergence patterns. Size and composition of the seed bank as well as aboveground weed flora reflect past and present weed, crop, and soil management (Roberts and Neilson, 1981). Reducing the size of the weed seed bank has been a long-term goal of weed management strategies, especially for fields cropped continuously (Schweitzer and Zimdahl, 1984). Conservation tillage is one of the most important changes that have taken place in the development of sustainable agriculture systems (Swanton et al., 1999; Tanner, 1999). Changes in tillage practices can affect weed population dynamics, including weed seed distribution and abundance in the soil (Mulugeta and Stoltenberg, 2001). Conventional tillage brings weed seeds to the surface where they can germinate and be desiccated by additional tillage (Akobundu, 1987). Weed seed depth in the soil influences germination and seedling development. Seed at or just below the soil surface often germinate more than seed buried deeper in the soil. Weed species with long dormancy are favored by plowing. Seed buried deep in the soil also take longer to emerge and develop seedling characteristics than seed placed shallow (Mester and Buhler, 1991).

For example, in most soils small-seeded weeds such as kochia, Canada thistle and common lambs quarters germinate at very shallow depths (less than ½ inch). Large seeded weeds such as common sunflower have more seed reserves and may germinate from deeper depths.

Shift in weed population from annual to perennials have been observed in the CT. This may be due to lack of disturbance of the root system and may encourage theses perennials reproductive structures by not burying them to depths that are unfavorable to emergence or by failing to uproot and kill them. Weed species and aerial mass are lowest under conventional tillage (Menalled *et al.*, 2001). Reduced tillage seems to favor occurrence of perennial weeds (Gill, Arshad, 1995). The perennial species, sow thistle (*Sonchus* L.) and quack grass (*Elymus repens* L.) have been associated with conventional and reduced tillage systems and have increased in zero-tillage (Derksen *et al.*, 2002). The infestation of couch grass (*Elymus repens* L.) in reduced tillage is often so severe that chemical control with glyphosate is needed (Vanhala and Pietola, 2003).

Tillage systems not only influence the total recruitment of a weed species, they can also influence the periodicity of weed emergence. Dormancy and hard seed generally require physical or chemical scarification or weathering in the soil to enhance germination. Dormancy in some weed species, such as wild radish, is largely due to pod surrounding the seeds. Seeds of some species, such as *Malva parviflora* L. have a hard seed coat that needs to be scarified to stimulate germination. Therefore any mechanism that can increase pod breakdown will result in an increase in germination and emergence in these types of seeds.

In CT systems the presence of residue on the soil surface may influence soil temperature and moisture regimes that affect weed seed germination and emergence patterns by altering the environment surrounding the seeds over the growing season. However weed response to residue depends on the quantity, position and allelopathic potential of the residue and the biology of the weed species. Emergence of many weeds can be suppressed if mulches are left on the soil surface. Also decaying residues can immobilize large amounts of nitrogen, resulting in low nitrate content in the soil, which could prevent alleviation of dormancy of species. Generally through, weed emergence decreases if the system buries surface seed deeper in the soil. Different types of tillage equipments leave weed seeds at different depths and this differential distribution of the seed in the soil profile has the potential to change seedling recruitment and weed population dynamics. Similarly germination of different weed species show response to light and darkness. Exposure to light breaks dormancy and eventually increases germination in many species. Generally small seeded species are found to be more sensitive to light than large seeded ones. Eliminating light penetration during tillage can help in reduction of emergence of buried light sensitive species.

Table 5.Effect of different tillage and residue management practices on barley-rice cropping systems under dry land agro-ecosystem

Treatment	Barley			Rice		
	Grain yield (t/ha)	Weed dry weight (t/ha)	Available N (µg/g soil)	Grain yield (t/ha)	Weed dry weight (t/ha)	Available N (µg/g soil)
Conventional tillage without residue	1.40	2.22	12.6	0.92	1.90	11.6
Conventional tillage with residue	1.98	2.31	14.9	1.13	1.80	14.4
Minimum tillage without residue	1.67	2.38	12.6	0.92	1.76	13.5
Minimum tillage with residue	2.17	2.30	15.6	1.17	1.61	16.6
Zero tillage without residue	0.64	4.11	7.8	0.67	3.16	7.8
Zero tillage with residue	1.00	2.35	8.2	0.76	2.85	9.6

Source: Experimental Agriculture, 2005

The effects of zero, minimum (reduced) and conventional tillage were evaluated in barley-rice cropping system under dry land ecosystem. These practices influenced weed growth and available soil N, leading to variable crop productivity. The yields of both crops decreased under no tillage but remained more or less unaffected under minimum and conventional tillage. Residue management increased N availability under all tillage practices and gave higher productivity than without residue. There was no effect of residue on weed growth under minimum and conventional tillage, but had a marked influence under zero tillage conditions.

Table 6: Effect of tillage and weed management on weed growth and grain yield of wheat at Karnal

Tillage	Weed growth (g/m^2)		Grain yield (t/ha)	
	Control	Metribuzin	Control	Metribuzin
Surface seeding	397.0	69.5	2.88	3.08
Zero tillage	288.0	37.8	3.97	5.09
Rotary tillage	201.8	25.2	4.70	5.67
Conventional tillage	257.2	28.3	4.64	5.09
FIRBS (3 rows)	277.5	12.8	4.89	5.52
Reduced tillage	393.8	49.8	4.31	5.13
CD (p=0.05)	61.4		0.22	

Source: Experimental Agriculture, 2005

There are indications of some negative impact of zero tillage technology like increase in soil density, reduced infiltration rate and pore space, increased incidence of broad-leaved weeds *(Rumex* spp., *Malva* spp.), grasses (wild oat) and perennials *(Cynodon dactylon, Paspalum distichum)* and damage of wheat seedlings by pink stem borer of rice. Higher crop residues sometimes interfere in sowing. The seedling establishment in zero tillage is 20 per cent less than in conventional methods. Under such conditions, it is necessary to ensure optimum soil moisture at sowing, use 20-30 per cent more seed and fertilizer, and adopt suitable herbicide for weed control for realizing optimum productivity (Table 6).

Walia and Brar (2006) reported that the zero till wheat crop sown after direct seeded rice recorded significantly higher dry matter accumulation by *Phalaris minor* as compared to conventionally sown wheat. Similarly Brar and Walia (2007) conducted a field survey during 2004-05 and 2005-06 in the three districts of Punjab i.e. Patiala, Sangurur and Moga with the objective to study the shift in weed flora in wheat in relation to the different tillage practices. Thirteen weed species were found infesting wheat fields and of theses, *Phalaris minor, polypogan monspeliensis, Poa annua, Rumex dentatus, Medicago denticulate, Anagallis arvensis and Malva nelgecta were most common.* Slightly higher population of broadleaf weeds was observed in zero tillage as compare to the conventional methods while adverse trend was seen in case of broadleaf weeds (Table 7)

Table7. Effect of tillage systems on weed population and weed dry weight in wheat.

Treatments	Population (No./m^2)				Dry weight (g/m^2)			
Districts	Grass weeds 04-05	05-06	Broadleaf weeds 04-05	05-06	Grass weeds 04-05	05-06	Broadleaf weeds 04-05	05-06
Patiala	7.25*	6.89	5.31	4.89*	20.66*	19.42	24.91*	18.78
ZT	8.69	7.89	4.45	4.00	25.66	21.78	18.88	16.26
CT								
Sangrur								
ZT	11.55	12.41	8.41*	7.39*	26.70*	29.01	35.16*	33.74*
CT	13.91	14.35	6.75	6.08	32.82	34.25	29.05	27.91
Moga								
ZT	6.76	11.62	3.43*	9.57	18.43	27.98*	15.96*	38.32*
CT	7.38	13.42	2.62	8.24	21.78	33.81	12.06	32.25
Combined data of three districts								
ZT	8.68	10.34	5.80*	7.40	22.12*	25.54	25.54*	30.80*
CT	10.17	11.93	4.69	6.25	26.92	30.07	20.24	25.62

Source: Brar and Walia (2007)

Arif *et al.*,(2007) in maize noted that the major were *Cyperus rotundus*, *Cynodon dactylon*,*Chenopodium album*, *Echinochloa crus-galli* and *Cucumis prophetarum* and were sorted into groups according to their life cycle. Annual weeds did not show dependable response to tillage system except *E. colonum* which decreased with increase in tillage intensity. These results agree with Bostrom and Fogelfors (1999) who reported that soil disturbance has limited influence on the summer annual weeds. Among the perennial weeds, the density of *C. dactylon* decreased with increase in tillage intensity while *C. rotundus* showed inconsistent response to tillage intensity. Many researchers stated that reduced tillage system increases perennial weed densities and diversity (Gill and Arshad, 1995).

Conclusion

The findings of the various studies clearly indicated the weed stress on the productivity of rice-wheat cropping system. Out of the various management practices, the conservation tillage may have positive effect on the suppression of weeds in wheat. By understanding the nature of weed seed bank, various methods of integrated weed control should be formulated. The adoption of recommended agronomic practices, understanding the nature of the weeds and conservation agriculture can help the farmers to obtain the maximum productivity of rice-wheat cropping system.

References

Akobundu, I.O. (1987). *Weed Science in the Tropics: Principles and Practices***.** John Wiley and Sons. 522 p.

Arif Muhammad, Fazal Munsif, Muhammad Waqas, Ibni Amin Khalil & Kawsar Ali. (2007). Effect of tillage on weeds and economics of Fodder maize production. *Pak. J. Weed Sci. Res. 13(3-4): 167-175, 2007*

Arif, M., Khan, M.A., Akbar, H. Sajjad & Ali, S. (2006). Prospects of wheat as a dual purpose crop and its impact on weeds. Pak. *J.Weed Sci. Res*. 12(1-2):13-17.

Bostrom, U. & Fogelfors, H. (1999). Type and time of autumn tillage with and without herbicides at reduced rates in southern Sweden. Weed flora and diversity. *Soil Tillage Res.* 50:283– 293.

Brar, A. S. & Walia, U. S. (2009). weed dynamics and wheat (*Triticum aestivum* l.) productivity as influenced by planting techniques and weed control practices. *Indian J. Weed Sci.* **41** (3 & 4) : 161-166 (2009)

Brar, L. S. (2002). *Current Status of Herbicide Resistance in Punjab and its Management Strategies*. Paper presented in International Workshop on Herbicide Resistance Management & Zero Tillage in Rice-Wheat Cropping System. March 4-6, 2002, Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004, India..pp- 12-16

Buhler, C.D. (1992). Population dynamics and control of annual weeds in corn as influenced by tillage systems. Weed Sci. 40:241-248.

Clements, D.R., Benoit, D.L. & Swanton, C.J. (1996). *Tillage effects on weed seed return and seedbank composition*. Weed Science 44: 314-322.

Davis, A., Renner, K. A., Sprague, C., Dyer, L. & Mutch, D. (2005). *Management "One Year's seeding*" Extension Bulletin E-2931. East Lansing, MI. Michigan State University.

De Datta, S.K. (1981). *Principles and practices of rice production.* John Willey and sons, New York. pp 618.

Derksen, D. A., Anderson, R. L. & Blackshaw, R. E. (2002). Weed Dynamics and Management Strategies for Cropping Systems in the Northern Great Plains. *Agronomy Journal* 94: 174-185

Derksen, D. A., Blackshaw, R. E. & Boyetchko, S. M. (1996). Sustainability, conservation tillage and weeds in Canada. *Canadian Journal of Plant Science* 76: 651-659

Feldman, S.R., Alzugaray, C., Torres, P.S. & Lewis, P. (1998). Gap colonization by weeds in a wheat crop grown under different cultivation regimes. *Weed Res.* 38: 35-45.

Gill, K. S. & Arshad M. A. (1995). Weed flora in the early growth period of spring crops under conventional, reduced, and zero tillage systems on a clay soil in northern Alberta, Canada *Soil Tillage Research* 33: 65-79

Gill, M. S., Pal, S. S. & Ahlawat, I.P.S. (2008). Approaches for sustainability of rice (*Oryza sativa*)- wheat(*Triticum aestivum*) cropping system in Indo-Gangetic plains of India- A review. *Indian journal of Agronomy* 53 (2): 81-96(June 2008)

Gill, K.S. & Arshad, M. A.. (1995). Weed flora in the early growth period of spring crops under conventional, reduced and zero tillage systems on a clay soil in northern Alberta. *Canada. Soil Till. Res*. 33:65-79.

Gupta, R. K., Naresh, R. K, Hobbs, P.R., Jiaguo Jheng & Ladha, J. K. (2003). Sustainability of Post green revolution Agriculture: The Rice-Wheat cropping systems of the Indo Gangetic Plains and China. In: Ladha J K *et at* (Eds.). Improving the productivity and sustainability of rice-wheat cropping systems: Issues and impact. ASA, Spec. Publ. 65. ASA Madison, WI pp125.

Karlen, L.D., Buhler, D.D. Ellusbury, M. M. & Andrew,s S.S. (2002). Soil, weeds and insect management strategies for sustainable agriculture. *J. Biol. Sci.* 2(1):58-62.

Khan, I., Hassan,G., Khan, M. I. & Khan, I. A. (2004). Efficacy of some new herbicidal molecules on grassy and broadleaf weeds in wheat-II. Pak. *J. Weed Sci. Res.* 10(1-2):33-38

Ladha, J..K., Fischer, K.. S., Hossain, M., Hobbs, P. R. & Hardy, B. (2000). Progress towards improving the productivity and sustainability of rice-wheat systems: a contribution by the consortium members.IRRI Discussion Paper No. 40.

Malik, R. K. & Singh, S. (1993). *Evolving strategies for herbicide use in wheat : resistance and integrated weed management.* Proc. International Symposium on Integrated Weed Management for Sustainable Agriculture, 18-20 Nov. Department of Agronomy,

Malik, R. K. & Singh, S. (1995). Little seed canary grass (*Phalaris minor* Retz.) resistance to isoproturon in India. *WeedTechnol.* **9** : 419-425.

Malik, R. K., Yadav, A., Garg, V. K., Balyan, Y. S., Malik, R. S., Singh, S. & Dhawan, R.(1995). *Herbicide resistance-wheat status and research findings*. Extn.Bull., CCS Haryana Agricultural University, Hisar,India.37 pp.

Menalled, F. (2008). *Integrated Strategies for Managing Agricultural Weeds: Making Dropping Systems Less Susceptible to Weed Colonization and Establishment*. MSU Extension Mont Guide (MT200808 AG)New7/2008.

Menalled, F. D., Gross, K. L. & Hammond, M.(2001). Weed aboveground and seed bank community responses to agricultural management systems . Ecological Applications. 11: 1586-1601

Mester, T. C. & D. D. Buhler. (1991). Effects of soil temperature, seed depth, and cyanazine on giant foxtail (*Setaria faberi*) and velvetleaf (*Abutilon theophrasti*) seedling development. *Weed Sci.* 39: 204-209.

Miyazawa, K., Tsuji, H., Yamagata, M.(2004). Response of weed flora to combinations of reduced tillage, biocide application and fertilization practices in a 3-year crop rotation . *Weed Biology and Management*. 4: 24-34

Mohler, C.L. (2001). *Weed life history: identifying vulnerabilities.* Pp. 40-98 in M. Liebman, C.L. Mohler, and C.P. Staver (eds.). Ecological Management of Agricultural Weeds. Cambridge, U.K.: Cambridge University Press.

Mulugeta, D. & Stoltenberg, D. E. (2001). Weed species area relationships as influenced by tillage. Weed Sci. 49: 217-223.

Roberts, H. A. & Neilson, J. E. (1981). Changes in the soil seed bank of four long-term crop/herbicide experiments. *J. Appl. Ecol*. 18: 661-668.

Schweizer, E. E. & Zimdahl, R. L. (1984). Weed seed decline in irrigated soil after six years of continuous corn and herbicides. *Weed Sci.* 32: 76-83.

Singh, R. K., Bohra, J. S., Srivastava, V. K. & Singh, R P. (2008). Effect of diversification of Rice-wheat system on weed dynamics in Rice. *Indian J. weed Sci.* 40 (3&4): 128-131.

Singh, Dheer & Singh, Y. (1996). Weed management in different rice cultures and their effect on wheat grown in rice-wheat sequence. *Indian J. Weed Science*. 28: 30-35.

Swanton, C. J., Shretha,Anil., Roy, R. C. & Knezevic, S. Z. (1999). Effect of tillage systems, N,and cover crop on the composition of weed flora. *Weed Sci.* 47: 454-461.

Tanner, D.G. (1999). Principle and prospects for integrated weed management in the wheat Production systems of Ethiopia. *Arem*. 5: 27- 65

Vanhala, P., Pietola, L. (2003). Effect of conservation tillage and peat application on weed infestation on a clay soil. *Agricultural and Food Science in Finland.* 12: 133-145

Walia, U.S. & Brar, L. S. (2006). Effect of tillage and weed managem4nt on seed bank of *Phalaris minor* in wheat under rice-wheat sequence. *Indian J Weed Science*,38(1&2): 104-107

Walia, U. S., Brar, L. S. & Dhaliwal, B. K. (1997). Resistance to isoproturon in *Phalaris minor* Retz. in Punjab. *Plant Protec. Quarterly* 12: 38-140

Yadav, A., Malik, R. K., Sayre, K.. D. Brar L. S. & Singh, G. (2001). *Cross-resistance in Phalaris minor against fenoxaprop–Red signals appear in India.* Abstr. In : Proc.1st Binn. Conf. in the New Millennium on Eco-friendly Weed Management Options for Sust. Agric., organized by ISWS and UAS, Bangalore from May 23-24.