



# SUSTAINABLE INTEGRATED WEED MANAGEMENT IN TRANSPLANTED RICE BASED CROPPING SYSTEMS IN INDIA: A REVIEW

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## ABSTRACT

Among all the rice production systems in India the major constraint is the weed competition. With their added costs of weed control, they account for yield losses equating to about more than half of total rice imports. In case of upland rice, the prevailing weed species are Cogon grass, Nut grass, Devil weed, Desert poinsettia and Striga the parasitic weed species. while the perennial weeds species include Nut grass, Red rice being annuals, Goose weed, Rice sedge, Barnyard millet, Grass like fimbry and African wild rice may cause serious losses in rice. Conventional practices followed in Indian weed management practices in rice based cropping systems are trash burning, hand hoeing, tilling of soil, weeding, applying herbicides, flooding with water, fallowing and crop rotation practices either used in particular or in combinations to control weeds. Indian farmers face a lot of problems due to shortage of labour, lack of awareness about weed management practices and lack of sufficient inputs and funds. Integrated and ecologically balanced approaches are suggested to minimise the cost of socio- economic and environmental factors to get benefits. Emphasis should be on local practices that are affordable and are easily adaptable by the farmers. One needs to focus on the biology of weeds, their ecology and analyse the results of various weed management approaches with respect to environmental influence on weeds. To bring in the issue of the diversity of rice-based cropping systems in

India, there is a need to set priorities, information delivered considering local conditions. To achieve this there is a need for researchers and farmer participatory approaches like conservation tillage, rotation of crops, smothering crops and zero tillage.

**Key words:** Integrated weed management, Cropping systems, Seed weed bank, Rice, Tillage.

## 1. Introduction

Most used method for rice cultivation in India is transplanting. Rice is being cultivated in almost all ecosystems ranging from irrigated, shallow low-lying areas to mid deep low-lying areas and from deep water lands to uplands. Shortage of labour made it difficult for transplanting of rice in addition to water scarcity and less profits. Weeds being major constraint in crop production of rice by competing for resources and affecting yields. Under severe conditions weeds may result in total crop loss. About one third of stresses effecting crops come under weeds. Transplanting of rice has advantage over direct seeding competing with weeds (Singh et al., 2005; Rao et al., 2007). Under dry seeded, wet seeded and transplanted weeds effect has been calculated on yield and yield was reduced by 75.8%, 70.6% and 62.6% (Singh et al., 2005). When weeds were removed, the yields were comparable in all methods of rice used thus proved that weed management is essential for improving crop productivity in rice.

With increase in population growth there is need to increase food production in India, but the agricultural growth has slowed down (2008-2009), less than 2% as per the reports of GOI, 2010. To meet this increase in food demand, weed management plays an important role and by adapting new technologies in managing weeds would result enhanced production in rice. Problems due to weeds are multi oriented so integrated approach involving holistic and multidisciplinary actions should be practiced. Integrated weed management (IWM) offers sustainable ways to manage weeds in production of rice. The most limiting factor in crop production of rice is weed (Buhler, 1992). Weeds have a markable impact on yield by reducing the quality of produce and lowering their market value (Arif et al., 2006). Weeds consume nutrients and moisture by depleting fertility of soil and compete with crop plants for light and space affecting the yield (Khan et al., 2004). If not managed, weeds may consume 80% of yield of crop (Karlen et al., 2002). In rice it was around 45% based on the moisture availability of the area (De Datta, 1981). Important weed species and their communities are listed in weed seed banks. So, knowledge for understanding seed bank is important in order to develop effective weed management strategies.

Uncontrolled weeds minimise the grain yield more under dry-seeded rice conditions (DSR), then in WSR and followed by transplanted rice (TPR), respectively (Singh et al., 2005). Weed control is very first important step to be considered for improving rice productivity and production using different methods of crop establishment.

Technologies that are effective in weed management if adapted contribute to higher rice production. As the weed problems are diverse rooted, there is a need for holistic or multi-disciplinary and integrated approach. This paper provides a review on integrated weed management in transplanted rice-based

cropping system in a sustainable approach in India and suggest areas of future research on integrated weed management.

Weed control is the first considered factor in crop production (Buhler, 1992). The weeds effect the crop yield and spoil the quality of produce which results in reduction of the market value of the product (Arif et al., 2006). They result in the yield reduction as they compete for space and light with crop plants and use up the soil fertility, available soil moisture and soil nutrients, (Khan et al., 2004). The weeds in many fields have potential to reduce the yields by more than 80% (Karlen et al., 2002). Depending upon the soil type and rainfall pattern of a particular area system, the yield reduction to the extent of 45% in rice due to weeds has been reported in rice-wheat (De Datta, 1981).

## 2. INTEGRATED WEED MANAGEMENT

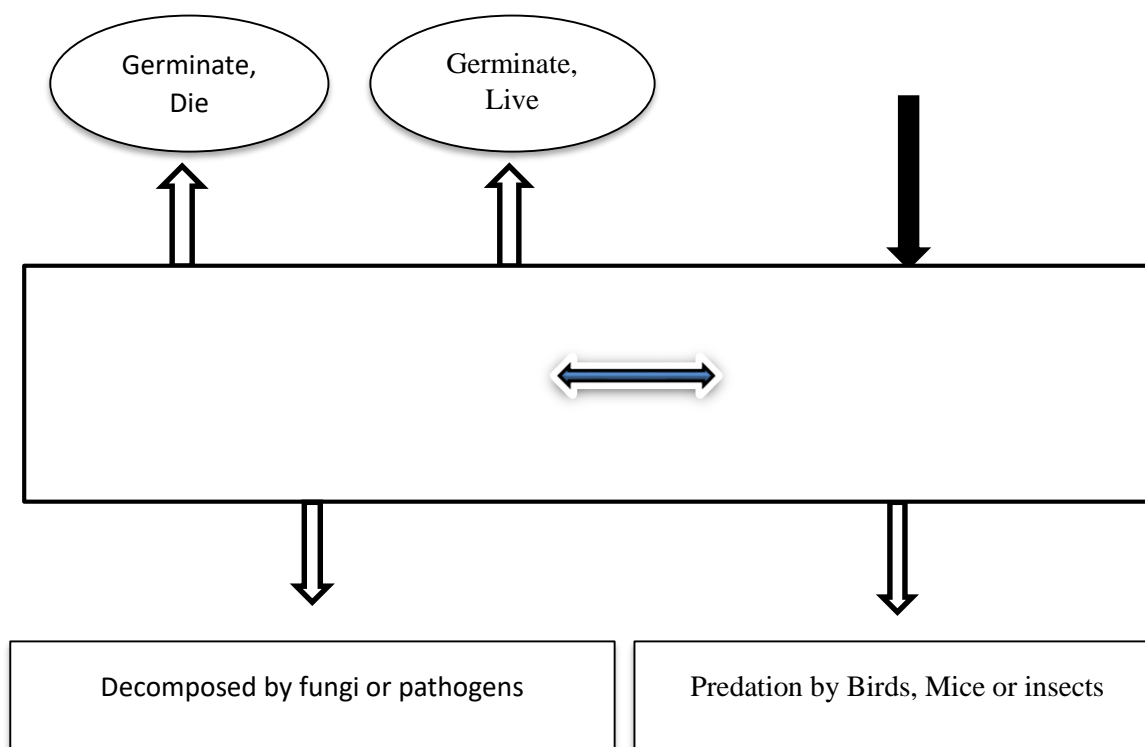
Integrated weed management (IWM) can be defined as a holistic approach to weed management that integrates different methods of weed control to provide the crop with an advantage over weeds (Harker and Donovan, 2013).

### a. Weed seed bank:

All the viable weed seeds and their related species are maintained in records in weed seed banks. This record consists of older weed seeds that have been in the soil for several years as well as the newly evolved weeds in recent times. Apart from providing the ancestral history the records of the success as well as failure of different cropping systems used, weed seed bank serve in predicting crop weed competition relations and to estimate the effect of weeds on crop yield and production (Menalled, 2008). This knowledge helps us in having record on weed seeds that have been shed and helps to manage and take decisions that affect weed seed bank by giving importance to minimise inputs in the seed bank and provide various weed seed bank management steps.

### b. Weed seeds post shedding:

In soil weed seeds accumulate and become part of soil through various ways. These weed seeds maintained in seed banks have been gathered from locally matured weeds which have set seed and various ways in which weed seeds enter into agricultural fields are either by wind, animals, birds, wind and human activity including cultivation and harvesting operations. So, the dispersal process of weeds decides the distance they travel. The knowledge on this seed dispersal mechanisms is important in order to plan proper weed management methods. Once they get dispersed out to the field they may result in various fates (fig.1). Some of them will germinate and produce more weed seeds while others die which are fatal in germination and become decayed in soil or will be eaten by birds. Some of them will remain dormant in soil and will not germinate in any environment and this dormancy is not permanent, they become non dormant in particular environmental conditions (Menalled, 2008).



Source: Menalled, 2008.

(Fig 1. Seed banks with entered weed seeds shown black arrows entered and losses with white arrow.)

#### c. Changes in weed flora under rice-based cropping system:

Under rice-based cropping systems annual weeds are dominant. *Phalaris minor* has been problematic weed in early 1990's under rice-based cropping system and this has adversely affected productivity in rice. To control this, urea-based herbicides have been used extensively and directed for resistant *Phalaris* biotypes evolution (Malik et al., 1995; Walia et al., 1997). Though managing weeds is under control, cross resistance has become a new problem. To these new biotypes which are resistant to three herbicides named Pyridinyl Sulfonylurea (Leader 75 WG), Aryloxy Phenoxy Propionate (Topic 15 WP) and Puma Power 10 EC have been recommended in rice-based cropping systems.

#### d. Weed seed bank management under rice-based system of cropping:

As a result of interaction in environmental, agronomic as well as ecological evolutionary selection processes are the present weed communities remained in agricultural fields. These factors should be considered for managing and for introduction of new weed species that form the composition of the weed community (Derksen et al., 1996). Proper weed control approach should be directed towards maintaining sustainability and increasing diversity of species along with the maintenance of biomass of weeds below the threshold level against crops growth and development (Miyazawa et al., 2004). For evolving genetic resistance, the resistant trait should be available within the population and respective selections to be made for resistance and the rate of resistance evolved is based on the type of weed seed bank present in the soil, the type of intensity of selection impacting their evolution naturally. So, considering importance of selection intensity guided by selection pressure in evolving herbicide resistant to *Phalaris*

minor have been developed and these practices include crop rotation, various cropping systems and herbicides and seed longevity.

**e. Seed longevity:**

Tilling soil with weed seeds in it helps bury them in soil and helps in enhancing their longevity in seed banks, while leaving them on soil surface exposes them to predatory animals and birds.

**f. Crop rotation:**

Rotation can cause a change in prevailing weed species composition. Studying about them is a need to change their composition in weed seed bank from undesirable to easy-to-manage species. Singh et al., 2008 shown that there is reduction in weed number per unit area and biological matter production of weeds, when there is a change in rice-based cropping system. Rice- wheat- green gram sequence recorded lowest population of all the three groups of weeds followed by rice-wheat, rice-chick pea and rice-pea sequence.

**g. Cultural weed management approaches:**

Crop rotation is an important component of Integrated Weed Management. In basic farming practices, rotations comprise of a variety of crops which have different crop durations and growth and development stages. Different planting and harvest dates among these crops provide more opportunities for farmers and helps them to reduce or avoid the multiplication of weed seeds by creating unfavourable conditions for their germination.

In rice cropping system summer cowpea for fodder, for green manuring sesbania can be used which resulted in significantly lower the grasses and sedges but failed to affect broadleaf weeds (Singh et al., 2008). Rice followed by lentil intercropped with mustard (3: 1) followed by cowpea, rice followed by maize intercropped with pea (1: 1) -followed by cowpea and rice followed potato followed by green gram gave high yield (Singh et al., 2008). Weed survival was under control using Pretilachlor along with Safener @ 400 g/ ha. when intercropped with Daincha and dual cropped with azolla in wet seeded rice in early stages using cono weeder (Subramanian and Martin, 2006).

In rice-wheat system of cropping, application of Butachlor to rice sequentially and Isoproturon to wheat crop followed by hand weeding were found to be effective to control *Echinochloa* weed sp. and *Fimbristylis* weed sp. Butachlor in rice, when used repeatedly solved the problem of *Echinochloa colona* in rice (ICAR, 2007). Crop rotation played an important role in suppressing weeds together with sequencing of crops that vary in competitiveness, disturbing soil, allelopathic effect and relations. Yet crop rotations and intercropping patterns effecting weed species is to be explored.

**h. Tillage levels:**

Weed management is possible by managing tillage operations effecting weed seed production and creating disturbance in pattern of soil. Weed seeds get buried and thus do not germinate in deep soil weed.

**i. Increased crop density:**

Crop density if increased can smother weeds but practically it may not be possible to increase density of plants in rice by 33 plants per meter square.

**j. Impact of tillage in weed management**

Tillage is to get seed- bed prepared, improving soil structure, to control weeds, conserve moisture and soil, increase infiltration capacity of soil, aeration in soil, penetration of roots, killing pests, insects, inversion of soil etc. Tillage helps to control weeds by removing weeds that otherwise compete for moisture, nutrients, light, and CO<sub>2</sub> in the soil and enhance crop growth and development. Tillage aids germination of weeds and on further tilling they get destroyed either due to tilling action or by spraying weedicides in soil. Also, they cause death of weed seeds by burying them to deeper layers in soil. The relationship of weeds with soil is altered with tillage. Conservative approaches include zero tillage practice that won't disturb total soil and conserving moisture in soil and aid in controlling weeds. This approach including modern technologies which would enhance the quality and properties of soil. Zero tillage reduces disturbance in soil which helps to conserve soil and moisture and judicious application of chemical inputs followed by healthy management of crop and soil.

**k. Integration of crop competitiveness and effect of herbicides:**

Along with weed control methods farmers use high yielding crop variety which can compete with weeds is the economical method followed. Weed competitiveness and higher yields were shown by upland rice cultivars like Vandana, Kalinga-III and RR-151-3 under optimal weed management condition (ICAR, 2007). Gautam (high yielder) variety and Prabhat which is a better weed minimizer in addition with butachlor at 1.5 kg PE and 2,4- D at 0.5 kg/ ha. The increase in density of plants from 22 to 44 hills per meter square in addition to application of Pyrazosulfuron 0.015 kg per ha. control *L. chinensis* (Aulakh and Mehra, 2006).

**l. Weed competition and critical period of weeds:**

Weed species and their abundance is affected by many factors in rice fields. These factors are altered to establish proper rice stand and create favourable environment for rice production. The critical period in crop growth stage is the stage at which if affected by weeds would result in yield losses (Zimdahl, 1988).

When observed for crop weed competition (CWC) and critical period of CWC is first 30 to 70 days are critical, based on the variety and the method of rice sown. The loss in yield in unchecked rice fields was higher than the loss in grain yield in direct seeded rice under judicious N- application (Sharma, 1997). In case of rice after transplantation weed *Cyperus iria* caused less than 13% of the total yield losses in initial one month and later in 40 days caused nearly half i.e., 44% of the total losses in yields (Dhammu and Sandhu, 2002). Removal of *Cyperus iria* resulted in reduction of yield up to 35.2% when weeding was delayed by 40 DAT (Singh et al., 1996). This knowledge of weeds in rice and weed emergence patterns is useful for successful implementation of critical period of crop weed competition concept.

### 3. CONCLUSION

Among all the weed management practices, the positive effect was shown by conservation tillage practice in suppressing weeds in rice. Depending on the nature of weed flora available in weed seed banks, various integrated methods are to be formulated. Adopting recommended agronomic practices, by understanding the nature of weeds and following various agronomic practices farmers can harvest maximum yields under rice-based cropping systems. Integration of chemical methods of weed control together with alternative methods of weed management should be practised for economic and ecological benefits. There is a huge need to educate the farmers towards coordinated and extensive management of weeds under judicious use of herbicides in India by integrating with other weed management practices. Farmers must manage herbicides and other inputs that would drive the adapted species against reaching troublesome proportions. Prospects in coming days should aim to deliver the information and facilitate tools for these approaches.

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