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Study on weed management practices in rice - a review

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Abstract
Rice (*Oryza sativa* L.) is the principal food for more than 50% people and contributes about one-fifth to the total calories consumption of the world. In recent years, rice production has increased with the introduction of high yielding varieties, but their maximum yield potential has not been fully realized owing to improper weed management. Weed management is an important key factor in obtaining higher crop yield. Unchecked weed growth causes a reduction in grain yield by about 30- 36% in transplanted rice. Weeds compete for an adequate supply of the nutrients, moisture, light and the growing space. Successful weed management for rice more important to exploit its maximum production potential. These weeds could be controlled through cultural, manual, mechanical and chemical methods. Cultural, Manual and Mechanical methods are though very common but cost intensive. Herbicides when applied alone is although economical but may have limitation of resistance development, shift in weed flora etc. Therefore, presently there is a need to use high efficacy herbicides in combination coupled with broad spectrum nature to control the complex weed flora in transplanted rice Also, the combination of herbicides increase the range of weed control, save time and reduce the cost of cultivation.

Keywords: Weed management, herbicides, weed flora

1. Introduction
Rice (*Oryza sativa* L.), is the principal food for more than 50% people and contributes about one-fifth to the total calories consumption of the world (Singh *et al*., 2012) [18]. Rice is cultivated world-wide over an area of about 163.20 million ha with an annual production of about 758.90 million tonnes (503.80 million tonnes, milled basis) and productivity 4.60 tonnes per hectare in 2017-18 (WTO). About 90% of all rice grown in the world is produced and consumed in the Asian region. To meet the food and nutritional requirements in these densely populated and rice dominant regions, the projected demand for rice by 2030 has been estimated at 904 mt for the world and 824 mt for Asian region (Kubo and Purevdorj, 2004). India alone would require about 156 mt of rice by the year 2030 (ICAR, 2010) [8] at an annual increment of 3 mt in the current rice production (Dass *et al*., 2016) [7].

In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.50 M ha with a production of 111.10 million tonnes of rice. However, rice productivity (2590 kg ha^{-1}) in India is very low (WTO, 2017-18). There several are reasons for its low productivity, and out of that losses caused due to weeds is one of the most important. Weeds are most severe and widespread biological constraints to crop production in India. Weeds are responsible for heavy yield losses in paddy, to the extent of complete crop failure under severe infestation. Uncontrolled weeds reduced the grain yield by 75.8%, 70.6% and 62.6% under dry-seeded rice (DSR), wet seeded rice (WSR) and transplanted rice (TPR), respectively, (Singh *et al*., 2005) [20]. Chauhan and Johnson, (2011) reported that the average yield losses in rice due to weed competition are estimated to vary between 40 and 60% which may go up to 94-96% with uncontrolled weed growth. Weed infestation reducing grain yield directly and indirectly. Rice and rice weeds have similar requirements for growth and development. Competition occurs when one of the resources (nutrients, light, moisture and space) fall short of total requirement of rice and weeds. Weeds by virtue of their high adaptability and faster growth dominate the crop habitat and reduce the yield potential. Weed free period during the critical period of competition is essential for obtaining optimum rice yield. This can be achieved by removing weeds manually, mechanically and through chemical sprays or by their combinations. Manual weeding is although effective and most common method, however, scarcity and high wages of labour particularly during peak period of agricultural operations make this method uneconomic. Further, it is possible only when the weed growth is to a size large enough for hand removal,

by that time the weeds have done considerable damage to the crop. Further, mechanical method of weed management is also time taking, cost intensive, much tedious and also does not remove all the weeds. Weed management in transplanted rice through herbicide application may be the best suited option. It is practiced by farmers for past several years as it offers selective and economic control of weeds right from the beginning of crop growth and thus, minimize the crop-weed competition. It also save valuable time by covering more area in short period and is also cost effective. Raising cost of labour and their reduced availability has led to search for alternative methods such as herbicide use either alone or in combination with manual or mechanical weeding.

Weed species in rice field

A broad spectrum of weed flora infests rice crop. The dominant grass weed species were *Echinochloa crusgalli* and *Echinochloa colonum*, sedges were *Cyperus iria, C. rotundus* and *Fimbristylis miliacea* and broad leaved weed species were *Ammania baccifera, Marsilia quadrifolia* and *Potamogeton distinctus* under puddle condition of sandy clay loam soil during rainy season. Singh *et al.*, (2005) [20] found that grasses constituted 14.1%, sedges 71.4% and broad-leaf weeds 14.5% of the total weed population in rice crop at 30 days stage. Mukherjee *et al.*, (2008) noticed that 20-40 days after transplanting was the most critical period of crop weed competition and found that weedy situation throughout the crop growth caused yield reduction to the tune of 57-61% in transplanted rice. Ramachandra (2010) recorded the dominant weed species in transplanted rice as *Echinochloa crus-galli* (L.) and *E.colona* (L.) under grasses; *Cyperus difformis* (L.), *Cyperus iria* (L.) and *Cyperus rotundus* (L.) under sedges and *Eclipta alba* (L.) Hassak and *Ammania baccifera* (L.) among broad leaved weeds.

Crop-weed competition and losses caused due to weeds

Weed competition is one of the most important factors in limiting the yield of rice. Competition between crop and weed begins when the supply of any of the growth factor is limiting and falls below the demand of both crop and weeds, when they grow in close proximity. Weeds having faster growth rate, accumulate large amount of biomass in a short period, which interferes with the growth of rice plants and ultimately affects the yield of rice crop.

Among the different weed species, grassy weeds pose greater competition. They have an extensive and fibrous root system. Similarly, sedges grow huge in number and cause serious competition for nutrients. The roots of the sedges also dominate the surface feeding zone and obstruct nutrient flow to crop roots. weeds interferes with rice growing by competing for one or more growth limiting resources i.e. nutrients, water, space, light and carbon dioxide, because of the limited supply of these valuable elements, their association therefore, leads to competition for these elements for the survival. Generally, one-third duration of the crop period should be maintained weed free. The critical crop weed competition from 28-45. Chinnusamy *et al*. (2000) [6] reported that maintaining a weed free period up to 45 DAS was essential to augment the yield of medium duration rice. Critical period for crop weed competition in rice was up to 40 days after transplanting (Thapa and Jha, 2002) [22].

Crop yield losses due to weeds mainly depend upon their intensity as well as type of weed flora. Janiya (2002) [10] reported that grain yield losses due to weeds in lowland rice field ranges 20% to 60% and 30% to 80% in transplanted and direct-seeded rice, respectively. Reddy *et al.,* (2003) from Hyderabad noticed that *Cyperus spp., Paspalum spp., Caesulia axillaris, Rotala densiflora* and *Monocharia vaginalis* caused 28-40% reduction in yield of transplanted rice. Sandhu (2002) observed that *Cyperus iria* competition for the first 30 days caused less than one-fourth (12.9%) of the total yield loss in transplanted rice while competition for 40 days resulted in more than half (43.5%) of the total yield loss due to the weeds.

Methods of weed control in rice field:

Weed control methods are grouped into cultural, manual, mechanical, chemical and biological methods. Each of them has their own advantage and disadvantage and single method is rarely found effective so, summarized reviews are given below particularly for manual weeding and chemical methods of weed control in transplanted rice.

1. Cultural methods

Several cultural practices like tillage, planting, fertilizer application, irrigation etc., are employed for creating favorable condition for the crop. These practices is used properly, help in controlling weeds. Cultural methods, alone cannot control weeds, but help in reducing weed population. Puddling and submerged condition under transplanting reduced weed germination. The closely spaced crop effectively smothered the weeds growing under crop canopy by not providing sufficient space for weed growth complemented by restricting sunlight from penetrating downwards (Brar and Walia, 2001) [4]. Prasad *et al*. (2001) [14] stated that transplanting recorded the lowest weed population (63.5 m^{-2}) and weed dry weight (24.1 gm^{-2}) which was followed by sowing of sprouted seeds in puddle condition and dry drilling seeds.

2. Manual weeding

The earliest ways of weed control in rice were cultural methods. In spite of labor intensive hand weeding is still most common direct weed control method in rice in India using bare hands and hand tools. These practices are only effective when weeds attain height to provide better grip for uprooting Bhan *et al., (*1980) [3]. Rekha *et al.,* (2002) [16] reported that twice hand weeding resulted in lower weed density as compared to herbicides and untreated control. Jayadeva *et al.,* (2009) [11] from Karnataka observed that Hand weeding twice (20 and 24 DAT) recorded lower weed dry weight and higher mean grain and straw yield in rice.

3. Mechanical or Physical weeding

This methods includes the use of hand tools, implements and machinery operated either with the help of man power or machine power for control of weeds. These are costly and time consuming methods. However, these methods cause minimum damage to the environment. Rotary weeder was effective in controlling the weeds present in inter row space, but failed to control the weeds in intra row space or those in the vicinity of the crop. Cono-weeding alone was found to contribute 17.43 per cent for grain yield when the average grain yield under the cono-weeding treatments 3376 kg ha^{-1} was compared against the average grain yield under hand weeding treatments 2875 kg ha^{-1} (Sreedevi, 2006) [21]. Mrunalini and Ganesh (2008) opined that the implements like cono-weeder that helped to save labour, time and reduced man days required for weeding from 30 to 10 as they become more experienced in handling the cono-weeder implement.

4. Chemical weed control

In general, cultural and mechanical methods of weed control are time consuming, cumbersome and laborious apart from being less effective because of chance of escape and regeneration of weeds from roots or rhizome that are left behind. The morphological similarity between the crop and certain grassy weeds makes hand weeding difficult. The use of herbicides therefore, appears to be the only alternative. In present context it is most preferable and farmer can easily go for it because day by day increases labour problems. Under puddle sown rice culture, chemical method of weed control is the efficient method for controlling grasses, sedges and broad-leaved weeds, and reducing the labour cost and achieving higher grain yield.

Kumar *et al.* (2008) [12] conducted the field experiment at crop research centre, GBPUAT; (Pantnagar) during Kharif season of 2006 and reported that Anilophos @ 0.6 kg a.i. ha^{-1} applied at one DAS integrated with one hand weeding at 45 DAS proved significantly superior over all other treatments in reducing weed population and obtaining maximum grain yield. Maximum weed control efficiency (86.93%). Singh and Singh (2010) [19] reported that application of pretilachlor @ 0.75 kg a.i. ha^{-1} as pre-emergence followed by 2, 4-D @ 0.50 kg a.i. ha^{-1} as post emergence proved to be most effective in minimizing the density of weeds and their dry weight, it enhances the weed control efficiency (84.24%); grain yield (4.73 t ha^{-1}), NPK uptake by crop, net return (Rs. 26,610) and B: C ratio (1.92). Angiras and Kumar, (2005) [1] found that application of pyrazosulfuron ethyl @ 20 or 25 g ha^{-1} at 3 or 10 DAT significantly reduced the weed density and weed dry matter in transplanted rice during *kharif* season.

5. Integrated weed management

Sangeetha *et al.* (2011) [17] conducted field experiment at Tamilnadu Agricultural university; Coimbatore during rainy season of 2004-2005 and reported that application of pretilachlor with safener @ 0.45 kg a.i. ha^{-1} at 5 DAS followed by hand weeding at 45 DAS, registered lower weed density, weed biomass, highest weed control efficiency (WCE), zero per cent weed index (WI), lowest depletion of NPK nutrients by weeds and highest grain yield of crop with high B-C ratio.

Jadhav and Pawar (2013) [9] conducted field experiment on weed management at AICRP, Parbhani during *Kharif* season of 2009 and 2010 and reported that maximum weed control efficiency observed in weed free situation followed by pre-emergence application of butachlor @ 1.5 kg a.i. ha^{-1} +2 hand weeding at 30 and 60 DAS, respectivel y. Parthipan *et al.* (2013) [13] observed that among the herbicides, the pre-emergence application of pretilachlor + safener @ 0.45 kg/ha followed by one hand weeding at 45 DAS was effective in controlling all weeds and registered higher yield attributes and yield in direct-seeded rice which was at par with two hand weeding.

Conclusion

Weeds pose a major problem in rice production as they not only compete with crop but also hinder the quality of rice produce. Any delay in weeding will lead to increased weed biomass as a result there is drastic reduction in total yield of the crop. Therefore, to avert the economic losses a broad spectrum weed control should be affective during the life cycle especially during the critical stages of rice crop. Effective control of weeds in rice could be achieved with the help of cultural methods, manual weeding, mechanical weeding and chemical weed control.

Chemical weed control is getting importance in areas, where labour is scarce and costly. Some of the herbicides either alone or their combinations at lower dose have been proved economically viable alternative to hand weeding in management of weeds in rice field. This use of all suitable management technique are utilized in such a compatible way as to reduce weed population below economic threshold levels without deteriorating environment quality.

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