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WEED MANAGEMENT IN DIRECT SEEDED RICE: A REVIEW

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ABSTRACT

Presently there is a need of meeting the increasing food demand of the largely growing population as well as taking care of the ecosystem and conserving the natural resources. Rice is one of the important staple foods of our country. Among different methods of rice establishment, direct seeding is more advantageous than other methods. This method helps to maintain the environmental health and conserve the natural resources by different ways such as it helps to reduce the amount of water used which is an important, scarce and hence precious natural resource. It also reduces the greenhouse gas emission mainly methane gas. Dry direct seeding, in contrast to wet direct seeding and transplanting method, avoids puddling operation that destroys soil structure and therefore, maintains soil health and quality. It also increases the overall farm income by reducing labour requirement, maintaining optimum planting time, increasing resource use efficiency, promoting crop diversification, facilitating earlier physiological maturity etc. But the main biotic constraint of this method (DSR) is greater weed pressure compared to traditional puddled transplanted rice. Weeds can cause up to 90 percent yield reduction in case of dry direct seeded rice. Hence, effective weed management within proper period of time is essential for the success of DSR. The preventive method of weed management includes use of certified seeds; well decomposed FYM; proper cleaning of farm implements; bunds; irrigation channels and bund areas; restricting the transfer of soil from infested fields etc. Mechanical weeding encompasses both manual weeding done by hand and the use of mechanical tools. Cultural method includes skipping the basal dose of nitrogen, co-cultivation with sesbania, residue mulching, soil solarization, stale seed bed technique, proper land preparation and land levelling, crop rotation etc. Chemical method includes the application of different herbicides as PPI, PE and/or PoE. Different weed management strategies need to be integrated to achieve effective, long term and sustainable weed management in direct seeded rice.
***Keywords*: Rice, Weed, Herbicide, Cultural method**

Introduction

Rice (*Oryza sativa L.*) holds a critical position in ensuring the worldwide food security especially in Asian countries. Nearly 90% of the world's rice is not only produced but also consumed in Asia (Muthayya *et al.*, 2014). Rice provides on an average 30-70% of total calories intake of different Asian countries where more than 500 million people are undernourished (von Barun and Bos, 2004). Rice has profoundly influenced the diets, cultures and economies of billions of people. Recognizing its pivotal role, the United Nations designated 2004 as the "International Year of Rice". Consumption rate of rice has increased worldwide over the last several years. In 2008-2009 crop year the intake of rice was 437.18 million metric tons which rose up to about 520.4 million metric tons in the crop year 2022-23 (Statista, 2024). Different ready-to-eat products are prepared from rice such as canned rice, popped rice, puffed rice, rice flakes etc. Rice husk & rice bran are rich in nutrients and can be used as cattle feed, poultry feed, fuel purpose etc. Rice bran is an important source of protein and can also be used in production of bran oil.

The demand for food is increasing due to growing population in the world. To meet the global food demand by 2050, food production needs to be increased by 70% (Muthayya *et al*., 2014). However, expanding rice cultivation horizontally is becoming increasingly difficult due to shrinking agricultural land. Therefore, boosting rice production must primarily focus on increasing productivity. Key obstacles to achieving this goal include water and labor shortages, rising wage rates, high production costs as well as degradation of natural resources and environment.

There are different methods of rice establishment such as direct seeding, transplanting, System of Rice Intensification (SRI) etc. In the Indo-Gangetic Plains, traditional rice cultivation involves manual transplanting in standing water after puddling. Transplanting offers numerous benefits like- it increases the presence of different nutrients such as phosphorus, iron, zinc etc. and it also helps in suppression of weed species. In puddling method, mixing of soil and water is done to create a hardpan beneath the tillage depth, which reduces the permeability of soil, destructs capillary pores; breaks soil aggregates, thus causes problems for the proper germination, establishment and growth of the succeeding crops. This practice known to harm soil quality, health and productivity. Transplanted flooded rice causes surface evaporation and percolation losses of water (Farooq *et al*., 2011). Due to labour-intensive transplanting and rising costs, there's a pressing need to improve productivity and sustainability. Consequently, farmers are increasingly adopting direct seeding. Direct seeding method is of three types - dry direct seeding, wet direct seeding and water seeding. Wet direct seeding has been adopted in the places where there is labour scarcity and high labour wage. On the opposite side, the areas where there is scarcity for both labour and water, dry direct seeding is the best alternative to conventional practice for sustaining the production (Gathala *et al*., 2014). Dry direct seeding is a new method of rice cultivation where rice seed is sown into the dry cultivated land and optimum moisture level is maintained for proper seed germination and crop establishment (Joshi *et al*., 2013). It is a method that offers benefits such as earlier crop establishment, reduced methane emissions, lower labour costs and also preserving soil quality. The scarcity of water, recent trends in rice production technology and economic factors have increased the need of the method of direct seeded rice cultivation (Pandey and Velasco, 2002).

Advantages of direct seeding method over transplanting method of rice cultivation

Reduced water requirement

Rice cultivation necessitates substantial water requirement than compared to maize or wheat. Water is a valuable scare resource that needs to be conserved. Hence, water use in rice cultivation needs to be reduced by enhancing the water use efficiency through reduction of seepage, percolation and evaporation losses of water. DSR is the better alternative to increase the water use efficiency. DSR has shown notable water saving up to 35-35% than compared to traditional transplanted rice (Peng *et al*., 2006 and Bhushan *et al.,* 2007) as it avoids flooding.

No yield penalty under proper management

Due to continuous mono cropping, productivity of dry direct seeded rice is reduced while high yield could be achieved when dry direct seeded rice is grown once in a whole year (Guimaraes and Stone, 2000). Though many reports revealed that dry direct seeding provided lower yield than conventional puddled transplanted rice, by adopting proper nutrient management, water management and weed management practices higher yield can be achieved from direct seeded rice. The yield potentiality of DSR is equivalent to that of transplanted rice when proper management practices such as irrigation management and weed management are properly practiced (Awan *et al*., 1989). It indicates that the success of dry direct seeding technology mainly depends on proper crop management. The yield of DSR was equivalent to transplanting and the net profit was higher (Singh *et al*., 2005). In Northen China, it was found from research works that dry direct seeded rice produced significantly more yield than transplanted rice (Pandey and Velasco, 2002). Some researchers also showed that there was an increase of 5.33% grain yield and reduction of about 25-30% water use under dry direct seeded rice than traditional transplanted rice growing method (Zhao *et al*., 2007).

Less labour requirement

Recent development of industrial sector causes high demand of labours in non-agricultural sectors which leads to labour scarcity and high labour wage in agricultural sector (Dawe, 2005). Direct seeding of rice requires less labour as it eliminates the requirement for nursery establishment, seedling uprooting and transplanting and can thereby reduce the overall labour requirements by 11–66% (Kumar *et al*., 2009). Thus, it helps not only to reduce the labour but also the cost total cost of production. Dry direct seeding method reduces about 11.2% of total production cost over puddled transplanted rice (Mitra *et al*., 2005).

Facilitating timely sowing of succeeding crops

Labour scarcity results delayed transplanting which causes reduction in rice yield (Mahajan *et al.*, 2009) as well as become an obstacle for the timely sowing of the subsequent crop. On the other hand, the crop matures 8-10 days earlier in DSR which is helpful in maintaining optimum planting time of succeeding crops.

Increased resource use efficiency

It improves resource use efficiency such as water and nutrient, promotes enhanced root development for efficient water acquisition and drought tolerance, reduced lodging incidence and higher yield of succeeding crops.

Reduced greenhouse gas emission

Different greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) are produced due to agricultural activities. The contribution of agriculture sector to the emission of different greenhouse gases such as N_2O, CH_4, and CO_2 are 60%, 39%, and 1%, respectively (OECD, 2001). The traditional puddled rice influences the production of methane gas. Under flooded anaerobic condition, different methanogens become active and produces methane gas. Anaerobic condition is the most favourable for the activities of methanogens but in dry direct seeding method aerobic condition is maintained which does not favour the activity of methanogens; thus, reducing production of methane gas. The methane gas emission from dry direct seeded field was 0.6–4.9 kg/ha and puddled transplanted field was 42.4–57.8 kg/ha (Pathak *et al.*, 2013).

Crop diversification

Dry direct seeded rice also helps to promote crop diversification and intensification thus helps in not only maintaining soil health but also increasing productivity.

Reduced arsenic content in grains

The water management practice followed in rice cultivation also influences the arsenic content of rice grains. Studies has shown that grains which are produced under anaerobic transplanted condition contain more arsenic than aerobic direct seeded rice grains (Daum *et al.*, 2001).

Other benefits

There are numerous additional advantages of direct seeding over the transplanting method such as - DSR helps to increase the fertilizer use efficiency due to direct application of fertilizers in crop root zone. Puddling reduces the yield of succeeding wheat crop by two ways: firstly, by damaging the soil structure and secondly by delaying the sowing of succeeding wheat crop (Hobbs *et al.*, 1994; Sharma *et al.*, 1985). There was a reduction of 8-9% yield of succeeding wheat crop when it was sown after transplanted puddled rice than after direct seeded rice (Kumar and Ladha, 2011). DSR helps to avoid the transplanting shock and thus obtains earlier physiological maturity and avoids the chances of facing late season drought (Tuong *et al.*, 2008). DSR method is less energy consuming and less expensive.

Effective traits for direct seeding encompass early submergence tolerance, robust seedling vigour for weed suppression, erect leaves with high chlorophyll content for optimal growth, sturdy culms and lower-positioned heavy panicles for lodging resistance and high genetic yield potential with efficient input usage in direct seeded rice (Kumar and Ladha, 2011).

Weeds, the major biotic constraint of direct seeded rice

While direct-seeded rice (DSR) offers numerous benefits, it faces greater weed pressure compared to traditional puddled transplanted rice. Unlike in transplanted rice systems where standing water and transplanted seedlings suppress weeds, DSR's aerobic soil conditions and alternate wetting and drying cycles promote weed germination and growth. Weeds pose a more significant challenge in DSR compared to transplanted rice due to two main reasons - firstly, DSR seedlings exhibit reduced competitiveness with emerging weeds and secondly, the initial weed infestation is not suppressed by flooding in both wet and dry-DSR (Kumar *et al.*, 2008a; Rao *et al.*, 2007). Research indicates that without effective weed control measures, direct seeded rice (DSR) experiences higher loss of yield due to weeds compared to transplanted rice (Baltazar and De Datta, 1992; Rao *et al.*, 2007). This tremendous weed presence in DSR can result in significant grain yield losses of up to 80% (Mahajan *et al.*, 2009). If left uncontrolled, weeds can significantly diminish grain yield, reducing it by up to 96% in dry direct-seeded rice and 61% in wet direct seeded rice (Maity and Mukerjee, 2008). Therefore, effective weed management within proper time is essential for the success of DSR. In case of direct seeded rice, the first 30 to 40 days of crop growth are particularly crucial. The extent of yield reduction in direct seeded rice is proportional to the duration of competition during this critical initial period. A period of 14 to 56 days after sowing (DAS) is very crucial phase for weed management in rice to obtain 95% of weed-free yield (Chauhan and Johnson, 2011). The critical period of crop-weed competition in direct seeded rice is 15-60 DAS (Mukherjee *et al*., 2008).

In Southeast Asia, a change in the weed composition in dry direct seeded rice has been reported. There is a noticeable transition towards more robust and competitive grasses and sedges. Weeds pose a significant challenge in the cultivation of direct-seeded rice, particularly in Dry-DSR. The rice fields are susceptible to various types of weeds, including aquatic, semi-aquatic and terrestrial species. While there are about 350 weed species reported in rice cultivation overall (Singh *et al*., 2016), approximately 50 weed species have been found invading DSR crop fields (Caton, 2003; Rao *et al*., 2007). Major weeds found in direct seeded rice include *Digitaria sanguinalis* (L.), *Echinochloa colona* (L.), *Paspalum notatum* among grasses; *Eclipta alba* (L.), *Spilanthes calva*, *Ludwigia parviflora*, *Alternanthera philoxeroides* and *Oldenlandia corymbosa* (L.) among broad-leaved weeds; *Cyperus iria* (L.) and *Fimbristylis miliacea* (L.) among sedges and *Cyanotis axillaris* among monocots (Jaiswal and Duary, 2023). Grasses are a significant challenge in rice production globally, followed by sedges and broad-leaved weeds (Singh *et al*., 2016). Predominant weeds in direct-seeded rice include *Amaranthus viridis*, *Oldenlandia corymbosa*, *Spilanthes acmella*, *Ludwigia parviflora*, *Cleome rutidosperma*, *Malvastrum coromandelianum* among broad-leaved weeds, *Digitaria sanguinalis* among grasses and *Cyperus iria* among sedges (Chakraborti *et al*., 2017)

Table 1: Weed flora found in direct seeded rice

Scientific Name	Family	Common Name
Grasses		
Echinochloa colona	Poaceae	Jungle rice
Echinochloa crus-galli	Poaceae	Barnyard grass
Eleusine indica	Poaceae	Goose grass
Leptochloa chinensis	Poaceae	Sprangletop
Digitaria sanguinalis	Poaceae	Crab grass
Brachiaria ramosa	Poaceae	Signal grass
Cynodon dactylon	Poaceae	Bermuda grass
Dactyloctenium aegyptium	Poaceae	Crownfoot grass
Sedges		
Fimbristylis miliacea	Cyperaceae	Globefingerrush
Cyperus difformis	Cyperaceae	Small flower umbrella sedge
Cyperus iria	Cyperaceae	Flat sedge
Cyperus rotundus	Cyperaceae	Purple nut sedge
Broad leaved weeds		
Alternanthera philoxeroides	Amaranthaceae	Alligator weed
Alternanthera sessilis	Amaranthaceae	Khaki weed
Ammania baccifera	Lythraceae	Redstem
Caesulia axillaris	Asteraceae	Pink node flower
Celosia argentia	Amaranthaceae	Quail grass
Cleome viscosa	Cleomaceae	Cleome
Commelina benghalensis	Commelinaceae	Wandering Jaw
Commelina communis	Commelinaceae	Day flower
Cyanotis axillaris	Commelinaceae	Creeping cradle
Digera arvensis	Amaranthaceae	Digera kondra
Eclipta alba	Asteraceae	False daisy
Ludwigia parviflora	Onagraceae	Water primerose
Malvastrum coromandelianum	Malvaceae	False mallow

Source: Singh *et al*., 2016; Jaiswal and Duary, 2023; Chakraborti *et al*., 2017

Weed management practices in direct seeded rice

There are several methods of weed management such as preventive method, mechanical or physical method, cultural method, chemical method, integrated weed management etc.

Preventive method

The preventive measures of weed management in DSR becomes more crucial than in TPR. Preventive measures compliment curative tactics like use of certified seeds; well decomposed FYM; proper cleaning of farm implements; proper cleaning of bunds; irrigation channels and other non-crop areas; restricting the transfer of soil from infested fields; quarantine measures etc. During harvesting and threshing, many weeds like *Echinochloa colona* mature along with rice and can easily mix with it. Contaminated weed seeds not only spread herbicide resistance but also introduce new weed species. These practices primarily focus on minimizing weed seed banks and preventing the entry of new weeds into crop fields to stop further infestations. Poor agronomic practices often allow new weed seeds to enter crop fields, leading to the accumulation of significant weed seed banks in the soil.

Mechanical method

Mechanical weeding encompasses both manual weeding done by hand and the use of mechanical tools like cono-weeder (Devkota and Yadav, 2014). Many direct seeded rice farmers in Asia typically use mechanical weeding methods two or three times throughout the growing season, which requires up to 190 man days ha^{-1} in hand weeding (Roder, 2001). This approach, while environmentally friendly, is known to be straightforward but requires significant labour, time, and expense. Manual weeding typically involves uprooting of weeds from the soil around 25-40 days after sowing (DAS) when they have grown sufficiently large, though this can result in soil loss during the initial stages of crop growth (Bista, 2018). Manual weeding has become non reliable due to high labour wage and labour scarcity (Rao *et al.,* 2007). To mitigate herbicide use and prevent weed seed production and accumulation, one or two rounds of hand weeding are recommended (Devkota & Yadav, 2014). Studies have shown that twice hand weeding resulted in lower weed density compared to using herbicides or leaving fields untreated (Rekha, 2002). While mechanical weeding with hand operated tools is laborious and time-consuming (Chauhan, 2012), it does reduce labour requirements to some extent compared to manual weeding. However, mechanical weeders are only practical in areas where rice is sown in well-defined rows (Raj and Syriac, 2017).

Cultural method

This method includes - skipping the basal dose of nitrogen, stale seed bed technique, land preparation and land levelling, co-cultivation of sesbania, residue mulching, crop rotation, soil solarization etc.

Weed growth is stimulated when basal dose of nitrogen is added to the soil. Therefore, until the weeds are removed basal dose of nitrogen need to be avoided.

Under stale seed bed technique, after land preparation the field is irrigated and left fallow to encourage weed growth. Once the weeds have emerged, they are eradicated either through the application of a non-selective herbicide like paraquat or glyphosate or through tilling before rice planting (Devkota and Yadav, 2014). This approach not only minimizes weed emergence but also decreases the quantity of weed seeds in the soil's seed bank (Rao *et al*., 2007). Under stale seed bed technique 53% less weed density is found (Singh *et al*., 2009b). The effectiveness of stale seedbeds depends on various factors - (a) the approach to preparing the seedbed (b) the method employed to eliminate emerged weeds (c) the types of weeds present (d) the duration of the stale seedbed period (Ferrero, 2003) and (e) environmental factors such as temperature during this period. Certain weed species, notably *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliacea*, *Leptochloa chinensis* and *Eclipta prostrata* (L.), may exhibit greater vulnerability to the stale seedbed technique in conjunction with zero-tillage due to their limited seed dormancy and they can't emerge from depth more than 1 cm (Chauhan and Johnson, 2010). Stale seed bed technique produces higher number of grains per panicle, lower sterility and highest harvest index than normal seed bed (Marahatta *et al*., 2017).

Proper land preparation which involves both tillage and precise levelling is crucial for managing weeds in dry direct seeded rice. Tillage specifically influences vertical distribution of weed seeds in the soil, seed predation, dormancy, longevity and the ability of seedlings to emerge from various soil depths. This process significantly influences seedling establishment (Chauhan *et al*., 2006). Reduced tillage may lead to decreased survival and emergence of annual weeds over time, assuming that their seed production doesn't increase under reduced tillage systems. However, for perennial weeds, which reproduce through vegetative means, avoiding tillage might worsen weed issues if effective control isn't achieved with a nonselective herbicide like glyphosate before planting crops. In situations where weed control is not optimal and having a high weed seed load, conventional tillage may be more appropriate as it can bury weed seeds below the germination zone and help mitigate weed problem. Accurate land levelling enhances weed management by allowing precise water management and increasing the effectiveness of herbicides. This approach can reduce weed population by up to 40%, reduce labour requirement by 75% (16 person-days per hectare) and decrease weeding costs by 40% (Rickman, 2002).

Sesbania, a leguminous plant, is utilized as a green manure in rice farming, either preceding the rice crop or grown along with rice (Singh *et al*., 2009b). Co-cultivation of Sesbania with rice helps to reduce broadleaf and grassy weed density by 76–83% and 20–33%, respectively and total weed biomass by 37–80% compared to growing rice alone (Singh *et al*., 2007).

Crop residues retained on the surface of the soil help to preserve soil quality and moisture levels and also prevent the emergence of weeds. However, the impact of these residues on weed growth depends on various factors such as the ability of the residues to produce chemicals that inhibit weed growth (allelopathy) and the characteristics of the weed species themselves (Chauhan, 2012). Residual mulch acts as a physical barrier to prevent weeds from emerging and also releases chemicals that can hinder the early growth and development of weeds (Bista, 2018). For instance, using 4 tons of wheat residue per hectare was found to reduce the emergence of grassy weeds by 44-47% and broadleaf weeds by 56-72% (Singh *et al*., 2007). Additionally, a high volume of residue can block sunlight, causing a delay in weed emergence, which ultimately makes the weeds less competitive compared to rice plants (Chauhan, 2012).

Alternating rice cultivation with other crops like soybean, mungbean, cotton, maize, etc., is an effective strategy for managing weedy rice. This approach also permits the utilization of herbicides and cultural practices (Singh *et al*., 2013). Crop rotation disrupts the cycle of weed seeds which in turn impacts the demographics and subsequent population of weeds, resulting in improved weed control.

The soil solarization method involves raising soil temperatures to lethal levels for controlling many weed seeds and soil-borne pathogens by using a transparent polyethylene sheet, typically made of LDPE film. This sheet is placed over the soil surface to capture solar radiation, thereby the raising soil temperature which helps in suppressing weeds by eliminating them before they emerge (Raj and Syriac, 2017). Covering the soil with 100 µ thickness LDPE sheets for 30 days prior to planting of crops effectively reduces the density of grassy weeds, broadleaved weeds and overall, the total dry weight of weeds, particularly in hot regions (Khan *et al*., 2003). Under transparent mulch, soil temperatures at a depth of 5 cm increased by 10-15°C, while at 10 cm depth, temperatures rose by 10-20°C (Raj and Syriac, 2017).

Chemical method

Chemical methods are typically most effective when targeting emergence and early growth stages of weeds as they become harder to manage as they mature (Bastiaans *et al*., 2008). Effective suppression of weeds during critical crop- weed competition period leads to minimal yield losses. It's essential to choose the appropriate herbicide based on the specific weed species present in a given field. Correct dosage, timing and method of application of herbicides should be considered for effective control of weeds. In India, herbicides have become increasingly integral component of weed management (Mallikarjun *et al*., 2014). Herbicides offer easy, convenient, cost-effective and efficient weed control in Direct Seeded Rice (DSR) (Bhurer *et al*., 2013). Various herbicides have been evaluated and proven effective for pre-plant incorporation, pre-emergence and post-emergence weed control in case of dry direct seeded rice condition. Unlike other upland cereals, a single application of a specific herbicide rarely provides sufficient weed suppression in DSR. The combined use of pre- and post-emergence herbicides, when applied correctly, proves highly effective in managing weeds in DSR (Khaliq *et al*., 2011). Farmers apply both pre- and post-emergence herbicides to control weeds (Mahajan *et al*., 2013). Weeds present the most significant challenge and timely weed management is essential to enhance the productivity of direct seeded rice (Rao *et al*., 2007). In such scenarios, the use of pre-emergence herbicides like pendimethalin has immense roles in weed control (Singh and Singh, 2010). Similarly, various authors have noted that pyrazosulfuron ethyl, penoxsulam and post-emergence herbicides like bispyribac sodium (Khaliq *et al*., 2012) offer viable alternatives to hand weeding. In DSR weed control is much more complex. Thus, sequential application of herbicides provides an effective control of weeds and also increases crop growth (Jabran *et al*., 2012 and Khaliq *et al*., 2013). Flat jet & flat fan types of nozzles are very much effective for spraying herbicide.

Table 2: Pre-emergence herbicides for weed management in direct seeded rice

Herbicide	Dose of the active ingredient (g/ ha)	Time of application	Weeds controlled
Pendimethalin 30 EC	1000-1500	0-3 DAS	Annual grasses and some BLWs control
Pretilachlor 30.7% EW	450-600	0-3 DAS	Grassy weed (E. colona, E. crus-galli) and sedges (C. iria& C. difformis) under wet DSR puddled condition.
Oxadiargyl 6 EC	90	0-3 DAS	Controlling grasses and sedges, BLWs control is not satisfactory.

Anilophos 30 EC	400	3-5 DAS	Annual grasses and some BLWs
Oxidiazon 25 EC	500-750	Pre or early PoE	Control broad spectrum of weed. (No soil disturbance after application

Source: Singh *et al.*, 2016

Table 3: Post-emergence herbicides for weed management in direct seeded rice

Herbicide	Dose of the active ingredient (g/ ha)	Time of application	Weeds controlled
Cyhalofop-butyl 10 EC	75-80	15-20 DAS	Annual grass mainly *Echinochloa* spp.
Bispyribac-sodium 10 SC	20	15-20 DAS	Annual grass, some BLWs and sedges
Penoxsulam 24 SC	22.5	15-20 DAS	Annual grass, some BLWs and sedges
Chlorimuron-ethyl + metsulfuron methyl 20 WP	4 (2+2)	15-20 DAS	Broad spectrum weed including annual BLWs and grasses
2,4-D 38 EC, 80 WP	750-1000	20-25 DAS	Apply where sedges and BLWs were dominant. Good against water hyacinth and *Monochoria* spp.
Ethoxysulfuron 15% WDG	12.5-15	15-20 DAS	Broad leaves and sedges
Fenoxaprop-P-ethyl 9.3% EC	60	25 DAS	Excellent control of annual grassy weeds mainly *Echinochloa* spp.
Fenoxaprop-P-ethyl 6.9 EC+ safener	60-90	15-20 DAS	Excellent control of annual grassy weeds, safe on rice at early stage
Azimsulfuron 50% DF	17.5-35	15-20 DAS	Broad-spectrum weed control of grasses, sedges and broadleaves, excellent controlling of sedges including *Cyperus rotundus*
Carfentrazone 40% DF	20	15-20 DAS	Effective on broadleaved weeds
Bispyribac 2% SL+ Azimsulfuron 50% WG	25+ 17.5	15-25 DAS	Broad-spectrum weed control of grasses, broadleaves and sedges (including *C. rotundus*)
Fenoxaprop 6.9 EC + Ethoxysulfuron 15 WDG	56+ 18	15-25 DAS	Broad-spectrum weed control of grasses, sedges and broadleaves. Excellent control of all major grasses including *Leptochloa chinensis* and *Dactyloctenium aegyptium*

Source: Singh *et al.*, 2016; Kumar and Ladha, 2011

Conclusion

DSR has several advantages over transplanting method of rice cultivation but in DSR weed is one of the major global threats. To achieve effective, long term and sustainable weed management in direct seeded rice, there is a need to integrate different weed management strategies (such as integration of preventive methods, mechanical methods, cultural methods and chemical methods of weed management). Among the different methods of weed management the chemical method i.e., the use of herbicides is useful to kill and suppress weeds for quick result in case of severe infestation. This method also promotes timely and cost-effective weed management by reducing the time & labour requirement.

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