The Pharma Innovation Journal 2022; SP-11(6): 1426-1431

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 1426-1431

www.thepharmajournal.com
Received: 27-04-2022
Accepted: 30-05-2022

Jaspreet Kaur
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Sandeep Menon
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Tejishwar Singh Romana
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author
Sandeep Menon
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Role of herbicides in management of weeds in rice crop

Jaspreet Kaur, Sandeep Menon and Tejishwar Singh Romana

Abstract
Rice is a staple food source for people all over the world. Weed growth in paddy fields, on the other hand, is a serious biological threat to increased rice yield and quality. Several cultural, chemical, biological, and physical strategies influence weed production and composition in paddy fields. In most circumstances, herbicides can effectively control weeds, however chemical-based weed management is not a long-term answer. The different weed kinds and their consequences on rice production are discussed in this article, as well as weed management approaches for suppressing weed development in rice fields. The essential arguments are that rice has a wide variety of weeds (grassy, sedges, and broad leaf), weeds cause crop losses, and weed management solutions are restricted. Researchers will be able to learn more about how to boost agricultural productivity and manage weeds in a sustainable manner because of this research.

Keywords: Rice, weeds, herbicide, management

Introduction
Rice (*Oryza sativa* L.) is a staple meal in Asia and the Pacific, with the Asia-Pacific region producing and consuming more than 90% of the world's rice (Chauhan and Johnson, 2011; Chauhan, 2013; Chuhan and Abugho, 2013; Nadir *et al*. 2017) [6, 7, 28]. Rice consumption per capita has been gradually falling in medium and high-income people in Asian countries such as Korea and Japan as affluence and rates of urbanization have increased. However, because low-income workers account for around one-fourth of the Asian population, there will be enormous unmet demand for rice soon as rice consumption rises in these nations. In comparison to the base year of 1995, the global population is predicted to expand by 51% on average by 2025, and by as much as 87% in some cases (Papademetriou, 2000) [31]. Rice is also seen as a "lifeline" in many Asia-Pacific countries, according to Venkatesh (2016) [50], with over 90% of the world's rice accounting for 56% of population, manufacturing, and a variety of other industries. As a result, rice consumption is predicted to outpace supply in most countries. Aside from that, rice production necessitates a consistent supply of large amounts of water. Inconsistent rainfall, on the other hand, has caused a worldwide water scarcity (Simma *et al.*, 2017) [41].
In India, total cultivated area of rice 43 Mha, production 112million tones and productivity 4.3tones per hectare. Rice producing leading states is west Bengal, Uttar Pradesh, Punjab, Odisha, Andhra Pradesh, Bihar, and Chhattisgarh. India is 2nd largest state produces of rice followed by China. India is not achieved self-sufficiency in rice but also produces surplus to export. In both area and production West Bengal is at the top and followed by the Uttar Pradesh. In production Andhra Pradesh is at the 3rd no. but in area at 3rd place Bihar is there. In India in productivity Punjab top the list with 34q/ha. Mainly rice is grown in two ways. One is direct seeded rice and other is transplanted rice. Transplanted rice method best for crop production. Transplanted rice not profitable because farmer face problem due to unavailability of labor and labor wages. In transplanted rice there are several operations like puddling, nursery preparation, labor for transplanting and high irrigation etc. they cost more but yield is also more in this than direct seeded rice. In Direct seeded rice (DSR) there is 1 main problem that is weed. IN DSR weed are present in more population than Transplanting method and it reduced the yield in more amounts. Yield reduction in transplanted rice 25%, direct seeded rice 52%and puddle rice 32% due to weed (Manna 1991) [25]. There are so many reasons for low production. Weeds are a major problem in rice. Average 40 to 60% yield loss in rice due to weed completion (Chauhan and Johnson) [6]. Weeds compete with crop for nutrient, moisture, space, light, and other growth factor (Parameswari and Srinivas.) [47]. Generally, weed cause 45% yield loss compared to other problem i.e., insect/pest, disease etc. In rice it also same but many times it is over 60%. Weeds produce large no. of seed. There is a famous phrase related weed “one year seeding seven-year weeding”.

Generally, first 30-40 days are important for crop because in that weed infestation is more. According to the Thapa and Jha, 2002 report in transplanting method weed competition critical period is up to 40 DAT. Weed reduces the grain yield. Weed infestation decrease the grain yield directly and indirectly.

Uncontrolled weed in dry seeded rice 75.8%, transplanted rice (TPR) 62% and wet land rice 70.6% reduction in grain yield (Singh *et al.*, 2005) [42]. Most important Competition weed reduces up to32%grain yield (Singh *et al.*, 2007c) [44]. Transplanted rice major dominant grass weeds are *Echinochloa crusgalli, Echinochloa colona, Chloris barbata, Panicum sp., Cynodon dactylon broad* weed species are *Ammania baccifera, Marsilia quadrifolia, Potamogeton distinctus, Sphaeranthus indicus, Asteracantha longifolia,* and *Ruellia* tuberose sedges species are *Cyperus iria, C. rotundus* and *Fimbristylis miliacea* (Ramachandra (2010)[34]. Weed infestation in transplanted rice leads to low yields and poor-quality products. Uncontrolled weeds in transplanted rice reduced productivity by 76% (Singh *et al.*, 2004) [46]. Weeds appear 7-30 days after transplanting and compete with the rice plant until it reaches the tillering stage, when around 60% of weeds appear. Weed competition in lowland rainfed rice is critical 30 to 60 days after seeding, according to Moorthy and Sasha (2005) [26]. Weed free period through the critical period of competition is essential for obtain best rice yield. Weed management done by manual, mechanically and with chemical spray. Manual weeding is very common and effective method. In manual weeding weeds remove with hand. Manual weeding needs more numbers of labors. Mechanical method is very costly and not suitable.

Rice is mostly grown in the warm/cool humid subtropics, where there is a lack of water control owing to flooding and drought, as well as considerable weed infestation, and the crop suffers as a result. Weeds are one of the most significant biological threats to improved rice yields around the world, and controlling them in rice is a tough, complex, costly, and regulated procedure. As a result, to control the numerous weed invasions in rice fields, planned weed management procedures must be addressed. The scorching complexities of "prolific weed invasion" have been added to by the unavailability of labor due to seasonal migration and a lack of farm activities during the peak of the rice growing season, and precision weed removal/control is now a must to maximize output sustainability and effective resource use. Chemical weed control is the most used method for weed control in rice because it is simple, quick, timesaving, cost-effective, and reliable. Due to the herbicidal resistance limitations of older molecules, it is necessary to promote new herbicide molecules and their combinations (a long-term sustainable solution) for efficient weed control.

Losses due to weed

Weed competes with crop plants for nutrients, moisture, and sunlight in the field. Weed species, weed infestation intensity, weed infestation duration, crop plant competitive capacity, and soil-climate parameters that affect crop and weed growth all influence the form and severity of weed competition. The degree of weed competition is proportional to the decline in grain production. Because different species of weed flora require diverse agro-ecosystems, the prominent weed flora found in rice fields at various stages of crop growth and under varied environmental conditions differ. Sedges and broad-leaved weeds were the most active competitors, followed by grassy weeds (Umapathy and Sivakumar 2000) [48]. When compared to weed management methods, Kumar *et al.* (2010) [21] discovered that uncontrolled weeds in weedy plots reduced rice grain output by 70.4% in 2006 and 67.4% in 2007. Puniya*et al.*, (2007) [33] found the highest loss of nutrients in unweeded rice in Pantnagar'skharifin silt loam soil (42.07, 10.00, and 21.80 kg NPK/ha) due to increased density and dry weight of weeds.

Types of weeds found in rice fields

Vincent (2016) [51] studied the weed diversity in Kenya's Kirinyaga County rice fields. The study took place at Kenya's largest public irrigation scheme, the Mwea Irrigation Scheme. The most common broad leaf weed species surveyed were *Ludwigia adscendens* L., *Marsilea minuta* L., and *Sphaeranthus cycloides*, which accounted for 97%, 94%, and 84%, respectively, of the total. The least abundant species in this group of weed species was *Eclipta prostrate* L. (16%), which was found in the Scheme. The only four species with a presence of less than 50% were *Monochoria vaginalis* Burm. f (23%), *Ammania coccinea* Rottb. (39%), *Sphaeranthus africanus* (32%), and *Eclipta prostrata* L. (16%). *Leptochloa chinensis* L. was determined to be the most abundant grass species (97%), whereas *Echinochloa crus-galli* L. was the least abundant (77%). The most intriguing aspect of the grass species was that, compared to grasses and sedges, all four were relatively common, accounting for more than 71% of the total. Sedge species had a lower species frequency than broadleaf and grass species, accounting for less than 33% of the total.

Relative density of weeds

The dominant weed species associated with transplanted rice were sedges and shared the highest % age of total weed density (73.3%) (Singh *et al.*, 2005) [42]. Saha (2006) [37] observed that predominant weed species consisted of 14.3% grasses, 46.2% sedges and 39.5% broad leaved weeds at 30 DAT in unweeded check. The major weed density observed were 16.5% grasses, 51.5% sedges and 32% broad leaved weeds in transplanted rice of Andhra (Kiran *et al.*, 2010) [19]. Patra *et al.*, (2011) [32] noted that 27.2% grasses, 36.8% sedges and 36% broad leaved weeds in rice. Unweeded check registered more *Cyperus rotundus* insodic soil environment of Tiruchirappalli (Revathi *et al.*, 2017) [36].

Table 1: Weeds found in rice reported by Nagargade *et al*. (2018) [29]

Sr. No	Types of weeds	Weed Species	Scientific Name	Reference
1.	Grassy weed	Wild rice Barnyard rice Bermuda grass	*Echinochloa colona*, *Echinochloa crus-galli*, *Echinochloa* species, *Echinochloa glabrescens*, *Cynodon dactylon*, *Panicum repens*. *Eleusine indica*, *Ischaemum rugosum*, *Leptochloa chinensis*, *Paspalum distichum*	Kumar *et al*., (2013) [23], Nagargade *et al*. (2018) [29], Bhimwal and Pandey (2015) [5] Yadav *et al*., (2009) [52] Nivetha *et al*., (2017) [30],
2.	Broad leaf weed		*Ammannia baccifera*, *Marsilea quadrifolia*, *Caesulia axillaris*, *Ipomoea aquatica*, *Ludwigia octovalvis*, *Ludwigia adscendens*, *Monochoria vaginalis*, *Sphenoclea zeylanica*	Nivetha*et al*., (2017) [30], Revathi*et al*., (2017) [36] and Manisankar*et al*., (2019) [24] Bhimwal and Pandey (2015) [5], Nagargade *et al*.(2018)[29]
3.	Sedges	Yellow sedge Common sedge Purple nut sedge	*Cyperus iria*, *Cyperus difformis*, *Cyperus rotundus*	Kumar *et al*., (2013) [23] Saini and Chopra (2015) [39] Yadav *et al*., (2009) [52] Nagargade *et al*., (2013) [29]

Effect of herbicides on weeds in rice field

Due to their broad-spectrum activity, which controlled most weed species, herbicides effectively controlled the weed population, lowering weed dry matter production, and it gradually grew towards crop maturity due to the reduction of weed population at early stages of crop growth. Pre emergence and early post emergence herbicide used are very effective at initial stage. These herbicides are preventing the weed seed germination and control the weed growth seedling. Use of herbicides to get effective weed control on timely. Use of herbicide keeps the weed free crop at initial crop weed competition stages and it will help to reduce the cost of weeding and damage level (Gnanvel *et al.*, 2010) [14]. Most herbicides are very effective for selective weed control, but one herbicide cannot control all different weed species (Corbelt *et al.*, 2004) [10]. Use of pre-emergence and post emergence herbicide along with cultural, mechanical, and other method of weed control gives the good result.

Herbicide is very easy and effective method to control weeds in rice field. Herbicide control weeds pre-sowing, pre-emergence, early post-emergence, and combination of all of them is very effective for weed control. All herbicides are easily available in the market like azimsulfuron (50%DF), Chlorimuron-ethyl (25%WP), cinmethylin (10%EC), clomazone (50%EC). Brar and Mishra, 1989 reported that herbicide is time saving, Easy and economical method as compared to hand weeding.

Whip super is selective herbicide having action against *Echinochloa* sp. and other grassy weeds in rice field. It is post emergence herbicide. The researcher used the different dose of whip super against weeds. They noticed that the different doses decrease the population of *Echinochloa* sp in rice field.

The research revealed that Azimsulfuron 50 DF (dry flow able) @ 30g a.i/ha was recorded effective in broad leaf weeds like *Sphenoclea zeylanica* and reducing the density of sedges (*Cyperus difformis*). An experiment to study the efficacy of Azimsulfuron against complex weed flora in transplanted rice done by Saha and Rao (2012) [38]. Jayadeva *et al.*, (2011) [17] conducted an experiment to find the efficacy of Azimsulfuron 50 DF in weed control in transplanted rice during Kharif season. The authors proved that among other herbicides treatments, application of Azimsulfuron @ 27.5g a.i ha^{-1} + Metsulfuron methyl @ 2g a.iha^{-1} + 0.2% surfactants was more effective in controlling weeds. An experiment to find the bio efficacy of Azimsulfuron against sedges conducted by Singh *et al.*, (2006) [45]. They found that increase the dose of azimsulfuron from 25-30g/ha than reduce the weed dry weight and weed density in crop growth stages. A field experiment at Karnal was conducted to evaluate the efficacy of Azimsulfuron alone and in combination with ready mix of Almix applied to transplanted rice by Singh *et al.*, (2006) [45]. Azimsulfuron at 20 DAT @ 25-30g/ha effectively control broad leaf weeds and sedges.

Council active: it is new latest post emergence rice herbicide. It is highly effective herbicide to weed control resulted high production and savings of time and labour cost. An experiment Evaluation of bioefficacy of herbicide combinations including new herbicides in transplanted rice. He used the combination treatment premix of triafamone + ethoxysulfuron 60 gha^{-1} 15 DAT and resulted that more effective against *Leptochloa chinensis* and *Ludwigia parviflora*, but not effective against *Echinochloa spp.* triafamone + ethoxysulfuron east weed count and weed dry matter at 42 days after application in direct seeded rice (Deivasigamani 2016)[11]. Combinations of triafamone + ethoxysulfuron were found to be very effective to obtained higher grain yield.

Chlorimuron-ethyl: it is highly effective post emergence herbicide to control the broad leaf weeds in rice. It belongs to sulfonylurea. An experiment conducted at Kalyani 'C' Block Farm of Bidhan Chandra Krishi Viswavidyalaya. The treatments were Control, Hand Weeding, Chlorimuron Ethyl 25% WP @ 3.0 g^{-1}a.i. ha, chlorimuron ethyl 25% WP @ 6.0 g a.i. ha^{-1}chlorimuron ethyl 25% WP @ 9.0 g a.i. ha^{-1}chlorimuron ethyl 25% WP @ 12.0 g a.i.$^{-1}$ ha, check-standard chlorimuron ethyl 25% WP @ 6.0 g^{-1}a.i. ha. It was reported that higher dose of chlorimuron ethyl more effective against grassy weeds than lower dose of chlorimuron ethyl. Dubey *et al.* (2000) [13] reported the similar observation that application of chlorimuron ethyl at 9 and 12 g a.i/ha more effective and reduce the sedges and broad leaf weeds.

Cinmethylin is active on several important grasses in rice (*Echinochloa* spp., *Cyperus* spp., and *Monochoria vaginalis*) at rates from 25 to 100 g a.i /ha. An experiment was conducted to evaluate the effects of a wet table powder mixed with 10% cinmethylin and bensulfuron-methyl on weed control and crop yield. The resulted were recorded 10% cinmethylin and bensulfuron-methyl WP very effective to control *Echinochloa crus-galli* (L.) *Monochoria vaginalis* (Burm. F.), *Rotala indica*, and *Marsilea quadrifolia* L in transplanted rice fields.

clomazone is selective herbicide it is used to control broad leaf weed and grasses. An experiment conducted to Rice Tolerance to Saflufenacil in Clomazone Weed Control Program. Weed control with clomazone low cost and very effective to control grassy weeds. An experiment was conducted to study the

performance of Clomazone. It is used for grass control in direct-seeded rice and water seeded rice. He observed that pre- and early post emergence treatment of clomazone at 180 to 240 g ai ha^{-1} effective control of *E. crus-galli* in water-seeded rice. Spraying 2, 4-D with dhaincha reduced total weed count by 78% while reducing weed dry matter generation by 59%. The use of 2, 4-D to suppress dhaincha-controlled broadleaved weeds and sedges effectively (Anitha *et al.,* 2012) [2]. Different herbicides altered weed density in transplanted rice, according to Shahbaz *et al.,* (2018) [40], and there were substantial differences at three locations during kharif 2015. At all areas, all the treatments dramatically reduced weed density when compared to the weedy control. At all three locations, the weedy check plot had the highest weed populations (91.00, 67.34, and 56.30), while the plot treated with bispyribac sodium had the lowest weed populations (7.66, 3.67, and 5.60). According to Vaishya and Tomar (2000) [49], a post-emergence application of 2,4-D @0.4kg ha^{-1} was found to be effective in lowering weed dry weight/unit area.

S. No	Herbicide class	Herbicide name	Mode of action	Weed efficiency
1.	Post emergence	Pyrazosulfuron ethyl	ALS inhibitor	An increase of 87–188% was recorded in rice yield in herbicide treated plots than weedy check (control)
2.	Pre emergence	Pretilachlor	Selective	Among all treatments, 79.53% weed control was obtained by application of pretilachlor at 30 DAT
3.	Pre emergence	Butachlor	Selective	Weed dry biomass was 56.92% less in treatment having machete (butachlor) application over weedy check.
4.	Pre+Post emergence	Pendimethalin-followed by-bispyribac-sodium + azimsulfuron	ALS inhibitor	Application of these herbicide provided 85% weed control over other herbicides with minimum weed dry biomass
5.	Pre and post emergence	Isoproturon + 2, 4-D	Selective systemic herbicide	Rice yield was 11–15% higher and 0.19 more B:C ratio (net monetary return) than weedy control
6.	Pre emergence	Pretilachlor	Selective	Rotational use of pretilachlor with butachlor reduces sedges population and increased paddy yield by 3–5%

Effect of weeds on yield

In order to maximize crop yield, all of this growth should be in the form of the crop. Moody reported that any weeds growing with main crop will reduce the vegetative potential and resulted is loss in yield. Many research reported the effect of crop weed completion on yield and growth. Weeds in crop are major problem to reduce the yield and quality of crop. Weed completes with crop for moisture light, nutrient and space. (Singh *et al.,* 2004). Weeds absorb available nutrient earlier before crop resulted in decrease the availability for crop. More population weed has several harmful effects: according to the Bhargavi and Yellamandareddy (1994) [4] report weed decreased the shoot and plant height and it also affect the grain production (Srinivasan and palaniappan, 1994) [47]. Dobermans and Firhurst, (2000) [12] reported that yield loss range between 30 to 100% caused by weed competition with crop. maintaining the weed free crop up to 45DAT was essential dispute the yield of medium duration rice (Chinnusamy *et al.,* 2000) [8]. Grain yield loss in transplanted rice range 30 to 80% and lowland rice ranged 20 to 60% (Janiya 2002) [16]. These weeds *Cyperus spp., Paspalum spp., Caesulia axillaris, Rotala densiflora and Monocharia vaginalis* cause 28-40% yield loss in transplanted rice (Reddy *et al.,* 2003). Different types of weeds like broad leaf weed, sedges and grass caused 76% yield loss in transplanted rice (Mukherjee and Singh 2004) [27].

Conclusion

it can be concluded that weed effectively compete with the crop up to 40-45 DAT/S and reduce grain yields ranging from 10 to 83 per cent. Chemical weed control is getting importance in areas, where labor 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. Moreover, any weed management approach should be aimed at controlling weeds only during critical period of weed competition for a more cost-effective and eco-friendly weed management. In 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.

References

1. Ali M, Sardar MSA, Biswas PK, Sahed Bin Mannan AKM. Effect of integrated weed management and spacing on the weed flora and on the growth of transplanted aman rice. Int. J Sustain. Crop Prod. 2008;3(5):55-64.
2. Anitha S, Mathew J, Abraham CT. Concurrent growing of green manure with wet-seeded rice for cost-effective weed management, 2012.
3. Ashraf U, Anjum SA, Ehsanullah KI, Tanveer M. Planting geometry-induced alteration in weed infestation, growth and yield of puddled rice. Pak J Weed Sci Res. 2014;20(1):77-89.
4. Bhargavi K, Yellamanda Reddy T. Growth pattern of weeds and semi-dry rice (*Oryza sativa*) under various weed management practices. Indian J Agron. 1994;39(1):113-116.
5. Bhimwal JP, Pandey PC. Bio-Efficacy of flucetosulfuron for broad spectrum weed control in transplanted rice (*Oryza sativa* L.). Annals of Agricultural Research. 2015;36(1):82-85.
6. Chauhan BS, Johnson DE. Row spacing and weed control timing affect yield of aerobic rice. Field Crops Research. 2011;121(1):226-231. DOI:10.1016/j.fcr.2010.12.008.
7. Chauhan BS. Strategies to manage weedy rice in Asia. Crop Prot. 2013;48:51-56. DOI:10.1016/j.cropro.2013.02.015Return
8. Chinnusamy C, Kandasamy OS, Sathyamoorthy K, Chandrasekar CN. Critical period of crop-weed competition in lowland rice ecosystems. In: Proc. of State level Seminar on Integrated Weed Management in New Millennium. Feb, 27-28. Depoli Chapter of Indian Society of Agronomy, Ratnagiri (Maharashtra), 2000.
9. Chuhan BS, Abugho SB. Fertilizer placement affects weed growth and grain yield in dry-seeded rice (*Oryza sativa* L.) system. Am J Plant Sci. 2013;4:126.

10. Corbett JL, Askew SD, Thomas WE, Wilcut JW. Weed efficacy evaluations for bromoxynil, glufosinate, glyphosate, pyrithiobac, and sulfosate. Weed Technology. 2004;18(2):443-453.
11. Deivasigamani S. Study of bio-efficacy and phytotoxicity of new generation herbicides on triafamone and ethoxysulfuron in direct seeded rice (*Oryza sativa*). IRA-International Journal of Applied Sciences. 2016;3(2):106-112.
12. Dobermann A. Rice: Nutrient disorders & nutrient management. Int. Rice Res. Inst, 2000
13. Dubey MP, Singh R, Tiwari UK, Kunnvanshi SM, Goswami SR, Jain SK. Response of Soybean [*Glycine max* (L.) Merrill] and Associated Weeds to Pre-emergence Application of Chlorimuron Ethyl and Metolachlor. Indian Journal of Weed Science. 2000;32(3-4):153-155.
14. Gnanavel I, Anbhazhagan R. Bio-efficacy of pre and post emergence herbicides in transplanted aromatic basmati rice. Res. J Agric. Sci. 2010;1(4)315-317.
15. Jabran K, Farooq M, Hussain M, Khan MB, Shahid M, Dong-Jin L. Efficient weeds control with penoxsulam application ensures higher productivity and economic returns of direct seeded rice. International Journal of Agriculture and Biology, 2012, 14(6).
16. Janiya JD. Weed management in major crops in the Philippines. Los Banos, Laguna, Philippines: In Weed Science Society of the Philippines. Yield losses, major weed species, and suggested management systems in selected major crops: rice, 2002, 17-37.
17. Jayadeva HM, Bhairappanavara ST, Somashekarappa PR, Hugar AY, Rangaswamy BR, Mallikarjun GB, *et al*, Evaluation of azimsulfuron for weed control in transplanted rice (*Oryza sativa* L.). Indian Journal of Agricultural Research. 2011;45(3):239-243.
18. Khaliq A, Matloob A, Chauhan BS. Weed management in dry-seeded fine rice under varying row spacing in the rice-wheat system of Punjab, Pakistan. Plant production science. 2014;17(4):321-332.
19. Kiran YD, Subramanyam D, Sumathi V. Growth and yield of transplanted rice (*Oryza sativa*) as influenced by sequential application of herbicides. Indian Journal of Weed Science. 2010;42(3).
20. Koskei VK. Diversity of Weed and Their Integrated Management Practices in Paddy Rice (*Oryza Sativa*) Production (Doctoral dissertation, University of Nairobi), 2016.
21. Kumar J, Singh D, Puniya R, Pandey PC. Effect of weed management practices on nutrient uptake by direct seeded rice. *Oryza*. 2010;47(4):291-294.
22. Kumar M. Halosulfuron Methyl 75% WG (Sempra): A New Herbicide for the Control of *Cyperus rotundus* in Maize (*Zea mays* L.) Crop in Bihar. International Journal of Current Microbiology and Applied Sciences. 2018;7(3):2319-7706.
23. Kumar P, Singh Y, Singh UP. Evaluation of cultivars and herbicides for control of barnyard grass and nutsedge in boro rice. Indian J Weed Sci. 2013;45:76-79.
24. Manisankar G. Evaluation of sequential herbicide application in transplanted rice under sodic soil. M.Sc. (Ag.) Thesis, Department of Agronomy, Anbil Dharmalingam Agriculture College and Research Institute, Tamil Nadu agricultural university, Trichy-620 027, 2019b.
25. Manna GB. Weed management for increasing efficiency of fertilizer. Proceedings of summer institute on nutrient transformation and management in flooded soil-rice ecosystem, CRRI, Cuttack, 1991, 1-20.
26. Moorthy BTS, Sanjoy Saha. Studies on crop – weed competition in rainfed direct seeded low land rice. Indian J Weed, Sci. 2005;37(3-4):267-268.
27. Mukerjee D, Singh RP. Efficacy of Certain Low Doses Herbicides in Medium Land Transplanted Rice (*Oryza sativa* L.). Indian Journal of Weed Science. 2004;36(1-2):47-49.
28. Nadir S, Xiong H, Zhu Q. *et al*. Weedy rice in sustainable rice production. a review. Agron. Sustain. Dev. 2017;37(46). DOI:10.1007/s13593-017-0456-4
29. Nagargade M, Singh MK, Tyagi V. Ecologically sustainable integrated weed management in dry and irrigated direct-seeded rice. Adv. Plants Agric. Res. 2018;8:319-331.
30. Nivetha C, Srinivasan G, Shanmugam PM. Effect of Weed Management Practices on Growth and Economics of Transplanted Rice under Sodic Soil. Int. J Curr. Microbiol. App. Sci. 2017;6(12):1909-1915.
31. Papademetriou MK. Rice production in the Asia-Pacific Region: Issues and perspectives. In Bridging the Rice Yield Gap in the Asia-Pacific Region. FAO, UN, Bangkok, Thailand. RAP Publication. 2000;16:2000.
32. Patra KA, Halder J, Mishra MM. Chemical weed control in transplanted rice in Hirakud command area of Orissa. 2011.
33. Puniya R, Pandey PC, Bisht PS, Singh DK. Nutrient uptake by crop and weeds as influenced by trisulfuron, trisulfuron + pretilachlor and bensulfuron methyl in transplanted rice. Indian Journal of Weed Science. 2007;39(3-4):239-240.
34. Ramchandra C, Denesh GR, Sydanwarulla. Weed management practices in transplanted rice by using glyphosate. Biennial Conference on "Recent Advances in Weed Science Research-2010", February 25-26, 2010, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhatisgarh), 2010, 68pp
35. Rekha KB, Raju MS, Reddy MD. Effect of Herbicideson Weed Growth, Grain Yield and Nutrient Uptake in Rainfed Low Land Rice. Indian Journal of Weed Science. 2003;35(1-2):121-122.
36. Revathi M, Annadurai K, Chinnusamy C. Effect of various pre and post emergence herbicides on crop yield and weed dynamics under different rice establishment methods in Sodic soil environment. International Journal of Chemical Studies. 2017;5(5):1531-1536.
37. Saha S. Comparative study on efficacy of sulfonylurea herbicides and traditional recommended herbicides in transplanted rice (*Oryza sativa*). Indian Journal of Agronomy. 2006;51(4):304-306.
38. Saha S, Rao KS. Efficacy of azimsulfuron against complex weed flora in transplanted summer rice. Oryza-An International Journal on Rice. 2012;49(3):183-188.
39. Saini MK, Chopra S. Influence of weed control methods on weeds, yield, energetics and economics of basmati rice (*Oryza sativa*) under sub-mountaineous conditions of Punjab. Indian Journal of Agronomy. 2015;60(3):410-413s.
40. Shahbaz MD, Sher MD, Ahmad F, Sajjad A, Riaz MD, Nabi G. Effect of different post emergence herbicides on weed density and some agronomic attributes of transplanted rice in rice-wheat cropping system under

adaptive research zone Sheikhupura, Pakistan. Pakistan Journal of Weed Science Research. 2018;24(1):1-8.
41. Simma B, Polthanee A, Goggi AS, *et al*. Wood vinegar seed priming improves yield and suppresses weeds in dryland direct-seeding rice under rainfed production. Agron. Sustain. Dev. 2017;37(56). DOI:10.1007/s13593-017-0466-2
42. Singh PV, Singh G, Singh M. Effect of Bensulfuron-methyl (Londax 60 DF) on sedges and non-grassy weeds in transplanted rice. Indian Journal of Weed Science. 2005;37(1-2):40-44.
43. Singh V, Jat ML, Ganie ZA, Chauhan BS, Gupta RK. Herbicide options for effective weed management in dry direct-seeded rice under scented rice-wheat rotation of western Indo-Gangetic Plains. Crop Protection. 2016;81:168-176.
44. Singh I, Ram M, Nandal DP. Efficacy of new herbicides for weed control in transplanted rice under rice-wheat system. Indian J Weed Sci. 2007c;38:28-31.
45. Singh UP, Singh RP, Singh Y. Integrated weed management in direct dry seeded rainfed lowland rice. Indian Journal of Weed Science. 2006;38(1-2):49-53.
46. Singh UP, Singh RK, Singh RP. Performance of herbicides and cultivars under zero till situation of rainfed lowland rice eco-system. Indian J. Weed Sci. 2004;36(1-2):122-123.
47. Srinivasan G, Palaniappan SP. Effect of major weed species on growth and yield of rice (*Oryza sativa*). Indian J Agron. 1994;39(1):12-15.
48. Umapathy K, Sivakumar C. Studies on crop- weed competition in rice-rice cropping system. In Proc. State level seminar on Integrated Weed Management in new millennium, Ratnagiri, Maharashtra, 2000, 57.
49. Vaishya RD, Tomar SK. Weed control in puddled seeded rice (*Oryza sativa*) with herbicides. Indian Journal of Agronomy. 2000;45(2):334-337.
50. Venkatesh K. Rice production in the Asia-Pacific region. Research and Reviews Journal of Agriculture and Allied Sciences.2016;5(2):40-50.
51. Vincent KK. Diversity of weed and their integrated management practices in paddy rice (*Oryza sativa*) production. Master of Science in Crop Protection, University of Nairobi, 2016.
52. Yadav DB, Ashok Yadav, Punia SS. Evaluation of bispyribac-sodium for weed control in transplanted rice. Indian Journal of Weed Science. 2009;41(1-2):23-27.
53. Zein AA, Abd-El-Baky MA, Hassan SM, Derbalah AS, Hamza AM. Evolution and mechanism of rice weeds resistance to herbicides. I-Resistance of Echinochloa colonum to bispyribac-sodium herbicide with respect to its effect on chlorophyll content. Journal of Agricultural Research. 2010;36:480-494.