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*S&T REVIEW*

# A COMPREHENSIVE REVIEW ON HERBICIDAL STRATEGIES FOR DRY DIRECTLY SEEDED RICE (DDSR) IN NEPAL'S CENTRAL MID-HILL REGION

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**ABSTRACT**

This review aims to provide a comprehensive overview of herbicidal strategies for weed control in DDSR systems specifically tailored to Nepal's central mid-hill region. We discuss the prevalent weed species in DDSR fields and their ecological characteristics, emphasizing the importance of integrated weed management approaches. Furthermore, the efficacy, selectivity, and environmental impacts of various herbicides commonly used in DDSR, considering factors such as application timing, dosage, and formulation is reviewed under this paper. Additionally, the role of cultural practices, such as crop rotation, residue management, and intercropping, in augmenting the effectiveness of herbicidal weed control strategies are also studied under the topic. By synthesizing existing knowledge and identifying research gaps, this review aims to inform policymakers, agronomists, and farmers about the most suitable herbicidal strategies for sustainable weed management in DDSR systems in Nepal's central mid-hill region. This review thoroughly assesses different chemical weed control methods and their suitability, effectiveness, and long-term viability in this particular situation

**KEYWORDS**

Herbicidal strategies, Chemical weed control, directly seeded rice

## 1. INTRODUCTION

Rice (*Oryza sativa* L.) is most important staple food of Nepal, crucial for food security and livelihoods as it stands as the predominant crop in Nepal, constituting approximately 50% of both the agricultural land and overall production in the nation. With the productivity of 3.47 t/ha from 1.47 Million ha of land contributing 21% of GDP of the country and 50% calorie requirement of the nation plays crucial role in the maintaining food security of the country (MOALD, 2020/21).

The usual method of cultivating rice involves transplanting after repeated puddling, which is time-consuming and uses considerable amount of water. Puddling offers numerous benefits that can greatly enhance your agricultural practices. By creating anaerobic conditions, it promotes the uptake of essential nutrients such as phosphorus, iron, and zinc, resulting in improved nutrient absorption for your crops. Additionally, puddling effectively reduces weed populations, (Singh et al., 2002). This means less competition for resources and a healthier crop yield. Puddling and transplanting seedlings use a considerable amount of water, sometimes reaching 30% of overall water requirement of the rice. This causes the farmers to switch to directly seeded rice systems from manual transplanting.

The benefits directly seeded rice provides early maturity, simple mechanization, less labour and reduced water consumption. DDSR rice offers a remarkable advantage over transplanted rice by maturing 1-2 weeks earlier. This crucial benefit significantly minimizes the risk of terminal drought, ensuring a higher chance of a successful harvest. Moreover, the early maturity of DDSR rice enables farmers to plant the succeeding crop in rotation much earlier, maximizing their yield potential. By choosing DDSR rice, it also helps to mitigate the threat of drought but also gain the opportunity to optimize your crop rotation schedule for enhanced productivity.

The utilization of DDSR offers several benefits; however, the primary challenge associated with its implementation is the risk of biotic hazards caused by weeds. The estimated yield losses under DDSR can be as high as 75%, which accounts for more than 30% of the total expenses incurred in rice cultivation. The detrimental impact of weeds on rice production cannot be underestimated, as they can lead to yield losses ranging from 50 to 91% (Rao et al., 2007). In the context of DDSR cultivation, the control of weeds has been achieved through manual means, specially hand weeding. Nevertheless, the practice of chemical weed management has gained prominence as a substitute for manual weeding.

This shift can be attributed to the limited availability of labour, the increasing costs associated with manual labour, and physical exertion involved in the process. The utilization of chemicals itself a superior and efficient alternative. Consequently, employing pre-emergence and early post-emergence herbicide will yield significant effectiveness. These herbicides possess the capability to either impede the growth of unwanted vegetation to hinder the germination process of weed seeds (Pawar et al., 2018). The objective of this review was to facilitate the assessment of the effectiveness and economic feasibility of chemical weed control in order to enhance the productivity and profitability of rice cultivation under the zero tillage DDSR system.

## 2. WEED FLORA ASSOCIATED WITH DDSR

Many effects of weed infestations on crop growth and yield are strongly influenced by weed species and their density in a crop region The spread and persistence of particular weed species in a particular area while weed a presence and surrounding ecosystems are greatly affected These factors together determine the potential, abundance, extent, and distribution of weeds. Consequently, it is important to prioritize research on weed species and weights in competition with rice cultivation in order to develop effective weed management strategies. Rice fields are home to a staggering 350 reported weed species (Singh et al., 2016). But that's not all, when it comes to DSR crops fields, around 50 weed species have been known to invade (Caton BP, 2003; Rao et al., 2007).

Common grass weed that DSR had been found infested are: *Echinochloa*

*colona, E. crusgalli, Elusine indica, Leptochola chinensis, Digiteria sanguinalis, Bracheria ramose, Cyanodon dactylon, Dactylotenium aegyptium* and *Alternanthera sessilis, Ammania baccifera, Caesulia axillaris, Celosia argentia, Cleome viscosa, Comelina benghalensis, C. communis, Cyanotis axillaris, Digera arvensis* are some broad leaf weeds.

## 3. Chemical Weed Control Method in DSR

The chemical method of weed control is a superior method as compared to other methods like manual weeding, it is labour-intensive, tedious, expensive and time consuming. It has been observed that the use of chemical herbicides use is more efficient and cost-effective (Singh et al., 1998). When weeds are abundant in an area, it is difficult to deal with manual weed removal, but herbicides can easily solve the issue. The use of chemical herbicides can save money and labor. For direct seeded rice (DSR), herbicides are an effective strategy to control large weeds and reduce agricultural costs (Jacob et al., 2014).

The research conducted by a group researcher, it aimed to assess the impact of various herbicide treatments on the growth and yield of Khumal-10 variety of rice (Gaire et al., 2019). The experiment employed a randomized complete block design with nine treatments and three replications, focusing on different herbicide combinations and a weedy check treatment. The study considered biometrical observations, including plant height, leaf area index (LAI), above-ground biomass, yield attributes, grain and straw yield, and economic aspects such as the benefit-to-cost ratio (B: C). The experiment also evaluated weed parameters, such as weed density, weed index, and weed control efficiency (WCE). The findings from this experiment contribute valuable insights into the effectiveness of herbicide treatments and their impact on rice cultivation in the specific geographic and climatic conditions of central Nepal.

## 4. Effect of Different Chemical Treatments

The co-cultivation of Sesbania with a combination of pendimethalin and 2, 4-D showcased remarkable outcomes in terms of plant height and leaf area index (LAI). These positive effects can be attributed to Sesbania's ability to fix nitrogen, suppress weed growth, and conserve moisture, thereby creating optimal conditions for the growth of rice plants. These findings align with previous research, further validating their significance. Moreover, when pendimethalin was combined with pyrazosulfuron, it resulted in the highest above-ground biomass, highlighting the crucial role of weed control. Throughout the various treatments, the level of intra-specific competition remained consistent, underscoring the substantial impact of inter-specific competition between the crop and weeds on the overall biomass of the crop reported (Gaire et al., 2019).

Among the different treatments, the combination of pendimethalin 1.0 kg/ha followed by 2,4-D 1.0 kg/ha showed the highest number of effective tillers per square meter, reaching an impressive 169.7 tillers/m2. Additionally, the longest panicle was observed in the plots treated with the same combination of herbicides but in the presence of Sesbania co-culture, measuring 24.7 cm. Interestingly, the plots treated with pendimethalin 1.0 kg/ha followed by pyrazosulfuron 35 g/ha, penoxsulam 14 g/ha, and a tank mixture of pyrazosulfuron 20 g/ha + byspyribac-Na 25 g/ha also showed a similar number of filled grains per panicle (Gaire et al., 2019). However, the weedy check plot had the lowest number of grains per panicle, indicating the negative impact of weed density on grain. To achieve the maximum effective tillers per square meter, it is recommended to use pendimethalin 1.0 kg/ha in combination with 2, 4-D 1.0 kg/ha as reported (Gaire et al., 2019).

## 5. Effects of Different Chemical Treatments on Grain Yield and Sterility

The use of different herbicidal combinations had a significant impact on grain and straw yield as well as sterility percentage in rice cultivation. The highest grain yield was observed in plots treated with pendimethalin 1.0 kg/ha combined with pyrazosulfuron 20 g/ha and bispyribac-Na 25 g/ha, which was statistically similar to other effective treatments (Gaire et al., 2019). Conversely, the lowest yield occurred in weedy check plots, indicating the negative impact of weed competition on yield. Similar trends were observed in the straw yield, with the most favourable results obtained from the same herbicidal combination. The average sterility percentage was 8.99%, with variations among different herbicide treatments. The combination of pendimethalin 1.0 kg/ha and 2, 4-D 1.0 kg/ha resulted in the lowest sterility percentage (7.01%), comparable to other effective treatments as reported (Gaire et al., 2019). Additionally, the study found that the application of herbicides did not have a significant effect on thousand grains weight. Overall, the results suggest that specific herbicidal combinations can effectively enhance rice yield and reduce sterility, highlighting the importance of weed management in rice cultivation.

Study conducted reported that the effects of different herbicide treatments on weed density and control efficiency over a 60-day period after sowing (Gaire et al., 2019). The combination of pendimethalin, pyrazosulfuron, and bispyribac-Na proved to be the most effective in reducing weed density, with only 70.5 no. /m2 compared to other treatments. The study also found that the type and combination of herbicides used had a significant impact on weed control efficiency, with the mentioned combination exhibiting the highest efficiency at 43.36% (Gaire et al., 2019). These findings are consistent with previous studies by Kumar et al. (2017), while variations in weed control were also observed in studies by Rao (2005) and Nayak et al. (2014) in paddy fields.

The experiment showed a range of weed index values, with the lowest being -2.23% in plots treated with a pendimethalin tank mixture of pyrazosulfuron and bispyribac-Na, and the highest being 58.13% in the weedy check plot. This means that the presence of weeds caused a significant reduction in yield. Similar results were found in Chitwan, where weed interference caused a 65% reduction in direct-seeded rice yield (Sharma, 2013). The weedy check plot had a much higher weed index than other treatments, due to the persistent presence of invasive weed species that were not removed. These findings highlight the importance of effective weed management strategies in agriculture, as weeds can have a substantial impact on crop yield.

## 5. Economics

Various herbicidal treatments have a significant impact on the cost of cultivation, gross return, net return, and B: C ratio. Specifically, when using pendimethalin 1.0 kg/ha in combination with 2, 4-D 1.0 kg/ha under Sesbania co-culture, the cost of cultivation was higher. However, when pendimethalin 1.0 kg/ha was combined with a tank mixture of pyrazosulfuron 20 g/ha and bispyribac-Na 25 g/ha, there was a notable increase in gross return, net return, and B: C ratio.

## 6. Conclusion

Direct-seeded rice faces a significant challenge in the form of weed infestation. Weeds have a profound impact on various growth factors, ultimately leading to a decrease in the yield of direct-seeded rice. The initial 40 days after sowing are crucial for ensuring optimal crop growth. To effectively manage weeds in direct-seeded rice in an environmentally friendly and sustainable manner. However, in cases of severe weed infestation where immediate results are required, chemical methods can serve as an alternative to effectively eliminate and suppress weeds. The study concluded that the use of herbicides had a significant impact on the growth and yield of the crop. By effectively controlling weeds, the herbicides reduced competition from dense weed growth. The most effective herbicide application involved using pendimethalin at a rate of 1.0 kg/ha before emergence, followed by a tank mixture of pyrazosulfuron at 20 g/ha and bispyribac-Na at 25 g/ha as a post-emergence herbicide. This treatment not only controlled a wide range of weed species but also resulted in higher grain yield. Furthermore, it was found to be more cost-effective in dry direct seeded rice production. The discoveries propose that delving into the realm of chemical weed control techniques in the cultivation of dry direct seeded rice holds great promise as a captivating avenue for future research and development within the opulent Nepalese rice production system.

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