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Effect of weed management practices on *Kharif* rice- A review

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Abstract

Rice is an important staple food crop of India. Several factors are responsible for reducing the yield of *Kharif* rice. However, weed infestation is the major threat to productivity of *Kharif* rice. Weeds by the virtue of their high adaptability and faster growth dominate the crop habitat and reduce the yield potential of the crop. These weeds could be controlled through various methods. Manual method is though very common but cost intensive. Herbicides when applied alone are although economical but may have limitation of resistance development and 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 *Kharif* rice.

Keywords: Herbicides, Weed management, Rice

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1. Introduction

Rice (*Oryza sativa* L.) is the most important staple food grain crop of the world which constitutes the principle food for about 60 per cent of the world's population. Rice contributes 43 per cent of total food grain production and 46 per cent of total cereal production in India. Rice based production system provides the income and employment for more than 50 million households. One third of Asia's rice production is consumed in China and one fifth in India. In the world, rice is grown in 114 countries across the world on an area about 158 million hectares with annual production of over 527 million tones, constituting nearly 11 per cent of the world's cultivated land. More than 90 per cent of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition. India is the world's second largest rice producer and consumer next to China. Rice has unique position in Indian economy. In 2017 rice cultivated on an area of 43.57 million hectares with an annual production 104.32 million tones and productivity about 2.98 tones ha^{-1} (Anonymous, 2017). The slogan "Rice is life" is most appropriate for India as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural households.

Weed competition is one of the major factors responsible for low yield of rice. Competition offered by weeds is most important and it reduces the grain yield up to the extent of 32 per cent (Singh et al. 2007). Thus, it is important that they are controlled in time to avoid unproductive use of growth factors to enable the crop plant to express fully by utilizing these factors meant for them. Herbicides are effective against weed species, but most of them are specific and are effective against narrow range of weed species (Mukherjee and Singh, 2005a). Therefore, appropriate and economical weed management technology is to be developed for the sustainable rice cultivation. For direct seeded rice, it is important to keep field weed free for first 30 days. Therefore, use of pre-emergence or early post-emergence herbicides is effective and economical at initial stages. The pre-emergence or early post-emergence herbicide either prevents weed seeds germination or inhibits the growth of seedlings.

Weed control methods such as hand pulling or hand weeding by weeding hook are laborious, tedious drudgery causing and expensive process. The labour requirement for such operations may be 60 to 70 man days during peak season demand. Weed management is an important aspect regarding obtaining higher crop yield as weeds are silent, malignant and massive forces, which reduce yield drastically. Though manual weeding is considered as best method but it is time consuming and uneconomical due to high wage rates and scarcity of labors because of urbanization and industrialization. Therefore, it has given importance to the development and warrants the use of herbicides to get timely as well as effective weed control.

Crop yield losses due to weeds mainly depend upon their intensity as well as on type of weed flora. There is a linear correlation between yield loss and population of weeds. However, above certain population limits, yield reductions become nearly constant due to self-competition among weed plants. The greatest loss caused by the weeds resulted from their competition with crop for growth factors *viz*., nutrients, soil moisture, light and space etc. (Walia, 2006). In this context review has been made to study the effect of weed management practices on growth, yield and quality of rice.

Effect of weed management practices on growth and development of *Kharif* rice

Kankal (2015) conducted a field experiment at Dapoli during 2013-14 and 2014-15 to study the effect of establishment techniques, weed control and integrated nutrient management on growth, yield and quality of drilled rice. They revealed that, significantly maximum height (74.04cm), numbers of tillers/0.25 m^2 (37.43) and dry matter accumulation (61.02 g) in rice crop was recorded by weed free check over the unweeded control.

An experiment was conducted by Shelar (2014) at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Agronomy farm Dapoli during *Kharif* 2013 to find out effect of methods of sowing and weed control on the performance of direct seeded rice in *Konkan* region reported that maximum plant height (76.45 cm), tillers/m2 (457.08) and dry matter accumulation (1260.07 g m^{-2}) in plant was observed in the treatment of weed free check (hand weeding at 20, 40 and 60 DAS) followed by treatment of pre-emergence application of oxadiargyl @ 120 g/ha + post-emergence application of bispyribacsodium @ 25 g/ha which were at par with each other but significantly superior over rest of the weed control treatments. Walia et al. (2012) concluded that, the maximum plant height (68.5 cm) was observed under treatment of pre-emergence application of Oxadiargyl @ 60 g a.i. ha^{-1} over unweeded control (55.7 cm) in rice. Jadhav et al. (2010) conducted the experiments during the *Kharif* 2005, 2006 and 2007 at Agricultural Research Station, Karad to study the effect of integrated weed management in upland rice. From the data it revealed that the treatment of hand weeding thrice (20, 40 and 60 DAS) gave significantly highest plant height of rice than the treatment of weedy check.

Sharma et al. (2007) reported that, among the weed management practices, dry weight at two hand weedings at 20 and 40 DAS (6.4 g m^{-2}) and pre emergence application of Butachlor @ 1.5 kg a.i. ha^{-1} combined with one hand weeding at 30 DAS (6.8 g m^{-2}) were at par with each other and significantly superior over unweeded control (21.4 g m^{-2}) in rice. Sawant (2003) conducted field experiment during *Kharif* season 2002 at Agronomy Farm, College of Agriculture, Dapoli (M.S.) and reported that, the weedy check recorded significantly the lowest number of tillers in rice (281.25 m^{-2}) than other weed control treatments. Gogoi et al. (2000) reported that, the different weed control practices like two hand weedings, one hoeing and use of different herbicides (Pyrazosulfuron, Bispyribac-Na and Pendimethalin @ 20 g a.i ha^{-1}, 25 g a.i ha^{-1} and 1000 g a.i ha^{-1}, respectively)

significantly reduced weeds dry matter (12.2 g m^{-2}) and increased the yield (5.375 kg ha^{-1}) of rice over unweeded check (3.380 kg ha^{-1}).

Moorthy and Das (1998) showed that plant height was significantly reduced with increase in the density of the weeds, registering the least value under 400 weeds/m^2. Behera and Jena (1998) carried out a field experiment during *Kharif* 1993 and 1994 at Chiplima, Orissa on weed control in direct-seeded, rainfed upland rice. They reported that the significantly highest weed population and biomass were found where weeds were not disturbed during whole season of the crop growth and lowest when plots were seasonally weed free. Hand weeding twice recorded 84.5 and 76.3 per cent weed control efficiency during 1993 and 1994, respectively. Hand weeding twice also recorded significantly less weed dry matter than unweeded control. The field investigation was carried out on integrated weed control in direct-seeded upland rice by Dutta and Gogoi (1994) during summer 1992 at Jorhat. The results revealed that, hand weeding (15, 25 and 35 days after sowing) recorded significantly lower weed population and dry weight. The field investigation carried out on weed management in direct seeded rice by Gosavi (1991) at Department of Agronomy, Konkan Krishi Vidyapeeth, Dapoli, India revealed that significantly maximum height, numbers of tillers/m^2 and dry matter accumulation in rice crop was recorded by weed free check compared to unweeded control.

Effect of weed management practices on yield and yield attributes of *Kharif* rice

Kankal (2015) conducted a field experiment at Dapoli during *Kharif* 2012-13 and 2014-15 to study the effect of establishment techniques, weed control and integrated nutrient management on growth, yield and quality of drilled rice. They revealed that, significantly improved weed control efficiency, better yield attributes, and higher grain and straw yields in plant was observed in the treatment of weed free check (hand weeding at 20, 40 and 60 DAS) followed by treatment of pre emergence application of oxadiargyl @ 0.12 kg/ha + post emergence application of bispyribac sodium @ 0.025 kg/ha which were at par with each other but significantly superior over rest of the weed control treatments was recorded by weed free check compared to unweeded control. Sanjay et al. (2014) conducted field experiments for 4 consecutive seasons (2009 *Kharif*, 2010 summer and *Kharif* and 2011 summer) at Main Research Station, UAS, Hebbal, Bengaluru on weed management practices for aerobic rice. Mean data of 4 seasons indicated that 3 hand weedings at 20, 40 and 60 DAS recorded significantly higher grain yield (4.18 t/ha) compared to all other treatments except T_2 i.e. pre emergence application of bensulfuron methyl 60 g + pretilachlor 600 g/ha (3.93 t/ha).

Naseeruddin and Subramanyam (2013) conducted field investigation during *Kharif* 2012 at S.V. Agricultural College farm, Acharya N.G. Ranga Agricultural University, Tirupathi, Andhra Pradesh in order to know the response of drum seeded rice to different pre and post emergence herbicides. The results revealed that among the weed management practices, pre

emergence application of oxadairgyl 75 g/ha followed by post-emergence application of azimsulfuron 30g/ha recorded significantly higher yield attributes, *viz*., panicles/m ^{2} (318), filled grains/panicle (105.8) and thousand grain weight (18.75 g) and grain yield (5.75 t/ha) of drum seeded rice. The lowest grain yield attributes and yield were recorded with unweeded check. Raj et al. (2013) from their experiment at Rice Research Station, Moncopu, Alappuzha and Kerla reported that the unweeded check recoded the lowest number of panicles/m^2 (147), panicle weight (1.55 g), fertile grains/panicle (56.2) and test weight (22.74 g). These were due to severe weed competition exerted by sedges and broad leaved weeds for space, light and nutrients throughout growth period.

Walia et al. (2012) conducted experiments during *Kharif* 2007 and 2008 at Punjab Agricultural University, Ludhiana on direct seeded rice under unpuddled (dry) conditions revealed that maximum grain yield was obtained with pre emergence application of pendimethalin 0.75 kg/ha followed by bispribacsodium 25 g/ha which was closely followed by oxadiargyl (90 g/ha) followed by bispribacsodium 25 g/ha. There were 152.4 and 142.9 per cent increase in grain yield over unweeded control with these treatments, respectively. Ramana et al. (2007) reported that, the pre-emergence application of Oxadiargyl @ 80 g a.i. ha^{-1} with the use of star weeder at 40 DAS, followed by pre-emergence application of Oxadiargyl @ 80 g a.i. ha^{-1} alone resulted in improved weed control efficiency (77.2%), better yield attributes, and higher grain and straw yields (3.14 tons ha^{-1} and 5.33 tons ha^{-1}), besides fetching higher net returns (Rs. 23,415 ha^{-1}) and B: C ratio (1:8) compared with weed free check in rice.

Dhanawate (2000) reported that in case of drilled rice the yield attributing characters like number of panicles/m^2, length of panicle, filled grains/panicle, weight of filled grains/panicle and test weight were significantly higher under weed free check and hand weeding twice than the remaining weed control treatments control (unweeded). Sinhababu et al. (1992) reported that, the unchecked weeds compete with rice plants for light, nutrients and moisture. The reduction in the yield was up to 80 per cent.

Effect of weed management practices on the quality, uptake of nutrients and soil fertility in *Kharif* rice

Kankal (2015) conducted a field experiment at Dapoli during *Kharif* 2012-13 and 2014-15 to study the effect of establishment techniques, weed control and integrated nutrient management on growth, yield and quality of drilled rice. They reported that maximum total uptake of N, P and K by rice plants was recorded in the treatment of weed free check (hand weeding at 20, 40 and 60 DAS) in rice crop over the unweeded control. An experiment was conducted by Shelar (2014) at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Agronomy farm Dapoli during *Kharif* 2013 to study effect of methods of sowing and weed control on the performance of direct seeded rice in *Konkan* region. The results revealed that

treatment of weed free check (hand weeding at 20, 40 and 60 DAS) resulted in significantly higher protein content (7.46 %), maximum total uptake of N, P and K and significantly lowest removal of N, P and K by weeds. Singh and Singh (2010) conducted a field experiment during rainy (*Kharif*) season of 2006 and 2007 to study the efficacy of herbicides under different methods of direct seeded rice establishment. The results revealed that rice established by drum seeding method had minimum NPK (4.091.534.49 kg/ha) uptake by weeds.

Tendulkar (2004) conducted an experiment at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Agronomy farm Dapoli during *Kharif* 2003 and reported that significantly lower protein content in rice grain under unweeded control than the remaining treatments. Singh et al. (1999) conducted a field experiment during the wet seasons of 1995 and 1996, to study the effect of crop weed competition on weed growth and on the yield and nutrient uptake in direct seeded rice (*Oryza sativa cv.* Mahasuri). The uptake of nutrient by rice was significantly higher in weed free treatment. The rice crop under weed free up to maturity removed 60, 26 and 80 kg/ha of N, P_2O_5 and K_2O, respectively. Ramamoorthy (1991) conducted a field experiment at Tamilnadu Agricultural University, Coimbatore and reported that the uptake of nutrients by rice plants in weed control treatments (56.1, 4.9, 44.3 N, P_2O_5 and K_2O kg ha^{-1}, respectively) was higher than the unweeded control (15.2, 1.2, 15.8 N, P_2O_5 and K_2O kg ha^{-1}, respectively). Goydani and Tiwari (1990) reported that in case of direct seeded rice the nutrient loss through weeds in one hand weeding treatment was 3.5 times more than three hand weeding. The losses of N, P and K under one hand weeding during respective years were 22.4 kg and 27.8 kg N, 4.5 kg and 6 kg P_2O_5 and 42.7 kg and 76.5 kg K_2O, respectively. Prasad et. al., (1980) reported that highest nitrogen uptake by rice was recorded when it was transplanted and lowest when rice was direct-seeded.

Effect of weed management practices on weed flora, weed density, weed index and weed control efficiency in *Kharif* rice

An experiment was conducted by Shelar (2014) at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Agronomy farm Dapoli during *Kharif* 2013 to find out effect of methods of sowing and weed control on the performance of direct seeded rice in *Konkan* region reported that significantly lowest weed dry matter of monocot and dicot weeds was recorded in the treatment of weed free check (hand weeding at 20, 40 and 60 DAS) over rest of the weed control treatments, while significantly highest weed dry matter of monocot and dicot weeds was recorded in treatment of unweeded check over all other weed control treatments. Naseeruddin and Subramanyam (2013) observed that the pre-emergence application of Oxadiargyl @ 75 g a.i. ha^{-1} followed by post-emergence application of Bispyribac-Na @ 30 g a.i. ha^{-1} reduced the dry weight of grasses and broad-leaved weeds in rice by 90.8 percent and 88 percent, compared to unweeded check at harvest. Mohitsham

et al. (2013) conducted a field experiment on different mulch techniques on weed infestation in aerobic rice and they reported that density of broad leaf weeds and narrow leaf weeds was highest in weedy plot per m^2 (no mulch) 27.33 and 45.33 and lowest in weed free plot per m^2 (no mulch) followed by polythene sheet mulch 6.33 and 14.33 respectively. Reddy (2010) reported that direct planting system recorded less total weed dry weight (1062 kg ha^{-1}) and nutrient removal by weeds (31:16:52 kg NPK ha^{-1}) over drum seeding in rice. However, weed control efficiency was similar for both establishment methods. Singh and Singh (2010) conducted a field experiment during rainy (*Kharif*) season of 2006 and 2007 to study the efficacy of herbicides under different methods of direct seeded rice establishment. Rice established by drum seeding method had minimum density of grasses, sedges and broad leaved weeds and dry weight of grasses (6.18 and 8.77 g/m^2), sedges (3.32 and 4.97 g/m^2), broad leaved weeds (1.85 and 2.74 g/m^2) at 45 and 60 DAS and maximum weed control efficiency (67.02%).

Singh et al. (2008) conducted experiments for 2 years to develop effective and economical methods for managing weeds in aerobic rice grown by direct seeding or transplanting on flat land or furrow irrigated raised bed systems (FIRBS). Total weed dry weight and weed density were highest with aerobic direct seeded rice on a FIRBS (ADSB), followed by aerobic direct seeded rice (ADSR). In terms of weight grassy weed constituted 78 – 96 per cent of total weed weight in all systems of rice establishment. Ramana et al. (2007) revealed that, the pre-emergence application of Oxadiargyl @ 80 g a.i. ha^{-1} along with the use of star weeder at 40 DAS resulted in the lowest weed density followed by pre-emergence application of Oxadiargyl alone @ 80 g a.i. ha^{-1} as compared with weed free check in *Kharif* rice. Mahajan et al. (2007) reported that the weed population under rice straw and plastic mulch was found statistically same but significantly decreased over unmulched soil condition. However, plastic mulch resulted in significant reduction in dry matter accumulation of weeds by 37.4 and 63.8 percent over rice straw mulch and unmulched soil condition, respectively. Singh and Deo (2004) revealed that hand weeding (20 and 40 days after sowing) showed 72 per cent weed control efficiency over unweeded control in direct seeded rice plants. Singh and Singh (2001) carried out a field study during spring seasons (Feb.-Sept.) of 1996–98 under rainfed low valley situation of Uttaranchal and revealed that competition with *Cyperus rotundus* resulted in 52.5 per cent reduction in grain yield of rice. The highest weed control efficiency was obtained by weed free condition followed by two hand weeding done at 25 and 45 days after sowing (DAS).

Economics of weed management practices in *Kharif* rice

An experiment was conducted by Shelar (2014) at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Agronomy farm Dapoli during *Kharif* 2013 to find out effect of methods of sowing and weed control on the performance of direct seeded rice in *Konkan* region reported that maximum net returns (Rs.16878.66) and B:C ratio (1.37) was recorded in the

treatment of pre emergence application of oxadiargyl @ 120 g/ha + post emergence application of bispyribac sodium @ 25 g/ha. Gaire et al. (2013) studied the effect of different mulching materials on weed dynamics and yield of direct seeded rice in Chitwan, Nepal and concluded that three hand weeding gave highest gross return, net return and lowest B:C ratio (1.8) as compared to wheat straw mulch (1.9) and lowest B: C ratio (1.5) recorded under weedy check. Mishra and Dash (2013) found that, the pre-emergence application of Oxadiargyl @ 70 g a.i. ha^{-1} gave the highest B: C ratio (2.59) than other chemical treatments like Pyrazosulfuron-ethyl @ 25 g a.i. ha^{-1}, Pretilachlor @ 750 g a.i. ha^{-1} and Chloromuron-ethyl with Metasulfuron-methyl @ 4 g a.i. ha^{-1} with B: C ratio 2.41, 2.48 and 2.39 respectively in rice. The higher economic benefit were obtained in Oxadiargyl @ 70 g a.i. ha^{-1} treated plots (Rs.9,343 ha^{-1}) over the farmer's practice, followed by the Pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} treatment (Rs.8,425 ha^{-1}) in rice crop.

Singh et al. (2008) conducted experiments years in Punjab, India for 2 years to develop effective and economical methods for managing weeds in aerobic rice grown by direct seeding or transplanting on flat land or furrow irrigated raised bed systems (FIRBS). They revealed that the aerobic direct seeded rice was effective as conventionally puddle transplanted rice in giving higher return when weeds were kept under control. Ramana et al. (2007) reported that, the pre-emergence application of Oxadiargyl @ 80 g a.i. ha^{-1} with the use of star weeder at 40 DAS, followed by pre-emergence application of Oxadiargyl @ 80 g a.i. ha^{-1} alone resulted in improved weed control efficiency (77.2%), better yield attributes, and higher grain and straw yields (3.14 tons ha^{-1} and 5.33 tons ha^{-1}), besides fetching higher net returns (Rs. 23,415 ha^{-1}) and B: C ratio (1:8) compared with weed free check in rice. Pinjari (2007) found that the cost of cultivation, gross return, net return were higher under polythene mulch and lowest with control during both the years. However, the B: C ratio under polythene mulch was at par with control. Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn, observed that the gross return, net profit and B:C ratio were higher under polythene mulch. Prasad et al. (2001) reported that, transplanting of rice gave significantly higher net return (Rs.7092 ha^{-1}) and B: C ratio (0.92) as compared to dry drilling Rs.987 ha^{-1}, 0.12 respectively. The field investigation carried out on weed management in direct seeded rice by Gosavi (1991) at Department of Agronomy, Konkan Krishi Vidyapeeth, Dapoli, India showed that weed free check recorded highest net profit of Rs. 4716.7/ha.

Conclusion

Manual method of weed control is though very common but cost intensive. Herbicides when applied alone are although economical but may have limitation of resistance development and shift in weed flora etc. Therefore, use of high efficacy herbicides in combination coupled with broad spectrum nature to control the complex weed flora in *Kharif* rice are found most effective and economical.

Conflict of interest

Authors declare no conflicts of interest for this study.

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