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# Productivity and Economics of Kharif Rice (*Oryza sativa* L.) Influenced by different Establishment Techniques and Weed Management Practices

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**Abstract**

**The research entitled "productivity and economics of kharif rice (*Oryza sativa* l.) influenced by different establishment techniques and weed management practices" was conducted at Agronomy Farm (17.10º North latitude and 73.10º East longitude), College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during Kharif 2017. The field experiment was laid out in strip plot design. The main plot treatments comprised of five crop establishment techniques ($T_1$:Seed sowing on flat bed with drum seeder, $T_2$:Transplanting by hand operated transplanter, $T_3$:Transplanting by mechanical transplanter, $T_4$:Dibbling on BBF with polymulch and $T_5$:Recommended manual transplanting with puddling) and the sub plot treatments consisted of three weed management practices ($W_1$:Weedy check, $W_2$:Weed free check (hand weeding 20, 40 and 60 DAS/DAT) and $W_3$:Pre-emergence (Oxadiargyl @ 0.12 kg ha$^{-1}$) + one hand weeding at 30 DAS/DAT)). There were 15 treatment combinations replicated three times. From investigation, concluded that rice crop established by seed sowing on flat bed with drum seeder along with pre-emergence application of oxadiargyl @ 0.12 kg ha$^{-1}$ + one hand weeding at 30 DAS ($T_1W_3$) gave higher grain and straw yield, higher net returns and B: C ratio followed by seed sowing on flat bed with drum seeder with weed free check ($T_1W_2$).**

**Key words***:* Establishment techniques, *Kharif* rice, Weed management practices, Quality and Yield)

## 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. India is the world's second largest rice producer and consumer next to China. In India during 2015 rice cultivated on an area of 44.10 m ha with an annual production 107.40 m t and productivity about 2.98 t ha-$^{1}$ (Anonymous 2015). In Maharashtra, rice is cultivated on 15.13 lakh ha area in almost all four regions *viz.,* Vidharbha (7.95 lakh ha.), Konkan (3.83 lakh ha.), Western Maharashtra (3.23 lakh ha.) and Marathwada (0.12 lakh ha.) with annual production of 41.71 lakh tones unmilled (brown rice) and 28.78 lakh tones milled rice.

Rice in *Konkan* region of Maharashtra is being grown mostly as puddled transplanted crop. This method of cultivation involves labour intensive practices like traditional *'Rab',* raising seedlings, uprooting and transplanting them in puddled fields. Continuous adoption of puddling and transplanting for rice cultivation has been reported decline soil and crop productivity (Nambiar and Abrol 1989).

In the recent years, rural labour have migrated towards industrial sector which had led to the non-availability of labour. Continuous growing of rice in the same field not only disturbs the physical condition of the soil but also causes great depletion of nutrients due to higher demand of rice plant and loss by leaching. It results in delayed transplantation of rice which results in yield reduction. Transplanting of paddy seedlings is common method in the irrigated rice systems of Asia but transplanting is labour intensive (30 persons ha$^{-1}$day$^{-1}$). It also promotes the formation of hard pan which effects rooting depth of next crop (Bhuiyan *et al.* 1995).

Dry direct seeded rice differs from transplanted rice in terms of crop establishment as well as subsequent crop management practices, which offers many advantages such as more efficient water use, high tolerance to water deficit, less methane gas emission, reduced cultivation cost, prevents the formation of hard pan in sub-soil and minimizes labour input (Balasubramanian and Hill 2002).

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The mechanical transplanting of rice has been considered the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that contributes to high productivity. Hence in the present study power operated four row paddy transplanter suitable for root wash seedlings was evaluated for its performance on field scale. The productivity and sustainability of rice based systems are threatened because of (i) the inefficient use of inputs (fertilizer, water, labour); (ii) increasing scarcity of resources, especially water and labour (iii) changing climate (iv) the emerging energy crises and rising fuel prices (v) the rising cost of cultivation; and (vi) emerging socioeconomic changes such as urbanization, migration of labour, preference of non agricultural work, concern about farm related pollution. At present, rice cultivation is as direct seeded in America, Western Europe such as Italy and French, Russia, Japan, Cuba, India, Korea and the Philippines and in some parts of Iran due to high technology and high labour cost and shortage of skilled labour (Akhgari 2004).

Plastic mulches can offer a barrier against weeds, moisture loss, nutrient loss, erosion, insect and disease injury, while it encourages plant establishment and subsequent development and thus results in better yield. Weed competition is one of the major factor 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 2005).

Therefore by keeping all these points in a view, a field experiment, entitled "productivity and economics of *kharif* rice (*Oryza sativa* l.*)* influenced by different establishment techniques and weed management practices" was carried out.

**Material and methods**

The experiment entitled "productivity and economics of *kharif* rice (*Oryza sativa* l.*)*influenced by different establishment techniques and weed management practices" was conducted at Agronomy Farm (17.10º North latitude and 73.10º East longitude), College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *Kharif* 2017. The field experiment was laid out in strip plot design. The main plot treatments comprised of five crop establishment techniques ($T_1$:Seed sowing on flat bed with drum seeder, $T_2$:Transplanting by hand operated transplanter, $T_3$:Transplanting by mechanical transplanter, $T_4$:Dibbling on BBF with polymulch and $T_5$:Recommended manual transplanting with puddling) and the sub plot treatments consisted of three weed management practices ($W_1$:Weedy check, $W_2$:Weed free check (hand weeding 20, 40 and 60 DAS/DAT) and $W_3$:Pre-emergence (Oxadiargyl @ 0.12 kg $ha^{-1}$) + one hand weeding at 30 DAS/DAT)). There were 15 treatment combinations replicated thrice.

The seed of rice variety Karjat-3 used for sowing. The variety is multiple resistance to diseases and pests (HR Neck Blast, MR - Leaf blast, RTV, Brown spot and sheath rot and MR Stem borer.

*a) Raising of seedlings on nursery bed For transplanting*

The soil was ploughed twice by tractor and subsequently brought under fine tilth. The raised beds of 10 m length, 1 m breadth and 15 cm height were prepared. Good quality farm yard manure was spread and mixed with soil over the beds. Urea and single super phosphate were applied @ 1 kg and 3 kg 100 $m^{-2}$ respectively at the time of sowing. The seed of rice variety Karjat-3 which was treated with thirum @ 3 g $kg^{-1}$ seed was sown in line 10 cm apart at 2-3 cm depth. Germination started from third day and completed by the fifth day. Top dressing with urea @ 1 kg 100 $m^{-2}$ area was done at 15 days after sowing. The need based plant protection and weed control measures were carried out in the nursery.

*b) Dry Sowing*

The sowing of seeds was carried out by using manually operated four coulter drum seeder at about 3-5 cm depth with row spacing of 22.5 cm on 10th June 2017. After sowing, the seeds were covered with soil.

*c) Dibbling of seeds on polymulch*

The silver black polythene mulch of 25 micron thickness was used for polymulch treatment. After applying polymulch Seeds of rice were dibbled on raised bed on 10th June 2017 at spacing of 20 cm × 15 cm as per the treatment.

*d) Transplanting of seedlings*

Twenty one days old seedlings were transplanted on 1st July, 2017 with the recommended spacing of 20 cm × 15 cm.

While in the treatments of mechanical and hand operated

transplanting the healthy and vigorous seedlings of 21 days old age were used for transplanting. While uprooting the seedlings care was taken that roots should remain attached to the seedlings and same were used for transplanting after washing the roots. Two to three seedling were transplanted per hill. Transplanting was carried out on 1st July 2017 Transplanting was done in lines at distance 20 cm, 22.5 cm and 23.5 cm between two rows in treatments $T_5$, $T_2$ and $T_3$ respectively. In recommended manual transplanting 15 cm distance was kept between two hills.

FYM was applied in experimental plots @ 5 t $ha^{-1}$ at the time of land preparation before layout. The crop was fertilized with 100 kg N, 50 kg $P_2O_5$ and 50 kg $K_2O$ $ha^{-1}$. At the time of sowing and transplanting 40 kg N $ha^{-1}$ was applied with full dose of $P_2O_5$ and $K_2O$ as a basal dose. The remaining 40 kg N $ha^{-1}$ was applied at 30 DAS/DAT as per treatments and 20 kg at panicle initiation stage (75 DAS). Nitrogen was supplied through urea having (46% N) while phosphorous and potash was supplied through single super phosphate (16% $P_2O_5$) and muriate of potash (60% $K_2O$).

In case of treatment dibbling on broad bed furrow (BBF) with polymulch remaining urea was applied through deep point placement method at the centre of four hills.

*d) Application of herbicides*

The herbicide Oxadiargyl was applied as pre emergence and one hand weeding at 30 DAS/DAT as per treatments. The three hand weedings were undertaken at 20, 40 and 60 DAS/DAT as per treatments to keep the experimental crop plot weed free wherever necessary.

*e) Plant protection measures*

Since the seeds were treated with thiram before sowing, the crop was free from disease during the early growth stages, but crab attack was observed at the early growth stage which was controlled by the application of Phorate 10 g granules.

**Results and Discussion**

***Effect of establishment techniques***

Recommended manual transplanting was at par with dibbling on BBF with polymulch in respect of number of panicles $m^{-2}$, length of panicle, number of filled grains $panicle^{-1}$, number of spikelets $panicle^{-1}$ and test weight and which was significantly superior over the transplanting by mechanical transplanter, transplanting by hand operated transplanter and seed sowing on flat bed with drum seeder. Thus, recommended manual transplanting with puddling recorded significantly higher grain yield $ha^{-1}$ (41.43 q) over rest of the establishment techniques except dibbling on BBF with polymulch. The increase in grain yield recorded under recommended manual transplanting with puddling over dibbling on BBF with polymulch, transplanting by mechanical transplanter, transplanting by hand operated transplanter and seed sowing on flat bed with drum seeder was to the tune of 1.91, 2.93, 5.44 and 6.80 per cent, respectively. The increased yield attributes might be due to increased growth and development parameters which ultimately resulted in increased grain. The present results are inconsonance with those of Singh et al. (2006), Jagtap (2011) and Jagtap et. al. (2012).

Higher straw yield (48.93 q $ha^{-1}$) (Table 1) recorded by recommended manual transplanting of rice was significantly superior over seed sowing on flat bed with drum seeder, transplanting by hand operated transplanter, transplanting by mechanical transplanter and which was on par with dibbling on BBF with polymulch. Increase in mean straw yield observed under recommended manual transplanting over dibbling on BBF with polymulch, transplanting by mechanical transplanter, transplanting by hand operated transplanter and seed sowing on flat bed with drum seeder was to the tune of 1.28, 2.47, 3.99 and 4.97 per cent respectively. This might be due to increased morphological characters *viz.,* plant height, number of leaves $m^{-2}$, number of tillers and dry matter production $m^{-2}$ observed under transplanting. Similar findings were also reported by Singh et. al. (2003), Mangat Ram et al. (2006), Jagtap et. al. (2013) and Jagtap et. al. (2016). Thus, the results clearly showed that recommended manual transplanting with puddling method of establishment was superior and which was at par with dibbling on BBF with polymulch for obtaining higher grain and straw yield $ha^{-1}$ from rice.

Recommended manual transplanting of rice (Table 1) gave the highest gross returns (₹ 71,930.56) and required highest cost of cultivation (₹ 76,848.86) followed by dibbling on BBF with polymulch, transplanting by mechanical transplanter, transplanting by hand operated transplanter and seed sowing on flat bed with drum seeder and seed sowing on flat bed with drum seeder was recorded highest net return (₹ 9151.70) and benefit to cost ratio (1.17).

Among all these establishment techniques seed sowing on flat bed with drum seeder was most remunerative as its mean B: C ratio was 1.17. The B: C ratios recorded under dibbling on BBF with polymulch, transplanting by mechanical transplanter, transplanting by hand operated

**Table 1.** Effect of establishment techniques and weed management practices on grain yield, straw yield, gross returns, cost of cultivation, net return and B:C ratio of rice.

| Treatments | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Gross return (₹ $ha^{-1}$) | Cost of cultivation (₹ $ha^{-1}$) | Net returns (₹ $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|
| Establishment techniques | | | | | | |
| $T_1$:Seed sowing on flat bed with drum seeder | 38.79 | 46.61 | 67504 | 58353 | 9152 | 1.17 |
| $T_2$:Transplanting by hand operated transplanter | 39.29 | 47.05 | 68349 | 69422 | -1073 | 0.99 |
| $T_3$:Transplanting by mechanical transplanter | 40.25 | 47.75 | 69929 | 71762 | -1833 | 0.98 |
| $T_4$:Dibbling on BBF with polymulch | 40.65 | 48.31 | 70640 | 70148 | 492 | 1.01 |
| $T_5$:Recommended manual transplanting with puddling | 41.43 | 48.93 | 71931 | 76849 | -4918 | 0.94 |
| SE± | 0.32 | 0.35 | -- | -- | -- | -- |
| CD at 5% | 1.04 | 1.14 | -- | -- | -- | -- |
| Weed management practices | | | | | | |
| $W_1$:Weedy check | 38.57 | 46.11 | 67733 | 68353 | -2034 | 0.99 |
| $W_2$:Weed-free check | 41.52 | 49.16 | 71470 | 71145 | 4839 | 1.01 |
| $W_3$:Pre-emergence (Oxadiargyl @ 0.12 kg $ha^{-1}$) + one hand weeding | 40.16 | 47.93 | 69809 | 68449 | 347 | 1.04 |
| SE± | 0.43 | 0.56 | -- | -- | -- | -- |
| CD at 5% | 1.69 | 2.21 | -- | -- | -- | -- |
| Interaction effect | | | | | | |
| SE± | 0.67 | 0.71 | -- | -- | -- | -- |
| CD at 5% | 2.00 | N.S. | -- | -- | -- | -- |
| General mean | 40.08 | 47.73 | | | | |

transplanter and recommended manual transplanting with puddling were 1.01, 0.98, 0.99 and 0.94 respectively. The increased net returns and benefit cost ratio due to seed sowing on flat bed with drum seeder technique were mainly due to lower cost of cultivation under over rest of the establishment techniques. Similar findings were also reported by Singh and Singh (2010), Jagtap et. al. (2011) and Jagtap and Mahadkar (2017).

***Effect of weed management practices***

The beneficial effect of weed management practices in enhancing the growth through increased height, number of leaves, number of tillers, and dry matter production ultimately reflected in higher yield attributing characters *viz*., length of panicle, number of panicles $m^{-2}$, number of spikelets $panicle^{-1}$, number of filled grains $panicle^{-1}$ and test weight. The grain yield of rice is a function of yield attributes of an individual plant *viz*., length of panicle, number of panicles, number of spikelets $panicle^{-1}$, number of filled grains $panicle^{-1}$ and test weight and ultimately the grain yield obtained from the plant.

The weed free check treatment recorded significantly higher grain and straw yield of 41.52 q $ha^{-1}$ and 49.16 q $ha^{-1}$ respectively, which were followed by treatment pre-emergence application of oxadiargyl @ 0.12 kg $ha^{-1}$ + one hand weeding but which was at par with each other and found significantly superior over weedy check. The increase in grain and straw yield of rice might be due to significant improvement in growth and yield attributes, which finally resulted in increased grain and straw yield. The results are in confirmation with the results reported by Walia et al. (2012) and Shelar (2014).

From economic analysis, it was noticed that different weed management practices influenced with respect to cost of cultivation, gross return and net returns in

the year of study. Treatment weed free check i.e. hand weeding at 20, 40 and 60 DAS/DAT reported the highest cost of cultivation whereas weedy check reported the lowest cost of cultivation during study. Treatment weed free check earned the highest gross returns (₹ 71,469.80) as compared to pre-emergence application of oxadiargyl @ 0.12 kg $ha^{-1}$ + one hand weeding and weedy check during the study. Treatment pre-emergence application of oxadiargyl @ 0.12 kg $ha^{-1}$ + one hand weeding 30 DAS/DAT gave the higher net returns (1359.14) with higher benefit cost ratio (1.04). These results are in close confirmation with the results of Walia *et al.* (2012) and Shelar (2014).

***Interaction effect of establishment techniques and weed management practices***

The grain yield significantly influenced by interaction effects of establishment techniques and weed management treatments.

Yield data presented in Table 2 revealed that, recommended manual transplanting with puddling recorded significantly maximum grain yield (q $ha^{-1}$) with weed free check ($T_5W_2$) over rest of the treatment combinations followed by dibbling on BBF with polymulch with weed free check ($T_4W_2$) treatment combinations during the course of study. Weed free condition under manual transplanting resulted in more number of spikelets per panicle ultimately there was increase in grain yield. Similar results were reported by Baloch *et al.* (2006).

***Economics of different treatments***

The interaction effect was significant between establishment techniques and weed management practices on yield of the rice. However, the adoption of any technology by the farmers depends upon its cost effectiveness. The same principle is followed while deciding the crop establishment techniques and weed management options for rice. Therefore, while arriving at any conclusion and deriving any inference, a detail economic analysis is a must. Therefore, though the interaction effects on the yield were found to be non-significant in the present study, the economics of treatment combinations was worked out.

Data from Table 3, revealed that the highest gross returns (₹ 74,370.33) were obtained under the treatment combination of recommended manual transplanting with weed free check ($T_5W_2$). On the other hand the higher net returns (₹ 16,327.53) as well as B: C ratio (1.32) was obtained under the treatment combination of seed sowing on flat bed by drum seeder with pre-emergence application of oxadiargyl @ 0.12 kg $ha^{-1}$ + one hand weeding at 30 DAS ($T_1W_3$) which were comparable with the net returns and B:C ratio of other treatment combinations.

**Table 2**. Interaction effect of establishment techniques and weed management practices on grain yield (q $ha^{1}$) of rice as influenced by different treatments.

| Establishment techniques | Grain yield q $ha^{-1}$ | | |
|---|---|---|---|
| | Weed management practices | | |
| | $W_1$ | $W_2$ | $W_3$ |
| T1 | 116.04 | 117.20 | 115.85 |
| T2 | 108.52 | 125.73 | 119.38 |
| T3 | 118.97 | 123.89 | 119.41 |
| T4 | 115.62 | 127.41 | 122.84 |
| T5 | 119.44 | 128.55 | 124.88 |
| S.Em.± | | 0.67 | |
| C.D. at 5% | | 2.01 | |
| F Test | | Sig. | |

## Conclusion

From investigation, concluded that rice crop established by seed sowing on flat bed with drum seeder along with pre-emergence application of oxadiargyl @ 0.12 kg $ha^{-1}$ + one hand weeding at 30 DAS ($T_1W_3$) gave higher grain and straw yield, higher net returns and B: C ratio followed by seed sowing on flat bed with drum seeder with weed free check ($T_1W_2$).

## References

Akhgari H. 2004. Rice (Agronomy, Fertilization and Nutrition). Islamic Azad University Press, Rasht, Iran, pp. 376.

Anonymous 2015. Annual report of agriculture cooperation on rice of India.

Balasubramanian V. and Hill J. 2002. Direct wet seeding of rice in Asia. Emergence issues and strategic research needs for the 21st century. In: Proc Annual Workshop of Directorate of Rice Research, Hyderabad.

Baloch M. S., Awan I. U., Hassan G. and Khakwani A. A. 2006. Effect of establishment methods and weed management practices on some growth attributes of rice. Rice science 2006. 13: 131-140.

Bhuiyan S. I., Sattar M. A. and Tabbal D. F. 1995. Improving water use efficiency in rice irrigation through wet seedling. *Irrigation* Sci. 16:1-8.

Jagtap D. N. and Mahadkar U. V. 2017. Rice establishment methods in Konkan, Maharashtra. Pp 156.

**Table 3.** Economics of different treatment combinations of rice

| Sr. No. | Treatment combination | Cost of cultivation (₹ $ha^{-1}$) | Gross returns (₹ $ha^{-1}$) | Net returns (₹ $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| 1 | $T_1W_1$ | 64351.14 | 67975.33 | 3624.20 | 1.05 |
| 2 | $T_1W_2$ | 59798.97 | 67302.33 | 7503.36 | 1.12 |
| 3 | $T_1W_3$ | 50907.80 | 67235.33 | 16327.53 | 1.32 |
| 4 | $T_2W_1$ | 62970.46 | 62941.33 | -29.12 | 1.00 |
| 5 | $T_2W_2$ | 74624.07 | 72923.00 | -1701.07 | 0.98 |
| 6 | $T_2W_3$ | 70670.46 | 69181.33 | -1489.12 | 0.98 |
| 7 | $T_3W_1$ | 76507.01 | 71526.67 | -4980.34 | 0.93 |
| 8 | $T_3W_2$ | 65980.47 | 69002.33 | 3021.86 | 1.05 |
| 9 | $T_3W_3$ | 72798.84 | 69257.67 | -3541.17 | 0.95 |
| 10 | $T_4W_1$ | 67325.09 | 67024.00 | -301.09 | 1.00 |
| 11 | $T_4W_2$ | 72886.26 | 73751.00 | 864.74 | 1.01 |
| 12 | $T_4W_3$ | 70231.98 | 71145.33 | 913.35 | 1.01 |
| 13 | $T_5W_1$ | 70473.55 | 69198.67 | -1274.88 | 0.98 |
| 14 | $T_5W_2$ | 82435.49 | 74370.33 | -8065.16 | 0.90 |
| 15 | $T_5W_3$ | 77637.55 | 72222.67 | -5414.88 | 0.93 |


Jagtap D. N., Mahadkar U. V. and Chavan S. A. 2016. Response of rice varieties to establishment methods under Konkan conditions. *Indian* Society of Coastal Agricultural Research 34: 85-87.

Jagtap D. N., Mahadkar U. V. and Chavan L. S. 2013. Response of Hybrid Rice to Different Crop Establishment Methods and Fertilizer Sources. *Bioinfolet* 10: 327-332.

Jagtap D. N., Mahadkar U. V., Chavan L. S. and Ch. Srinivasarao., 2012. Performance of rice (*Oryza sativa* L.) influenced by different crop establishment methods and fertilizer sources. Ind. J. Dryland Agri. Res. and Dev. 27: 55-58.

Jagtap D. N. 2011. Studies on the response of hybrid Rice to different crop establishment methods and sources of fertilizer application under Konkan upland situation. Ph.D. Thesis (Unpub.), Dr. B.S.K.K.V.,Dapoli, India (M.S.).

Jagtap D. N., Mahadkar U. V. and Chavan L. S. 2011. Productivity and economics of rice influenced by different crop establishment methods and fertilizer sources. Internat. J. Forestry and Crop Improv. 2: 170-175.

Mangat Ram, Om H. , Dhiman S. D. and Nandal D. P. 2006. Productivity and economics of rice-wheat cropping system as affected by establishment methods and tillage practices. Ind. J. Agron.51: 77-80.

Mukherjee D. and Singh R. P. 2005. Effect of micro-herbicides on weed dynamics, yield and economics of transplanted rice. Ind.J. Agron. 50:292-295.

Nambiar K. K. M. and Abrol I. P. 1989. Long term fertilizer experiments in India: An overview. *Fertilizer News*. 34: 11-20.

Panse V. G. and Sukhatme P. V. 1967. Statistical methods for Agricultural workers, I.C.A.R., New Delhi.

Shelar S. K. 2014. Effect of methods of sowing and weed control on the performance of direct seeded rice in Konkan region. M. Sc. (Agri.) thesis (unpublished), Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, India.

Singh M. and Singh R. P. 2010. Influence of crop establishment methods and weed management practices on yield and economics of directseeded rice (Oryza sativa). Indian J. Agron. 55 :224-229.

Singh I., Ram M. and Nandal D. P. 2007. Efficacy of new herbicides for weed control in transplanted rice under rice-wheat system. Ind. J. Weed Sci. 38: 28-31.

Singh Y. P., Singh G., Singh S. P., Kumar A., Sharma G., Singh M. K., Mortin M. and Johnson D. E. 2006. Effect of weed management and crop establishment methods on weed dynamics and grain yield of rice. Ind.J. Weed Sci. 38: 20-24.

Singh R. P., Singh C. M. and Singh A. K. 2003. Effect of crop establishment methods, weed management and splitting of N on rice and associated weeds. Indian J. weed sci., 35: 33-37.

Walia U. S., Walia S. S., Singh A., Sidhu V. and Nayyar S. 2012. Bioefficacy of pre and post-emergence herbicides in direct-seeded rice in Central Punjab. Indian J. Weed Sci. 44: 30–33.