International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 2879-2883

Received: 25-01-2020
Accepted: 27-02-2020

**Sumit**
M.Sc. Scholar, Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India, India

**Dr. KL Nandeha**
Professor & Head Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

**Sunil Kumar**
Scientist, Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India, India

**Corresponding Author:**
**Sumit**
M.Sc. Scholar, Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India, India

# Effect of different weed management practices on growth, yield attributes and yield of direct seeded rice (*Oryza sativa* L.)

**Sumit, Dr. KL Nandeha and Sunil Kumar**

**DOI:** https://doi.org/10.22271/chemi.2020.v8.i2ar.9188

**Abstract**
A field experiment was conducted on Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* season 2018 to evaluate the new formulation of oxyfluorfen (20 % DF) on weed control in direct seeded rice. Oxyfluorfen is a diphenyl-ether herbicide as a pre-emergence herbicide used for control of annual, perennial and broad leaved weeds in a various field crops. Pre-emergence (PE) application of oxyfluorfen 20 DF @ 720 g ha$^{-1}$ gave significantly lower total weed density, weed dry weight and higher weed control efficiency at all the intervals. However, Oxyfluorfen 20 DF @ 240 g ha$^{-1}$ as PE herbicide can keep the weed density and dry weight below the economic threshold level and increase the grain yield (49.51 q ha-$^{1}$) and straw yield (64.52 q ha-$^{1}$) in direct seeded rice. Unweeded control accounted for lower grain yield (5.83 q ha-$^{1}$) which causes higher weed density and dry weight, respectively due to heavy competition of weeds for nutrients, space and light.

**Keywords:** Oxyfluorfen, direct seeded rice, yield attribute, yield

## Introduction
Rice (*Oryza sativa* L.) is one of the important cereal crops which plays a vital role in food security. More than 90 per cent of total rice production in the world is consumed by Asian countries, where it is a staple food for a majority of the population (Mohanty, 2013) [11]. During 2015-16, India had record production of rice to the tonne of 104.32 million tonnes (Anonymous, 2016) [2, 3] but considering the present growth rate of population as well as per capita income, the demand for rice has been projected as 156 million tonnes by 2030 (Anonymous, 2016) [2, 3]. Chhattisgarh is 13.51 m ha of which 5.9 m ha area is under cultivation. Rice occupies an area of 3.68 m ha with productivity of 20.20 q ha$^{-1}$. In Chhattisgarh, rice is compeletly grown under *kharif* season, which covers around 74, 97 and 95 per cent cropped area of total area of Chhattisgarh plain, Bastar plateau and Northern hill zones, respectively. Chhattisgarh state devote 5.26 per cent of the total rice production of the country. However the production and productivity of rice per unit area of state is very poor (Anonymous, 2017) [4]. Weeds are one of the major problems in agriculture that also reduce the yield and also utilize essential nutrients. Most of the improved crop management practices in rice cultivation failed due to poor and improper practices for containing weeds. There are several reasons for low productivity and the one due to weeds is the most important. Weeds competetation with rice for moisture, nutrients, light, temperature and space. Moorthy and Saha, (2005) [12]. Estimated the extent of yield reduction due to weeds to be over 50% in direct seeded upland rice, 30-35% in direct seeded rice under puddled condition and around 15-20% in transplanted rice. Manhas *et al*., (2012) [10] and Ghosh, *et al*. (2016) [9]. Hand weeding is the traditional weed control method in rice cultivation practices. However, due to high labour cost, non-availability of labour and time taken for manual removal, farmers are forced to decide for most alternative of chemical weed control. Many herbicides are being used successfully for weed control in rice both as pre-emergence and post-emergence application. Commenly used pre-emergence herbicides like pretilachlor, pendimethaline, alachlor, butachlor *etc*. New herbicides are used desirable to reduce the problem of residue buildup. Shift in weed flora and development of herbicide resistance in weeds. Hence, the present investigation was to study the effect of different weed management practices on growth and yield of direct seeded rice.

## Material and Methods

Field experiment was conducted during *kharif* season of 2018 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, geographically, Raipur situated in mid–eastern part of Chhattisgarh state and lies at 210 16′ North Latitude and 810 36' East Longitude with an altitude of 314.15 m above the mean sea level. Climatologically, Raipur comes under the Chhattisgarh plains agro climatic sub zone which having sub humid climatic condition. The region receives an average of 1104 mm annual rainfall, out of which about 87 per cent received during the rainy season (June to September) and the rest of 13 per cent during the winter season (October to February). The soil was neutral (pH 7.1) in reaction with medium in fertility having 0.46% soil organic carbon, low nitrogen (214 kg ha-1), medium phosphorus (17.5 kg ha-1) and high potassium (301 kg ha-1) content. The experiment was laid out in Randomized Block Design (RBD) with three replication. The treatments comprised of eleone treatments. The test variety used in experiment MTU-1010. It is recommended for direct- seeded upland and rainfed ecosystem in different region of the country (including Chhattisgarh). It It is a semi dwarf variety matures about 115-120 days. Oxyflourfen 20 DF @160 g *a.i.* ha$^{-1}$ Oxyflourfen 20 DF @ 200 g *a.i.* ha$^{-1}$ Oxyflourfen 20 DF @ 240 g *a.i.* ha$^{-1}$ Oxyflourfen 20 DF @ 480 g *a.i.* ha$^{-1}$ Oxyflourfen 20 DF @ 720 g *a.i.* ha$^{-1}$ Oxyflourfen 23.5 EC @ 105.75 g *a.i.* ha$^{-1}$ Pretilachlor 30.7 EC @ 187.27 g *a.i.* ha$^{-1}$ Pendimethaline 30 EC @ 187.27 g *a.i.* ha$^{-1}$ were used in the experiment. The water are require 0.5 liter per plot and application of herbicide at 2 DAS after sowing. Rice was sown in rows 20 cm apart during the fourth week of June and harvesting is done in October last week.

## Results and Discussion

### Plant hight

Data with respect to the plant hight are presented in table-1 Significantly highest plant height was recorded under weed free treatment at all the growth stages which was statistically superior over However, it was at par to treatment hand weeding. Similarly, the least plant population (53.88 m$^{-2}$) was observed at harvesting stage in unweeded check. This may be due death of plants because of smoothering weeds. rest of the treatment. Among the different doses of oxyflourfen 20 DF, the lowest plant height (88.9 cm) was recorded with 160 g *a.i.* ha$^{-1}$. The logic for variation in plant hight of all the treatment may be due to the lower competition between weeds and crop for light, nutrients and space along with availability of water which allowed the crop to grow to their potential [Yadav *et al* (2009), Saha and Rao (2010)] [21].

### Dry matter accumulation

The data of dry matter production of crop plants are presented in table-1. It is evident from perusal of data that, the dry matter production of rice was increased with the advancement of crop age under all the treatments. Maximum dry matter was recorded at under weed free (7.14 g) followed by hand weeding (6.81 g). Dry matter of rice was significantly affected by the different doses of herbicides at growth periods Oxyflourfen 20 DF @ 240 g *a.i.* ha$^{-1}$ resulted in to higher (6.24 g) dry matter accumulation among different doses of oxyflourfen at harvest. The lowest dry matter of rice was recorded under unweeded check which might be due to adverse effect of excessive crop-weed competition as evident from maximum dry matter production of weeds which resulted in decline of nutrient uptake and dry matter accumulation by crop. Similar results have been reported by [Singh and Bhan (1998) and Sahu (2016)] [29, 21].

### Number of tillers

Data are presented in table-1 number of tillers was significantly affected by the different doses of herbicides. The maximum number of tillers m$^{-2}$ (473.33) was recorded under weed free treatment which were statistically superior over rest of the treatments. The minimum number of tillers m$^{-2}$ (119.33) was recorded under unweeded check Among the different doses of oxyflourfen 20 DF, its pre-emergence application @ 240 g *a.i.* ha$^{-1}$ did produce higher number of tillers as compared to rest four doses [EI-Desoki (2003) and Ashraf *et al*. (2006)] [14, 5].

### Leaf area index

Data are presented in table-1.The highest leaf area index (5.91) was recorded under weed free treatment, followed by (5.83) with hand weeding while the minimum leaf area index (2.16) was noted under unweeded check. Pre-emergence application of oxyflourfen @ 240 g *a.i.* ha$^{-1}$ resulted in to higher leaf area index (5.75) as compared to other doses of this herbicide at 60 DAS. Leaf area expantion might have reduced due to crop- weed competition and hence, the lower values of leaf area index have been observed in unweeded check. On the other hand, due to weed free environment more leaf area index was noticed in weed free treatment. Similar results were also reported by Halder and Patra (2010).

### Effective tillers (No. m$^{-2}$)

Grain yield of cereals is completely dependent upon the number of productive tillers produced by each plant. The data on effective tillers are presented in table-2. Data indicate that, weed free treatment showed maximum number of effective tillers (389.33 m$^{-2}$) which was significantly superior over all treatments, except in hand weeding. Pre-emergence application of oxyflourfen 20 DF@ 240 g *a.i.*. ha$^{-1}$ did produce more number of tillers (349.33 m$^{-2}$) as compared to its other doses.

### Panicle length (cm)

The data on panicle length as influenced by different treatments are presented in table-2. Observation of data acknowledges that, it was significantly affected by herbicidal treatments. The highest panicle length (23.52 cm) was observed under the treatment weed free which was statistically longer over all treatments followed by hand weeding (23.49 cm). Longer panicles were produced when oxyflourfen 20 DF was applied as pre-emergence @ 240 g *a.i.* ha$^{-1}$ as compared to its other treatments. Larger panicle length from these treatments might be due to minimum crop- weed competition which allowed more growth of rice because of more availability of light, moisture, nutrients and space which led to production of longer size of panicle. [Singh *et al* (2005), Sathya Priya, *et al* (2017)] [27, 25].

**Table 1:** Effect of different weed management practices on crop growth of direct seeded rice

| Treatment | | Plant height (cm) at harvest | Dry matter accumulation, g $m^{-2}$ at harvest | No. of tiller ($m^{-2}$) at harvest | Leaf area index (60 DAS) |
|---|---|---|---|---|---|
| $T_1$ | Oxyflourfen 20 DF@160 g *a.i.* $ha^{-1}$ | 88.97 | 5.52 | 396.00 | 5.34 |
| $T_2$ | Oxyflourfen 20 DF@ 200 g *a.i.* $ha^{-1}$ | 94.71 | 5.81 | 431.33 | 5.51 |
| $T_3$ | Oxyflourfen 20 DF@ 240 g *a.i.* $ha^{-1}$ | 99.03 | 6.24 | 454.33 | 5.75 |
| $T_4$ | Oxyflourfen 20 DF@ 480 g *a.i.* $ha^{-1}$ | 97.70 | 5.94 | 440.00 | 5.63 |
| $T_5$ | Oxyflourfen 20 DF@ 720 g *a.i.* $ha^{-1}$ | 92.86 | 5.77 | 411.33 | 5.46 |
| $T_6$ | Oxyflourfen 23.5 EC@ 105.75 ml $ha^{-1}$ | 84.30 | 5.37 | 389.33 | 5.24 |
| $T_7$ | Pretilachlor 30.7 EC@ 187.27 ml $ha^{-1}$ | 75.41 | 4.94 | 381.00 | 5.04 |
| $T_8$ | Pendimethalin 30 EC@ 105.75 501ml $ha^{-1}$ | 80.09 | 5.12 | 374.67 | 5.15 |
| $T_9$ | Hand Weeding | 101.77 | 6.81 | 457.67 | 5.83 |
| $T_{10}$ | Weed free | 104.20 | 7.14 | 473.33 | 5.91 |
| $T_{11}$ | Unweeded Check | 53.88 | 4.03 | 119.33 | 2.16 |
| | Sem± | 2.74 | 0.17 | 2.23 | 0.02 |
| | CD (P=0.05) | 6.83 | 0.49 | 6.57 | 0.05 |

**Panicle weight (g)**

The data on panicle weight as affected by various treatments and are presented in table-2. Among all the treatments, the maximum panicle weight (2.64 g) was recorded under weed free treatment which was heavier over all treatment but was found at par to hand weeding, however the lightest panicle (0.88g) was produced with unweeded check. Heavier panicles might be due to better transfer of photosynthates to the sink which contributed to increase the weight of panicles. The results are in line with Saini (2005) [23], Subramaniyam *et al* (2007) [30] and Singh Parmajeet *et al* (2018) [26].

**Table 2:** Effect of different weed management practices on yield attributes and yield of direct seeded rice.

| Treatment | | Effective tillers ($No.m^{-2}$) | Panicle length (cm) | Panicle weight (g) | No of grains $panicle^{-1}$ | 1000 grain weight (g) | Grain yield (q $ha^{-1}$) | Straw yield (q $ha^{-1}$) | Harvest index (%) | Weed index (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | Oxyflourfen 20 DF@160 g *a.i.* $ha^{-1}$ | 223.33 | 22.07 | 1.99 | 121.17 | 23.23 | 35.15 | 50.47 | 41.11 | 35.79 |
| $T_2$ | Oxyflourfen 20 DF@ 200 g *a.i.* $ha^{-1}$ | 284.00 | 22.67 | 2.22 | 128.33 | 23.76 | 42.33 | 58.70 | 42.09 | 22.68 |
| $T_3$ | Oxyflourfen 20 DF@ 240 g *a.i.* $ha^{-1}$ | 349.33 | 23.13 | 2.48 | 136.33 | 24.14 | 49.51 | 64.52 | 43.36 | 9.57 |
| $T_4$ | Oxyflourfen 20 DF@ 480 g *a.i.* $ha^{-1}$ | 311.67 | 22.94 | 2.37 | 133.67 | 23.95 | 46.23 | 61.54 | 42.79 | 15.56 |
| $T_5$ | Oxyflourfen 20 DF@ 720 g *a.i.* $ha^{-1}$ | 273.33 | 22.62 | 2.18 | 126.00 | 23.69 | 41.41 | 57.22 | 42.00 | 24.36 |
| $T_6$ | Oxyflourfen 23.5 EC@ 105.75 ml $ha^{-1}$ | 202.33 | 21.67 | 1.89 | 118.67 | 22.99 | 30.75 | 45.37 | 40.52 | 43.83 |
| $T_7$ | Pretilachlor 30.7 EC@ 187.27 ml $ha^{-1}$ | 170.33 | 19.91 | 1.64 | 112.33 | 22.68 | 22.50 | 33.56 | 40.03 | 58.90 |
| $T_8$ | Pendimethalin 30 EC@ 105.75 501ml $ha^{-1}$ | 182.33 | 20.21 | 1.76 | 114.67 | 22.77 | 26.58 | 39.17 | 40.27 | 51.45 |
| $T_9$ | Hand Weeding | 381.00 | 23.49 | 2.60 | 140.67 | 24.32 | 53.91 | 67.06 | 44.58 | 1.53 |
| $T_{10}$ | Weed free | 389.33 | 23.52 | 2.64 | 142.33 | 24.39 | 54.75 | 67.93 | 44.64 | - |
| $T_{11}$ | Unweeded Check | 58.33 | 10.95 | 0.88 | 79.33 | 22.02 | 5.83 | 13.80 | 29.71 | 89.35 |
| | Sem± | 5.17 | 0.43 | 0.11 | 3.63 | 0.10 | 2.86 | 3.26 | 1.82 | - |
| | CD (P=0.05) | 15.26 | 1.27 | 0.33 | 10.72 | 0.29 | 8.43 | 9.62 | 5.37 | - |

**Number of grains $panicle^{-1}$**

The data on total number of grains $panicle^{-1}$ as affected by different treatments are presented in table-2. Among all the treatments, the highest number of grains $panicle^{-1}$ (142.33) was observed in treatment weed free which was significantly superior over all treatments but was found at par to hand weeding (140.67). The minimum number of grains $panicle^{-1}$ (79.33) was recorded under unweeded check. Among various doses of oxyflourfen 20 DF, its 240 g *a.i.* $ha^{-1}$ as preemergence application did produce more grains $panicle^{-1}$ as compared to remaining doses of oxyflourfen 20 DF. The higher number of grains $panicle^{-1}$ recorded in these treatments which might be due to the lower weed competition in terms of dry matter of weeds which created overall congenial environment for growth and development of rice which resulted more availability of light, moisture, nutrients and space for rice plant which led to produce more number of sound grains $panicle^{-1}$. The results of investigation confirm the findings of Saini *et al* (2001) [24] and Kiran *et al* (2010) [18].

**1000-grain weight (g)**

The weight of thousand grains is also an important attributes to yield and data are presented in table-2. The highest weight of 1000-grain (24.39 g) was found in weed free treatment which was statistically superior over all treatments except hand weeding and the lowest weight of 1000-grain (22.02 g) was found in unweeded check. These results are similar to the findings of Ganeshwor and Gadadhar (2000) [15], Khan and Tarique (2011) [17] and Popy *et al* (2017) [20].

**Grain yield (q $ha^{-1}$)**

On perusal of data given in table-2 reveal that the highest grain yield (54.75 q $ha^{-1}$) was recorded under weed free treatment which was significantly superior over all treatments, followed by hand weeding (53.91 q $ha^{-1}$). The minimum grain yield (5.83 q $ha^{-1}$) was recorded under unweeded check. So for as the different doses of oxyflourfen 20 DF is concerned, pre- emergence application of it @ 240 g *a.i.* $ha^{-1}$ did produce higher grain yield (49.51 q $ha^{-1}$) which has been significantly higher over its lower dose of 800 g *a.i.* $ha^{-1}$ whereas, it was at par with its 1000, 2400 and 3600 g *a.i.* $ha^{-1}$. Higher grain yield is due to better control of weeds at critical stages and thus, providing favourable environment for better growth and development leading to enhanced yield and yield attributes. In rice, productivity is mainly decided by the weed control efficiency of weed management methods as earlier observed by Abraham *et al* (2010) [1]. This corroborates the result of Singh *et al* (2007) [28]

**Straw yield (q ha-[1])**

The data on straw yield under different treatments have been presented in table 2. The straw yield was significantly affected by different treatments. The highest straw yield (67.93 q $ha^{-1}$) was recorded under treatment weed free which was significantly superior over all treatments but was found at par with hand weeding (67.06 q $ha^{-1}$). The minimum straw yield (13.80 q $ha^{-1}$) was recorded under unweeded check. Pre-emergence application of oxyflourfen @ 240 g *a.i.* $ha^{-1}$ did produce (64.52 q $ha^{-1}$) straw yield which was statistically higher over its two lower doses (160 and 200 g *a.i.* $ha^{-1}$), however it was at par with its doses 480 and 720 g *a.i.* $ha^{-1}$. This may be because of better weed control which reduce the competition with crop and thus, better crop growth and thus, yield (Azad *et al.*, 1990) [6].

**Harvest index (%)**

The data on harvest index for different treatments have been presented in table. The highest harvest index (44.64%) was found in weed free treatment which was statistically superior over all treatments; however, it was at par to treatment hand weeding at 15 and 30 DAS (44.58%). The lowest harvest index was found in unweeded check (29.71%). So for as effect of oxyflourfen 20 DF is concerned, similar trend was followed as in grain yield. Deberman and Fairhurst (2000) [8] concluded that, lower harvest index may be due to the more competition during the critical periods which results in lower number of tillers, leaves, less number of grains and lower translocation of photosynthates towards the reproductive parts of the crop plant and act as a barrier for lower economic as well as biological yield.

**Weed index (%)**

On perusal of data on weed index table showed that, there was maximum yield reduction to the tune of (89.35%) under unweeded check, however the least yield reduction of 1.53% was observed in hand weeding treatment. Among different doses of oxyflourfen, pre-emergence application of its 240 g *a.i.* $ha^{-1}$, the least yield reduction (9.57%) as against its 160, 200, 240, 480 and 720 g *a.i.* $ha^{-1}$. The more grain yield reduction is obviously due to greater weed infestation which negatively affected the plant growth, yield attributes and yield of direct-seeded rice. On the other hand yield was relatively less reduced in the treatment having better weed control. Similar result was found by Mukherjee and Singh (2005) [19].

**Conclusion**

Among the herbicide treatments, significantly highest values of yield attributes, grain yield, straw yield, harvest index and weed index was recorded under weed free but at par to hand weeding 15 and 30 DAS and Oxyflourfen 20 % DF@ 240 g *a.i.* $ha^{-1}$.

**Reference**


1. Abraham CT, Prameela P, Priya lakshmi M. Efficacy of oxyfluorfen for weed control in transplanted rice. Journal of Crop and Weed. 2010; 6(2):67-71.
2. Anonymous. Pocket Book on Agricultural Statistics 2013. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, New Delhi, 2016, 102.
3. Anonymous. Vision 2030. Indian Council of Agricultural Research, New Delhi, 2016.
4. Anonymous. Report of Agriculture Department, Chhattisgarh Government. Krishi Diary, Directotrate of Extension Services, IGKV, Raipur (C.G.) 2017, 4.
5. Ashraf MM, Awan TH, Manzoor Z, Ahmad M, Safdar ME. Screening of herbicides for weed management in transplanted rice. Journal of Animal and Plant Science 2006; (1, 2):16
6. Azad BS, Singh H, Bhagat KL. Efficacy of Oxyfluorfen in controlling weeds in transplanted rice. Oryza. 1990; 27:457-459.
7. Chauhan BS, Opena J. Weed management and grain yield of rice sown at low seeding rates in mechanized dry-seeded systems. Field Crops Res. 2013; 141:9-15
8. Dobermann A, Fairhurst T. Rice nutrient disorders and nutrient management. International Rice Research Institute, Manila, Philippines, 2000.
9. Ghosh D, Singh UP, Ray K, Das A. Weed management through herbicide application in direct-seeded rice and yield modeling by artificial neural network. Spanish Journal of Agricultural Research, 2016; 14(2):1003.
10. Manhas SS, Govindra Singh, Dhasima Singh, Khajuna V. Effect of tank-mixed herbicides on weeds and transplanted rice (*Oryza sativa* L.) Annals of Agricultural Research, New Series. 2012; 33(1, 2):25-31.
11. Mohanty S. Trends in global rice consumptions. Rice Today. 2013; 12(1):44-45.
12. Moorthy BTS, Saha S. Studies of crop-weed competition in rainfed direct seeded lowland rice, Central Rice Research Institute, Cuttack. Indian J Weed Sci. 2005; 37:267-268.
13. Nayak BNS, Khan MM, Mosha K, Rani PP. Plant spacing and weed management techniques influence weed competitiveness of drum seeded rice (*Oryza sativa* L.). International Journal of Applied Biology and Pharmaceutical Technology. 2014; 5(3):13-22.
14. EI-Desoki ER. Effect of some weed control treatments on transplanting rice and nutrients uptake by rice and weeds. Journal of Agricultural Science Mansou-ra University, 2003; 28(1):23-35.
15. Ganeshwor T, Gadadhar M. Effectiveness of herbicides on controlling weeds in transplanted rice. Nio-Botanica. 2000; 8(1, 2):1-6.
16. Halder J, Patra AK. Effect of chemical weed control methods on productivity of transplanted rice. Indian Journal of Agronomy. 2007; 52(2):111-113.
17. Khan TA, Tarique MH. Effects of weeding regime on the yield and yield contributing characters of transplant (*aman)* rice. Int. J Sci. and Advan. Technol. 2011; 11:11-14.
18. 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, 4):229-228.
19. Mukherjee D, Singh RP. Effect of micro herbicides on weed dynamics, yield and economics of transplanted rice. Indian journal of Agricultural Sciences. 2005; 50(4):292-295.
20. Popy FS, Islam AKMM, Hasan AK, Anwar MP. Integration of chemical and manual control methods for sustainable weed management in inbred and hybrid rice. J Bangladesh Agril. Univ., 2017; 15(2):158-166
21. Saha S, Rao KS. Efficacy of metsulfuron-methyl for controlling broad-leaved weeds in transplanted rice under rainfed shallow lowland. Indian Journal of Agricultural Sciences. 2010; 80(6):522-526.

22. Sahu PK. Yield variation under Rice-Weed competition in direct-seeded low land condition (Doctoral dissertation), 2016.
23. Saini JP. Efficacy of Cyhalofop-butyl alone and in combination with 2, 4-D against mixed weed flora in direct seeded upland rice. Indian Journal of Agronomy. 2005; 50(1):38-40.
24. Saini JP, Angiras NN, Singh CM. Effect of cyhalofop butylin controlling weeds in transplanted rice. Indian Journal of Agronomy. 2001; 46(2): 222-226.
25. Sathya Priya R, Chinnusamy C, Murali Arthanari P, Janaki P. Carryover effect and plant injury from oxyfluorfen herbicide applied in transplanted rice, 2017.
26. Singh Paramjeet, Shrivasatava GK, Verma AK, Paikra IS. Effect of different doses of herbicides and mechanical weeding on yield attributes and grain yield of direct seeded rice (*Oryza sativa* L.) varieties under Inseptisols of Chhattisgarh plain. International Journal of Chemical Studies. 2018; 6(1):1929-1933.
27. Singh DK, Tewari AN. Effect of herbicides in relation to varying water regimes in controlling weeds in direct seeded puddled rice. Indian Journal Weed Science. 2005; 37(3, 4):193-196.
28. Singh P, Singh P, Singh R, Singh KN, Sofi P, Bahar FA. Efficacy of herbicides for controlling weeds in transplanted rice. 2007; 95(4):412-354.
29. Singh S, Bhan VM. Performance of Sulfonyl Urea herbicides on weed control in transplanted rice. Annals of Plant Protection Science. 1998; 6(1):89-91.
30. Subramanyam D, Reddy CR, Reddy DS. Influence of puddlingintensity and water-management practices on weed dynamics and yield of transplanted rice. Indian Journal of Agronomy. 2007; 52(3):225-230.
31. Yadav DB, Yadav A, Malik RK, Gill G. Efficacy of PIH 2023, Penoxsulam Azimsulfuron for post emergence weed control in wet direct seeded rice. Proc. ISWS Biennial Conference on new and emerging issues in weed science. CCS HAU, Hissar, 2007, 92.