International Journal of Plant & Soil Science

33(21): 187-194, 2021; Article no.IJPSS.73821
ISSN: 2320-7035

Effect of Nutrient and Weed Management Practices on Weed Dynamics and Productivity of Aromatic Rice in Semi-arid Region of Bihar

Shashimala Kumari[1], Vinay Kumar[2], Vijay Kumar[3], Shashidhar Yadav[1], Santosh Kumar Singh[4], Rajan Kumar[1] and Ravi Nandan[1]

[1]Department of Agronomy, Dr. Rajendra Prasad Central Agricultural University, Pusa-848125, Bihar, India.
[2]IARI, Regional Station, Pusa- 848125, Bihar, India.
[3]Krishi Vigyan Kendra, Manjhi, Saran, Dr. Rajendra Prasad Central Agricultural University, Pusa-841313, Bihar, India.
[4]Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa-848125, Bihar, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2130671
Editor(s):
(1) Prof. Rusu Teodor, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania.
Reviewers:
(1) Charles Nyarang'o Nyamwamu, Kenyatta University, Kenya.
(2) Mona Gergis Dawood, National Research Centre, Egypt.
(3) Sheela Barla, Birsa Agricultural University, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73821

Original Research Article

Received 11 July 2021
Accepted 21 September 2021
Published 23 October 2021

ABSTRACT

A field experiment was conducted during *kharif* season of 2017 at Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) to investigate the "Effect of nutrient and weed management practices on weed dynamics and productivity of aromatic rice''. The experiment was laid out in split-plot design and was replicated thrice. The treatments comprised three nutrient levels *viz*., N1= 100% RDF; N2=75% RDF + FYM 5 t/ha**;** N3=50% RDF + FYM 10 t/ha in main-plot, and six weed management practices *viz*., W1 = Brown manuring; W2= Bispyribac- sodium @ 25 g/ha as post emergence; W3= Chlorimuron ethyl + Metsulfuron methyl (Almix) @ 4 g/ha at 20 days after transplanting (DAT); W4= Pyrazosulfuron @ 25 g/ha; W5=Weed free; W6= Weedy check in sub-plot. The results revealed that treatment N1 recorded the maximum- recorded the grain yield of

**Corresponding author: E-mail: vinaypusa@gmail.com;*

rice. Among weed management practices, treatment W5 recorded the maximum grain yield of rice. Weed population and weed dry matter were found maximum in N3. Weed control efficiency and weed index was the maximum in W5 and W6 respectively. Thus, it may be concluded that the nutrient level N1 is superior to N2 & N3. Secondly, high cost involved in manual weeding makes herbicidal treatments more viable proposition. The weed management practice W2 is a most effective for transplanted aromatic rice.

Keywords: Aromatic rice; nutrients; weed; management; yield.

1. INTRODUCTION

Rice (*Oryza sativa*) is the major staple food for most of Asia including India. It is a monocotyledonous angiosperm belonging to family Graminae and is self-pollinated crop. Among cereal crops, it serves as principal source of nourishment for half of world's population [1]. In India, rice is cultivated across the length and width of the country occupying about 43.39 million hectares area under four major eco-systems *i.e.,* irrigated (21 million ha), rain fed lowland (14.2 million ha), rain fed upland (6.3 million ha) and flood-prone (3.1 million ha) with total production of 104.32 million tones and average productivity of 2.4 t/ha. Whereas, in Bihar rice is cultivated in 3.21 million hectares with total production of 6.49 million tones [2].

Aromatic rice found all over the world and it is most important and famous cereal grain crops of India [3]. It is sweet in taste and has pleasant aroma. The highly aromatic rice has proved as a gift to the whole world. The world's total production of aromatic rice is 70% in India and the rest of it is produced in Pakistan. In India, Punjab, Haryana, Uttar Pradesh, Uttarakhand and Jammu & Kashmir are major states of basmati production-aromatic. Now, Madhya Pradesh, Telangana and Andhra Pradesh states have also started cultivation of basmati production- aromatic. The area under cultivation and production in India was 27 lakh hectares and 81 lakh tones, respectively [4].

A major hindrance in successful cultivation of rice is heavy infestation of weed causing drastic reduction in yield. Besides chemical fertilizer, organic manure is also an important source of nutrient added to the soil but contain low amount of nutrient and therefore, whole crop requirement cannot be fulfilled by its sole application. Chemical fertilizers are available in fixed grades. Hence, all nutrients are not supplied in balanced quantities [5].

Nutrient management must be sound for achieving the production target in sustainable manner. Use of chemical fertilizer is the fastest way of counteracting the pace of nutrient mining. It promotes the growth and development of rice crop and is responsible for over 50% of the crop yield increment. These essential plant nutrients play a vital role in boosting the yield of aromatic rice. It responds to judicious application of fertilizer, especially nitrogen, phosphorus and potassium and gives higher yield from aromatic varieties at a particular fertilizer level [5].

Weed is one of the most important negative factors limiting the rice production, which do not only compete with crop for applied nutrients but also impair the quality of the produce. Yield reduction in transplanted rice has been reported to be 28-45% due to uncontrolled weeds [6]. Besides yield reduction, weeds deplete nutrient from soil to an extent of 42.07 kg nitrogen, 10 kg phosphorus and 21.80 kg potassium per hectare respectively [7].

Manual weeding is very effective but it is tedious, time consuming and expensive in large scale cultivation. Continuous rains in rainy season and unavailability of man power make manual weeding difficult. In such situation, herbicides hold great promise as they can arrest weed growth from the beginning of crop growth. In recent days, the chemical weed control by herbicides is gaining popularity in rice due to their fast effects and low expenditure. Use of herbicides to keep the crop free from weeds at initial crop weed competition stages will help in reducing the cost of weeding as well as managing weed below damaging level. Most of the herbicides have very effective option for selective weed control but only one herbicide alone cannot control all weeds of different species [1].

Many time due to various constraints at farm level, the application of herbicides within 3-4 days after transplanting is not possible and continuous use of same herbicide might cause resistance in weeds under such situation, the post-emergence herbicide may be another option [7]. Weed management is an important component of plant protection improving the production potential of crops. Information available on nutrient and weed management under aromatic rice is not sufficient. Therefore, the aim of the study was to evaluate the effect of nutrient and weed management under aromatic rice.

2. MATERIALS AND METHODS

2.1 Study Area

A field experiment was conducted during *Kharif* season 2017 at research farm of the Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar). The experimental plot had uniform topography with good drainage and assured irrigation facility. The average rainfall of the area is 1276.1 mm out of which nearly 1026.0 mm is received during the monsoon season between June to September. The soil of the experimental site was sandy loam in texture with alkaline pH, low in organic carbon and available N, P, K & S content.

2.2 Experimental Design

The experiment was laid out in split-plot design with nutrient management in main-plot and weed management in sub-plot with three replications. The treatments involved three nutrient levels *viz*., N1= 100 % RDF; N2=75 % RDF + FYM 5t/ha**;** N3=50 % RDF + FYM 10 t/ha in main plot, and six weed management practices *viz*., W1 = Brown manuring; W2= Bispyribac-sodium @ 25 g/ha PoE; W3=Chlorimuron ethyl + Metsulfuron methyl (Almix) @ 4 g/ha at 20 DAT; W4=Pyrazosulfuron @ 25 g/ha; W5=Weed free; W6= Weedy check in sub plot.

2.3 Agronomic Practices

Nursery raising: The seed was treated with fungicide SAAF (Carbendazim+Mencozeb) @ 3g/kg seed before sowing to protect the crops from seed borne diseases. Seed of rice variety *Rajendra Bhagwati* was raised in nursery by “Wet bed method”. Seed beds of 8.0 m × 1.25 m size were prepared in dry condition. In addition 1 kg of nitrogen, 1 kg of phosphorus and 0.5 kg of potash were also applied @ 1000 sqm through Urea, DAP and MOP, respectively at the time of last ploughing. Further, top dressing was done with @ 1.0 kg N/1000 sqm in the form of urea at 10 days after sowing. Need based irrigation and weeding was also done.

Field preparation: The experimental field was ploughed immediately after the harvest of previous wheat crop by a tractor drawn harrow in summer to expose weeds and the eggs of harmful insects. The field was prepared by following two cross disc harrowing and two cross tiller operations and finally the field was levelled by planking. Thereafter, the field was flooded with water and puddled by tractor. After puddling field was levelled finally.

Nutrient application and sowing: Recommended fertilizer dose of nitrogen (120 kg/ha), phosphorus (60 kg/ha), potash (40 kg/ha) and FYM as per treatment was applied. Half dose of nitrogen & potassium and full dose of phosphorus & FYM were applied as basal dose whereas, remaining half dose of nitrogen and potassium were applied at the time of tillering.

Irrigation: Plot wise frequent irrigations were given to maintain the 5 cm level of standing water in early growth stages. At later stages, irrigations were given as and when required to maintain saturated soil condition.

Herbicide application: Herbicides like Bispyribac-sodium @ 25 g/ha, Almix @ 4 g/ha, Pyrazosulfuron @ 25 g/ha were applied as post emergence at 20 DAT, in an aqueous solution using 800 litres of water.

Brown manuring: In brown manuring practice introduced where *Sesbania* seed @ 40 kg/ha is broadcasted three days after rice sowing and allowed to grow for 30 days and dried by spraying 2, 4-D ethyl ester which supplies up to 35 kg N/ha dry matter, control of broad leaf weeds.

2.4 Data Collection

Weed population/m^2: Weed density species wise and total from experimental plots was recorded at 30, 60 and 90 days after transplanting with the help of quadrate of size 0.5 × 0.5 meter thrown randomly at two places. The weed number counted was converted into number per square meter.

Weed dry matter (g/m^2): Weeds lying within quadrate area in each plot were cut from the ground levelat 30, 60, 90 days after transplanting (DAT). The samples were first sun-dried and then dried in oven at 70 °C for about 72 hours. Subsequently, samples were weighed and dry matter accumulation (g/m^2) by weeds was recorded species wise and total.

Weed control efficiency (%): Weed control efficiency (WCE) was computed by the formula given by Tripathi and Mishra [8] as:

$$WCE\ (\%) = \frac{X - Y}{X} \times 100$$

Where, X = Dry weight of weeds in untreated plot
Y = Dry weight of weeds in treated plot

Weed Index (%): Weed Index (%) is present reduction in yield due to weeds as compared to total yield of weed free treatment. The weed index was calculated by employing the formula given by Gill and Kumar [9]:

Grain yield: Net plots were harvested after removing the border rows. Grain yield was recorded after threshing, winnowing and cleaning the produce. The moisture content of the samples drawn from each plot was determined with the help of moisture meter and the yields were adjusted at 14 per cent moisture. The grain yield obtained from the net plot area was finally converted into quintal per hectare (t/ha).

2.5 Statistical Analysis

Data pertaining to various plant characters were subjected to statistical analysis by the technique of analysis of variance as described by Cochran and Cox [10]. The significance of treatment effect was tested by "F" test [11], standard error of differences was computed and recorded along with the summary results. Critical differences for different groups of treatments and their interactions at 5 per cent level of significance were calculated where ever F-test was significant.

3. RESULTS AND DISCUSSION

3.1 Weed Population and Dry Matter

Weed population: The problem of weed infestation has been very intense in India because of tropical conditions, which has been further aggravated by the introduction of new high yielding varieties of crops. Weeds compete with crop plants in the field for alimentation, moisture and sunlight. The nature and severity of weed competition depends on types of weed species, intensity of weed infestation, duration of weed infestation, competing ability of the crop plants, soil and climatic conditions which affect the crop and weed growth. In the present survey, the weed population was significantly affected by nutrient levels at all the growth stages (Table 1). At N3 level of nutrient significantly higher weed population was observed as compared to others level of fertilizer. However, at 90 DAT, weed population decreased significantly with increasing levels of fertilizer. This may be due to better establishment and vigorous growth and development of crops over weed population at higher nutrient rate. A well-marked outcome of weed management practices on weed population was recorded at all the stages of growth. Weed population was observed the minimum under hand weeding followed by Bispyribac-sodium @ 25 g/ha, Pyrazosulfuron @ 25 g/ha PoE and Chlorimuronethyl+Metsulfuron methyl (Almix) @ 4 g/ha at all the growth stages except 30 DAT, brown manuring where Bispyribacsodium @ 25 g/ha recorded significantly lower weed count than Pyrazosulfuron @ 25 g/ha PoE. The maximum weed population was observed in weedy check. The trend was almost similar at all the stages of growth. The reason for low weed population under hand weeding (weed free) treatments was due to the removal of weed at 30 and 60 days after transplanting. However, higher weed count under brown manuring plots as compared to hand weeding (weed free) was because of that the brown manuring fail to stop weed emergence after transplantation of the crop. Weed population under chemical weeding increased slowly due to the decreasing efficiency of the herbicides with the lapse of time towards crop maturity. This was because the chemical which were used did not persist in the soil for more than 10 weeks. Mostly, the grassy weeds *i.e., Cynodon dactylon, Echinochloa crus-galli* and Sedges (*Cyperus rotundus/iria*) emerged and their intensity also considerably increased with the growth and development of the crop. This finding is in conformity with the findings of Shah et al. [12]; and Channabasavanna et al. [13].

Weed dry matter: Dry matter production of weeds is the demonstration of the degree of weed flora and its vigor. Accumulation of dry matter by weeds steadily increased towards maturity of the crop under all the treatments and maximum value was found at 30 DAT (Table 1). Among the nutrient levels minimum weed dry weight was observed at 100% RDF (120-60-40 NPK kg/ha) level of fertilizer at all the stages of growth which increased significantly with increasing levels of fertilizer and recorded maximum value at 50% RDF+FYM 10 t/ha. Weed nourished with same nutrients as is required by the crop plant. At higher fertilizer levels weed rob higher quantity of nutrients and grow profusely hence, accumulated more dry matter. Similar result was obtained by Rajkhowa et al. [14]. Weed dry matter was also significantly affected by weed control treatments, maximum weed dry matter inflation was obtained in the weedy check at all the stages of growth. Among the weed control treatments, weed free (hand weeding) recorded lowest weed dry matter which was significantly lower than brown manuring and chemical weeding at all the stages. Bispyribac-sodium @ 25 g/ha also had significantly lower weed dry matter than Chlorimuronethyl+Metsulfuronmethyl (Almix) @ 4 g/ha at 20 DAT at all the stages.

Under weedy check weeds were allowed to grow freely, were greater in number and enjoyed all the growth factors more aggressively in an undisturbed ecosystem and as such accumulated higher weed dry matter. The lower weed dry matter in weed free (hand weeding) and Bispyribac-sodium @ 25 g/ha treatments were due to slower pace of growth of subsequent flushes of weeds after 30 and 60 days after transplanting and thereafter emergence of new flushes of weeds could not attain full growth under the shade of crop plants. On theother hand, the surviving weed after herbicidal treatments had better growth and greater dry matter accumulation. In herbicidal treated plots too, the regeneration and re-growth of weeds took place due to loss of persistency of herbicides in the soil with the lapse of time. Significantly lower weed dry matter in Bispyribac-sodium @ 25 g/ha as compared to Chlorimuronethyl + Metsulfuron methyl (Almix) @ 4 g/ha at 20 DAT was due to wide spectrum control of weeds under Bispyribac-sodium @ 25 g/ha treated plots which resulted in lower weed dry matter. Effectiveness of herbicides in controlling the weeds has been reported by several workers. Shekhar et al. [15]; and Depthi and Subramanyam [16] reported that both the predominant sedges *viz.*, *Cyperus difformis* and *Fimbristylis miliancea* was best controlled with Bispyribac-sodium @ 25 g/ha applied as post-emergence.

3.2 Weed Control Efficiency and Weed Index

Weed control efficiency: Weed control efficiency (WCE) measures the efficiency of any weed control method by comparing it with weed free control. Weed management practices positively affected the WCE (Table 2). Among the weed control treatments, cultural weed control practices enhanced the weed control efficiency over chemical weeding at all the growth stages. Under weed free (hand weeding) conditions, weed control efficiency was observed the maximum at all the stages which was closely followed in order by W2 (Bispyribac-sodium @ 25 g/ha). This might be ascribed due to the fact that when Bispyribac-Sodium @ 25 g/ha applied alone was not proved as effective as combined application of herbicide because of poor control of later emerging weeds.These findings were conformity with the findings of Singh et al. [17]; and Kumar et al. [18].

Table 1. Effect of nutrient and weed management practices on weed population and weed dry matter in rice cropping

Treatments	Weed population/m2			Weed dry matter (g/m2)		
	30 DAT	**60 DAT**	**90 DAT**	**30 DAT**	**60 DAT**	**90 DAT**
Nutrient management						
N1	23.66	20.45	20.63	47.25	37.29	39.57
N2	26.62	23.10	22.95	51.93	43.23	43.64
N3	29.61	25.51	25.28	55.66	47.13	48.46
$LSD_{(0.05)}$	1.58	0.90	0.72	2.81	1.91	2.51
Weed management						
W1	33.98	26.12	23.36	66.92	49.31	45.23
W2	16.45	12.46	11.44	31.20	22.72	23.20
W3	25.99	19.55	10.07	50.35	35.85	36.36
W4	24.57	18.36	16.95	47.26	34.44	32.89
W5	14.59	11.37	10.09	27.43	21.12	20.20
W6	44.18	50.25	57.81	86.51	91.86	105.45
$LSD_{(0.05)}$	1.57	0.93	0.81	2.78	1.84	1.67
Interaction (N×W)	NS	NS	NS	NS	NS	NS

N1= 100 % RDF; N2=75 % RDF + FYM 5t/ha; N3=50 % RDF + FYM 10t/ha in main plot, and six weed management practicesviz.,W1 = Brown manuring; W2= Bispyribac- sodium @ 25 g/ha PoE; W3= Chlorimuron ethyl + Metsulfuron methyl (Almix) @ 4 g/ha at 20 DAT; W4=Pyrazosulfuron @ 25 g/ha; W5=Weed free; W6= Weedy check in sub plot

Table 2. Effect of nutrient and weed management practices on weed dry matter and weed control efficiency in rice cropping

Treatments	Weed control efficiency (%)			Weed index
	30 DAT	60 DAT	90 DAT	
Nutrient management				
N1	-	-	-	
N2	-	-	-	
N3	-	-	-	
Weed management				
W1	24.51	48.48	57.78	19.22
W2	70.32	80.05	79.47	5.74
W3	46.61	67.32	65.91	9.38
W4	51.33	68.06	71.17	8.23
W5	75.81	83.81	85.11	-
W6	-	-	-	44.16

N1= 100 % RDF; N2=75 % RDF + FYM 5t/ha; N3=50 % RDF + FYM 10t/ha in main plot, and six weed management practicesviz.,W1 = Brown manuring; W2= Bispyribac- sodium @ 25 g/ha PoE; W3= Chlorimuron ethyl + Metsulfuron methyl (Almix) @ 4 g/ha at 20 DAT; W4=Pyrazosulfuron @ 25 g/ha; W5=Weed free; W6= Weedy check in sub plot

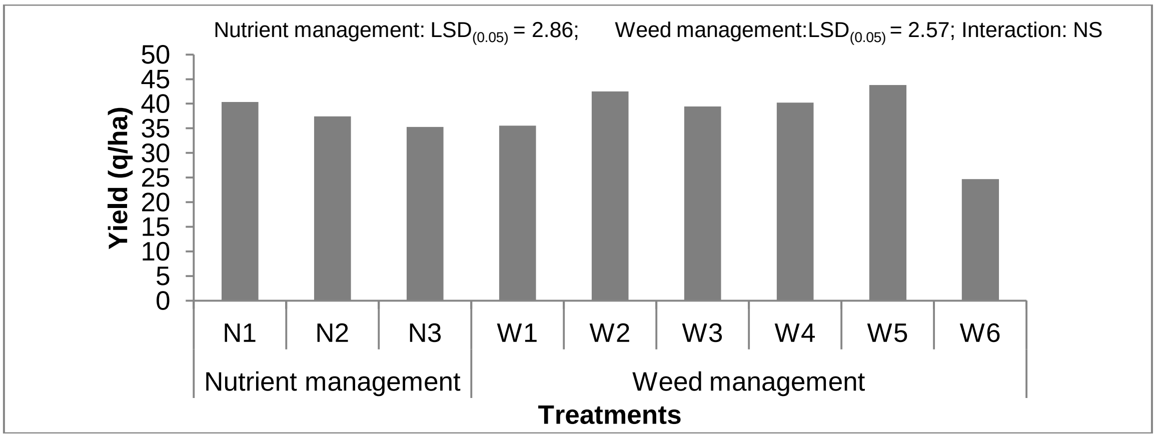

Fig. 1. Effect of nutrient and weed management practices on grain yield of rice

Weed index: Weed control treatments exerted positively effect on weed index (Table 2) at all the growth stages than weedy check. Among the weed control treatments, the magnitude of weed index was minimum under Bispyribac-sodium @ 25 g/ha (W2), which was closely followed by Pyrazosulfuron @ 25 g/ha PoE (W4).This might be due to less number of weeds germinated that results in minimizing biomass production. These findings were conformity with the findings of Singh et al. [17]; and Kumar et al. [18].

3.3 Grain Yield

The highest grain yield (Fig. 1) was obtained in treatment N1 which was found significantly superior over N2 & N3. Similarly, treatment N2 recorded significantly higher yield over N3. Grain yield was significantly influenced by weed control treatments. Weed management practice like weed free (W5) obtained the highest grain yield closely followed by W2 and in turn both had significantly higher grain yield than W4, W3 and W1. The grain yield recorded among the chemical weeding did not vary significantly among them. The reduction in grain yield in weedy check was possibly due to severe weed infestation in the crop field. The weeds grow freely and attained vigor enabling to compete with the crop plants for nutrient, moisture and sunlight throughout the growing season and thus suppressed the crop growth which hampers the fullest yield potential.

However, the reason for higher yield under weeding condition particularly under cultural treatment might be due to increased aeration through pulverization of soil which provided better crop growth condition for proper development of root and reduced the state of crop weed competition during the early stages of crop growth. The plant did not face either the nutrient or moisture deficits caused by heavy weed infestation and enjoyed weed free condition during its peak vegetative and developmental phases and had favorable soil moisture conditions for optimum physiological functions. The finding is in agreement with the observation of Singh et al. [19].

4. CONCLUSION

On the basis of one cropping season experimentation it may concluded that 100% RDF and Bispyribac-sodium @ 25g/ha as post emergence would give maximum yield of aromatic rice under the semi arid region of Bihar. Weed population and weed dry matter were the maximum under 50% RDF+ FYM 10 t/ha. Among the weed management practices, the minimum values of weed biomass were recorded under weed free. Weed control efficiency was also the greater under weed free while the weed index was the lower under Bispyribac-sodium @25 g/ha respectively.

ACKNOWLEDGEMENT

The support of Department of Agronomy, and Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University Pusa, Bihar, for providing basic infrastructure for this study is duly acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jaswal A, Kumar R, Kumar A, Singh A, Singh M, Janeja HS. Impact of different herbicides on transplanted basmati rice in a Typic Haplustept soil of Punjab, India. Research on Crop. 2017;18(4):583-588.
2. DAC FW. Operational guideline for targeting rice fallow areas, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India; 2016.
3. Maclean JL. Rice almanac. Source Book for the Most Important Economic Activity on Earth. International Rice Research Institute; 2002.
4. Kumar J, Singh D, Singh B, Singh R, Panwar S, Gupta AK. Sowing time and weed management practices to enhance yield of direct-seeded rice. Indian Journal of Weed Science. 2012;44:207-09.
5. Kumari S , Kumar V , Yadav S, Kumar V, Singh SK, Kumar R, Nandan R. Effect of Nutrient and Weed Management Practices on Yields and Economics of Aromatic Rice in Semi-Arid Region of Bihar, India. International Journal of Current Microbiology and Applied Sciences. 2020;9(3):89-95.
6. Singh S, Singh H, Narwal S, Malik PK. Performance of herbicides in transplanted rice.Indian Journal of Weed Science. 2003;35(1 & 2):114-116.
7. Puniya R, Pandey PC, Bisht PC. Performance of Trisulfuron, Trisulfuron + Pretilachlor and Bensulfuron- methyl in transplanted rice. Indian Journal of Weed Science. 2007;39(1&2):120-122.
8. Tripathi RS, Mishra R. Phytosociological studies of the crop weed association at Varanasi, Journal of Indian Botanical Society. 1971;50:142-152.
9. Gill GS, Kumar V. Weed index: A new method for reporting weed control trial. Indian journal of Agronomy. 1969;41:96-98.
10. Cochran WC, Cox GM. Experimental designs. Asia Publishing house, Bombay; 1952.
11. Fisher RA. Statistical method for research workers (13th Ed.). Olive and Boyd, Edinburgh; 1958.
12. Shah RA, Kumar S. Effect of integrated nutrient management on vegetative growth and yield of transplanted hybrid rice (*Oryza sativa* L.) crop.International Journal of Agriculture and Crop Sciences. 2014;7(11):863-869.
13. Channabasavanna AS, Kitturmath MS, Rajakumar H. Effect of bispyribac sodium on *Echinochloa* sp. in rice nursery (*Oryza sativa* L.). Journal of Farm Science. 2017;30(2):281-282.
14. Rajkhowa DI, Deka NC, Borah N, Barua IC. Effect of herbicides with or without paddy weeder on weeds in transplanted summer rice (*Oryza sativa*).Indian Journal of Agronomy. 2007;52(2):107-110.
15. Shekhar J, Mankotia BS, Bindra AD. Bio-efficacy of some new herbicides again weeds in transplanted rice. Indian Journal of Weed Science. 2004;36(1&2):50-53.

16. Dipthi KY, Subramanyam. Performance of pre-emergence herbicideson weed flora and yield on transplanted rice (*Oryza sativa*). Indian Journal of Weed Science. 2010;42(3&4):229-231.
17. Singh M, Bhullar MS, Chauhan BS. Influence of tillage, cover cropping, and herbicides on weeds and productivity of dry direct seeded rice. Soil & Tillage Research. 2015;147:39-49.
18. Kumar A, Naresh V, Ghasal PC. Weed management of effects on weedcontrol efficiency, yield and economics of transplanted rice in topic ustochrept soil of Uttar Pradesh. International Journal of Chemical Studies. 2017;5(4):1346-1351.
19. Singh B, Malik PK, Yadav A, Nandalal DP. Herbicide efficacy in seeded rice with different method under wet and dry conditions. Indian Journal of Weed Science. 2009;41(1&2):37-40.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73821