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HERBICIDE EFFICIENCY INDEX, PRODUCTIVITY AND ECONOMIC EFFICIENCY AS INFLUENCED BY PRE AND POST EMERGENCE HERBICIDES IN TRANSPLANTED RICE

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Abstract

A field experiment was conducted to manage the weeds by pre and post emergence herbicide combinations in transplanted rice during February-May 2020 at the Experimental Farm, Department of Agronomy, Annamalai University, Tamil Nadu, India. Treatments comprised of pre-emergence herbicides (butachlor, pretilachor and pyrazosulfuron ethyl) and post emergence herbicides (bispyribac sodium, metsulfuron methyl + chlorimuron ethyl, fenoxaprop-p-ethyl and triafamone + ethoxysulfuron), hand weeding twice (20 and 40 DAT) and unweeded control plot. Among the weed management practices hand weeding twice at 20 and 40 days after transplanting (DAT) notably reduced the weed counts, increased crop resistance, higher growth and yield attributes and grain yields. It was statistically on par with application of pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT followed by bispyribac sodium 25 g ha^{-1} PoE at 20 DAT. Best it was superior to hand weeding twice interms of net income (₹48,997) and BCR (2.06). The results suggested that application of pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT followed by bispyribac sodium 25 g ha^{-1} PoE at 20 DAT were the best broad spectrum effective herbicides in order to manage the diverse weed flora in transplanted rice.

Keywords: Economics, Herbicides, Transplanted rice and Weed management.

Introduction

Rice occupies a pivotal place in Indian Agriculture as it is staple food for more than 68 per cent of population and a source of livelihood for about 120 – 150 million rural households. Rice is consumed by approximately half of the world's population, the majority of whom reside in underdeveloped countries. For 40 per cent of the world's population, rice is the primary source of

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calories. Rice is grown on 162.06 million hectares worldwide, with a production of 500 million tonnes and a productivity of 3.1 t ha^{-1} (Anonymous, 2019). Rice is grown on 43.86 million hectares in India, with a production of 104.80 million tonnes and a productivity of 2.4 t ha^{-1} (Anonymous, 2019). Rice is grown on 1.85 million hectares in Tamil Nadu, with a production of 6.95 million tonnes and a productivity of 3.7 tonnes ha^{-1} (Ministry of Agriculture, 2019).

Rice yields in India are low due to variety of issues, one of which being weeds, which are the primary enemy. Weeds impair photosynthetic efficiency, dry matter production, and distribution to economically valuable regions of the plant, reducing the crop's sink capacity and resulting in poor grain yield. According to reports, the drop in rice grain yield ranges from 28 to 45 percent, depending on the type of weed species in the standing crop (Naik *et al*., 2019).

There are various weed management strategies available to decrease yield losses due to weeds, including mechanical, cultural, chemical, and biological treatments. Traditional hand weeding is the most effective and extensively used weed management method in Tamil Nadu. However, due of high rates, it is physically demanding, labour intensive, time consuming, and pricey, limiting the cultivation's revenues. In light of these constraints, the employment of the best method for resolving multiple weed problems in rice fields in a timely and cost-effective manner has gained a significant advantage over traditional methods. Pre-emergence herbicide application alone is insufficient to provide effective weed control and keep the weed-free condition up to the threshold level. In these circumstances, the only realistic alternative for weed management in transplanted rice is to use a pre-emergence herbicide followed by a post-emergence herbicide. Continuous use of the same herbicides (or herbicides with the same mode of action) may, nevertheless, result in weed resistance. In light of these considerations, a study titled “Weed management by pre and post emergence herbicide combinations and its influence in transplanted rice" was conducted.

Materials and methods

Field experiment was conducted at the Experimental farm, Department of Agronomy, Annamalai University, Cuddalore district, Tamil Nadu during (February – May) 2020. The experimental farm is geographically located at 11 ^{0} 24’ North latitude and 79^{0} 44’ East longitude and at an altitude of +5.79 m above mean sea level. The soil of the experimental field is clay loam in texture. The nutrient status of the soil was low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in randomized block design with three replications and fourteen treatments. The treatment details are *viz*. Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_1), Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT (T_2), Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1} PoE at 20 DAT (T_3), Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_4), Pretilachor 500 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_5), Pretilachor 500 g ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT (T_6), Pretilachor 500 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1} PoE at 20 DAT (T_7), Pretilachor 500 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_8), Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9), Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb metsulfuron methyl +

chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT (T_{10}), Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1} PoE at 20 DAT (T_{11}), Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}), Hand weeding twice (20 and 40 DAT) (T_{13}) and Unweeded control plot (T_{14}). As per the treatment schedule required quantity of pre and post emergence herbicides were sprayed with knapsack sprayer fitted with a flat fan nozzle using 500 liters of water ha^{-1}. Pre emergence herbicides *viz*., butachlor, pretilachor and pyrazosulfuron ethyl were sprayed on 3 DAT and post emergence herbicides *viz*., bispyribac sodium, metsulfuron methyl + chlorimuron ethyl, fenoxaprop-p-ethyl and triafamone + ethoxysulfuron were sprayed on 20 DAT. Need based plant protection measures were taken up based on the economic threshold level of pest and disease. Twenty one days old rice seedlings were transplanted with three seedlings hill^{-1} and adopt a spacing of 15 x 10 cm. The rice variety 'ASD-16' was chosen for the study. The fertilizers were applied to the experimental field as per recommended manurial schedule of 120 Kg N, 40 Kg P_2O_5 and 40 Kg K_2O ha^{-1}. The entire dose of P_2O_5, half dose of N and K_2O was applied as basal. Remaining half dose of N and K_2O was top dressed with equal splits at maximum tillering and panicle primordial initiation stages.

Total weed count

A quadrat of size 0.25 m^2 was placed in the sampling area of each plot and the weeds falling within the frames of quadrat were counted, recorded and the mean values were expressed in number m^{-2}. The density of grasses, sedges, broad leaved weeds and the total weed counts (grasses + sedges + broad leaved weeds) were recorded at 60 DAT.

Crop resistance index (CRI)

Crop resistance index at was calculated using the formula suggested by Rana and Kumar (2014).

$$CRI = \frac{\text{Crop dry weight in treated plot}}{\text{Crop dry weight in control plot}} \times \frac{\text{Weed dry weight in control plot}}{\text{Weed dry weight treated plot}} \times 100$$

Herbicide efficiency index (HEI)

Herbicide efficiency index (HEI) was calculated using the formula suggested by Das, 2013.

$$HEI = \frac{\dfrac{(Y_T - Y_C)}{Y_T} \times 100}{\dfrac{WDM_T}{WDM_C} \times 100}$$

where,

Y_T is crop yield from the treated plot

Y_C is crop yield from unweeded control plot

WDM_T is weed dry matter weight in the treated plot and WDM_C is weed dry matter in the unweeded control plot

Biometric observations on plant

Five plants in each plot were selected at random in border rows and tagged. These plants were used for recording all biometric observation at different stages of crop growth. Harvesting was done in each plot separately from the net plot area leaving the border rows. Grains were separated, dried, cleaned and grain yield was recorded plot wise at 12 per cent moisture content. The grain and straw yield were computed to kg ha^{-1}. The data on various characters studied during the course of investigation were statistically analyzed as suggested by Gomez and Gomez (1984). The data on weed count were subjected to square root transformation. Treatment differences, which were not significant, were denoted by NS (not significant).

Result and discussions

Weed flora in the experimental field

The weed flora in the experimental plots encompassed weed species namely, *Echinochloa colonanum*, *Echinochloa crus-galli*, *Leptochloa chinensis*, *Cyperus difformis*, *Cyperus iria*, *Cyperus rotundus*, *Bergia capensis*, *Eclipta alba*, *Phyllanthus madraspatensis*, *Sphenoclea zeylanica* and *Marsilea quadrifolia* were occurring in more number and contributed largely for total weed population. This finding is supported by the earlier reports of Kathiresan *et al*. (2019) and Kavitha *et al*. (2019).

Total weed count (no. m^{-2})

The data recorded at 30 and 60 DAT regarding the total weed count are presented in the table 1. All the weed management practices significantly influenced the total weed count. Hand weeding twice (20 and 40 DAT) (T_{13}) significantly recorded the least total weed count 11.94 m^{-2} at 60 DAT. Lower weed count probably due to hand weeding removed the weeds completely at early crop stage resulted in lower count of weeds. The results of the study also corroborate with the findings of Mondal *et al*., (2019). However, it was on par with pyrazosulfuron ethyl 20 g ha^{-1} PE 3 at DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9) and pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}). Early control of weeds by inherent ability of the pyrazosulfuron-ethyl herbicide which inhibits cell division in shoots and roots and growth by inhibiting plant enzyme acetolacto synthase, thereby, blocking branches chain of amino acid biosynthesis, hence the plant suffers and phloem transport of the plant is hampered. Besides, secondary effect is stunted growth on account of cessation of cell division and slow plant death (Kabdal *et al*., 2018). Further, the late emerging weeds were effectively controlled by post emergence application of bispyribac-sodium 25 g a.i ha^{-1} due to its inhibiting character of the plant enzyme acetolacto synthase (ALS), which was involved in biosynthesis of the branched-chain amino acids. Without these amino acids, protein synthesis and growth are inhibited, ultimately causing plant death. The result of the current study are also in agreement with earlier finding of better weed suppression with proper use of both pre and post emergence herbicides in transplanted rice (Saravanane, 2020).

The unweeded control plot (T_{14}) registered higher total weed count of 133.86 m^{-2} at 60 DAT. This might be due to continuous growth of weeds throughout the period of crop cultivation which increased the population of the weeds and this is in accordance with the findings of Bhagavathi *et al*., (2020).

Crop Resistance Index (CRI)

The data on crop resistance index was ascertained and tabluted in table 1. Hand weeding twice (20 and 40 DAT) registered higher crop resistance index of 21.08 per cent. Among the herbicidal treatments, pre emergence application of pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9) registered higher crop resistance index of 10.00 per cent and it was followed by pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}) (9.59 per cent). Effective control of weeds in aforesaid treatments could be assigned to the reason for superior crop resistance index. These results are in close conformity with those of Menon *et al*. (2016). Unweeded control recorded the lowest value of CRI (1.0) indicating highest harmful effect on crop. Similar results have been reported by Rana *et al*., (2019).

Herbicide efficiency index

The data on herbicide efficiency index are furnished in table 1. Among the treatments, maximum herbicide efficiency index of 3.32 per cent was observed under the pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9). This was followed by pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}). A higher herbicide efficiency index value indicated the superiority of the treatment in higher magnitude of weed suppression. These results corroborate the findings of Sarita *et al*., (2021). The lower herbicide efficiency index of 0.62 per cent was registered under butachlor 1.25 kg ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT (T_2).

Effects on yield attributes and yield of rice

Yield attributes like number of productive tillers m^{-2} (340.00) and number of filled grains panicles (90.00) were found higher under hand weeding twice at 20 and 40 DAT which was comparable with pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9) and pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}) (Table 2). This better results of pyrazosulfuron ethyl along with bispyribac sodium may because of its capacity to improve the crop growth by suppressing all type of weeds as a result of which the crop rice received minimum competition from weed and utilize the resources maximum. Similar kind of results by Mondal *et al*. (2017).

Hand weeding (5963 kg ha^{-1}) treatment recorded maximum grain and straw yield of rice. Superiority of two hand weedings might be ascribed to absence of weed competition due to complete removal of weeds from field and hence better crop growth and yield attributes, which directly reflected on high grain and straw yield. However, it was comparable with pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT (T_9) and pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT (T_{12}). This could be possibly due to reduction in weed growth with the herbicide application which allowed the crop to get adequate nutrient supply resulting in higher LAI and thus more production and assimilation of photosynthates contributing to higher grain and straw yields. Similar results have been reported by (Dharumarajan *et al*. 2009 and Mondal *et al*. 2017).

Economics

Among the weed management treatments higher benefit cost ratio of 2.06 was observed with the application of pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} at 20 DAT (T_9). When compared to manual weeding and other herbicidal treatments, this treatment had a greater benefit cost ratio due to higher grain output and a reduced variable cost of cultivation (Hossain and Malik, 2017). Though manual weeding twice outperformed herbicidal treatments in terms of grain output, the rising cost of labour makes this treatment more expensive, and the benefit cost ratio is much lower (1.83).

Conclusion

From the above study, it may be concluded that pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} at 20 DAT can profitability and safely be used to replace the tedious, back breaking, time consuming and expensive hand weeding practice for weed management in transplanted rice.

Table 1. Effect of weed management treatments on total weed count (no.m^{-2}), crop resistance index and herbicide efficiency index of transplanted rice

Treatments	Total weed count (no. m^{-2})	CRI	HEI
T_1- Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	6.00 (35.49)	66.38	90.7
T_2 - Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	7.42 (54.57)	48.31	81.11
T_3 - Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb fenoxaprop- p-ethyl 60 g ha^{-1} PoE at 20 DAT	7.44 (54.86)	48.03	80.00
T_4- Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	6.10 (36.71)	65.23	89.93
T_5 - Pretilachlor 500 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	5.20 (26.55)	74.85	96.92
T_6 - Pretilachlor 500 g ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	7.30 (52.81)	49.97	84.00
T_7- Pretilachlor 500 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1} PoE at 20 DAT	7.36 (53.73)	49.11	82.31
T_8- Pretilachlor 500 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	5.33 (27.96)	73.52	96.57

T_9- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	4.40 (18.89)	82.11	103.9
T_{10} – Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	6.28 (38.91)	63.15	89.67
T_{11}- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1}PoE at 20 DAT	6.46 (41.24)	60.93	88.33
T_{12}- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	4.48 (19.57)	81.46	103.4
T_{13}- Hand weeding twice (20 and 40 DAT)	3.09 (9.08)	91.40	105.68
T_{14}- Unweeded control	10.30 (105.57)	-	72.37
S. Ed	0.29		2.35
C.D (p=0.05)	0.60		4.81

Figures in parentheses are original values and those outside are square root transformed x+0.5 values. Transformed values were statistically analysed; PE : Pre emergence; PoE : Post emergence; fb : followed by; DAT : Days after transplanting

Table 2. Effect of weed management practices on yield attributes, yield and economics of transplanted rice

Treatments	**No. of productive tillers**	**No. of filled grains panicle^{-1}**	**Grain yield**	**Straw yield**	**Benefit cost ratio**
T_1- Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	284.02	75.13	4455	6382	1.57
T_2 - Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	254.00	67.16	3507	5574	1.30
T_3 - Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb fenoxaprop- p-ethyl 60 g ha^{-1}PoE at 20 DAT	253.06	67.00	3528	5563	1.28

T_4- Butachlor 1.25 kg ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	283.97	75.00	4398	6230	1.54
T_5 - Pretilachlor 500 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	310.36	81.91	5306	6895	1.87
T_6 - Pretilachlor 500 g ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	257.43	70.33	3780	5591	1.41
T_7- Pretilachlor 500 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1}PoE at 20 DAT	256.14	68.30	3651	5585	1.34
T_8- Pretilachlor 500 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	310.00	80.86	5254	6890	1.83
T_9- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb bispyribac sodium 25 g ha^{-1} PoE at 20 DAT	337.45	88.91	5847	7410	2.06
T_{10} – Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1} PoE at 20 DAT	283.73	74.89	4387	6180	1.63
T_{11}- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb fenoxaprop-p-ethyl 60 g ha^{-1}PoE at 20 DAT	282.58	73.13	4300	6100	1.56
T_{12}- Pyrazosulfuron ethyl 20 g ha^{-1} PE at 3 DAT fb triafamone + ethoxysulfuron 60 g ha^{-1} PoE at 20 DAT	336.31	88.10	5772	7395	2.03
T_{13}- Hand weeding twice (20 and 40 DAT)	340.00	90.00	5963	7466	1.83
T_{14}- Unweeded control	220.00	52.00	2378	5029	0.95
S. Ed	12.20	2.34	146	246	-
C.D (p=0.05)	25.00	4.79	300	505	-

PE : Pre emergence; PoE : Post emergence; fb : followed by; DAT : Days after transplanting

References:

- Anonymous. 2019. Agricultural statistics division, Department of Economics and Statistics, Department of agriculture and cooperation. New Delhi, India.

- Bhagavathi, S., Baradhan, G., Kumar, S.M., and Arivudainambi, S. 2020. Effect of different crop establishment methods and weed management practices on weed in rice. Plant archives. **20:** (2). 6564 – 6568.
- Das TK. 2013. Weed Science Basics and Applications. Jain Brothers, New Delhi.
- Dharumarajan S, Sankar R and Arun S. 2009. Evaluation of bioefficacy and residues of pretilachlor in transplanted rice. Indian Journal of Weed Science. **41** (1 and 2): 62 -66.
- Gomez, K. and Gomez, A. 1984. Statistical Procedures for Agricultural Research, John and Wiley and Sons. Inc., New York,.
- Hossain A and Malik GC. 2017. Herbicide combinations for control of complex weed flora in transplanted rice in Lateritic belt of West Bengal. Indian Journal of Weed Science**. 49** (3): 276-278.
- Kabdal P, Pratap T, Yadav VR. 2018. Weed Management in Transplanted Rice-A Review. International Journal of Current Microbiology and Applied Science **7** (04): 1660-1669.
- Kathiresan R.M, Vishnudevi, S, Sarathkumar, M, Sudhanshu Singh and Uma S. Sigh. 2019. Role of submergence tolerant rice cultivator and herbicides in managing invasive alien weeds. Indian Journal of Weed Science. **51** (4): 333 – 336.
- Kavitha. R., Thiruppathi, M, Thanunathan. K. 2018. Phytosociological study of weed flora in low land rice ecosystems in Annamalai nagar, Tamil nadu, India. Journal of Plant Stress Physiology. **4** : 45 – 47.
- Menon MV, Bridgit TK and Girija T. 2016. Efficacy of herbicide combinations for weed management in transplanted rice. Journal of Tropical Agriculture, **54** (2): 204-208.
- Ministry of agriculture. 2019. A. Policy Note, Demand No.5 - Agriculture. Government of Tamil Nadu, India.
- Mondal D, Gosh A, Roy D, Kumar A, Shamurailatpam D, Bera S, Ghosh RK, Bandopadhyay P and Majumder A. 2017. Yield losses assessment of rice (*Oryza sativa*) due to different biotic stresses under system of rice intensification (SRI). Journal of Enotology and Zoology Studues. 5 (4): 1974-1980.
- Naik MA, Babu PR, Reddy MS, Kavitha P. 2019. Effect of weed management practices on weed density and yield of transplanted rice. Journal of pharmacognosy and phytochemistry. **8** (4):678-682.

- Priyanka Kadal, Tej Pratap, Vimal Raj Yadav. 2018. Weed management in Transplanted Rice-A Review. International Journal Current Microbiology Applied Science. **7** (4): 1660-1669.
- Rana SS and Kumar S. 2014. Research Techniques In Agronomy. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 64p.
- Rana SS, Gurdeep Singh, M.C. Rana, Neelam Sharma, Sanjay Kumar, Gurpreet Singh and D. Badiyala. 2019. Imapact of imazethapyr and its ready-mix combination with imazamox to control weeds in blakgram. Indian Journal of Weed Science **51** (2): 151-157.
- Saravanane P.2020. Effect of different weed management options on weed flora, rice grain yield and economics in dry direct-seeded rice. Indian Journal of Weed Science. **52** (2): 102-106.