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Research Article

Impact of SSBT and Herbicides on Weed Dynamics, Crop Growth and Yield in Transplanted Rice

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ABSTRACT

The present study entitled Impact of Stale Seedbed and Herbicides on Crop Growth, Yield Attributes and Weed Indices in Transplanted Rice was carried out during the Late samba season (September 2022 - February 2023) at Annamalai University Experimental Farm, Chidambaram, Tamil Nadu, India. The nine treatments comprised different weed management practices viz., Unweeded control (T1), weed-free check(T2), Stale seed bed technique (SSBT) alone (T3), SSBT followed by one hand weeding at 25 DAT (T4), SSBT followed by Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} at 3 DAT (T5), SSBT followed by Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T6), SSBT Followed by 2,4-D sodium salt @ 1560 g ha^{-1} at 35 DAT (T7), Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by hand weeding at 35 DAT (T8), Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} Followed by 2,4-D sodium salt @ 1560 g ha^{-1} at 35 DAT (T9). The results revealed that the treatment SSBT followed by One Hand Weeding at 25 DAT (T4) which was statistically on par with SSBT followed by Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T6) recorded the lower weed biometrics, lower weed index, higher crop growth, yield and weed indices in transplanted rice.

Keywords: *SSBT, Triafamone, ethoxysulfuron, Hand weeding, weed biometrics, Weed indices, Crop growth and yield.*

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important and extensively grown crop in tropical and subtropical regions of the world. It is the staple food for over 70 per cent of the world's population and is extremely important for a country's food and livelihood security.

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Globally, the output of paddy (rice) has increased by more than thrice between 1961 and 2019, from 215 million tonnes to 75 million tonnes, with Asia accounting for most of the growth. More than 80% of the world's rice is produced in seven Asian nations viz., China, India, Indonesia, Bangladesh, Vietnam, Myanmar and Thailand (Rahman & Zhang, 2023). Although the climatic factor and soil type of the Cauvery delta zone of Tamil Nadu, India, is favourable for paddy cultivation throughout the year, rice productivity is still very low compared to other rice-growing countries. The low productivity of rice isdue to various reasons like improper crop establishment methods, water insufficiency, weed infestation, unpredictable monsoon seasons etc. Although transplanting in rice is considered an effective method for higher productivity of rice crops, sometimes it is not very profitable due to the unavailability of labour during peak periods of operation. Weeds are the major biotic constraint to reduce the rice productivity in worldwide. In transplanted rice, about 60 % of the weeds emerge in the period of one week to one month after transplanting. These emerging weeds compete with rice during the effective tillering stage, and the decline in the number of panicles reduces grain yield (though, 2010). In transplanted rice, 45-51% yield reduction caused by weeds (Veeraputhiran & Balasubramanian, 2013). Among them, weeds pose a major threat to rice productivity. Severe weed infestation not only causes yield reduction and also impairs the quality of the produce due to competition for nutrients, moisture, light, and to some extent for space. Weeds are identified as the major biological constraints that hinders the attainment of optimal rice productivity in major rice producing countries of South Asia, such as India (Rao et al., 2015) and Sri Lanka (Weerakoon et al., 2011).

The productivity and profitability of transplanted rice can be increased by adopting better appropriate production technologies like stale seedbed technique and weed management practices. There is a need to integrate with other weed management strategies along with chemical control (Chahal et al., 2015). Senthilkumar et al. (2019) reported that the success of stale seedbed depends on several factors: method of seedbed preparation, method of killing emerged weeds, weed species, duration of the stale seedbed, and environmental conditions (e.g., temperature) during the stale seedbed period. The stale seedbed technique should not be viewed as a stand-alone treatment that maintains weed suppression during the entire cropping cycle and thus may often require it be part of an integrated weed management (IWM) programme. Stale seedbed reduces weed emergence as well as the soil weed seed bank (Rao et al., 2007). This practice is effective for weeds present in the top layers of soil with low initial dormancy and also helps to reduce the problems of hard to control weeds such as Cyperus rotundus L., weedy rice and volunteer rice seedlings (Chauhan, 2012). Application of herbicides along with different weed management practices caused a significant reduction in weed density, weed dry matter, highest weed control efficiency and the lowest weed index, which ultimately resulted in an increase in yield attributes and yield in transplanted rice. Therefore, this study was done to evaluate the effect of herbicide mixture and seedbed preparation methods on weed indices, crop growth and yield in transplanted rice.

MATERIALS AND METHODS

The experiments were conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar, Tamil Nadu. The experimental farm was geographically located at 11^o 24' N latitude and 79^o 44' E longitude and an altitude of +5.79 mabove mean sea level (MSL). During the cropping period, the maximum temperature ranged from 28.2 to 35.4 °C with a mean of 30.7 °C, and the minimum temperature ranged from 17.4 to 26.2 °C with a mean of 21.4 °C. The relative humidity ranged from 68 to 91 per cent with a mean of 79.6 per cent. The soil experimental field is clay loam, low in available nitrogen 228 kg ha^{-1}, medium in available phosphorus 18.9 kg ha^{-1} and high in potassium 295 kg ha^{-1}. The promising rice variety BPT 5204 was chosen for the study. The experiment was laid out in RBD and replicated thrice with nine treatments it including stale seed bed and herbicide combination *viz.*, T_1 - Unweeded control, T_2 - Weed free check, T_3 - Stale seedbed technique (SSBT) alone, T_4 - SSBT followed by One Hand Weeding at 25 DAT, T_5-SSBT followed by Pretilachlor 6.0%+ pyrazosulfuron ethyl 0.15% GR @ 660 g ha^{-1} at 3 DAT, T_6 -SSBT followed by Triafamone 20% + ethoxysulfuron 10% WG @ 220g ha-1 at 8 DAT, T_7 -SSBT Followed by 2,4-D sodium salt @ 1560 g ha^{-1} at 35 DAT, T_8 -Pretilachlor 6.0%+ pyrazosulfuron ethyl 0.15% GR @ 660 g ha^{-1} followed by Hand weeding at 35 DAT, T_9 -Pretilachlor 6.0%+ pyrazosulfuron ethyl 0.15% GR @ 660 g ha^{-1} followed by 2,4-D sodium Salt @ 1560 g ha^{-1} at 35 DAT.

A fertilizer schedule of 150 kg N, 50 kg P_2O_5 and 50 kg K_2O was followed. The entire dose of phosphorous and half dose of nitrogen and potassium were applied as basal. The remaining half the dose of nitrogen and potassium was top dressed in equal splits at the maximum tillering stage and panicle initiation stage. A stale seedbed is based on the principle of flushing out germinal weed seeds before planting the crop, depleting the seed bank in the soil surface layer and reduci n g subsequent weed seedling emergence (Johnson & Mullinix, 2000). The area should be puddled, levelled and irrigated to allow the weeds to germinate. About 7 to 10 days after the rain or irrigation, perform shallow tillage with hoe to kill the weeds. Again, irrigate the field to germinate weeds. About 7 to 10 days after the rain, perform shallow tillage with a rake or hoe to kill the weeds. The area is now ready for planting. Twenty-six days old seedlings were planted @ 2 seedling hill^{-1} with a spacing of 20 cm x 15 cm as per the treatment schedule, hand weeding was done on 25 DAT and 35 DAT.

Herbicide was applied with the help of knapsack sprayer fitted with a flat fan nozzle delivering a spray volume of 500 litres ha^{-1}. The pre-emergence herbicide Pretilachlor 6.0% + pyrazosulfuron ethyl 0.15 % GR @ 660g ha^{-1} on 3 DAT, the early post-emergence Triafamone 20% + ethoxysulfuron 10% WG @ 220g ha^{-1}on 8 DAT and the post-emergence herbicide 2,4-D Sodium salt @1 kg a.i. ha^{-1} was applied on 35 DAT. Five sample plants in each plot were selected at random and peg marked permanently for recording crop biometric observations. The matured crop was harvested from the net plot area, and the grain was hand threshed, winnowed, and sun-dried sufficiently, and the yield was recorded net plot-wise and computed to kg ha^{-1}. The weeds count on 30 DAT and 60 DAT were recorded separately from four quadrants of size 0.5 x 0.5 m fixed permanently in each plot. In order to draw a valid conclusion, the weed count data were subjected to ($\sqrt{X+0.5}$) as suggested by Gomez and Gomez (1984) before statistical analysis.

RESULT AND DISCUSSION

WEED BIOMETRICS

The predominant weed species that were observed in the experimental plot during experimental period. Different weed species, *viz.*, grasses, sedges and broad-leaved weeds, were ascertained in the experimental field. In that, grasses *viz.*, *Echinochloa colonum, Leptochloa chinensis* followed by sedges, *Cyperus rotundus, Cyperus difformis* and broad-leaved weeds, *Bergia capensis*, *Eclipta alba* were in large numbers. At 30 and 60 DAT, total weed count m^{-2} was significantly influenced by various weed management practices. Lower total weed count of 4.53 m^{-2} and 6.56 m^{-2} on 30 and 60 DAT, respectively, were recorded by the treatment with Stale seedbed technique fb Hand weeding (T_4) which was statistically on par with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8

DAT (T_6) with the total weed count of 5.04 and 6.89 m^{-2} at 30 and 60 DAT, respectively. The treatment with Stale seedbed technique fb one hand weeding at 25 DAT (T_4) recorded lower total weed dry matter production of 30.87 kg ha^{-1} and 67.13 kg ha^{-1}, respectively at 30 and 60 DAT which was statistically on par with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T_6) recorded the values of 33.94 kg ha^{-1} and 72.91 kg ha^{-1}. The Unweeded control (T_1) recorded higher total weed count of 59.69 m^{-2} and 72.85 m^{-2} on 30 and 60 DAT, respectively, higher total weed dry matter production of 298.19 kg ha^{-1} and 617.56 kg ha^{-1} during the period of experimentation. The data was presented in table 1.

Stale seedbed technique fb one Hand weeding in the suppression of weed density and reduction of total weed dry weight was due to control of initial weed flushes through stale bed technique and later on by hand weeding (Kumar et al., 2020). The lesser weed count by Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT might be due to complete control of first and second flush of weeds by application of pre and early post emergence herbicide which was due to blocking of their penetration process and inhibition of their further rejuvenation and growth might have resulted in lesser weed density and weed DMP. This was in line with the findings of Mohapatra et al. (2021). The unweeded control plot registered the highest total weed count and maximum DMP at 30 and 60 DAT, respectively. This might be due to continuous growth of weeds throughout the period of crop cultivation which increased the population of the weeds and due to uninterrupted growth of weeds during critical period of crop-weed competition. This was in accordance with findings of Bhagavathi et al. (2020).

CROP GROWTH AND YIELD

Among the different weed management practices, Stale seedbed technique fb one hand weeding at 25 DAT (T_4) was found to be advances in plant height (106.37 cm), number of tillers m^{-2} (425), dry matter accumulation (11991 kg ha^{-1}), grain yield (5529 kg ha^{-1}) and straw yield (7585 kg ha^{-1}) Which was statistically on par with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1}. The treatment stale seedbed technique fb one hand weeding at 25 DAT records the higher growth attributes this was due to decline in weed growth at critical period of crop growth, leads to proper aeration and availability of nutrients for enhanced crop growth. It also could be the results of increased photosynthesis and generally favoured the crop growth. Similar results was reported by Peer et al. (2013). The treatment with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} also produced higher growth attributes. Efficient weed control by Triafamone + ethoxysulfuron provided effective weed control, resulting in a weed-free environment by reducing crop weed competition throughout critical stages of crop growth. This increased crop availability of growth resources led to an increase in internodal length. Reduced crop-weed competition may have improved the environment for rice, leading to an increase in plant height. These results are in conformity with those findings of Uma et al. (2014). Higher dry matter accumulation in this treatment may be the result of efficient use of resources including water, nutrients, light, and space in a conductive crop environment produced by less weed competition. A better crop environment produced by hand weeding later on by lowering crop-weed competition and successful weed control with pesticides in the beginning stages could be the cause of increased tiller production. These findings are in line with Yadav et al. (2019). Increased weed dry matter production and nutrient removal by weeds were the outcomes of unweeded control. Reduced tiller numbers and plant height due to increased weed nutrient removal resulted in the lowest dry matter of crops under unweeded control. This observation was in concomitant with Bhat et al. (2017). The implementation of distinct weed control strategies has a notable impact on grain yield (5529 ka ha^{-1}). Among the various methods for weed control higher grain yield were noticed with Stale seedbed technique fb One hand weeding at 25 DAT which was statistically on par with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT. The enhanced yield with stale seedbed could be due to efficient weed control which leads to significant improvement in accumulation of dry matter and higher number of effective tillers. Similar findings was reported by Shivram et al. (2020). This could result from severe competition among crop and weeds for limited available resources, leading to poor source and sink development with lesser growth and grain yield due to higher density and weed biomass. This is line with the findings of Pooja and Sarvanane (2021).

WEED INDICES

Among the various weed management practices, the treatment Stale seedbed technique fb one hand weeding at 25 DAT (T_4) recorded the higher weed control efficiency values of 92.41 and 91.81 at 30 and 60 DAT, respectively. This was followed by the treatment Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T_6), which recorded 91.56 and 91.40 per cent at 30 and 60 DAT, respectively. Higher weed control index values of 89.65 and 88.46 per cent at 30 and 60 DAT was observed Stale seedbed technique fb one hand weeding at 25 DAT (T_4). This was followed by the treatment Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T_6) was having 88.62 and 88.14 per cent at 30 and 60 DAT, respectively. Weed control efficiency and weed control index indicates the comparative magnitude of reduction in total weed count and weed dry weight respectively by different weed control treatments. This might due to timely control of weeds which led to lower weed count and lower weed dry matter production resulting in higher weed control efficiency and weed control index which may lead to better utilization of resources by the crop plants and resulted in better crop growth over weedy check plots. This was in accordance with findings of Ravikiran et al. (2019) and Phukan and Deka (2021). This treatment was on par with the Stale seedbed technique fb Triafamone 20% + ethoxysulfuron 10% WG @ 220 g ha^{-1} at 8 DAT. This might be due to the fact that the better placement of herbicides on the inter spacing provided and the better effect of herbicide in controlling the emerging weeds let to suppression of weeds from the beginning. The result coincides with the findings of Mathukia et al. (2017) and Mohapatra et al. (2021).

The treatment Stale seedbed technique fb one hand weeding at 25 DAT (T_4) recorded the lower weed index of 4.66 and next best treatment Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T_6) recorded 5.48. The effectiveness of weed control is directly proportional to crop growth performance and inversely proportional to the weed index. Comparing to weed-free plots which showed very negligible yield loss due to the absence of weeds, the large amount of yield loss was found in weedy check plots. This might be due to lower weed count and weed dry matter by effective weed control and reduced crop weed competition favoured the higher uptake of nutrients by crop and thus increased grain yield. These results were similar with the report of Nazir et al. (2022) and Das et al. (2017).

Table1. Effect of weed management practices on total weed count m^{-2} and Weed DMP on 30 and 60 DAT in transplanted rice

Treatments	Total weed count m^{-2}		Weed DMP kg ha^{-1}	
	30 DAT	60 DAT	30 DAT	60 DAT
T_1 - Unweeded control	7.76 (59.69)	8.56 (72.85)	298.19	617.56
T_2 - Weed free check	0.71 (0.0)	0.71 (0.0)	0.00	0.00
T_3 - Stale seedbed technique (SSBT) alone	3.74 (13.46)	4.37 (18.59)	65.78	132.98
T_4 - SSBT followed by One Hand Weeding at 25 DAT	2.24 (4.53)	2.66 (6.56)	30.87	67.13
T_5 - SSBT followed by Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} at 3 DAT	3.05 (8.78)	3.55 (12.12)	50.29	101.91
T_6 - SSBT followed by Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT	2.35 (5.04)	2.72 (6.89)	33.94	72.91
T_7 - SSBT Followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	3.69 (13.12)	4.17 (16.87)	64.01	129.05
T_8 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by Hand weeding at 35 DAT	4.17 (16.85)	4.72 (21.76)	78.91	159.75
T_9 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	4.20 (17.12)	4.80 (22.51)	80.76	163.27
S.Ed	0.12	0.15	6.06	10.84
CD (P=0.05)	0.26	0.32	12.86	22.92

(Figures in parenthesis indicate the original value)

Table2. Effect of weed management practices on crop growth and yield in transplanted rice

Treatments	Plant height at harvest	Number of tillers m^{-2}	DMP at Harvest	Grain yield	Straw yield
T_1 - Unweeded control	78.98	321	7996	3057	5187
T_2 - Weed free check	111.49	438	12669	5799	7933
T_3 - Stale seedbed technique (SSBT) alone	91.83	389	9717	4124	6086
T_4 - SSBT followed by One Hand Weeding at 25 DAT	106.37	425	11991	5529	7585
T_5 - SSBT followed by Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} at 3 DAT	99.34	407	11284	5002	6991
T_6 - SSBT followed by Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT	104.58	419	11894	5481	7531
T_7 - SSBT Followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	93.49	395	10663	4690	6600
T_8 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by Hand weeding at 35 DAT	85.94	372	9717	4124	6086
T_9 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	84.06	368	9375	3964	5902
S.Ed	2.34	5.02	276.89	124	162
CD (P=0.05)	4.96	10.65	587	262	343

Table3. Effect of weed management practices on weed Indices in transplanted rice

Treatments	Weed control efficiency		Weed control index		Weed index
	30 DAT	60 DAT	30 DAT	60 DAT	
T_1 - Unweeded control	-	-	-	-	47.29
T_2 - Weed free check	-	-	-	-	-
T_3 - Stale seedbed technique (SSBT) alone	78.02	78.93	77.94	77.82	22.41
T_4 - SSBT followed by One Hand Weeding at 25 DAT	92.41	91.81	89.65	88.46	4.66
T_5 - SSBT followed by Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} at 3 DAT	85.29	84.87	83.13	83.00	13.75
T_6 - SSBT followed by Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT	91.56	91.40	88.62	88.14	5.48
T_7 - SSBT Followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	77.45	76.79	78.53	78.48	19.13
T_8 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by Hand weeding at 35 DAT	71.77	72.83	73.54	73.36	28.89
T_9 - Pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 660 g ha^{-1} followed by 2,4-D Sodium salt @ 1560 g ha^{-1} at 35 DAT	71.32	71.89	72.92	72.77	31.64

CONCLUSION

Based on the results of the present study, it can be concluded that efficient weed control in transplanted rice could be achieved by the Stale seedbed technique fb one hand weeding at 25 DAT (T_4) which was statistically on par with Stale seedbed technique fb Triafamone 20 % + ethoxysulfuron 10 % WG @ 220 g ha^{-1} at 8 DAT (T_6). It effectively reduced the infestation of weeds in the experimental field and favoured the yield attributes by reducing the weed biometrics and increased the weed indices of rice. Hence this practice will be recommended to the rice growers to get higher economic returns.

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Conflict of Interest

The authors disclose no conflicts of interest related to the publications of this paper.

Authors Contribution

The first author Ramya karri, conducted the overall research and prepared the manuscript. The second author, Balasubramanian, supervised the research. The third and fourth authors, R. Gobi and S. Sathiyamurthy, guided during the field experiment.

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