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Studies on Efficacy and Economics of Herbicide Mixture in Wet Direct -Seeded Rice (*Oryza sativa* L.)

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ABSTRACT: Rice is one of the most important cereal crops grown all over in India. But day by day the growing population has become a challenge which is decreasing the agricultural land and water supplies. Since direct sowing is a convenient process as it requires less water during cropping. But in direct seeded rice, weeds are a serious issue since they thrive all season long and reduce output by roughly 35% when compared to weed-free conditions. Weed management is always been a crucial task for the farmers. But proper weed management helps in better weed control as well as good absorption and translocation of nutrients by plants with less competition. Herbicide use is currently the most popular method for weed infestation control among all available methods since it is seen as the most dependable, simple, time and money-saving solution. But most of the herbicides used in wet seeded rice are selective and weed specific, and thus control only a small portion of the diverse weed flora. Several new pre-mix herbicide products having broad spectrum activity are now available in the markets which could exclude the labour of tank mixing as well as the possibility of non-compatibility. The current study was conducted in *kharif* season in rice during 2022 at Post Graduate Research Farm, M.S. Swaminathan School of Agriculture. The experiment was laid out in randomized block design with 8 treatments and 3 replications. The treatments consisted of Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12-14 DAS (T_1), Fenoxaprop-p-ethyle + Ethoxysulfuran (50+15 g a.i. ha^{-1}) at 17-18 DAS (T_2), Metsulfuran-methyl + chlorimuron-ethyl Bispyribac-sodium (4+25) g a.i. ha^{-1} (T_3), Bispyribac-Na + Ethoxysulfuran (25+15g a.i.ha^{-1}) at 10-12 DAS (T_4), Preticlachlor + Bensulfuran-methyle (660g a.i.ha^{-1}) at 4-5 DAS (T_5), Bispyribac-Na (30g a.i. ha^{-1}) at 8-10 DAS (T_6), weed free (HW at 20, 40 and 60 DAS) (T_7) and Weedy check (T_8). The results revealed that the maximum growth, yield and weed parameter was significantly higher with the application of pre – emergent mixed herbicide Triafamone + Ethoxysulfuran (67.5 g a.i.ha^{-1}) at 12 -14 DAS to achieve the higher growth and to decrease the weed density through which it helped in high productivity of rice. Therefore, the application of this treatment might be beneficial to the farmers under southern Odisha condition.

Keywords: Herbicide mixture, Weed free, Weedy check, Yield.

INTRODUCTION

For the past 5000 years, rice has been grown for agricultural purposes. With a yield of 2576 kg/ha and an annual production of 117.94 Mt, rice is cultivated on 43.86 million ha in India (DAC&FW, 2019-20). Despite having a low productivity (1739 kg a.i. ha^{-1}), Odisha is one of the top producing states for rice in India in terms of acreage (3.77 million hectares) and production (6.55 million tonnes). According to Odisha agricultural data 2017-18, the rice crop is planted on 37.55 thousand hectares in the Gajapati district, with a production of 33.15 thousand Mt and a productivity of 883 kg a.i.ha^{-1}. The majority of today's high yielding rice varieties are thermo sensitive, and the microenvironment has a significant impact on the length of their growth periods and their phenological phases (Verma *et al.*, 2022).

Despite being a key crop, rice cultivation in India faces a variety of challenges, such as low yield due to outdated farming practices, water constraint, climate change, pest infestations, and the impact of weeds. It is exceedingly difficult to control the weeds that are common in rice fields, especially in direct seeded rice, and their numbers can only be decreased by using a single pre- or post-emergence herbicide. According to Mohapatra *et al.* (2020) in Odisha's wet seeded rice regions, there were 22% grasses, 40% sedges, and 32% broad-leaved weeds in the weed spectrum. Where weeds were not controlled throughout the season, the weed losses resulting from weed competition in direct seeded rice could reach 100%. So, herbicides must be used heavily in wet seeded rice cultivation to suppress weeds, either by increasing the frequency of post-emergence spraying or by applying these chemicals in

succession (Sheeja and Syriac 2018). Therefore, in order to increase rice yield under direct sowing condition it is crucial to find a new method of applying herbicides that will stop the evolution of weeds with resistant biotypes. In order to solve this issue, a recently developed technique called the application of herbicide mixtures with various modes of action can be used because it is labor- and cost-efficient and can control a wide range of weeds with a small amount of herbicide when compared to using a single herbicide to reduce weed flora in rice (Satpathy *et al.*, 2017).

However, the chemical strategy is the most effective and efficient way to control weeds in terms of cost, time, labour, and efficacy. Herbicide combinations can be used to control weeds that have become resistant to a single herbicide.

MATERIALS AND METHODS

The field experiment was conducted at Post Graduate Experimental Farm, M.S. Swaminathan School of Agriculture, Gajapati district, Odisha (18° 48′16″N latitude, 84° 10′48″E longitude and at 64m altitude above mean sea level) during *kharif* season of 2022. The sowing of experimental crop was done on July, 2022 and harvested on November, 2022. The weekly minimum and maximum temperature during that crop growth period ranged between 29.43°C and 33.71°C with a weekly relative humidity ranging from 90% to 92.57%, respectively. The soil of the experimental field was sandy clay loam in texture having sandy loam soil. The experiment was laid out in randomized block design (RBD) with eight treatments. The treatments were in combination of different herbicide mixtures of Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12-14 DAS (T_1), Fenoxaprop-p-ethyle + Ethoxysulfuran (50+15 g a.i. ha^{-1}) at 17-18 DAS (T_2), Metsulfuran-methyl + chlorimuron-ethyl Bispyribac-sodium (4+25) g a.i. ha^{-1} (T_3), Bispyribac-Na + Ethoxysulfuran (25+15g a.i.ha^{-1}) at 10-12 DAS (T_4), Preticlachlor + Bensulfuran-methyle (660g a.i.ha^{-1}) at 4-5 DAS (T_5), Bispyribac-Na (30g a.i. ha^{-1}) at 8-10 DAS (T_6), weed free (HW at 20, 40 and 60 DAS) (T_7) and Weedy check (T_8). The rice variety Naveen was sown in 20 cm x 10 cm spacing with seed rate of 80 kg/ha and all the recommended agronomic practices were practiced for successful raising of crop. The recommended fertilizer dose of 80:40:40 kg/ha N:P_2O_5:K_2O and the sources of fertilizers were Urea(N), SSP(P), MOP(K). The data were analysed statistically by following the standard ANOVA techniques and the difference between the treatment means was tested as for their statistical significance with appropriate critical difference (CD) values at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

A. Effect of herbicide mixtures on the growth parameters

The plant growth parameters were varied significantly with the application of different herbicide mixtures. At harvest, the maximum plant height was recorded in the weed free plot. Whereas, the minimum plant height was reported in weedy check plot. Similar trend has been found to be followed in dry matter accumulation (g a.i. m^{-2}), number of tillers per m^2.

The weed free plot recorded the highest growth parameter which might be attributed to the fact that because of lower weed population, crop-weed competition was less and as a result all the growth parameters increased due to good availability of space, water, sunlight, air and nutrient uptake. Whereas due to no weed management weed competition was highest in weedy check plot which affected the nutrient availability to the plant and resulted in lowest growth parameters. Similar opinion was forwarded by Tejaswini *et al.* (2020); Prasath *et al*. (2022); Kuotsu and Singh (2020).

B. Effect of herbicide mixtures on the yield attributes

Yield attributes namely number effective of tillers $meter^{-2}$, number of panicle $meter^{-2}$, 1000 grain weight were influenced significantly with the application of different herbicide mixture. The maximum yield attributes were obtained in the weed free plot and the minimum yield attributes were recorded in the weedy check plot.

The highest number of yield attributes may be attributed to the fact that in weed free plot plants got wider spacing due to less weed population as well as more nutrients, sunshine, water due to less crop-weed competition and it ultimately provided the plant more energy to increase all the yield attributing characters whereas in weedy check plot provision of energy was less to the plants because of more crop-weed competition. These results were corroborated with the findings of by Kumar *et al.* (2018); Jaswal and Singh (2019).

C. Effect of herbicide mixtures on the yield

Yield parameters include grain yield, straw yield, biological yield. Herbicide mixture had a great influence on the yield parameters. Weed free plot had recorded the maximum value at every aspect of yield *viz.*, grain yield, straw yield as well as biological yield.

Yield is the function of all the growth parameters. In weed free condition due to less crop-weed competition and less weed density, the dry matter accumulation as well as number of tillers per m^2 was highest which resulted in higher yield parameters. Whereas in weedy check plot due to more weed density crop suffered from crop-weed competition and it ultimately reduced photosynthesis and translocation of carbohydrate from source to sink. Similar results were observed by Berhan *et al.* (2021); Kumar *et al.* (2018); Prasath *et al*. (2022).

D. Effect of herbicide mixtures on the weed parameters

Weed control efficiency was found to be significantly higher in the weed free plot. Whereas, in weedy check plot it was least. But in case of weed index, maximum value was obtained in the weedy check plot. But it was minimum in the weed free plot. Similar findings were recorded by Kumar *et al.* (2018); Dhillon and Bhullar (2016).

Table 1: Effect of herbicide mixtures on growth parameters of direct seeded rice in *kharif*.

Notations	Treatments	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12 -14 DAS	16.7	40.8	68.8	96.9
T_2	Fenoxaprop - p - ethyl + Ethoxysulfuran (50+15 g a.i. ha^{-1}) at 17-18 DAS	15.8	38.7	64.1	93.4
T_3	Metsulfuron - methyl + Chlorimuron-ethyl Bispyribac –Sodium (4+25) g a.i. ha^{-1} 12-15 DAS	13.9	34.3	58.8	82.0
T_4	Bispyribac - Na + Ethoxysulfuran (25+15 g a.i. ha^{-1}) at 10-12 DAS	16.4	39.5	66.3	94.5
T_5	Pretilachlor + Bensulfuron-methyl (660 g a.i. ha^{-1}) at 4-5 DAS	14.0	34.7	59.4	84.6
T_6	Bispribac - Na (30g a.i. ha^{-1}) at 8-10 DAS	13.1	32.7	55.7	79.9
T_7	Weed free (HW at 20,40 and 60 DAS)	18.4	44.7	79.2	105.9
T_8	Weedy check	8.9	23.7	36.4	51.2
	S.Em. (±)	0.50	1.29	1.80	3.35
	CD (5%)	1.51	3.87	5.38	10.04

Table 2: Effect of herbicide mixtures on yield attributes of direct seeded rice in *kharif*.

Notations	Treatments	Effective No. of tillers m^{-2}	No. of panicles m^{-2}	No. of grainspanicles^{-1}	Test weight
T_1	Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12 -14 DAS	173	258	94	24.0
T_2	Fenoxaprop - p - ethyl + Ethoxysulfuran (50+15 g a.i. ha^{-1}) at 17-18 DAS	168	234	90	21.3
T_3	Metsulfuron - methyl + Chlorimuron-ethyl Bispyribac –Sodium (4+25) g a.i. ha^{-1} 12-15 DAS	153	201	77	20.1
T_4	Bispyribac - Na + Ethoxysulfuran (25+15 g a.i. ha^{-1}) at 10-12 DAS	169	243	91	22.1
T_5	Pretilachlor + Bensulfuron-methyl (660 g a.i. ha^{-1}) at 4-5 DAS	159	203	81	21.1
T_6	Bispribac - Na (30g a.i. ha^{-1}) at 8-10 DAS	151	194	74	19.5
T_7	Weed free (HW at 20,40 and 60 DAS)	196	285	108	25.1
T_8	Weedy check	55	139	51	19.2
	S.Em. (±)	6	8	2	0.8
	CD (5%)	19	26	8	2.6

Table 3: Effect of herbicide mixtures on yield of direct seeded rice in *kharif*.

Notations	Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12 - 14 DAS	5034	7966	13000	38.7
T_2	Fenoxaprop- p-ethyl + Ethoxysulfuran(50+15 g a.i. ha^{-1}) at 17-18 DAS	4764	7861	12625	37.9
T_3	Metsulfuron - methyl + Chlorimuron-ethyl Bispyribac–Na (4+25) g a.i. ha^{-1}) 112-15DAS	4247	7324	11571	36.7
T_4	Bispyribac - Na + Ethoxysulfuran (25+15 g a.i. ha^{-1}) at 10-12 DAS	4872	7920	12792	38.3
T_5	Pretilachlor + Bensulfuron-methyl (660 g a.i. ha^{-1}) at 4-5 DAS	4330	7590	11920	36.2
T_6	Bispribac - Na (30g a.i. ha^{-1}) at 8-10 DAS	4180	7315	11495	36.7
T_7	Weed free (HW at 20,40 and 60 DAS)	5275	7973	13248	40.4
T_8	Weedy check	2117	7110	9227	27.0
	S.Em. (±)	149	79	167	1.22
	CD (5%)	447	237	502	3.67

Table 4: Effect of herbicide mixtures on weed parameters of direct seeded rice in *kharif*.

Notations	Treatments	WCE at 60 DAS	Weed index
T_1	Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12 -14 DAS	86.8	4.6
T_2	Fenoxaprop - p - ethyl + Ethoxysulfuran (50+15 g a.i. ha^{-1}) at 17-18 DAS	81.3	9.7
T_3	Metsulfuron - methyl + Chlorimuron-ethyl Bispyribac –Sodium (4+25) a.i.g ha^{-1} 12-15 DAS	67.3	19.5
T_4	Bispyribac - Na + Ethoxysulfuran (25+15 g a.i. ha^{-1}) at 10-12 DAS	82.6	7.6
T_5	Pretilachlor + Bensulfuron-methyl (660 g a.i. ha^{-1}) at 4-5 DAS	69.9	17.9
T_6	Bispribac - Na (30g a.i. ha^{-1}) at 8-10 DAS	65.0	20.8
T_7	Weed free (HW at 20,40 and 60 DAS)	99.9	0.0
T_8	Weedy check	0.0	59.9
	S.Em. (±)	----	-----
	CD (5%)	----	-----

CONCLUSIONS

On the basis of experimental findings, it can be concluded that application of Triafamone + Ethoxysulfuran (67.5 g a.i. ha^{-1}) at 12-14 DAS and following with manual weeding at recommended timings helps in achieving maximum growth in plant. Besides, it increases the weed control efficiency through which it has achieved the higher yield.

FUTURE SCOPE

The implementation of manual weeding and herbicide mixture in weed management practices has the potential to exhibit the positive and favourable effects on enhancing overall growth of WDSR. Such comprehensive strategies not only enhance weed control efficiency but also contribute for optimizing crop growth, yield, and economic returns indirect seeded rice cultivation.

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Conflict of Interest. None.

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