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Evaluation of some new herbicides formulations alone and in combination with hand weeding in lowland rice

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Abstract
A field investigation was conducted during Samba season of 2017 to evaluate the efficacy of pre and post emergence herbicides in transplanted rice in Cuddalore. The new herbicides evaluated were Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} along with post emergence herbicides Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. Results of the study revealed that Pre-emergence herbicide application of Pretilachlor + Pyrazosulfuron-ethyl followed by post emergence herbicide application of Bispyribac-sodium recorded lower weed total population, higher growth parameters, grain yield (5163 kg ha^{-1}) and straw yield (7654 kg ha^{-1}) followed by Pretilachlor + Pyrazosulfuron-ethyl + Fenoxaprop-p-ethyl.

Keywords: Herbicides, weed management, transplanted rice

Introduction
In India rice was grown in an area of 433.88 l. ha with a production of 104.32 m. t and the productivity was 2.4 t. ha-^{1} (Annual report, 2016-17) [1]. To meet the future food requirements of ever increasing population and maintain self sufficiency, the estimated rice production in India should be 350 m. t by 2020 AD (Veeraputhitan and R. Balasubramanian, 2013) [11]. Transplanted rice is infested with wide range of weed species viz., grasses, sedges and broad leaved weeds. The major weed species in annamalai nagar are the broad leaved weeds like *Marsilia quadrifolia L., Bergia capensis, Sphenoclea zeylanica, Eclipta alba*, the grasses viz., *Echinochloa colona, Leptochloa chinensis, Cyanotis axillaries*, and sedges like *Cyperus rotundus and Cyperus iria* (Murugan.G and Kathiresan. Rm, 2010) [5].
Weed management is one of the major factors, which affect rice yield. Uncontrolled weeds may cause yield loss ranging from 50 to 90 per cent under transplanted conditions (Singh *et al.* 2016) [10]. Therefore, an efficient and economic weed management program is necessary to control different types of weeds throughout the cropping period.
Hand weeding though efficient is expensive, time consuming, difficult and often limited by scarcity of labour in time. On the other hand, herbicides offer economic and efficient weed control if applied at proper dose and stage. However, the continuous use of single herbicide or herbicides having the same mode of action may lead to the weed resistance problem and also weed shifts. Hence it is necessary to test some high efficacy herbicides to control mixed weed flora in transplanted rice. Keeping this in view, a field experiment was carried out to evaluate the performance of pre- and post-emergence herbicides alone and in combination in transplanted rice.

Materials and Methods
The field experiment was conducted at experimental farm, Annamalai University, Chidambaram, Tamilnadu, located at 11º24' N latitude and 79º44' E longitude and an altitude of +5.79 m above MSL. The soil of the experimental field is clayey loam in texture. The soil pH was 7.3 and EC was normal (0.37 dS m-^{1} which is safe limit), high in organic carbon and available P, medium in available N and K. The field experiment was conducted during Samba season (September-January, 2017) by transplanting rice seedling of variety 'ADT -49' in Randomised Block Design with three replications. The treatments included different pre-emergent herbicides applied alone, and their combinations with either post emergent herbicides or hand weeding. The new low dose herbicides used were Pretilachlor + Pyrazosulfuron-ethyl, Fenoxaprop-p-ethyl and + Bispyribac-sodium.

The Treatments were Un weeded check, Two hand weeding (20 and 40 DAT), Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} + one hand weeding, Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1} + one hand weeding, Bispyribac-sodium 10% SC @ 200 ml ha^{-1} + one hand weeding, Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} + Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1}, Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} + Bispyribac-sodium 10% SC @ 200 ml ha^{-1}. All herbicides were applied using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 l. ha^{-1}. Thirty days old seedlings of rice variety '*ADT 49*' were transplanted at a spacing of 20x10 cm. Half of the nitrogen and whole of phosphate and potash were applied at the time of final puddling and the remaining quantity of nitrogen was applied at panicle initiation stage.

A quadrat of size 50 x 50 cm was placed at random at two sites in the weed sampling area of each plot for weed observations. Ten sample plants were selected at random from the net plot area (avoiding two border rows) of each plot and tagged for recording crop observations. The data recorded at periodic intervals were subjected to Analysis of Variance techniques (ANOVA) after transformation wherever needed. Results of the study revealed substantial reduction in weed population in all the herbicide treated plots compared to weedy check (Table 1). Treatments receiving pre and post-emergence application of Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} + Bispyribac-sodium 10% SC @ 200 ml ha^{-1}recorded higher absolute density of weeds than Pretilachlor 6% + Pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} + Fenoxaprop-p-ethyl 9.3% w/w @ 875 ml ha^{-1} treated plots. Though no visual symptoms of phytotoxicity were observed in Bispyribac-sodium treated plots, its unfavourable effect on seed germination reduced the crop density.

Results and Discussion

Total weed population m^{-2}

All the weed control measures caused significant reduction in the population of all the weeds over weedy check. Weed population was highly influenced by differential application of herbicides, their combinations and integrations with manual weeding. Significantly lowest total weed population of 12.19 was recorded in treatment *i.e.,* Pretilachlor + Pyrazosulfuron-ethyl + Bispyribac-sodium, followed by Pretilachlor + Pyrazosulfuron-ethyl+ Fenoxaprop-p-ethyl (26.85) and the treatment twice hand weeding on 20 and 40 DAT (28.67) were on par. The highest total weed population of 129.40 on 60 DAT was recorded in un weeded control (Table 1). Similar trend has also been observed by Mubeen *et al*. (2014) [4] and Prashanthi *et al.* (2017) [7].

This might be due to the fact that the better placement of pre emergence herbicide on the inter row spacing provided and the better efficacy of herbicide in controlling the emerging weeds let to suppression of weeds from the beginning. The persistence of pretilachlor + pyrazosulfuron ethyl herbicides could have contributed significantly in controlling weeds because pretilachlor with a half life of 15.06 days and pyrazosulfuron ethyl with 24.75 days (Nagwanshi Anil *et. al.,* 2016) [6]. This might have delivered the weed control effect on the germinating weed seeds over a prolonged duration and thereby exhausting the weed seeds over a prolonged duration and thereby exhausting the weed seed reserves in the soil (Reddy *et al*., 2000) [9].

Application of pretilachlor + pyrazosulfuron ethyl drastically reduced the grasses, sedges and broad leaved weeds. The presence of pyrazosulfuron ethyl drastically reduced the grasses, sedges and broad leaved weeds. The presence of pyrazosulfuron ethyl controlled the broad leaved weeds and sedges and the presence of pretilachlor controlled the grassy weeds. Hence the combined action of both the above and efficient control of bispyribac sodium on annual and perennial grasses, sedges and broad leaved weeds attributed for efficient and prolonged control of wide spectrum weeds viz., grasses, sedges and broad leaved weeds. These are in line with the findings of Yadav *et al.,* 2009 [12].

Growth parameters

The data recorded on growth parameters are presented in the table 1. There was significant difference between treatments with regard to growth parameters. Among the treatments, (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac-sodium (T_7) recorded highest number of growth parameters viz., plant height of 75.57, leaf area index of 5.3, number of tillers m^{-2} of 434 and crop dry matter production of 11420 kg ha^{-1}. The treatment (Pretilachlor + Pyrazosulfuron ethyl) + Fenoxaprop-p-ethyl (T_6) was next in order and the treatment twice hand weeding on 20 and 40 DAT (T_2) were on par. The lowest growth parameters were recorded in unweeded control (T_1).

Pre-emergence herbicide application of Pretilachlor + Pyrazosulfuron-ethyl followed by post emergence herbicide application of Bispyribac-sodium produced more number of growth attributes and yield than un weeded control. The reason might be that the weed was putting forth a heavy competition especially for nutrients and moisture occurred during the active growth phase of rice where in most part of the key physiological functions like nutrient uptake, active cell division, growth and reduction division occur. Efficient and better control of weeds from the beginning and throught active growth phase thereby offering perfect and prolonged weed free environment and consequently enhanced the nutrient uptake by rice that have imparted better assimilatory to the crop and increased growth characters viz., plant height, number of tillers clump-1, LAI and crop dry matter production results by virtue of longer persistence and higher activity of pretilachlor+ pyrazosulfuron and bispyribac-sodium in the above said treatments Rajveer Singh Yadav *et al*. (2017) [8].

Grain and straw yield

All treatments significantly altered the grain yield. Among the treatments, T_7 recorded highest grain yield of 5163 kg ha^{-1}. The treatment T_6 was next in order and the treatment T_2 were on par. The lowest grain yield of 3046 kg ha^{-1} was recorded in T_1. As that of grain yield of rice, straw yield was also significantly influenced by various treatments. Among the treatments, T_7 recorded highest straw yield of 7654 kg ha^{-1}. The treatment T_6 was next in order and the treatment T_2 were on par. The least straw yield of 4600 kg ha^{-1} was recorded in T_1.

Pre-emergence herbicide application of Pretilachlor + Pyrazosulfuron-ethyl followed by post emergence herbicide application of Bispyribac-sodium produced more number of yield attributes and yield than un weeded control. The reason might be that the weed free situation at early stage favoured the vigorous growth of seeding, without any crop weed competition and sustained nutrient availability leads to better uptake of NPK by the crop might have contributed to synchoronous tillering and spikelet formation leading to higher mumber of panicles m^{-2} and higher post flowering photosynthesis and higher number of filled grains $panicle^{-1}$. It is logic to postulate that the resulting in increased grain and straw yields. Hence, the yield level of grain and straw fell in line with treatments that performed well in the earlier days (Jitendra Kumar *et. al*., 2012 and Leghari *et. al*., 2016) [2, 3].

Table 1: Effect of weed management practices on Total weed population and growth parameters of rice

Treatments	Total weed population m^{-2}	Plant height (cm)	LAI	No of tillers m^{-2}	DMP (kg ha^{-1})
T_1 - Un weeded control	11.40 (129.40)	61.23	3.37	323	6723
T_2 - HW twice on 20 and 40 DAT	5.40 (28.67)	72.06	4.67	409	10632
T_3 - (Pretilachlor + Pyrazosulfuron ethyl) + one HW	6.67 (44.04)	67.89	4.31	383	9856
T_4 - Fenoxaprop-p-ethyl + one HW	7.44 (54.90)	64.35	3.89	345	9315
T_5 - Bispyribac-sodium + one HW	6.57 (42.67)	68.53	4.37	389	10064
T_6 - (Pretilachlor + Pyrazosulfuron ethyl) + Fenoxaprop-p-ethyl	5.23 (26.85)	72.23	4.79	416	10886
T_7 - (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac-sodium	3.56 (12.19)	75.57	5.35	434	11420
S.Ed	0.12	1.26	0.09	7.18	190.64
CD (P = 0.05)	0.26	2.75	0.19	15.63	409.20

Table 2: Effect of weed management practices on Yield of rice

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 - Un weeded control	3046	4600
T_2 - HW twice on 20 and 40 DAT	4787	7150
T_3- (Pretilachlor + Pyrazosulfuron ethyl) + one HW	4437	6653
T_4 - Fenoxaprop-p-ethyl + one HW	4236	6303
T_5 - Bispyribac-sodium + one HW	4590	6850
T_6 - (Pretilachlor + Pyrazosulfuron ethyl) + Fenoxaprop-p-ethyl	4965	7366
T_7 - (Pretilachlor + Pyrazosulfuron ethyl) + Bispyribac-sodium	5163	7654
S.Ed	85.99	127.99
CD (P = 0.05)	187.38	278.89

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