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Efficacy of bensulfuron methyl plus pretilachlor against complex weed flora in transplanted *kharif* rice (*Oryza sativa* L.)

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Abstract
The improved practice with pre emergence application of bensulfuron methyl at 60g /ha + Pretilachlor at 600 g/ha at 3 DAT recorded weed dry weight (7.27, 19.69, 27.47 g m^{-2}) and the weed control efficiency (73.13, 33.61 & 43.92 %) at 30, 60 & 90 DAT respectively, which were higher than farmers practices of one hand weeding. The improved technology also produced grain yield (48.63 q ha^{-1}) which was 19.7% higher than local check with harvest index, Effectivity of tillers, spikelet fertility 46.5, 79.4 and 92.7 % respectively. The same also recorded higher gross return of Rs. 77024.98 ha^{-1} with a benefit cost ratio of 1.90 and additional net return of Rs.11321.08 ha^{-1} as compared to local check. Thus, pre-emergence application of bensulfuron methyl 60g /ha + pretilachlor 600 g/ha at 3 DAT was very effective in reducing the weed biomass in transplanting rice with higher grain yield and net realization.

Keywords: bensulfuron methyl, pre-emergence herbicide, pretilachlor, transplanted rice, weed density, yield

1. Introduction
Rice (*Oryza sativa* L.) is the predominant crop of Odisha with a total coverage of 4.0 million hectare which is about 65 % of the total cultivable area of the state. Area under rice crop in Angul district of the state is 0.08 million hectare with a productivity of 9.89 q ha^{-1} which is 48.8 % less than that of state (Samant, 2016) [4]. In India rice is grown over 42.4 million ha area with the production of 104.4 million tons and a productivity of 2.46 tons ha^{-1}. The average yield of rice in India is low due to several constraints. Among them weeds pose a major threat for increasing productivity. Uncontrolled weed growth caused 33-45% reduction in grain yield of rice. The weed flora of rice under transplanted condition is very much diverse and consists of sedges, grasses and broad leaf weeds causing yield reduction up to 76 percent. Herbicides like Pretilachlor applied alone are more effective against grasses, but less effective against sedges. While bensulfuron methyl is found more effective against sedges than other weeds (Masthana Reddy *et al*. 2012) [2]. Any delay in weeding will lead to increased weed biomass which has a negative correlation with yield. Hand weeding is the traditional weed control measure in rice cultivation practices. However, due to high labour cost, non-availability of labour and time taken for manual removal, farmers are forced to decide for cheaper alternative of chemical weed control. New herbicides are now coming in the market and the use of herbicides of different chemical composition is desirable to reduce the problem of residue buildup, shift in weed flora and development of herbicide resistance in weeds. Therefore, there is a necessity that these herbicides are supplemented with hand weeding to widen weed control spectrum (Sathyapriya *et al*. 2017) [5]. The present study was under taken to evaluate the efficacy of bensulfuron methyl plus pretilachlor against complex weed flora in transplanted *kharif* rice.

2. Materials and Methods
The study was carried out through front line demonstration during *kharif* season of 2016 in *Banuasahi v*illage of Angul district in Odisha (20^0 50' 26" N, 84^0 56' 27" E and an altitude of 195 m on farmers field with an objective to evaluate the efficacy of bensulfuron methyl plus pretilachlor against complex weed flora in transplanted *kharif* rice. The soil of the study area was sandy loam in texture with slightly acidic in reaction (pH-5.1 -5.8), medium organic carbon content (0.52-0.64 %), medium in available nitrogen (266-292 kg ha^{-1}), low in phosphorus (9.4-12.2 kg ha^{-1}) and medium in potassium (185-204 kg ha^{-1}) content. Ten different farmers each having 0.1 hectare of land cultivated the HYV rice *cv*. Pooja with recommended package of practices. They were supplied with herbicide (Bensulfuron methyl at 60g /ha + Pretilachlor at 600 g/ha) for application at 3 DAT. Besides farmers practice of one hand weeding at 40 DAT was selected as local check. A weedy check plot was selected for comparison of weed control efficiencies. Rice variety (*Pooja*) was transplanted during 2nd week of July and harvested during 3rd week of November. The required quantities of herbicide were broadcasted 10 kg per hectare. Need based plant protection measures were taken up. Weed counts per m^{-2} was sampled randomly at ten places with the help of one square meter quadrates at 30, 60 & 90 DAT and weed dry weight per m^{-2} were recorded. The weed control efficiency was worked out through following formula:

$$WCE = \frac{(DWC - DWT)}{DWC} \times 100$$

Where: DWC = Dry weight of weeds under control plot; DWT = Dry weight of weeds under treated plot.
Observations on different yield parameters were taken and

economic analysis was done by calculating cost of cultivation, gross return, net return and B:C ratio. Final crop yield (grain & straw) were recorded and the gross return were calculated on the basis of prevailing market price of the produce. Harvest index is the relationship between economic yield and biological yield (Gardener *et al*. 1985) [1].
It was calculated by using the Following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Tabular analysis involving simple statistical tools like mean was done by standard formula to analyze the data and draw conclusions and implications.

Details of Technology
Bensulfuron methyl 0.6% + Pretilachlor 6% GR) herbicide, is a pre-emergent herbicide for weed control in rice. It contains Bensulfuron methyl as an active ingredient and pretilachlor. It provides effective solution for weed control in rice by inhibiting the growth of the most important perennial, annual species of weeds namely *Echinochloa crusgalli*, *Echinochloa colonum* in grasses, *Cyperus iria*, *Cyperus difformis*, *Cyperus rotundus*, *Fimbristylis miliacea* in sedges, and *Ludwigia palviflora*, *Marsilea quadrifolia*, *Sphenoclea zeylancia*, *Eclipta alba*, *Ammania baccifera* in broad leaf weeds. The herbicide is highly selective to most varieties of Indian rice. It exhibits safety margins of 5-30 folds at recommended use rates. It gives farmers an additional benefit of easy hand dispersal in the rice puddle and enables them to protect their crop.

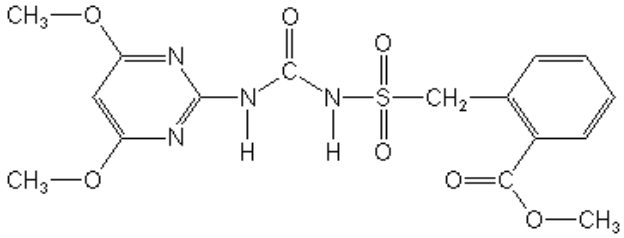

Fig 1: Bensulfuron methyl ($C_{16}H_{18}N_4O_7S$)

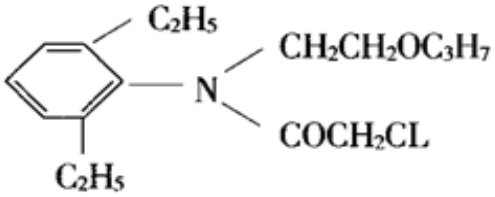

Fig 2: Pretilachlor (2-chloro-N -2', 6' -diethyl-N(2-propoxy ethyl)aceta nilide)

3. Results and Discussion
3.1. Weed flora
The weed flora of the study area (Table 1) was dominated by *Digitaria sanguinalis*, *Cynodon dactylon* among the grasses; *Ageratum conyzoides*, *Cleome viscose* among broad leaf weeds and *Cyperus rotundus* among the sedges. At 90 DAT grasses, broadleaved and sedges on an average constituted 36.5, 54.2 and 9.3 per cent of total weed population respectively. The results showed that the population of grassy weeds (13.5 to 47.2 m^{-2}), broad leaved weed (19.2 to 67.4 m^{-2}) and sedges (3.4 to 11.6 m^{-2}).

Table 1: Effect of herbicide on complex weed flora m^{-2} at 90 DAT

Sl. No.	Weed species	Bensulfuron plus pretilachlor	Hand weeding	Weedy check
	Grasses			
1	*Cynodon dactdylon*	3.5	6.7	10.6
2	*Digitaria sanguinalis*	5.3	9.4	20.8
3	*Panicum repense*	2.4	1.2	7.6
4	*Echinochloa glabrescens*	2.3	2.8	8.2
	Total monocot	13.5	20.1	47.2
	Broad leaved weed			
1	*Ageratum conyzoides*	6.4	12.6	23.4
2	*Cleome viscosa*	8.3	13.2	28.2
3	*Xanthium strumarium*	4.5	7.4	15.8
	Total dicot	19.2	33.2	67.4
	Sedges			
	Cyperus difformis	3.4	5.6	11.6
	Grand total	36.1	58.9	126.2

3.2. Weed infestation
3.2.1. Weed density
Pre-emergence application of bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT recorded better weed control than hand weeding with weed density 13.8, 24.7 and 36.1 m^{-2} at 30, 60 and 90 DAT respectively (Table 2). This was due to application of herbicide which might have prevented the germination of susceptible weed *spp* and also reduced the growth of germinated weeds by inhibiting the process of photosynthesis (Musik, 1970) [3]. Weedy check recorded the maximum weed density 71.2, 101.5 and 126.2 m^{-2} at 30, 60 and 90 DAT respectively.

Table 2: Effect of herbicide on weed control at different growth stages of transplanted rice

Practices	Weed density m^{-2}			Dry weed biomass (g m^{-2})			Weed control efficiency (%)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Bensulfuron plus pretilachlor	13.8	24.7	36.1	7.27	19.69	27.47	73.13	33.61	43.92
Hand weeding	21.7	33.1	58.9	9.59	23.93	34.54	64.55	45.37	29.49
Weedy check	71.2	101.5	126.2	27.07	36.05	48.98	-	-	-

3.2.2. Weed dry weight and Weed control efficiency

The lowest weed dry weight was recorded with application of bensulfuron methyl 60g /ha + pretilachlor 600 g/ha at 3 DAT with 7.27, 19.69 and 27.47 g m^{-2} at 30, 60 and 90 DAT respectively might be due to effective control of weeds during early stages of crop growth by herbicide (Table 2). Weedy check produced the maximum weed dry weight at all the crop growth stages (27.07 to 48.98 g m^{-2}) because of higher weed intensity and its dominance in utilizing the sunlight, nutrients, moisture *etc*. Similar observation was also recorded by Singh *et al* (2007) [6].

The weed control efficiency was higher with application of bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT than hand weeding which varies from 73.13% at 30 DAT to 43.92% at 90 DAT. This might be due to effect of weed during initial stages of crop growth with herbicide application. Singh (2012) [7] also reported similar results.

3.3. Effect on crop

3.3.1. Growth attributes and yield parameters

Results of front line demonstration indicated that the improved technology of application with bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT recorded maximum plant height(101.7 cm), tillers $plant^{-1}$(13.1), effective tillers $plant^{-1}$ (10.4), effectivity of tillers (79.4%) than hand weeding. The same also produced higher panicle length (22.6 cm), grains $panicle^{-1}$(102.6), filled spikelets $panicle^{-1}$) with spikelet fertility (92.7). The weedy check recorded the lowest growth and yield parameters. Yadav *et al* (2008) [9] also recorded similar results showing the effectiveness of herbicide for improving the yield attributing characters of rice with respect to the recommended herbicide.

3.3.2. Yield

Pre-emergence application of bensulfuron methyl 60g /ha + Pretilachlor 600 g/ha at 3 DAT produced grain yield 48.63 q ha^{-1} which is 14.3 % higher as compared to the farmers practices of one hand weeding(Table 4). This might be due to the production of higher growth and yield parameters owing to effective control of weeds in early stage which was in conformity with Earlier Reddy mastana *et al* (2012) [3] reported better performance of bensulfuron methyl plus pretilachlor combination in controlling weeds and increasing yield in transplanted rice.

The improved practices also produced the higher straw yield (55.41 q ha^{-1}) with harvest index (46.74%) as compared to hand weeding. Weedy check recorded the least grain yield, straw yield and harvest index.

Table 3: Effect of herbicide on growth attributes and yield parameters of transplanted rice

Practices	Plant height (cm)	Tillers $plant^{-1}$	Effective $plant^{-1}$	Effectivity of tillers (%)	Length of panicle	No of grains $panicle^{-1}$	No of filled spikelets $panicle^{-1}$	Spikelet fertility (%)
Bensulfuron plus pretilachlor	101.7	13.1	10.4	79.4	22.6	102.6	95.1	92.7
Hand weeding	95.5	11.5	8.7	75.7	22.1	97.5	88.2	90.5
Weedy check	89.2	8.2	5.8	70.7	21.3	95.7	73.1	76.4

Table 4: Effect of herbicide on yield of transplanted rice

Practices	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Harvest index (%)
Bensulfuron plus pretilachlor	48.63	55.41	46.74
Hand weeding	42.56	52.52	44.76
Weedy check	31.26	41.57	42.92

3.4 Economics

The improved practice of pre-emergence application of bensulfuron methyl 60g /ha + pretilachlor 600 g/ha at 3 DAT recorded the higher gross return of Rs.77024.98 ha^{-1} with additional net return of Rs. 11321.08 ha^{-1} over farmers practice (Table 5). Higher B:C ratio(1.90) was found in improved technology due to higher net return and saving of weeding cost Rs.2111.6 ha^{-1} as compared to farmers practice. The weedy check showed the lowest net return this was due to higher yield with use of herbicide in the early growth stage. These finding are similar with the findings of Teja *et al* (2015) [8].

Table 5: Effect of herbicide on economics of transplanted rice

Practices	Additional cost of input (Herbicide + Labour) (Rs ha^{-1})	Additional Net return (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Bensulfuron plus pretilachlor	2890.2	24025.58	40641.3	77024.98	36383.68	1.90
Hand weeding	5001.8	12704.5	42752.9	67815.5	25062.6	1.59
Weedy check	-	-	37751.1	50109.2	12358.1	1.33

*Sale price of paddy seed Rs.1470 $q^{-1}$and paddy straw Rs.100q^{-1} for the year 2016

4. Conclusion

The study clearly indicated that the pre-emergence application of bensulfuron methyl 60g /ha + pretilachlor 600 g/ha at 3 DAT was very effective in reducing the weed biomass in transplanting rice with higher grain yield and net realization.

5. Acknowledgement

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