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Effect of sequential application of herbicides on nutrient uptake and economics of rice cultivation

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Abstract
A field experiment was conducted during *Kharif* season 2016 at Zonal Agricultural and Horticultural Research Station, Mudigere to study the effect of sequential application of herbicides on nutrient uptake and economics of rice cultivation. The herbicides tested were two pre-emergent herbicides *viz.* Butachlor 50 EC, Bensulfuron methyl 0.6 + Pretilachlor 6 GR, five new post emergent herbicides *viz.* Bispyricbac sodium 10 SC, Metsulfuron methyl 20 WP, Ethoxysulfuron 15 WDG, Chlorimuron ethyl+Metsulfuron methyl 20 WP and old herbicide 2. 4 D Sodium salt 80. In addition to weed free up to 45 DAT and weedy check also included to make comparison. The experiment design was laid out in RCBD with ten treatments and three replication. Among sequential application of herbicidal treatments significantly maximum nutrients uptake by crop was recorded by Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT(88.95, 15.60 and 93.93 kg N, P and K ha^{-1}, respectively) which is on par with nutrient uptake by the crop was recorded under weed free up to 45 DAT (97.25, 18.26 and 102.89 kg N, P and K ha^{-1}, respectively) followed by Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb hand weeding at 15 and 30 DAT (93.54, 16.58 and 97.63 kg N, P and K ha^{-1}, respectively). Weedy check recorded higher nutrients (N, P and K) removal by weeds (14.46, 4.41 and 8.37 kg ha^{-1}, respectively). The maximum gross returns were obtained by weed free up to 45 DAT (Rs. 82374 ha^{-1}) followed by Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb hand weeding at 15 and 30 DAT (Rs. 79404 ha^{-1}) and Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (Rs. 74758 ha^{-1}) and lower gross returns were obtained in weedy check (Rs. 39217 ha^{-1}). Higher B:C ratio recorded in sequential application of Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (1.91) among the treatments.

Keywords: Pre and post emergent herbicides, nutrient uptake, Economics

Introduction
India occupies a pride place in rice production, among the food crops cultivated in the world. India has the largest area (43.95 m ha) among rice growing countries and stands second in production (106.54 m t) with a productivity of 2424 kg ha^{-1}. In Karnataka, it is grown in an area of 1.33 m ha with an annual production of 3.76 m t and a productivity of 2828 kg ha^{-1} (Anon, 2015). Rice production is facing various constraints including a declining rate of growth in yield, depletion of natural resources, labour shortages, gender based conflicts, institutional limitations and environmental pollution. Among several factors responsible for low rice production, weeds are the major ones which cause reduction in yield of rice production worldwide. Losses caused by weeds vary from one country to another, depending on the predominant weed flora and on the control methods practiced by farmers. Labour component in agriculture is becoming scarce, not available in time and High labour wages. The farmers experience difficulty in managing weeds, as the available labour force is migrating to urban areas. Use of herbicides to manage weeds forms an excellent alternative to manual weeding to reduce the human dredgery. Usage of pre-emergence herbicides assumes greater importance in the view of their effectiveness from initial stages. As the weeds interfere during the harvesting of the crop, post emergence herbicides at about 20-35 DAT may help in avoiding the problem of weeds at later stages.

Material and Methods
A field experiment was conducted during Kharif 2016 at Zonal Agricultural and Horticultural Research Station, Mudigere. Experiment involves 10 treatments includes two pre-emergent herbicides Butachlor 50 EC and Bensulfuron methyl 0.6% G @ 60 g a.i. ha^{-1} + Pretilachlor 6% G @ 600 g a.i. ha^{-1}, applied alone as pre-emergent at 3 DAT and six post emergent herbicides 2. 4 D Sodium salt 80, Fenoxyprop p ethyl 9.3 EC, Bispyribac sodium 10 SC @ 20g a.i. ha^{-1}, Metsulfuron methyl 20 WP @ 5 g ha^{-1}, Chlorimuron ethyl+Metsulfuron methyl 20 WP @ 8 g ha^{-1} and Ethoxysulfuron 15 WG @ 18.75g a.i. ha^{-1}.

Post emergent herbicide applied as alone and each were preceded by pre emergent herbicides which were compared with weed free up to 45 DAT and weedy check which was laid out under randomized block design with three replication. The data on weed population and dry matter were recorded at 30, 60, 90 DAT and at harvest with quadrate measuring 50 × 50 cm and expressed number/0.25 m^2 and g/0.25 m^2, respectively.

Plant and weed analysis: The randomly selected five plants of rice and weeds from each net plot were oven dried and used for chemical analysis after dry grinding. Nitrogen content was determined by digesting the plant samples with concentrated sulphuric acid and digestion mixture (100 parts of K_2SO_4, 20 parts of $CuSO_4$ and one part of Se powder). The digested samples were distilled by microkjeldhal method in an alkaline condition and titrated against standard acid (Hcl) (Piper, 1966) [5]. Phosphorus and potassium contents were determined after the samples were digested with diacid mixture (Nitric acid + per chloric acid 10:4 ratio).
Phosphorus content was determined by Vanadomolybdo phosphoric acid yellow colour method and observation N was recorded at 430 nm using Spectrophotometer (Piper, 1966) [5]. Potassium content was determined from the same diacid digested extract by using Digital Flame Photometer (Piper, 1966) [5]. The uptake of nitrogen, phosphorus and potassium by rice crop at harvest was computed by using the following formula.

$$\text{Nutrient uptake (kg } ha^{-1}) = \frac{\text{Nutrient content (\%)}}{100} \times \text{Dry weight (kg } ha^{-1})$$

Cost of cultivation: For computing the cost of cultivation, different variable cost items were considered. The cost includes expenditure on seed, organic manures, chemical fertilizers, plant protection chemicals and labour charges at prevailing market prices during 2016. Labour requirement was worked out on the basis of laborers engaged for performing different field operations**.**

Returns: Utility of adopting different practices was computed by using the following data.

Gross Returns: Total value of the produce (both grain and straw).

Net Returns: Gross returns - Cost of cultivation.

Benefit Cost Ratio: The benefit cost ratio was worked out by using the following formula.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns}(\text{Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

Treatment details: Details of treatments and the corresponding symbols used during the study are as follows.

T_1: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT followed by (fb) hand weeding at 15 and 30 DAT
T_2: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb 2. 4 D Sodium salt 80 @ 2.5 kg ha^{-1} at 21 DAT
T_3: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Fenoxyprop p ethyl 9.3 EC 1250 ml ha^{-1} at 21 DAT
T_4: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT
T_5: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Metsulfuron methyl 20 WP @ 5 g ha^{-1} at 21 DAT
T_6: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Ethoxysulfuron 15 WDG @ 15 g ha^{-1} at 21 DAT
T_7: Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Chlorimuron ethyl+Metsulfuron methyl 20 WP @ 8 g ha^{-1} at 21 DAT
T_8: Bensulfuron methyl0.6 + Pretilachlor 6 GR @ 12.5 kg a.i ha^{-1}fbFenoxyprop p ethyl 9.3 EC @ 1250 ml ha^{-1} at 21 DAT
T_9: Weedy check
T_{10}: Weed free check up to 45 DAT (Hand weeding)

Note: DAT- Days after transplanting
a.i- active ingredient

Table 1: Effect of weed control treatments on nutrient uptake by crop and weeds

	Nutrient removal by weeds (kg ha^{-1})			Nutrient uptake by crop (kg ha^{-1})		
Treatment	**Nitrogen**	**Phosphorus**	**Potassium**	**Nitrogen**	**Phosphorus**	**Potassium**
T_1	4.26	0.85	1.71	93.54	16.58	97.63
T_2	9.98	2.14	4.47	71.84	10.47	80.02
T_3	11.35	2.60	5.02	67.63	9.30	76.10
T_4	4.60	0.98	1.94	88.95	15.60	93.93
T_5	8.86	1.74	3.18	72.61	11.50	82.53
T_6	7.33	1.52	2.86	79.85	12.54	84.76
T_7	6.22	1.40	2.68	84.01	13.54	87.39
T_8	5.80	1.28	2.46	86.66	14.58	90.43
T_9	14.46	4.41	8.37	46.05	5.35	62.17
T_{10}	3.93	0.50	1.08	97.25	18.26	102.89
S.Em±	0.55	0.18	0.27	2.87	0.36	1.75
C.D. at 5%	1.65	0.54	0.81	8.61	1.08	5.25

Table 2: Economics of transplanted rice as influenced by herbicides application

Treatment	Total cost of cultivation (Rs. ha^{-1})	Cost of weed control (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C Ratio
T_1	44038	9125	79404	33616	1.80
T_2	38738	3825	59322	20584	1.53
T_3	38038	3125	56555	18517	1.48
T_4	39038	4125	74758	35720	1.91
T_5	37388	2475	63837	26449	1.70
T_6	37624	2711	64276	26652	1.71

T_7	37538	2625	65937	25602	1.75
T_8	39444	4531	68964	26636	1.74
T_9	34913	0.00	39217	4304	1.12
T_{10}	45163	10250	82374	32246	1.82

Results and Discussion

The predominant weed flora observed in the experimental field was *Panicum tripheron, Panicum repens, Echinochloa colonum* among grasses, *Cyperus difformis, Cyperus procerus, Euriocolon sp*. are among the sedges and *Monocoriavaginalis, Ammania baccifera* and *Marselia quadrifolia* and *Ludwigia parviflora* among the broadleaved weeds. Similar weed species under transplanted rice were also reported by Purushotam Singh *et al.* (2007) [6] and Singh Mandhata and Singh (2010) [7].

Nutrient uptake by weeds (kg ha^{-1}): The data pertaining to the influence of different herbicide treatments on nutrient removal (N, P and K) by weeds at harvest is presented in Table-1.

The nutrient removal by weeds was significantly influenced by different weed control treatments. Among herbicidal treatments significantly lower nutrient removal by weeds recorded under sequential application of Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (4.60, 0.98 and 1.94 kg N, P and K ha^{-1}, respectively) followed by Bensulfuron methyl0.6 + Pretilachlor 6 GR @ 12.5 kg a.i ha^{-1}fbFenoxyprop p ethyl 9.3 EC @ 1250 ml ha^{-1} at 21 DAT (5.80, 1.28 and 2.46 kg N, P and K ha^{-1}, respectively) which were on par with each other. Whereas, weedy check recorded significantly higher nutrient removal by weeds (14.46, 4.41 and 8.37 kg N, P and K ha^{-1}, respectively) since there was severe weed infestation. The nutrient removal by weeds is directly related to weed population and dry matter of weeds and inversely related to rice grain yield. Similarly increase in nutrient uptake by increase in weed competition also reported by Mallikarjun *et al*. (2014) [4] and Kumaran *et al*. (2015) [3].

Nutrient uptake by crop: Higher nutrient uptake by the crop was recorded under weed free up to 45 DAT (97.25, 18.26 and 102.89 kg N, P and K ha^{-1}, respectively) followed by Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb hand weeding at 15 and 30 DAT (93.54, 16.58 and 97.63 kg N, P and K ha^{-1}, respectively) which were on par with Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (88.95, 15.60 and 93.93 kg N, P and K ha^{-1}, respectively). This is due to better weed control efficiency as evidenced by lower weed population and weed dry weight which helped the crop to grow better and absorb more nutrients from the soil. While, nutrient removal by crop was significantly lower in weedy check due to severe weed competition which resulted in poor grain and straw yields. These results are in line with Kaliq *et al*. (2012) [2], Mallikarjun *et al.* (2014) [4] and Uma *et al.* (2016) [9].

Economics of weed control treatments: The data pertaining to the influence of different herbicide treatments on economics of rice cultivation are presented in Table-2.

Among the treatments higher net returns was obtained with sequential application of Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (Rs. 35720 ha^{-1}) followed by Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb hand weeding at 15 and 30 DAT (Rs. 33,616 ha^{-1}) and weed free up to 45 DAT (Rs. 32,246 ha^{-1}). The increase in net returns in this treatments was due to higher grain and straw yield as a result of better control of weeds. Net return was lower in weedy check (Rs. 4304 ha^{-1}) due to low grain and straw yield caused by reduced crop growth and yield components as a consequence of more weed competition.

The total cost of cultivation was high for weed free up to 45 DAT (Rs. 45163 ha^{-1}) and Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb hand weeding at 15 and 30 DAT (Rs. 44038 ha^{-1})because of more labour requirement for weeding and high cost of labour. But the profit per rupee spent on weed control was lower than T_4. These results are in line with the findings of Mallikarjun *et al.* (2014) [4] and Sreedevi *et al*. [8] However, among the treatments the profit per rupee spent was lower in weedy check (1.12). This was mainly due less crop yield and higher cost of cultivation incurred under this treatment. The profit per rupee spent on cultivation is highest in sequential applied Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT (1.91) due to higher grain and straw yield and lower cost of cultivation compared to other herbicidal treatments.

Conclusion

The results of the present investigation indicated that among the herbicides tested, sequential application of applied Butachlor 50 EC @ 1.25 kg a.i ha^{-1} at 3 DAT fb Bispyribac sodium 10 SC @ 20 g a.i ha^{-1} at 21 DAT and Bensulfuron methyl0.6 + Pretilachlor 6 GR @ 12.5 kg a.i ha^{-1}fbFenoxyprop p ethyl 9.3 EC @ 1250 ml ha^{-1} at 21 DAT resulted in higher grain yield, net return and B: C ratio besides giving broad spectrum of weed control.

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