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Productivity of direct seeded rice in response to various weed management practices and their residual effect on green gram

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Abstract

Field experiment was conducted during 2015-16 and 2016-17 at Agricultural College farm, Bapatla, Guntur, Andhra Pradesh to study the efficacy of sequential application of herbicides in direct sown rice-green gram cropping system. The experiment was laid out in randomized block design with three replications. Though weed free treatment (T_{13}) resulted in higher gross returns during both the years of study (Rs. 114376 and Rs. 124482 ha^{-1} during 2015-16 and 2016-17, respectively) the net returns and return per rupee investment were markedly higher under pre-emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} followed by post-emergence application of azimsulfuron @ 20 g a.i. ha^{-1} at 25 DAS andpost-emergence application of metsulfuron methyl and chlorimuron ethyl @ 4 g a.i. ha^{-1} applied at 45 DAS (T_9) during both the years.

Key words: Direct sown rice, post emergence, herbicides, pre emergence, weed management

Introduction

The rice-pulse cropping system is one of the most important agricultural production systems in the Krishna zone of Andhra Pradesh owing to its large acreage and production (Singh *et al*., 2017) of Rice-pulse cropping sequence is practically feasible, economic, eco-friendly, water saving technology for sustaining soil fertility and rice productivity. The productivity of rice-green gram system is decreasing due to emergence of multi-nutrient deficiencies, building up of soil pathogens and weed flora.

Weeds are major limiting factor in crop production (Buhler, 1992), causing maximum losses amongst crop pests. They reduce the crop yield and deteriorate the quality of produce and hence reduce the market value of the turn out (Arif *et al*., 2006). Weeds compete for available moisture and nutrients, space and light with crop plants, which result in yield reduction (Khan *et al*., 2004). If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80 per cent (Karlen *et al*., 2002). Appropriate weed management is considered one of the most important prerequisites in direct sown rice systems to ensure high crop yield. Chemical weed management is the most prominent method to manage weeds in direct sown rice because of its selectivity, cost effectiveness and more labour- and time-saving than other weed management practices (Mazid *et al*., 2003). The use of herbicides in rice for controlling weeds has increased significantly over the last several years (FAO, 2002). Since direct sown rice has complex and diverse weed species, no single herbicide will control all weed species. Therefore, a combination of herbicides applied in sequence is needed for effective control of sedges, broadleaves, and grasses. (Maity and Mukherjee, 2008). Several herbicides, with pre emergence activity, such as oxadiazon and oxadiargyl, have some limitations *viz*., limited window of application timing and an adequate soil moisture requirement at the time of their application (Singh *et al*., 2006). If optimum conditions are not available, post emergence herbicides may be a better option to manage weeds in direct sown rice systems (Mahajan and Chauhan, 2013). In view of this, the present experiment was conducted to study the system productivity and economics of rice-green gram cropping system as influenced by sequential application herbicides in direct sown rice

Materials and Methods

A field experiment was conducted during *Kharif* 2015 and 2016 at the Agricultural College Farm, Bapatla, Guntur, Andhra Pradesh. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction (pH 8.0 and 7.5), low in organic carbon (0.45 and 0.48%), low in available nitrogen (212 and 230 kg ha^{-1}), medium in available phosphorus (17 and 18 kg ha^{-1}) and medium in available potassium (261 and 285 kg ha^{-1}). There were fourteen treatments, as given here under.

Treatments	Dose (g ha^{-1})	Time (DAS)
$T_{1.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron	25 *fb* 20	Pre *fb* Post
$T_{2.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium	25 *fb* 25	Pre *fb* Post
$T_{3.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron	60 + 500 *fb* 20	Pre *fb* Post
$T_{4.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium	60 + 500 *fb* 25	Pre *fb* Post
$T_{5.}$ Oxadiargyl *fb* Azimsulfuron	75 *fb* 20	Pre *fb* Post
$T_{6.}$ Oxadiargyl *fb* Bispyribac-sodium	75 *fb* 25	Pre *fb* Post
$T_{7.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post
$T_{8.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post
$T_{9.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post
$T_{10.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post
$T_{11.}$ Oxadiargyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post
$T_{12.}$ Oxadiargyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post
$T_{13.}$ Weed free	-	-
$T_{14.}$ Weedy check	-	-

Note: Weed free condition maintained by employing manual weeding at regular intervals; *fb* – followed by

Pre and post emergence herbicides were sprayed using a knapsack sprayer fitted with a flat-fan nozzle at a spray volume of 500 l ha^{-1}. A seed rate of 50 kg ha^{-1} was adopted. Seeds were weighed separately for each plot and sown in solid rows in the furrows opened by line markers at 25 cm interval in both the years. Recommended dose of fertilizer (120:60:60 kg NPK ha^{-1}) was applied uniformly, entire dose of phosphorous and potassium was applied as basal dose before last ploughing and nitrogen in three equal splits at basal, active tillering and panicle initiation stages. Irrigation comprised of alternate drying and wetting followed by intermittent irrigation at seven days' interval up to 15 days before harvest. Other agronomic and plant protection measures were adopted as recommended during the crop growth. Grain yield was recorded from net plot and converted to grain yield per hectare.

Gross Returns (₹ ha^{-1})

The gross returns were calculated by considering the grain and straw yield asc well as prices of rice and green gram, prevailing in the local market.

Net Returns (₹ ha^{-1})

The net returns ha^{-1} was calculated by deducting the cost of cultivation from the gross returns ha^{-1}.

Net return (₹) = Gross income ha^{-1} (₹) - Cost of cultivation ha^{-1} (₹)

Returns per Rupee Investment (B:C Ratio)

The returns we get from each one rupee invested in the cultivation of rice and greengram was calculated as follows:

Net Returns/ Cost of Cultivation

Rice Equivalent Yiled of green gram:

Rice equivalent yield of green gram was calculated by multiplying the economic yield of green gram with the price kg^{-1} of green gram and divided by price of rice kg^{-1} in the local market by making use of the following formula as stated by Munda *et al.* (2008).

$$\text{Rice equivalent yield} = \frac{\text{Yield of green gram (kg)} \times \text{Price of green gram kg}^{-1}}{\text{Price of rice kg}^{-1}}$$

Cost of herbicides, fertilizers, rice and green gram seed and labour wages during 2015-16 and 2016-17

Herbicide	**Cost (Rs. ha^{-1})**	**Fertilizers**	**Cost (Rs. ha^{-1})**	**Output price (2015-16)**	
Pyrazosulfuron ethyl:	560	Nitrogen through Urea:	1482	Rice grain (Rs. 14.5 kg^{-1})	Green gram grain (Rs. 48.5. kg^{-1})
bensulfuron methyl + pretilachlor:	2425	Potassium through MOP:	773	Rice straw (Rs. 1.0 kg^{-1})	Green gram haulm (Rs. 0.5 kg^{-1})
Oxadiargyl:	819	Phosphorus through SSP:	3075	Output price (2016-17)	
Azimosulfuron:	1691	Total fertilizer cost :	5330	Rice grain (Rs. 15.1 kg^{-1})	Green gram grain (Rs. 52.3. kg^{-1})
Bispyribac-sodium:	2350	Labour wages :	300 d^{-1}	Rice straw (Rs. 1.0 kg^{-1})	Green gram haulm (Rs. 0.5 kg^{-1})
metasulfuron methyl and chlorimuron ethyl:	3800				

Results and Discussion

Total dry matter production of cropping system as a whole as influenced by weed management practices

Biological production potential of the rice-green gram cropping system as indicated by the total day matter production was significantly influenced by green gram crop in the cropping system as well as different weed management practices in rice (**Table 1**).

For the purpose of evaluating production potential of the cropping system, the total biomass produced was computed by adding the dry matter accrual of individual crop in the respective season. Among the different weed management practices imposed on rice, the treatment weed free (T_{13}) registered the highest dry matter production (13793 and 16847 kg ha^{-1}), which was comparable with the treatments T_9 and T_{10} but was superior to the treatments T_3, T_{14}, T_1, T_2, T_5, T_6 and T_{14}. Weedy check (T_{14}) resulted in the lowest dry matter accumulation of rice-green gram sequence.

Better performance of rice-green gram system under the influence of treatment T_{13} (weed free) was mainly due to higher dry matter accrual of both rice and green gram crops in the system. In the present study the first crop rice followed by green gram in the sequence resulted in elevating the biomass yield of the system. These findings conform to the report of Reddy *et al.* (2017).

Grain yield of rice (kg ha^{-1})

The highest grain yield (5284 and 5455 kg ha^{-1} during 2015-16 and 2016-17, respectively) was recorded under weed free treatment (T_{13}), which was significantly superior to rest of the treatments except treatment T_9, which was comparable to the treatments T_{10}, T_7, T_{11} and T_8. The lowest grain yield (2159 and 2529 kg ha^{-1}) was obtained in untreated i.e. weedy check (T_{14}) plot, significantly lower than any herbicidal treatment. Appropriate weed management in direct sown rice resulted in lower weed density and weed dry matter and higher dry matter accumulation and nutrient uptake by the crop. These results are in agreement with the findings of Yadav *et. al*. (2009), Singh *et. al*. (2010), Naseeruddin and Subramanyam (2013), Hossain and Mondal (2014), Rammu Lodhi, (2016), and and Ajay Singh *et al.* (2017).

Seed yield of green gram (kg ha^{-1})

The seed yield of succeeding green gram crop after rice was non-significant among the treatments during both the years of study (**Table 2**). This indicates that there was no marked difference among the treatments and the impact of herbicides applied to rice. The applied herbicides which sufficiently got degraded in the soil had no residual effect on the dry matter, number of pods as well as seed and haulm yields of green gram. This indicated that different weed management practices applied to rice had no adverse or favourable effect on growth and yield of succeeding green gram crop. Similar results were also reported by Kumaran *et al.* (2015) that herbicides applied to rice crop had no residual effect on succeeding crops growth and yields.

System Productivity

Economic yield of system productivity comprising rice-green gram presented as rice grain equivalent yield was not distinctly effected by green gram crop in the cropping system as well as weed management practices to rice during both the years of study (**Table 3**). Various weed management practices to rice in rice-green gram sequence exerted profound influence on the economic yield of the system as a whole. Among the weed management practices weed free (T_{13}) realized the highest economic yield in terms of rice grain equivalent in rice-green gram sequence studied, which was however comparable with treatments T_9 and T_{10}. Weedy check to rice crop has resulted in the lowest economic yield of the system during both the years of study.

For the purpose of judging the economic yield potential of rice-green gram system, the yields of green gram were converted into grain equivalent of rice and to this, the rice yield obtained in *kharif* season in respective treatments was added. Weed free (T_{13})

Table 1. Total dry matter production (kg ha^{-1}) and Grain yield (kg ha^{-1}) of rice-green gram sequence as influenced by weed management practices during *kharif* 2015-16 and 2016-17

Treatments	Dose (g ha^{-1})	Time (DAS)	Total dry matter production		Grain yield (kg ha^{-1})			
					Rice		Green gram	
			2015-16	2016-17	2015	2016	2015	2016
T_1 Pyrazosulfuron ethyl *fb* Azimsulfuron	25 *fb** 20	Pre *fb* Post	11407	12010	3844	3619	548	632
T_2 Pyrazosulfuron ethyl *fb* Bispyribac-sodium	25 *fb* 25	Pre *fb* Post	11057	12225	3604	3521	532	624
T_3 Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron	60 + 500 *fb* 20	Pre *fb* Post	12016	13652	4118	4203	556	652
T_4 Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium	60 + 500 *fb* 25	Pre *fb* Post	11071	13685	3674	3923	548	548
T_5 Oxadiargyl *fb* Azimsulfuron	75 *fb* 20	Pre *fb* Post	11062	11976	3593	3423	537	625
T_6 Oxadiargyl *fb* Bispyribac-sodium	75 *fb* 25	Pre *fb* Post	10587	11709	3302	3261	529	617
T_7 Pyrazosulfuron ethyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	13591	14863	4714	4687	559	652
T_8 Pyrazosulfuron ethyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	12960	14609	4599	4661	537	655
T_9 Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	13764	15833	5107	5313	571	662
T_{10} Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	13365	15618	4828	5014	565	656
T_{11} Oxadiargyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	13020	14308	4666	4601	530	649
T_{12} Oxadiargyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	12670	14549	4371	4437	534	642
T_{13} Weed free	-	-	14166	16247	5450	5455	585	662
T_{14} Weedy check	-	-	7971	8802	2159	2529	523	594
SEm ±	-	-	565	490	233	298	19	31
CD (P = 0.05)	-	-	1641	1424	678	865	NS	NS

fb – followed by

Table 2. System Productivity (kg ha^{-1}) of rice-green gram sequence as influenced by different weed management practices in rice-green gram sequence during 2015-16 and 2016-17 *kharif* and *rabi* seasons

Treatments	Dose (g ha^{-1})	Time (DAS)	2015-16			2016-17		
			Rice grain yield (kg ha^{-1})	Rice grain equivalent yield (kg ha^{-1})	System productivity (kg ha^{-1})	Rice grain yield (kg ha^{-1})	Rice grain equivalent yield (kg ha^{-1})	System productivity (kg ha^{-1})
$T_{1.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron	25 *fb** 20	Pre *fb* Post	3844	1821	5664	3619	2188	5806
$T_{2.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium	25 *fb* 25	Pre *fb* Post	3604	1767	5371	3521	2158	5679
$T_{3.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron	60 + 500 *fb* 20	Pre *fb* Post	4118	1848	5966	4203	2255	6458
$T_{4.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium	60 + 500 *fb* 25	Pre *fb* Post	3674	1820	5494	3923	1896	5819
$T_{5.}$ Oxadiargyl *fb* Azimsulfuron	75 *fb* 20	Pre *fb* Post	3593	1783	5376	3423	2163	5585
$T_{6.}$ Oxadiargyl *fb* Bispyribac-sodium	75 *fb* 25	Pre *fb* Post	3302	1757	5059	3261	2136	5397
$T_{7.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	4714	1857	6571	4687	2257	6944
$T_{8.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	4599	1785	6384	4661	2268	6929
$T_{9.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	5107	1897	7005	5313	2291	7604
$T_{10.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	4828	1877	6706	5014	2271	7284
$T_{11.}$ Oxadiargyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	4666	1762	6428	4601	2247	6849
$T_{12.}$ Oxadiargyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	4371	1773	6145	4437	2222	6658
$T_{13.}$ Weed free	-	-	5450	1942	7392	5455	2289	7744
$T_{14.}$ Weedy check	-	-	2159	1738	3896	2529	2056	4585

****fb* – followed by***

Table 3. Economics of rice-green gram sequence as influenced by different weed management practices during 2015-16 and 2016-17 *kharif* and *rabi* seasons

Treatments	Dose (g ha^{-1})	Time (DAS)	2015-16			2016-17		
			Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C Ratio	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Return per rupee investment
$T_{1.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron	25 *fb** 20	Pre *fb* Post	88138	38206	1.42	93095	40913	1.58
$T_{2.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium	25 *fb* 25	Pre *fb* Post	83704	33114	1.23	91480	38640	1.49
$T_{3.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron	60 + 500 *fb* 20	Pre *fb* Post	92673	40877	1.47	103790	49743	1.81
$T_{4.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium	60 + 500 *fb* 25	Pre *fb* Post	85495	33040	1.21	94512	39807	1.38
$T_{5.}$ Oxadiargyl *fb* Azimsulfuron	75 *fb* 20	Pre *fb* Post	83702	33511	1.26	90014	37573	1.47
$T_{6.}$ Oxadiargyl *fb* Bispyribac-sodium	75 *fb* 25	Pre *fb* Post	78872	28023	1.07	86969	33870	1.34
$T_{7.}$ Pyrazosulfuron ethyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	102137	48406	1.63	111866	55885	1.93
$T_{8.}$ Pyrazosulfuron ethyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	99181	44791	1.48	111856	55216	1.90
$T_{9.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	108647	53050	1.72	122288	64442	2.11
$T_{10.}$ Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	104208	47953	1.56	117337	58832	1.94
$T_{11.}$ Oxadiargyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	100139	46149	1.52	110100	53860	1.87
$T_{12.}$ Oxadiargyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	95825	41176	1.37	107566	50667	1.75
$T_{13.}$ Weed free	-	-	114376	48696	1.41	124482	56552	1.70
$T_{14.}$ Weedy check	-	-	60882	13202	0.63	74005	24075	1.05

***fb* – followed by**

treatment to *kharif* rice realized the highest economic yield in terms of rice grain equivalent yield in the rice-green gram system was however, comparable to other effective treatments (T_9 and T_{10}) owing to the cumulative effect of higher rice yield as well as seed yield of green gram in the system. Reddy *et al.* (2017) reported similar findings on rice grain equivalent yield with legumes as a component crop.

Economics

Varied weed management practices adopted in the rice rice-green gram system altered the economics of system as a whole during both the years of study (**Table 3**). Though weed free treatment (T_{13}) resulted in higher gross returns during both the years of study (Rs. 114376 and Rs. 124482 ha^{-1} during 2015-16 and 2016-17, respectively) the net returns and return per rupee invested were markedly higher under T_9 and T_{10}, respectively during both the years. Weedy check (T_{14}) registered the lowest gross returns, net returns and return per rupee investment during both the years of study.

The economics of rice-green gram sequence play a vital role in making a recommendation for adoption of technology on farmer's field. In the present investigation the pre-emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} followed by post-emergence application of azimsulfuron @ 20 g a.i. ha^{-1} at 25 DAS, post-emergence application of metsulfuron methyl and chlorimuron ethyl @ 4 g a.i. ha^{-1} applied at 45 DAS (T_9) was the most profitable with the net returns (Rs. 53050 and Rs. 64442 ha^{-1} during 2015-16 and 2016-17, respectively) over the other treatments. The findings are similar to the results in the report of Reddy *et al.* (2017).

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