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**RESEARCH ARTICLE :**

# New generation herbicide combinations on weed indices, yield and economics of transplanted rice in Telangana state

■ **P. SPANDANA BHATT, M. YAKADRI, M. MADHAVI, S. SRIDEVI AND P. LEELA RANI**

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**SUMMARY :** An experiment was conducted during *Kharif*, 2013 and 2014 at Hyderabad with 14 treatments consisting of pre emergence application of pretilachlor 625 g, pyrazosulfuron 20 g and bensulfuron methyl 60g+pretilachlor 600 g at 3 DAT, penoxulam 22.5 g and cyhalofop-p-butyl 100 as early post emergence at 15 DAT, bispyribacsodium 25 g and pretilachlor 750 g their combinations with ethoxy sulfuron 18.75g, metsulfuron methyl+ chlorimuron ethyl 4g, azimsulfuron 35g, pyrazosulfuron 20 g $ha^{-1}$ at 3DAT followed by hand weeding at 25 DAT, hand weeding twice at 25 and 45 DAT and weedy check in RBD replicated thrice. During both years of investigation the higher weed control efficiency and herbicide efficiency index was noticed with hand weeding twice at 25 and 45 DAT (81.12, 2.76), pyrazosulfuron ethyl 20 g $ha^{-1}$ as PE at 3DAT followed by manual weeding at 25 DAT (79.83, 2.57) and pretilachlor 750 g $ha^{-1}$ as PE at 3 DAT followed metsulfuron methyl+chlorimuron ethyl 4 g $ha^{-1}$ as PoE at 25 DAT (76.51, 2.23) respectively due to its selectivity and high bio efficacy. Significantly higher grain yield (6685 kg $ha^{-1}$) and gross returns (Rs 62273 $ha^{-1}$) was noticed with hand weeding twice at 25 and 45 DAT and was comparable with pyrazosulfuron ethyl 20 g $ha^{-1}$ as PE at 3 DAT followed by manual weeding at 25 DAT (6630), pretilachlor 750 g $ha^{-1}$ as PE at 3 DAT followed metsulfuronmethyl +chlorimuron ethyl 4 g $ha^{-1}$ as PoE at 25 DAT (6423) and bispyribac sodium 20 g $ha^{-1}$+metsulfuron methyl+chlorimuron ethyl 4 g $ha^{-1}$ as PoE at 25 DAT (Rs 6176 $ha^{-1}$). However, pyrazosulfuron ethyl 20 g $ha^{-1}$ as pre emergence at 3 DAT followed by manual weeding at 25 DAT noticed higher net returns (Rs 63541 $ha^{-1}$) and B:C ratio (2.67).

**KEY WORDS :**
Weed indices, Transplanted rice, herbicides

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**A**uthor for correspondence :

**P. SPANDANA BHATT**
Professor Jayashankar Telangana State Agricultural University, HYDERABAD (TELENGANA) INDIA

See end of the article for authors' affiliations

## BACKGROUND AND OBJECTIVES

Rice is one of the most important food grains produced and consumed all over the world. Globally, India stands first in rice area and second in production after China. It is also a staple food for more than 65% of the Indian population, accounts for more than 42% of food production. In India, rice is grown in an area of 44.1 million ha, with a production of

106.64 million tonnes with a productivity of 2416 kg $ha^{-1}$ (Ministry of Agriculture, 2014-15). Contributes 21.5% of global rice production. In Telangana state, area under rice crop is 2.00 million ha, with a production of 6.62 million tonnes and productivity of 3297 kg $ha^{-1}$. Rice provides about 700 calories $day^{-1}$ $person^{-1}$ for about 3000 million people, most of who live in developing countries.

Rice crop suffers from various biotic and abiotic production constraints. Weed competition is one of the major yield limiting factors among biotic constraints in rice. The reduction in paddy yield due to weed competition ranges from 9-51 per cent (Mani *et al*., 1986). The transplanted rice plays a vital role in terms of rice production of the country. But, the transplanted rice is infested with wide range of weed species. With the advent of capital intensive technology like dwarf high yielding varieties tailored to respond to external inputs like fertilizers, irrigation and new intensive cropping systems also aggregated the problem of weeds (Yaduraj and Mishra 2002). The direct and most important effect of weeds is the reduction in crop yields resulting from competition for water nutrients and sunlight, but also quality of grains is impaired besides causing some nuisance at the time of harvest (Rao *et al*., 2007). Greater yield losses can occur at times when weed competition coincides with the critical period of growth of rice. Yadav *et al*. (2008) reported 30 to 60 days after transplanting as critical period of crop weed competition. Reduction in grain yield due to unchecked weed infestation in transplanted rice varies between 29 and 83 per cent.

Herbicide technology offers an alternative method of selective and economical control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority. Herbicides not only save time and money but also allow coverage of more area in short period of time (Nyarko and Datta, 1991). The development of herbicides for weed control was a fascinating success story during the last decade, generally, most herbicides are effective for selective weed control and a single herbicide cannot control all weeds of the community (Corbelt *et al*., 2004). Combination products consisting of two or more herbicides have greater activity on diverse weed flora due to differential mode of action and have become popular in recent years.

## RESOURCES AND METHODS

The investigation was carried out during *Kharif* 2013 and 2014 at college farm, Professor Jayashankar State Agricultural university, Rajendranagar, Hyderabad, situated at an altitude of 542.3 m above MSL at 17°19' N latitude and 78°23' E longitude. It is in the Southern Telangana agro-climatic zone of Telangana state. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). Mean weekly maximum temperatures ranged from 25.3°C to 31.5°C and 27.5 °C to 34.0 °C, while mean weekly minimum temperatures varied from 11.4 °C to 25.0 °C and 16.1 °C to 24.5°C during 2013-14 and 2014-15, respectively.

The mean morning relative humidity RH (I) during the crop growing period varied from 84 to 92% and 76 to 93%, while mean weekly afternoon relative humidity RH (II) 37 to 91% and 24 to 81% during 2013-14 and 2014-15, respectively. The weekly mean sunshine hours fluctuated between 0.3 hours to 8.1 hours and 1.0 to 8.3. The average wind speed varied from 1.1 to 13.2 km $h^{-1}$ in 2013-14 and 1.8 to 14.5 km $h^{-1}$ in 2014-15. With respect to pan evaporation, mean pan evaporation ranged from 1.5 to 5.1 mm $day^{-1}$ and 1.4 to 5.6 mm $day^{-1}$ in 2013-14 and 2014-15, respectively. During the cropping period rainfall of 601.1 mm was received in 36 rainy days and 362.3 mm received in 35 rainy days in 2013-14 and 2014-15, respectively. MTU-1010 (Cotton Dora Sannalu) is short duration rice variety matures in 120-125 days and suitable for irrigated medium lands, semi dwarf in nature with medium tillering and green foliage. It has long slender grains and gives an average yield of 8 t $ha^{-1}$ and resistance to blast and showing tolerance to brown plant hopper apart from tolerance to salinity and submergence for 10 days. 14 treatments consisting of pre emergence application of pretilachlor 625 g, pyrazosulfuron 20 g and bensulfuron methyl 60g+pretilachlor 600 g at 3 DAT, penoxulam 22.5 g and cyhalofop-p-butyl 100 as early post emergence at 15 DAT, bispyribacsodium 25 g and pretilachlor 750 g their combinations with ethoxy sulfuron 18.75g, metsulfuron methyl+ chlorimuron ethyl 4g, azimsulfuron 35g, pyrazosulfuron 20 g $ha^{-1}$ at 3DAT followed by handweeding at 25 DAT, hand weeding twice at 25 and 45 DAT and weedy check in RBD replicated thrice

**Weed control efficiency (WCE %) :**

It denotes the efficiency of the applied herbicides or herbicidal treatments for comparison purpose. It was worked out by using the formula suggested by Mani *et*

*al.* (1973) and expressed in percentage.

$$WCE = \frac{DN_C - DN_T}{DN_C} \times 100$$

where,

$DN_C$ : Weed density in unweeded check

$DN_T$ : Weed density in treated plot

**Weed control index (WCI %) :**

It denotes the efficiency of the applied herbicides or herbicidal treatments for comparison purpose. It was worked out by using the formula suggested by Mishra and Tosh, 1979 and expressed in percentage.

$$WCI = \frac{DM_C - DM_T}{DM_C} \times 100$$

where,

$DM_C$ : Weed dry weight (g $m^{-2}$) in unweeded checks

$DM_T$ : Weed dry weight (g $m^{-2}$) in treated plot.

## OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

**Weed control efficiency (WCE) :**

WCE represents the comparative magnitude of reduction in weed density and was highly influenced under different weed management practices at various crop growth stages *viz.*, at 30 DAT, 60 DAT, 90 DAT and at harvest of rice. The WCE was markedly higher with weed management practices over weedy check at all crop growth stages. Weed control efficiency was high between 0-30 DAT then decreased sharply between 30 - 60 DAT, there after it decreased linearly toward harvest in both years owing to increase in weed density. High weed control efficiency in the initial growth stages appear to be mainly due to higher herbicide efficacy.

During both years of investigation higher WCE at all the stages was noticed in $T_4$ (pyrazosulfuron ethyl @ 20 g a.i. $ha^{-1}$ as PE at 3 DAT followed by manual weeding at 25 DAT), $T_{13}$ (hand weeding twice at 25 and 45 DAT) and $T_{12}$ (pretilachlor @ 750 g $ha^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g $ha^{-1}$ as PoE at 25 DAT) due to higher suppression of weeds with sequential application of herbicide / PoE herbicides or manual weeding and broad spectrum weed control. The treatment $T_{10}$ (bispyribac sodium @ 20 g a.i. $ha^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g

**Table 1 : Weed control efficiency and weed control index of rice as influenced by weed management practices**

| Sr. No. | Treatments | Weed control efficiency | | | | Weed control index | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 30DAT | 60DAT | 90DAT | Harvest | 30DAT | 60DAT | 90DAT | Harvest |
| $T_1$ | Pretilachlor @ 625 g a.i $ha^{-1}$ as PE at 3 DAT | 57.70 | 7.10 | 7.25 | 5.80 | 36.74 | 6.57 | 5.87 | 4.82 |
| $T_2$ | Pyrazosulfuron ethyl @ 20 g a.i $ha^{-1}$ 3 DAT | 63.17 | 31.25 | 18.61 | 18.16 | 46.41 | 10.24 | 9.79 | 9.66 |
| $T_3$ | Pretilachlor 6% + bensulfuron methyl 0.6% @ 10 kg granules $ha^{-1}$ as PE at 3 DAT | 66.34 | 46.55 | 38.32 | 34.49 | 49.04 | 32.90 | 37.80 | 35.33 |
| $T_4$ | Pyrazosulfuron ethyl @ 20 g a.i $ha^{-1}$ at 3 DAT followed by manual weeding at 25 DAT | 87.13 | 87.84 | 83.32 | 79.83 | 96.45 | 89.78 | 80.91 | 75.33 |
| $T_5$ | Penoxsulam @ 22.5 g a.i $ha^{-1}$ as early PoE at 12 DAT | 57.32 | 25.99 | 18.90 | 16.99 | 46.91 | 15.04 | 6.60 | 4.60 |
| $T_6$ | Cyhalofop-p-butyl @ 100 g a.i $ha^{-1}$ as early PoE 12 DAT | 5.63 | 3.56 | 1.24 | 1.53 | 5.20 | 5.24 | 2.70 | 2.60 |
| $T_7$ | Bispyribac sodium @ 25 g a.i $ha^{-1}$ as PoE 25 DAT | 24.93 | 21.51 | 14.17 | 12.57 | 10.38 | 13.62 | 8.36 | 7.63 |
| $T_8$ | Azimsulfuron @ 35 g a.i $ha^{-1}$ as PoE at 25 DAT | 48.49 | 45.15 | 34.58 | 34.26 | 10.80 | 42.53 | 29.86 | 28.88 |
| $T_9$ | Bispyribac sodium @ 25 g a.i $ha^{-1}$ + ethoxysulfuron 18.75 g a.i $ha^{-1}$ as PoE at 25 DAT | 42.14 | 53.07 | 41.69 | 39.37 | 10.84 | 42.00 | 33.83 | 32.99 |
| $T_{10}$ | Bispyribac sodium @ 20 g a.i $ha^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i $ha^{-1}$ as PoE at 25 DAT | 63.23 | 74.99 | 78.15 | 72.50 | 10.60 | 84.49 | 76.23 | 72.78 |
| $T_{11}$ | Pretilachlor @ 750 g a.i $ha^{-1}$ as PE at 3 DAT followed by ethoxysulfuron @ 18.75 g a.i $ha^{-1}$ as PoE at 25 DAT | 84.35 | 47.34 | 45.59 | 41.76 | 83.73 | 48.10 | 40.17 | 38.73 |
| $T_{12}$ | Pretilachlor @ 750 g a.i $ha^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i $ha^{-1}$ as PoE at 25 DAT | 85.66 | 82.70 | 79.52 | 76.51 | 87.23 | 85.00 | 76.60 | 72.90 |
| $T_{13}$ | Hand weeding twice at 25 and 45 DAT | 86.38 | 86.46 | 83.91 | 81.12 | 91.46 | 88.56 | 79.75 | 78.03 |
| $T_{14}$ | Weedy check | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

a.i. $ha^{-1}$ as PoE at 25 DAT) showed less WCE at 30 DAT and then from 60 DAT it showed comparatively higher WCE owing to PoE application of herbicide. It was clearly evident that combination of two chemicals gave higher weed control efficacy than sole application. The treatment $T_1$, $T_2$ $T_3$, $T_5$, $T_6$, $T_7$, $T_8$, $T_9$ and $T_{11}$ showed good WCE up to 30 DAT due to single application of PE herbicide alone as the herbicide controlled a portion of weed population. Poor weed control efficiency was noticed in $T_8$ azimsulfuron because it controls only sedges, $T_7$ bispyribac sodium controls only grasses and $T_6$ Cyhalofop-p-butyl control only barnyard grass at all crop growth stages in 2013 and 2014 (Parthipan and Ravi, 2014). A positive correlation existed between WCE versus weed density and the regressions accounted for 100 % variability in WCE.

**Weed control index (WCI) :**

The data pertaining to effect of different weed control treatments on weed control index recorded at 30 DAT, 60 DAT, 90 DAT and at harvest of rice. Higher mean weed control index was noticed in between 0 - 30 DAT then decreased sharply between 30 - 60 DAT, there after it decreased linearly toward harvest in both years owing to increase in weed dry weight. High weed control index in the initial growth stages appear to be mainly due to lower weed dry weight. WCI of weedy check was negative in both the years.

WCI represents the comparative magnitude of increase in weed dry weight. The treatment $T_4$ (pyrazosulfuron ethyl @ 20 g a.i. $ha^{-1}$ as PE at 3 DAT followed by manual weeding at 25 DAT), $T_{13}$ (hand weeding twice at 25 and 45 DAT) and $T_{12}$ (pretilachlor 750 g $ha^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g $ha^{-1}$ as PoE at 25 DAT) showed the higher WCI values at all the stages, due to suppression of weeds. The treatment $T_{10}$ (bispyribac sodium @ 20 g a.i. $ha^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. $ha^{-1}$ as PoE at 25 DAT) showed less WCI at 30 DAT, and then from 60 DAT it showed comparatively higher WCI owing to PoE application of herbicide. The treatment $T_1$, $T_2$ $T_3$, $T_5$, $T_6$, $T_7$, $T_8$, $T_9$ and $T_{11}$ showed good WCI at 30 DAT compared to other stages because of less weed population at earlier growth stage (30 DAT) due to PE herbicide application. At later stage the treatments showed lower efficiency which might be due to emergence of some new weed species at later stages.

**Table 2 : Grain yield (kg $ha^{-1}$), straw yield (kg $ha^{-1}$) and harvest index of rice as influenced by weed management practices**

| Sr. No. | Treatments | Grain yield | | Straw yield | |
|---|---|---|---|---|---|
| | | 2013 | 2014 | 2013 | 2014 |
| $T_1$ | Pretilachlor @ 625 g a.i $ha^{-1}$ as PE at 3 DAT | 2962 | 2838 | 4229 | 4410 |
| $T_2$ | Pyrazosulfuron ethyl @ 20 g a.i $ha^{-1}$ 3 DAT | 3200 | 3048 | 4392 | 4700 |
| $T_3$ | Pretilachlor 6% + bensulfuron methyl 0.6% @ 10 kg granules $ha^{-1}$ as PE at 3 DAT | 4247 | 4233 | 6133 | 5584 |
| $T_4$ | Pyrazosulfuron ethyl @ 20 g a.i $ha^{-1}$ at 3 DAT followed by manual weeding at 25 DAT | 6392 | 6868 | 8035 | 8425 |
| $T_5$ | Penoxsulam @ 22.5 g a.i $ha^{-1}$ as early PoE at 12 DAT | 3239 | 3375 | 4571 | 4787 |
| $T_6$ | Cyhalofop-p-butyl @ 100 g a.i $ha^{-1}$ as early PoE 12 DAT | 2775 | 2892 | 4286 | 4381 |
| $T_7$ | Bispyribac sodium @ 25 g a.i $ha^{-1}$ as PoE 25 DAT | 3033 | 3156 | 4387 | 4478 |
| $T_8$ | Azimsulfuron @ 35 g a.i $ha^{-1}$ as PoE at 25 DAT | 4542 | 4389 | 6310 | 5998 |
| $T_9$ | Bispyribac sodium @ 25 g a.i $ha^{-1}$ + ethoxysulfuron 18.75 g a.i $ha^{-1}$ as PoE at 25 DAT | 4321 | 4203 | 6272 | 5603 |
| $T_{10}$ | Bispyribac sodium @ 20 g a.i $ha^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i $ha^{-1}$ as PoE at 25 DAT | 5972 | 6381 | 7963 | 8311 |
| $T_{11}$ | Pretilachlor @ 750 g a.i $ha^{-1}$ as PE at 3 DAT followed by ethoxysulfuron @ 18.75 g a.i $ha^{-1}$ as PoE at 25 DAT | 4659 | 4838 | 6721 | 6410 |
| $T_{12}$ | Pretilachlor @ 750 g a.i $ha^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i $ha^{-1}$ as PoE at 25 DAT | 6169 | 6677 | 7972 | 8233 |
| $T_{13}$ | Hand weeding twice at 25 and 45 DAT | 6440 | 6929 | 8072 | 8476 |
| $T_{14}$ | Weedy check | 2770 | 2779 | 4148 | 4181 |
| | S.E. ± | 163 | 211 | 238 | 287 |
| | C.D. (P=0.05) | 477 | 615 | 694 | 840 |

**Yield and wconomics :**

Rice grain yield was significantly higher with $T_{13}$ (hand weeding twice at 25 and 45 DAT) treatment 6440 kg ha$^{-1}$ and 6929 kg ha$^{-1}$ during 2013 and 2014 respectively. However comparable with the grain yield recorded with $T_4$ (pyrazosulfuron ethyl @ 20 g a.i. ha$^{-1}$ as PE at 3 DAT followed by manual weeding at 25 DAT), $T_{12}$ (pretilachlor @ 750 g a.i. ha$^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. ha$^{-1}$ as PoE at 25 DAT) and $T_{10}$ (bispyribac sodium @ 20 g a.i. ha$^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. ha$^{-1}$ as PoE at 25 DAT) treatments, all these treatments were superior over rest of the treatments. There was no significant difference in grain yield among the treatments $T_{11}$, $T_8$, $T_9$ and $T_3$. On an average 28.96%, 33.19%, 36.24% and 36.80 % increase in grain yield of the crop was noticed in hand weeding twice at 25 and 45 DAT treatment over $T_{11}$, $T_8$, $T_9$ and $T_3$ respectively. The Lower grain yield was registered with $T_{14}$ (weedy check) and was statistically comparable with $T_5$ (penoxsulam @ 22.5 g a.i. ha$^{-1}$ as early PoE at 12 DAT), $T_2$ (pyrazosulfuron ethyl @ 20 g a.i. ha$^{-1}$ 3 DAT), $T_7$ (bispyribac sodium @ 25 g a.i. ha$^{-1}$ as PoE 25 DAT), $T_1$ (pretilachlor @ 625 g a.i. ha$^{-1}$ as PE at 3 DAT) and $T_6$ (cyhalofop-p-butyl @ 100 g a.i. ha$^{-1}$ as PoE 12 DAT) during both the years.

The economic indicators such as gross returns (Rs. ha$^{-l}$), net returns (.ha$^{-l}$) and B:C ratio were worked out and these indicators were analyzed statistically and presented.

Significantly the higher gross returns were achieved in ($T_{13}$) hand weeding twice at 25 and 45 DAT (Rs. 102273 and Rs. 109720) it was at par with ($T_4$) pyrazosulfuron ethyl @ 20 g a.i. ha$^{-1}$ at 3 DAT followed by manual weeding at 25 DAT (Rs. 101541 and Rs. 108788), ($T_{12}$) pretilachlor @ 750 g a.i. ha$^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. ha$^{-1}$ as PoE at 25 DAT (Rs. 98319 and Rs. 105833) and ($T_{10}$) bispyribac sodium @ 20 g a.i. ha$^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. ha$^{-1}$ as post emergence at 25 DAT (Rs. 95598 and Rs. 101798). In turn followed by $T_{11}$ (pretilachlor @ 750 g a.i. ha$^{-1}$ as PE at 3 DAT followed by ethoxysulfuron @ 18.75 g a.i. ha$^{-1}$ as PoE at 25 DAT), $T_8$ (azimsulfuron @

**Table 3 : Economics of rice as influenced by weed management practices**

| Sr. No. | Treatments | Gross returns (Rs.ha$^{-1}$) | | Net returns (Rs..ha$^{-1}$) | | BC ratio | |
|---|---|---|---|---|---|---|---|
| | | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| $T_1$ | Pretilachlor @ 625 g a.i ha$^{-1}$ as PE at 3 DAT | 47806 | 46353 | 11206 | 8753 | 1.31 | 1.23 |
| $T_2$ | Pyrazosulfuron ethyl @ 20 g a.i ha$^{-1}$ 3 DAT | 51388 | 49729 | 14588 | 11929 | 1.40 | 1.32 |
| $T_3$ | Pretilachlor 6% + bensulfuron methyl 0.6% @ 10 kg granules ha$^{-1}$ as PE at 3 DAT | 68652 | 67642 | 30327 | 28317 | 1.79 | 1.72 |
| $T_4$ | Pyrazosulfuron ethyl @ 20 g a.i ha$^{-1}$ at 3 DAT followed by manual weeding at 25 DAT | 101541 | 108788 | 63541 | 69788 | 2.67 | 2.79 |
| $T_5$ | Penoxsulam @ 22.5 g a.i ha$^{-1}$ as early PoE at 12 DAT | 52202 | 54436 | 13915 | 15149 | 1.36 | 1.39 |
| $T_6$ | Cyhalofop-p-butyl @ 100 g a.i ha$^{-1}$ as early PoE 12 DAT | 45275 | 47064 | 8295 | 7764 | 1.22 | 1.20 |
| $T_7$ | Bispyribac sodium @ 25 g a.i ha$^{-1}$ as PoE 25 DAT | 49037 | 50898 | 11006 | 11867 | 1.29 | 1.30 |
| $T_8$ | Azimsulfuron @ 35 g a.i ha$^{-1}$ as PoE at 25 DAT | 73058 | 70443 | 34733 | 31118 | 1.91 | 1.79 |
| $T_9$ | Bispyribac sodium @ 25 g a.i ha$^{-1}$ + ethoxysulfuron 18.75 g a.i ha$^{-1}$ as PoE at 25 DAT | 69902 | 67649 | 31159 | 27906 | 1.80 | 1.70 |
| $T_{10}$ | Bispyribac sodium @ 20 g a.i ha$^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i ha$^{-1}$ as PoE at 25 DAT | 95598 | 101798 | 57099 | 62299 | 2.48 | 2.58 |
| $T_{11}$ | Pretilachlor @ 750 g a.i ha$^{-1}$ as PE at 3 DAT followed by ethoxysulfuron @ 18.75 g a.i ha$^{-1}$ as PoE at 25 DAT | 75308 | 77341 | 37876 | 38909 | 2.01 | 2.01 |
| $T_{12}$ | Pretilachlor @ 750 g a.i ha$^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i ha$^{-1}$ as PoE at 25 DAT | 98319 | 105833 | 60832 | 67646 | 2.62 | 2.77 |
| $T_{13}$ | Hand weeding twice at 25 and 45 DAT | 102273 | 109720 | 62273 | 68720 | 2.56 | 2.68 |
| $T_{14}$ | weedy check | 44998 | 45173 | 8998 | 8173 | 1.25 | 1.22 |
| | S.E. ± | 2284 | 3977 | 2284 | 3977 | | |
| | C.D. (P=0.05) | 6677 | 9702 | 6677 | 9702 | | |

35 g a.i. $ha^{-1}$ as PoE at 25 DAT), $T_9$ (bispyribac sodium @ 25 g a.i. $ha^{-1}$ + ethoxysulfuron @ 18.75 g a.i. $ha^{-1}$ as PoE at 25 DAT) and $T_3$ (pretilachlor 6% + bensulfuron methyl 0.6% @ 10 kg granules $ha^{-1}$ as PE at 3 DAT). The lower gross returns was achieved under $T_{14}$ (weedy check) which was on par with remaining other weed management practices $T_5$, $T_2$, $T_7$, $T_1$ and $T_6$ in both the years.

However, in terms of net returns significantly higher net returns was noticed in ($T_4$) pyrazosulfuron ethyl @ 20 g a.i. $ha^{-1}$ at 3 DAT followed by manual weeding at 25 DAT (Rs. 63541 and Rs. 69788) and was at par with ($T_{13}$) hand weeding twice at 25 and 45 DAT (Rs. 62273 and Rs. 68720), ($T_{12}$) pretilachlor @ 750 g a.i. $ha^{-1}$ as PE at 3 DAT followed by metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. $ha^{-1}$ as PoE at 25 DAT (Rs. 60832 and Rs. 67646) and ($T_{10}$) bispyribac sodium @ 20 g a.i. $ha^{-1}$ + metsulfuron methyl + chlorimuron ethyl @ 4 g a.i. $ha^{-1}$ as post emergence at 25 DAT (Rs. 57099 and Rs. 62299) and superior over rest of the treatments, respectively during 2013 and 2014. In turn these were followed by $T_{11}$ and $T_8$ and then followed by $T_9$ and $T_3$. The lower net returns was achieved under $T_{14}$ (weedy check) and was on par with remaining other weed management practices $T_5$, $T_2$, $T_7$, $T_1$ and $T_6$ during both the years.

Authors' affiliations :

**M. YAKADRI, M. MADHAVI, S. SRIDEVI AND P. LEELA RANI,** Professor Jayashankar Telangana State Agricultural University, HYDERABAD (TELENGANA) INDIA

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