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# Bio-efficacy of Sulfentrazone 39.6% SC against Weed Flora of Soybean

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Inadequate weed control is one of the primary causes of a decrease in soybean production. Weeds compete for resources with crops (water, light and nutrients). This competition is especially important during the early stages of crop development, when production losses of up to 80 per cent are possible, and in extreme cases, harvest operations are hampered. As a result, the current study sought to identify an effective weed control practice in soybean.To assess the bio-efficacy of Sulfentrazone 39.6% SC as a post-emergent (PRE) herbicide for weed control in soybean. The experiment was laid in RCBD (Randomized complete Block Design). A field experiment was conducted at Agricultural Research Station, Bidar, University of Agricultural Sciences, Raichur, Karnataka, India during *kharif* seasons of 2019 and 2020. The study consisted seven treatments with three levels of Sulfentrazone as PRE (240, 360, and 480 g *a.i* $ha^{-1}$), two check herbicides (Authority XL @ 360 g *a.i.* $ha^{-1}$ and Pendimethalin @ 1 kg *a.i* $ha^{-1}$ as PRE), hand weeding twice at 20 and 40 days after sowing, and a weedy check replicated three times. Application of

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sulfentrazone 39.6%SC premergent herbicide significantly reduced weed density and dry biomass a during the critical period of crop-weed competition. Sulfentrazone 39.6% SC @ 360 g *a.i.* ha$^{-1}$ (PRE) application resulted in significantly higher weed control efficiency (WCE), yield, and economics in soybean, which was comparable to Sulfentrazone 39.6% SC @ 480 g *a.i.* ha$^{-1}$ (PRE) application. Hence, Application of sulfentrazone 39.6% SC @ 360 g *a.i.* ha$^{-1}$ as pre emergent herbicide is advocated to the farmers in effective control of weeds.

*Keywords: Soybean; sulfentrazone; weed density; weed dry weight; WCE; economic.*

## 1. INTRODUCTION

Soybean (*Glycine max* L.) plays an important role in increasing the country's oilseed production. Soybean is one of the most widely planted monocultured crops in the world [1]. The leading producers are the United States, Brazil, and Argentina, which account for more than 70% of total cultivated area. These five countries, along with China and India, account for 90% of global soybean production. Meanwhile, weeds are regarded as the most serious threat to productivity in major soybean producing countries. Weed management is critical for any current agricultural crop production system, particularly large monoculture areas that place a high strain on crop environment. Even with advanced technologies, producers report high weed-related losses. Weeds alone are estimated to cause a 37% reduction in soybean yield, while other fungal diseases and agricultural pests account for 22% of losses [2]. Sulfentrazone is a triazinone herbicide that inhibits protoporphyrinogen oxidase (PPO) (7). Sulfentrazone is a pre-emergence (PE) herbicide that provides residual control of both broadleaf and grassy weeds (2; 3 & 8). Although sulfentrazone has been reported to have excellent weed control (90%), the level of control was dependent on the weed community composition [3]. Keep in mind that, the study was initiated to evaluate the use of sulfentrazone as a pre-emergence herbicide and pendimethalin PE as a standard comparator in soybean.

## 2. MATERIALS AND METHODS

An experiment was conducted during the *kharif* season of 2019 and 2020 at the Agricultural Research Station (ARS), Bidar, located at latitude and longitude of 17° 92' N and 77° 53' E with a mean sea level of 654m, to evaluate the bio-efficacy of Sulfentrazone 39.6% SC as Pre-emergent (PRE) herbicide for weed control in soybean. The experiment used a randomised block design and included seven treatments, three levels of sulfentrazone as PRE (240, 360, and 480 g *a.i* ha$^{-1}$), two check herbicides (Authority XL @ 360 g *a.i.* ha$^{-1}$ and Pendimethalin @ 1 kg a.i ha$^{-1}$ as PRE), Weed free (two hand weeding at 20 and 40 days after sowing) and a weedy check replicated thrice. Soybean variety Dsb-21 was sown on 12$^{th}$ June, 2019 and15$^{th}$ June, 2020.

The populations of dominant weeds (grassy, broad-leaved and sedges) were recorded separately at 15, 30 and 45 Days after treatment (DAT) of the test herbicide while the dry weights of dominant weeds were recorded separately at 15, 30, 45 DAT and drying in hot air over at 70$^{o}$C. The density and dry weight of the weed flora was recorded by placing 1 m x 1 m quadrate thrice per plot for evaluating the relative efficacy of the products and the data were presented on per m$^2$ and g per m$^2$ basis, *respectively.* Weed control efficiency (WCE) of each treatment was determined by using the standard formula (WCE = dry weight of weeds in control - dry weigh of weeds in treatment/ dry weight of weeds in control x 100). Yield and yield attributes were recorded at the time of harvesting. Data on weed count /density have shown high degree of variation. A relationship between the means and variance was observed. Therefore, the data on weed count were subjected to $\sqrt{x+1}$ transformation to make analysis of variance more valid. The observation on phytotoxicity of soybean crop was done on the basis of rating scale (PRS) for the applied testing herbicides like Sulfentrazone 39.6% SC, Authority XL @ 360 g *a.i.* ha$^{-1}$ (Sulfentrazone 39.6% SC Market Sample), Pendimethalin 30% EC at each level of application as pre-emergent herbicides. The analysis and interpretation of data were done using the Fisher's method of analysis of variance technique [4]. The level of significance used in "F" and "t" test was p=0.05. Critical difference values were calculated whenever the "F" test was significant.

## 3. RESULTS AND DISCUSSION

### 3.1 Weed Density and Dry Weight

During investigation, soybean was infested mainly with important weeds observed in the experimental site. Broad leaved weeds *viz.,*

*Acalypha sp., Ageratum conyzoides, Alternanthera sessilis, Amaranthus viridies, Commelina benghalensis*, *Chenopodium album, Digera arvensis, Euphorbia hirta, Fumaria parviflora, Phyllanthus niruri*, *Parthenium hysterophorus, Portulaca oleracea, Trianthema portulacastrum* etc., were dominant. Among the grassy weeds, *Bracharia spp., Dinebra retroflexa, Echinochloa crusgalli, Eleusine indica, Brachiaria eruciformis, Digitaria sanginalis, Digitaria marinata, Dactyloctenium aegyptium,* were observed; *Cyperus rotundus* and *Cyperus deformis* were found as sedge. The hand weeding in weed free check was the most effective treatment, according to data on weed density $m^{-2}$ collected after 15, 30, and 45 days of application of treatments. Sulfentrazone 39.6% SC @ 480 g *a.i.* $ha^{-1}$was the herbicide that was most effective at controlling weed flora in soybeans. It was also comparable to Sulfentrazone 39.6% SC @ 360 g *a.i.* $ha^{-1}$, Pendimethalin 30% EC @ 1000 g *a.i.* $ha^{-1}$, and market sample. Other treatments, such as Sulfentrazone 39.6% SC @ 240 g *a.i*. $ha^{-1}$. The weed dry biomass recorded 15, 30 and 45 days after application of treatments showed similar trend of effectiveness of the treatments (Tables 1,2). Sulfentrazone alone controlled all weeds, including dicots, monocots, and sedges [5]. Sulfentrazone was also mentioned in earlier studies [6,3] as a potential herbicide in the soybean weed control.

## 3.2 Weed Control Efficiency

The highest weed control efficiency was observed at 30 and 45 days after sowing (DAS) with twice hand weeding (97 and100%, *respectively*). The weed control efficiency under sulfentrazone 39.6% SC @ 480 *a.i*. g $ha^{-1}$at all these three stages of observations was higher (67.24, 64.94 and 64.63%, *respectively*) than that recorded under check herbicides pendimethalin, but remained at par with Sulfentrazone 39.6% SC @ 360 *a.i.* g $ha^{-1}$ (62.97, 61.94 and 62.13%, *respectively*). The application of sulfentrazone was also found to be very effective to control the weeds as evidenced from the weed control efficiency data (Table 3). The weed count and drymatter recorded under these treatments determine the variation in weed control efficiency across treatments. Weed dry matter followed the same trend as weed control efficiency. However, the number of weeds and their dry matter are not linearly related because dry matter accumulation is dependent on weed species size and age at different stages of crop growth. This could be deduced from the fact that in the current study, increased weed control efficiency due to sulfentrazone herbicide resulted in higher yields and such good control over all weeds that provide competition for a relatively longer period of time. Sulfentrazone herbicide application resulted higher WCE in soybean [5]. Sulfentrazone alone completely eliminated giant foxtail, yellow nutsedge, common water hemp, common cocklebur, and ivy leaf morning glory from their respective areas [7]. Additionally, it has been demonstrated that sulfentrazone herbicide works better against yellow nutsedge [8].

## 3.3 Growth and Yield Attributes

Soybean yield was significantly superior with hand weeding at 20 and 40 DAS followed coupled with intercultivation (1925 kg $ha^{-1}$) over Sulfentrazone 39.6% SC @ 240 g *a.i.* $ha^{-1}$ (PRE) (1562 kg $ha^{-1}$), Pendimethalin 30% EC @ 1000 g *a.i.* $ha^{-1}$ (1630 kg $ha^{-1}$) and weedy check (973 kg $ha^{-1}$) in pooled data. However, it was on par with application of Sulfentrazone 39.6% SC @ 480 g *a.i.* $ha^{-1}$ (PRE) (18.45 q $ha^{-1}$) and Sulfentrazone 39.6% SC @ 360 g *a.i.* $ha^{-1}$ (PRE) (18.36 q $ha^{-1}$) and Authority XL market sample (18.16 q $ha^{-1}$). The yield increases due to different weed control treatments ranged from 60 to 97 per cent and from 11.41 to 18.10 per cent over weed control and Pendimethalin 30% EC @ 1000 g *a.i.* $ha^{-1}$. Higher soybean yield was recorded owing to higher yield attributing characteristics. Maximum pods per plant were also observed with hand weeding twice, and there was no significant difference with sulfentrazone at 480 and 360 g *a.i.* $ha^{-1}$. With two hand weeding's, the maximum 100 seed weight was also recorded, which was significantly higher than the control. Soybean yield attributing characteristics are determined by growth characteristics such as plant height and number of branches per plant. Treatments have an impact on the height of soybean plants (Table 4).

However, the significantly higher plant height was observed in hand weeding twice at 20 and 40DAS and on par with Sulfentrazone 39.6% SC over other treatments. This could be the result of weed-induced congestion at the canopy level, which pushed the growth of soybean plants upward. Weed-free and Sulfentrazone 39.6% SC free environments provide a better environment for plants to grow because yield is a complex trait that is controlled not only by genetic factors but also by environmental effects, with weed being a major

**Table 1. Weed density of monocots, dicots and sedges weed count at different growth stages of soybean as influenced by different weed management practices (Pooled over two years)**

| Treatments | Monocots weed density (no.m$^{-2}$)* | | | Dicots weed density (no. m$^{-2}$)* | | | Sedges weed density (no. m$^{-2}$)* | | |
|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| $T_1$- Sulfentrazone 39.6% SC @ 240 g *a.i.*/ha | 2.27 (4.16) | 3.34 (10.13) | 3.91 (14.27) | 2.20 (3.86) | 2.86 (7.18) | 3.18 (9.13) | 1.96 (2.86) | 2.22 (3.93) | 3.10 (8.59) |
| $T_2$- ulfentrazone 39.6% SC @ 360 g *a.i.*/ha | 1.78 (2.17) | 2.52 (5.35) | 3.02 (8.15) | 1.82 (2.30) | 2.16 (3.65) | 2.66 (6.05) | 1.82 (2.30) | 1.93 (2.74) | 2.63 (5.90) |
| $T_3$- Sulfentrazone 39.6% SC @ 480 g *a.i.*/ha | 1.79 (2.18) | 2.39 (4.70) | 2.97 (7.84) | 1.78 (2.15) | 2.09 (3.37) | 2.65 (6.02) | 1.79 (2.20) | 1.89 (2.58) | 2.58 (5.63) |
| $T_4$- Authority XL @ 360 g *a.i.*/ha (Sulfentrazone 39.6% SC Market Sample) | 1.91 (2.63) | 2.50 (5.26) | 3.04 (8.22) | 1.88 (2.53) | 2.19 (3.80) | 2.78 (6.73) | 1.88 (2.52) | 1.97 (2.89) | 2.72 (6.41) |
| $T_5$- Pendimethalin 30% EC @ 1000 g *a.i.*/ha | 1.92 (2.69) | 2.65 (6.01) | 3.06 (8.34) | 2.04 (3.16) | 2.32 (4.36) | 2.82 (6.97) | 1.90 (2.62) | 1.99 (2.94) | 2.74 (6.52) |
| $T_6$- Hand weeding at 20 and 40DAS | 2.45 (5.00) | 1.00 (0.00) | 1.00 (0.00) | 2.27 (4.16) | 1.00 (0.00) | 1.00 (0.00) | 2.24 (4.01) | 1.00 (0.00) | 1.00 (0.00) |
| $T_7$- Weedy check | 2.77 (6.00) | 4.82 (22.20) | 5.98 (34.84) | 2.36 (4.55) | 4.00 (15.04) | 4.62 (20.40) | 2.35 (4.51) | 3.19 (9.17) | 3.77 (13.23) |
| S.Em. ± | 0.022 | 0.029 | 0.052 | 0.030 | 0.032 | 0.046 | 0.013 | 0.030 | 0.036 |
| C.D. (*P=0.05*) | 0.068 | 0.089 | 0.161 | 0.092 | 0.098 | 0.142 | 0.041 | 0.092 | 0.112 |

** Figures in parentheses indicate original values are subjected to transformation (√X+1)*

**Table 2. Weed dry weight of monocots, dicots and sedges weed count at different growth stages of soybean as influenced by different weed management practices (Pooled over two years)**

| Treatments | Monocots weed dry weight (g m$^{-2}$)* | | | Dicots weed dry weight (g m$^{-2}$)* | | | Sedges dry weight (g m$^{-2}$)* | | |
|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| $T_1$- Sulfentrazone 39.6% SC @ 240 g *a.i.*/ha | 1.39 | 4.20 | 6.97 | 1.71 | 3.75 | 4.77 | 0.80 | 2.18 | 2.28 |
| $T_2$- Sulfentrazone 39.6% SC @ 360 g *a.i.*/ha | 0.97 | 2.44 | 4.75 | 1.01 | 2.77 | 3.07 | 0.39 | 1.68 | 2.53 |
| $T_3$- Sulfentrazone 39.6% SC @ 480 g *a.i.*/ha | 0.94 | 2.27 | 4.59 | 0.78 | 2.59 | 2.80 | 0.37 | 1.65 | 2.27 |
| $T_4$- Authority XL @ 360 g *a.i.*/ha (Sulfentrazone 39.6% SC Market Sample) | 1.15 | 2.59 | 4.93 | 0.86 | 2.76 | 3.17 | 0.42 | 1.76 | 2.66 |
| $T_5$- Pendimethalin 30% EC @ 1000 g *a.i.*/ha | 1.27 | 2.93 | 5.26 | 0.91 | 2.89 | 3.39 | 0.54 | 1.78 | 2.81 |
| $T_6$- Hand weeding at 20 and 40DAS | 2.10 | 0.00 | 0.00 | 2.12 | 0.50 | 0.00 | 1.59 | 0.00 | 0.00 |
| $T_7$- Weedy check | 2.31 | 6.91 | 11.59 | 2.32 | 6.78 | 8.68 | 1.77 | 4.40 | 7.07 |
| S.Em. ± | 0.04 | 0.135 | 0.190 | 0.05 | 0.05 | 0.15 | 0.03 | 0.04 | 0.11 |
| C.D. (*P=0.05*) | 0.12 | 0.416 | 0.584 | 0.17 | 0.16 | 0.46 | 0.10 | 0.14 | 0.33 |

**Table 3. Number of total weed count, dry weight and weed control efficiency at different growth stages of soybean as influenced by different weed management practices (Pooled over two years)**

| Treatments | Number of total weed count (no/m$^{-2}$)* | | | Total dry weight of weeds (g/m$^{-2}$) | | | Weed Control Efficiency (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| $T_1$- Sulfentrazone 39.6% SC @ 240 g *a.i.*/ha | 3.45 (10.88) | 4.72 (21.24) | 5.74 (31.98) | 3.90 | 10.13 | 14.02 | 39.01 | 43.94 | 48.62 |
| $T_2$- Sulfentrazone 39.6% SC @ 360 g *a.i.*/ha | 2.79 (6.78) | 3.57 (11.74) | 4.59 (20.10) | 2.37 | 6.89 | 10.34 | 62.97 | 61.94 | 62.13 |
| $T_3$- Sulfentrazone 39.6% SC @ 480 g *a.i.*/ha | 2.75 (6.54) | 3.41 (10.65) | 4.53 (19.50) | 2.09 | 6.50 | 9.67 | 67.24 | 64.05 | 64.63 |
| $T_4$- Authority XL @ 360 g *a.i.*/ha (Sulfentrazone 39.6% SC Market Sample) | 2.95 (7.68) | 3.60 (11.94) | 4.73 (21.36) | 2.43 | 7.10 | 10.76 | 61.99 | 60.72 | 60.64 |
| $T_5$- Pendimethalin 30% EC @ 1000 g *a.i.*/ha | 3.08 (8.47) | 3.78 (13.31) | 4.78 (21.83) | 2.71 | 7.59 | 11.46 | 57.62 | 57.98 | 58.04 |
| $T_6$- Hand weeding at 20 and 40DAS | 3.76 (13.17) | 1.00 (0.00) | 1.00 (0.00) | 5.80 | 0.50 | 0.00 | 92.0 | 97.23 | 100.00 |
| $T_7$- Weedy check | 4.09 (15.73) | 6.89 (46.41) | 8.33 (68.47) | 6.40 | 18.09 | 27.34 | 0.00 | 0.00 | 0.00 |
| S.Em. ± | 0.028 | 0.031 | 0.067 | 0.089 | 0.192 | 0.312 | 1.39 | 1.00 | 1.04 |
| C.D. *(P=0.05)* | 0.087 | 0.097 | 0.206 | 0.273 | 0.593 | 0.962 | 4.27 | 3.09 | 3.20 |

** Figures in parentheses indicate original values are subjected to transformation (√X+1)*

**Table 4. Growth and yield attributes of soybean as influenced by different weed management practices**

| Treatments | Plant height at harvest | | | Number of branches/plant | | | No. of pods /plant | | | 100 seed weight (g) | | | Grain yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled |
| $T_1$- Sulfentrazone 39.6% SC @ 240 g *a.i.*/ha | 39.16 | 44.24 | 41.70 | 1.51 | 1.78 | 1.65 | 13.25 | 14.11 | 13.68 | 10.44 | 11.44 | 10.94 | 1445 | 1679 | 1562 |
| $T_2$- Sulfentrazone 39.6% SC @ 360 g *a.i.*/ha | 42.75 | 48.95 | 45.85 | 1.87 | 2.17 | 2.02 | 15.94 | 16.53 | 16.23 | 11.59 | 12.39 | 11.99 | 1685 | 1987 | 1836 |
| $T_3$- Sulfentrazone 39.6% SC @ 480 g *a.i.*/ha | 43.08 | 50.55 | 46.81 | 1.93 | 2.33 | 2.13 | 16.13 | 16.87 | 16.50 | 12.03 | 12.58 | 12.31 | 1696 | 1994 | 1845 |
| $T_4$- Authority XL @ 360 g *a.i.*/ha (Sulfentrazone 39.6% SC Market Sample) | 42.28 | 48.37 | 45.32 | 1.55 | 2.07 | 1.81 | 15.34 | 15.77 | 15.56 | 11.42 | 11.81 | 11.62 | 1649 | 1982 | 1816 |
| $T_5$- Pendimethalin 30% EC @ 1000 g *a.i.*/ha | 41.58 | 47.54 | 44.56 | 1.57 | 1.98 | 1.78 | 15.21 | 15.56 | 15.39 | 10.93 | 11.97 | 11.45 | 1432 | 1827 | 1630 |
| $T_6$- Hand weeding at 20 and 40DAS | 43.15 | 51.56 | 47.35 | 2.13 | 2.43 | 2.28 | 16.55 | 17.01 | 16.78 | 12.88 | 13.01 | 12.95 | 1781 | 2068 | 1925 |
| $T_7$- Weedy check | 35.48 | 41.54 | 38.51 | 1.33 | 1.53 | 1.43 | 10.54 | 11.64 | 11.09 | 9.86 | 10.76 | 10.31 | 962 | 984 | 973 |
| S.Em. ± | 1.19 | 1.35 | 1.12 | 0.08 | 0.07 | 0.08 | 0.76 | 0.57 | 0.62 | 0.47 | 0.48 | 0.47 | 74 | 77 | 73 |
| C.D. (*P=0.05*) | 3.66 | 4.16 | 3.45 | 0.24 | 0.23 | 0.23 | 2.35 | 1.75 | 1.90 | 1.44 | 1.47 | 1.45 | 227 | 236 | 225 |

**Table 5. Economics of soybean as influenced by different weed management practices**

| Treatments | Gross returns (Rs. ha$^{-1}$) | | | Cost of cultivation (Rs. ha$^{-1}$) | | | Net returns (Rs. ha$^{-1}$) | | | B:C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled |
| $T_1$- Sulfentrazone 39.6% SC @ 240 g *a.i.*/ha | 69360 | 87308 | 78334 | 20396 | 21397 | 20938 | 48880 | 65911 | 57396 | 2.39 | 3.08 | 2.73 |
| $T_2$- Sulfentrazone 39.6% SC @ 360 g *a.i.*/ha | 80880 | 103324 | 92102 | 20647 | 21649 | 21148 | 60233 | 81675 | 70954 | 2.92 | 3.77 | 3.34 |
| $T_3$- Sulfentrazone 39.6% SC @ 480 g *a.i.*/ha | 81408 | 103688 | 92548 | 20899 | 21896 | 21398 | 60509 | 81792 | 71151 | 2.90 | 3.74 | 3.32 |
| $T_4$- Authority XL @ 360 g *a.i.*/ha (Sulfentrazone 39.6% SC Market Sample) | 79152 | 103064 | 91108 | 20645 | 21641 | 21143 | 58507 | 81423 | 69965 | 2.83 | 3.76 | 3.30 |
| $T_5$- Pendimethalin 30% EC @ 1000 g *a.i.*/ha | 68736 | 95004 | 81870 | 20896 | 21898 | 21397 | 47840 | 73106 | 60473 | 2.29 | 3.34 | 2.81 |
| $T_6$- Hand weeding at 20 and 40DAS | 85488 | 107536 | 96512 | 22543 | 23544 | 23044 | 62945 | 83992 | 73469 | 2.79 | 3.57 | 3.18 |
| $T_7$- Weedy check | 46176 | 51185 | 48681 | 19451 | 20542 | 19997 | 26725 | 30643 | 28684 | 1.37 | 1.49 | 1.43 |
| S.Em. ± | 3536 | 3985 | 3661 | - | - | - | 3536 | 3985 | 3661 | 0.17 | 0.18 | 0.17 |
| C.D. (*P=0.05*) | 10896 | 12279 | 11279 | - | - | - | 10896 | 12279 | 11279 | 0.52 | 0.56 | 0.53 |

factor influencing variation. Furthermore, the increased soybean yield in the weed free check treatment could be attributed to improved yield components such as pod number per plant and seed weight per plant. This improvement was caused by an increase in growth parameters such as plant height and the number of branches per plant under weed-free conditions [5]. Adequate weed control during the critical period of crop-weed competition allowed for more efficient use of natural resources and applied inputs, particularly nutrients, which improved plant growth, accumulation of plant dry matter, and yield attributes. Sulfentrazone increased soybean yield compared to other treatments, which is consistent with the current study's findings [9-13].

### 3.4 Economics

In pooled data, weed-free plots had significantly higher gross and net returns (Rs. 96512 and Rs. 73469 $ha^{-1}$, *respectively*). Among the herbicide treatments, Sulfentrazone 39.6% SC @ 480 g *a.i.* $ha^{-1}$ (PRE) at 0-3 DAS produced significantly higher gross and net returns (Rs. 92548 and Rs.71151 $ha^{-1}$, *respectively*) than the other treatments (Table 5). It was found to be comparable to treatments receiving pre-emergent herbicides like Sulfentrazone 39.6% SC @ 360 g *a.i.* $ha^{-1}$ (Rs. 92386 and Rs.70954 $ha^{-1}$, *respectively*), Market sample (Rs. 91108 and Rs.69965$ha^{-1}$, respectively), and Pendimethalin 30% EC @ 1000 g *a.i.* $ha^{-1}$ (Rs. 81870 and Rs.60473$ha^{-1}$, *respectively*). In pooled data, weed-free plots had significantly higher gross and net returns (Rs. 96512 and Rs. 73469 $ha^{-1}$, *respectively*). Among the herbicide treatments, Sulfentrazone (39.6% SC @ 480 g *a.i.* $ha^{-1}$ (PRE) at 0-3 DAS) produced significantly higher gross and net returns (Rs. 92548 and Rs. 71151 $ha^{-1}$, r*espectively*) than the other treatments (Table 5). It was found to be comparable to treatments receiving pre-emergent herbicides like Sulfentrazone (39.6% SC @ 360 g *a.i.* $ha^{-1}$; Rs. 92386 and Rs. 70954 $ha^{-1}$, *respectively*), Market Sample (Rs. 91108 and Rs.69965 $ha^{-1}$, *respectively*), and Pendimethalin (30% EC @ 1000 g *a.i.* $ha^{-1}$; Rs. 81870 and Rs.60473 $ha^{-1}$, *respectively*).

Weed free check was recorded significantly higher in cost of cultivation (23044 Rs. $ha^{-1}$). It is important to note that keeping the land free of weeds throughout the crop growing season is practically impossible for farmers due to the high labour costs involved, even though it provides better weed management than herbicide treatment. Along with this, the availability of labour in the villages has significantly decreased as a result of migration to the cities, and finding the necessary labour force at a particular stage of crop growth is challenging due to the demand for one-time needs by many farmers. Even though there is a labour force available, the persistent rains during a specific crop growth period make the situation worse. Additionally, it has been discovered that weeds significantly reduce yields by the time they are removed. Application of Sulfentrazone 39.6% SC @ 360 g a.i. $ha^{-1}$ (PRE) at 0-3 DAS, which was on par with weed free check and was found to be the best method of weed management, is an alternative and affordable weed control method under these conditions [5].

## 4. CONCLUSION

The treatment hand weeding found best to control weeds in terms of both population density and dry biomass in soybean and recorded significantly higher soybean yield and it was on par with Sulfentrazone 39.6% SC @ 480 and 360 g *a.i*. $ha^{-1}$ (PRE). The highest BC ratio was found in Sulfentrazone 39.6% SC @ 360 g *a.i.* $ha^{-1}$ (PRE) and it is on par with Sulfentrazone 39.6% SC @ 480 g *a.i.* $ha^{-1}$ (PRE). On the basis of two years results it could be concluded that application of sulfentrazone 39.6% SC @ 360 g *a.i.* $ha^{-1}$ as pre emergent herbicide is advocated to the farmers in effective control of weeds.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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