Influence of weed management practices on soil microbial populations, soil nutrient status and biological yield of aerobic rice (Oryza sativa L.)

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Influence of weed management practices on soil microbial populations, soil nutrient status and biological yield of aerobic rice *(Oryza sativa L.)*

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Abstract
Herbicide application has become a major breakthrough in agricultural productivity in the whole world since its benefit has been overwhelming over the years. Nevertheless, its harmful impact on the non-target soil microorganisms which plays important role in organic matter decomposition, N and nutrient recycling. The herbicides used in rice grown under aerobic condition may affect the biological equilibrium of the soil and thus affect the nutrient status, health and productivity of the soil. To study the effect of herbicides on soil microbial population in aerobic rice cultivation, a field experiment was carried out at the Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, GKVK, Bengaluru during 2017 to study the effect of different weed management practices on soil microbial population, soil chemical properties, available soil nutrients and biological yield of aerobic rice. Eleven weed management treatments were attempted viz., stale seedbed techniques, different mulching practices, application of pre and post-emergence herbicides, intercultivation and hand weeding. The results showed that there was no ill effect from different weed management treatments on the soil microbial population viz., fungi, bacteria and actinomycetes after harvest of rice. The reduced weed density and dry weight in the superior treatments reduced the loss of nutrients from soil thus helped in improving the soil available nutrient status after harvest. All weed management practices in combination with herbicides registered markedly higher biological yield over the weedy check.

Introduction
Rice is the most important staple food crop for about half of the world’s population, supplying 20 per cent of calories consumed worldwide. By 2035, it is estimated to meet the global rice demand, about 114 MT to meet the rice requirement of increasing population (Kumar and Ladha, 2011). Due to the receding water table, increased costs of labour for transplanting of paddy and the adverse effects of puddling on soil health, aerobic rice system of cultivation known as direct-seeded rice (DSR) is gaining more popularity. But, weeds are the main constraints for farmers practicing aerobic rice cultivation. Hence, the use of herbicides both pre- and post-emergence is required for establishment of a good crop. An unintended consequence of application of herbicides may lead to significant changes in the populations of microorganisms and their activities thereby influencing
Weed management practices on microbial population
the microbial ecological balance in soil and affecting the productivity of soils. Generally, chemical
herbicides are not harmful when applied to soil at the recommended dosage, but some of them
may exhibit certain side effects on non-target organisms including micro-organisms due to their
persistence nature (Anoop et al., 2016). The increasing reliance on rice cultivation on herbicides
has led to concern about their eco-toxicological behaviour in the rice fields. Soil health and microbial
diversity have become vital issues for sustainable agricultural practices (Simerjeet et al., 2014).

Thus, the present investigation was undertaken to find out the impact of different weed
management practices on the soil microbial populations such as total bacteria, fungi and
actinomycetes.

Material and Methods

A field trial was initiated at ZARS, University of Agricultural Sciences, GKVK campus, Bengaluru during
2017 to study the effect of different weed management practices on soil microbial population,
available soil nutrients status and biological yield of aerobic rice. The experiment was designed
with RCBD with 11 treatments replicated thrice. The treatments are stale seedbed technique,
application of straw mulch (rice straw), live mulch with dhaincha, live mulch with horsegram, spray
of pre-mergence herbicides namely pendimethalin 30% EC and pyrazosulfuron ethyl 10% WP and
one early post-emergence herbicide bispyribac sodium 10% SC, intercultivation and hand-weeding
were also practiced and weedy-check as well. Rice seeds were sown directly by dibbling at the
rate of 7 kg ha⁻¹ by following 25 cm x 25 cm spacing. The aerobic rice variety used was MAS 946-1.
The knapsack sprayer fitted with a flat fan type nozzle (WFN 40) was used for herbicide application,
using a spray volume of 750 and 500 litres ha⁻¹ in pre- and post-emergence herbicide respectively.
The weedy check plot was kept undisturbed for the entire cropping period. The recommended
dose of FYM @ 10 t ha⁻¹ was applied 15 days prior to sowing and fertilizer dose of 100: 50: 50 kg
N, P₂O₅, K₂O ha⁻¹ was applied through urea, SSP and MoP, respectively. The 50 per cent of N was
applied as basal dose and the remaining 50 per cent was applied in two splits i.e., at tillering and
panicle initiation stage. Whereas, SSP and MOP fertilizers were applied as basal dose at the time
of sowing.

The composite soil was sampled before sowing and after harvesting of rice to analyse soil chemical
reactions, soil nutrient status and microbial populations. Four samples of soil under each treatment
were taken from 0-30 cm soil depth and mixed to have a representative sample of the treatment.
The viable microbial counts were analysed by standard dilution plating technique. The bacterial
population was estimated by counting colony growth on soil extract agar medium (James 1958
and Allen 1957). The fungal population was estimated by using Martin’s Rose Bengal agar medium
(Parkinson et al., 1971), the actinomycetes population was estimated by using Küster’s agar medium
(Wellingtonn & Toth, 1963 and Küster & Williams, 1964). After incubation under suitable conditions
for 3-8 days, the colonies were counted and the number of viable bacteria, fungi and actinomycetes were expressed as colony forming units (cfu) per gram of dry weight of soil.

Weed density and dry weight were recorded at 30, 60, 90 DAS and at harvest. Weed density was recorded in 0.5 m × 0.5 m quadrat randomly at one spot in each plot. Weeds were uprooted, washed with tap water, sun-dried, oven-dried at 65°C for 48 hours. After attaining the constant weight, the samples were weighed and expressed in grams per m². The plants from net plot were cut at two inches above the ground, sun-dried for three days and threshed. The grain and straw dry weight from the net plot was recorded and expressed as kg ha⁻¹. The square-root transformation of original data of weeds was done for statistical analysis, the statistical significance of the treatment effects on different parameters was determined for the least significant difference (LSD) at 5 % level using analysis of variance as described by Cochran and Cox (1957).

**Results and Discussion**

**General weed flora of the experimental field, weed density and weed dry weight:** The infestation by different weed groups was observed in the experimental site. The analysis of the relative proportion of monocots, dicots and sedges weeds to total weed counts in weedy check was worked out during the crop growth period. The density of monocot weed count was higher than that of sedges and dicot weeds. Among the monocot weeds: *Eragrostis pilosa*, *Eleusine indica*, *Echinochloa crus-galli*, *E*. *colona*, *Digitaria marginata*, *D. sanguinalis* and *Dactyloctenium aegyptium* were predominant. Among the dicot weeds: *Achyranthes aspera*, *Borreria hispida*, *Portulaca oleracea*, *Oldenlandia corymbosa*, *Commelina benghalensis*, *Acanthospermum hispidum*, *Cleome monophylla*, *C*. *gynandra*, *Ipomoea sepiaria*, *I*. *carnea*, *Sida cordifolia*, *Parthenium hysterophorus*, *Amaranthus viridis*, *Cassia tora* and *Crotalaria pallid* and *Cyperus rotundus* among sedges. All the treatments resulted in significant reduction in total weed density and total weed dry weight over the weedy check during the course of the field experiment (Table 1).

During the crop growth period, significantly lower total weed density and weed dry weight at 60 DAS (29.33 and 7.53 g m⁻²) and 90 DAS (36.00 and 24.20 g m⁻²) were found with stale seedbed technique fb bispyribac sodium 10 % SC at 30 ml a.i. ha⁻¹ as early PoE + one IC at 40 DAS, followed by straw mulch at 6 t ha⁻¹ fb bispyribac sodium 10 % SC at 30 ml a.i. ha⁻¹ as PoE at 60 DAS (33.33 and 8.51 g m⁻²) and 90 DAS (40.00 and 26.17 g m⁻²).

The significant reduction in total weed density and dry weight might have originated from the efficient control of the weeds at all stages of crop growth period. Nevertheless, significantly higher weed density, total dry weight of grasses, broad leaved and sedges weeds observed in a weedy check plot. The results are relatively similar to the findings of Nadeem *et al.*, 2011; Arun *et al.*, 2017, Praneeth *et al.*, 2017 and Nivetha *et al.*, 2017.
Biological yield and harvest index of rice as influenced by different weed management practices:
The highest biological yield (15930 kg ha\(^{-1}\)) was found in a stale seedbed technique \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as early PoE + one IC @ 40 DAS which was statistically at par with straw mulch at 6 t ha\(^{-1}\) \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as PoE (15854 kg ha\(^{-1}\)), pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha\(^{-1}\) as PE \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as early PoE (15820 kg ha\(^{-1}\)), pendimethalin 30 % EC @ 1.5 L ha\(^{-1}\) as PE \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as early PoE (15774 kg ha\(^{-1}\)) and pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha\(^{-1}\) as PE + one IC as per package of practice (15766 kg ha\(^{-1}\)). However, the least biological yield was found in weedy check (1360 kg ha\(^{-1}\)). Similarly, the lowest harvest index (0.35) was found in a weedy check while the highest harvest index (0.38) was recorded with stale seedbed technique \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as early PoE + one IC @ 40 DAS followed by pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha\(^{-1}\) as PE + one IC as per package of practice (0.38). The harvest index of rice paddy crop was not significantly different among different weed management treatments (Table 1). Increased biological yield parameter and harvest index in these practices might be due to the lesser crop weed competition, better soil microbial activity which were resultant to the better growth, yield and yield attributes of rice (Ahmed \(et\ al\). 2015; Praneeth \(et\ al\). 2017; Arun \(et\ al\). 2017 and Nadeem \(et\ al\). 2011).

Effect of herbicide residues on soil microbial population: The impact of different weed management practices on soil microbial population was determined by standard dilution plating technique. There were no significant differences in the initial population of bacteria. However, slight significant differences were observed in the initial populations of fungi and actinomycetes in different treatments (Table 2).

Till the time of harvest of the crop, the microbial populations within all the weed management practices attained the level which was superior to the original level of population in all the treatments. The trend was similar with bacteria, fungi and actinomycetes. This indicates that, there were no long-term adverse effects of tested herbicides on the beneficial soil microbial populations. Nevertheless, a higher number of bacteria was found in live mulch with dhaincha @ 25 kg ha\(^{-1}\) (58.67 CFU x 10\(^5\) g\(^{-1}\) soil) which was at par with straw mulch @ 6 t ha\(^{-1}\) \(fb\) bispyribac sodium 10 % SC @ 30 ml a.i. ha\(^{-1}\) as PoE (58.33 CFU x 10\(^5\) g\(^{-1}\) soil) and live mulch with horsegram @ 30 kg ha\(^{-1}\) (58.33 CFU x 10\(^5\) g\(^{-1}\) soil). A similar trend was also observed with fungi and actinomycetes populations (Table 2).

The present findings of the research are in confirmation with the reports of Ghosh \(et\ al\). (2012) and Bera \(et\ al\). (2013) who have reported that microorganisms are able to degrade herbicides and utilize them as a source of biogenic elements for their own physiological processes. However, before degradation, herbicides have toxic effects on microorganisms, reducing their abundance, activity and consequently the diversity of their communities. The toxic effects of herbicides are normally
more severe immediately after application. Later on, microorganisms take part in a degradation process and then degrade the organic herbicides molecules that serve as carbon source for multiplication of microorganisms in the rhizosphere.

Besides, it is also revealed that the herbicide application to soil causes transient impacts on the growth soil microorganisms when applied at recommended field application rate (Adhikary et al., 2014; Michael et al., 2016 and Shashank et al., 2018).

**Soil chemical properties and status of available soil nutrients after harvest of rice:** The soil pH was within the range of 6.76 to 7.18. The electrical conductivity (0.28-0.34 dSm$^{-1}$) and organic carbon (0.47-0.56 %) were found to be non-significant after harvest of aerobic rice.

Among the various weed management practices, significantly lower soil available nitrogen (271.00 kg ha$^{-1}$), available phosphorus (18.33 kg ha$^{-1}$) and available potassium (133.67 kg ha$^{-1}$) were found in weedy check plots after the harvest of paddy compared to all other treatments. The higher density of weeds in this treatment resulted in weeds ability to grow much faster and denser than rice crop also, removing much of the nutrients from soil. It is obviously indicated that reducing the weed density is much important to retain soil fertility.

Significantly, higher soil available nitrogen (315.67 kg ha$^{-1}$) was found in stale seedbed technique $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE + one IC @ 40 DAS and was on par with pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE (315.33 kg ha$^{-1}$), pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE + one IC as per package of practice (PoP) (314.67 kg ha$^{-1}$) and straw mulch @ 6 t ha$^{-1}$ $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as PoE(314.33 kg ha$^{-1}$).

The higher amount of soil available phosphorus (30.67 kg ha$^{-1}$) was found to be significantly superior in stale seedbed technique $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE + one IC @ 40 DAS and was found to be on par with straw mulch @ 6 t ha$^{-1}$ $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as PoE(30.33 kg ha$^{-1}$), pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE (30.00 kg ha$^{-1}$) and pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE + one IC as per package of practice (PoP) (29.67 kg ha$^{-1}$).

Soil available potassium varied significantly among the various weed management practices. Stale seed bed technique $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE + one IC @ 40 DAS recorded significantly higher amount of available potassium (194.33 kg ha$^{-1}$). However, it was on par with straw mulch @ 6 t ha$^{-1}$ $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as PoE (192.67 kg ha$^{-1}$), application of pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE $f$bbispyribac sodium 10 % SC @ 30 ml a.i. ha$^{-1}$ as early PoE (191.67 kg ha$^{-1}$) and pyrazosulfuron ethyl 10 % WP @ 35 g a.i. ha$^{-1}$ as PE + one IC as per package of practice (PoP) (189.00 kg ha$^{-1}$) (Table 3).
The reduced weed flora in these treatments also reduced the loss of nutrients from soil thus helped to improve soil available nutrient status. The results of this research are in confirmation with the findings of Sudhalakshmi et al. (2006); Sarwar et al. (2008) and Mizuhiko, (2016).

**Conclusion**

The outcome of this research indicated that application of stale seedbed technique *fb* bispyribac sodium 10 % SC @ 30 ml a.i. ha⁻¹ as early PoE + one IC @ 40 DAS was found to be superior in increasing the biological yield of rice, reducing the weed density and weed dry weight which increased the competitive ability of rice crop to suppress the weeds and also maintaining the microbial population and nutrient status in the soil.

**Acknowledgment**

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**References**


Table 1: Total weed density (no.), weight (g m⁻²) at different stages, Biological yield and Harvest Index in rice as influenced by weed management practices

<table>
<thead>
<tr>
<th>Weed management practices</th>
<th>GODAS</th>
<th>JODAS</th>
<th>Biological yield (kg ha⁻¹)</th>
<th>Harvest Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weed density</td>
<td>Weed dry weight</td>
<td>Weed density</td>
<td>Weed dry weight</td>
</tr>
<tr>
<td>Stale seedbed technique &amp; two C @ 15 and 30 DAS</td>
<td>7.30 (62.57)</td>
<td>5.37 (28.53)</td>
<td>9.11 (82.67)</td>
<td>6.55 (42.44)</td>
</tr>
<tr>
<td>Stale seedbed technique &amp; sprybac sodium 10% SC @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>8.37 (30.57)</td>
<td>2.53 (26.33)</td>
<td>9.54 (92.67)</td>
<td>6.89 (48.41)</td>
</tr>
<tr>
<td>Stale seedbed technique &amp; sprybac sodium 10% SC @ 20 ml a.i. ha⁻¹ as early PoE</td>
<td>5.42 (29.53)</td>
<td>2.83 (7.58)</td>
<td>6.06 (36.53)</td>
<td>4.27 (24.20)</td>
</tr>
<tr>
<td>Straw mulch @ 6 t ha⁻¹, d, sparybac sodium 10% SC @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>5.31 (33.53)</td>
<td>2.59 (8.51)</td>
<td>6.50 (40.50)</td>
<td>5.16 (26.17)</td>
</tr>
<tr>
<td>Urea mulch @ 25 kg ha⁻¹</td>
<td>9.34 (60.57)</td>
<td>6.08 (36.49)</td>
<td>10.11 (108.06)</td>
<td>7.11 (53.07)</td>
</tr>
<tr>
<td>Live mulch with horsegram @ 10 kg ha⁻¹</td>
<td>8.33 (43.57)</td>
<td>5.84 (23.75)</td>
<td>8.44 (76.00)</td>
<td>7.12 (50.23)</td>
</tr>
<tr>
<td>P: rhizobin 30% EC @ 1.5 t ha⁻¹ as PE, &amp; sparybac sodium 10% SC @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>7.15 (60.57)</td>
<td>3.19 (9.69)</td>
<td>7.60 (57.33)</td>
<td>5.25 (27.14)</td>
</tr>
<tr>
<td>P: pyracetone ethyl 10% WP @ 3 g a.i. ha⁻¹ as PE &amp; sparybac sodium 10% SC @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>6.36 (40.00)</td>
<td>3.08 (9.03)</td>
<td>6.79 (46.67)</td>
<td>5.13 (26.84)</td>
</tr>
<tr>
<td>Pyracetone, or et al. 10% WP @ 35 g a.i. ha⁻¹ as PoE – one IC as per package of practice</td>
<td>7.72 (52.00)</td>
<td>3.30 (10.40)</td>
<td>8.12 (66.67)</td>
<td>5.41 (28.60)</td>
</tr>
<tr>
<td>Weed free</td>
<td>0.71 (0.39)</td>
<td>0.77 (0.03)</td>
<td>0.71 (0.03)</td>
<td>0.71 (0.03)</td>
</tr>
<tr>
<td>Weed check</td>
<td>20.16 (141.00)</td>
<td>5.73 (35.22)</td>
<td>22.27 (205.13)</td>
<td>15.78 (281.56)</td>
</tr>
<tr>
<td>S: Em.1</td>
<td>0.15</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>S: CD + 5%</td>
<td>0.45</td>
<td>0.24</td>
<td>3.42</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Values in parentheses are original values; data analyzed using transformation -√x + 0.5.
Table 2: Soil microbial populations in rice field as influenced by weed management practices.

<table>
<thead>
<tr>
<th>Weed management practices</th>
<th>Before sowing</th>
<th></th>
<th></th>
<th>After harvest</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacteria (CFUx10^9 g^-1 soil)</td>
<td>Fungi (CFUx10^8 g^-1 soil)</td>
<td>Actinomycetis (CFUx10^7 g^-1 soil)</td>
<td>Bacteria (CFUx10^9 g^-1 soil)</td>
<td>Fungi (CFUx10^8 g^-1 soil)</td>
<td>Actinomycetis (CFUx10^7 g^-1 soil)</td>
</tr>
<tr>
<td>T1: Stake and kill technique followed by GR880AS</td>
<td>51.33</td>
<td>21.00</td>
<td>15.00</td>
<td>36.67</td>
<td>24.33</td>
<td>16.67</td>
</tr>
<tr>
<td>T2: Stalk and kill technique followed by GR880AS</td>
<td>51.57</td>
<td>20.00</td>
<td>15.33</td>
<td>35.33</td>
<td>23.33</td>
<td>16.33</td>
</tr>
<tr>
<td>T3: Stalk and kill technique followed by GR880AS &amp; early post-emergence spray</td>
<td>49.30</td>
<td>19.67</td>
<td>16.33</td>
<td>35.67</td>
<td>24.07</td>
<td>16.67</td>
</tr>
<tr>
<td>T4: Straw mulch @ 5 m3 ha^-1 &amp; GR880AS</td>
<td>51.57</td>
<td>20.00</td>
<td>15.00</td>
<td>38.33</td>
<td>25.67</td>
<td>16.67</td>
</tr>
<tr>
<td>T5: Straw mulch and Bhainicha @ 25 g ha^-1</td>
<td>51.00</td>
<td>20.53</td>
<td>14.00</td>
<td>38.67</td>
<td>25.00</td>
<td>15.67</td>
</tr>
<tr>
<td>T6: Straw mulch with Homogemn @ 50 ghs</td>
<td>49.57</td>
<td>21.53</td>
<td>15.00</td>
<td>38.33</td>
<td>25.33</td>
<td>15.67</td>
</tr>
<tr>
<td>T7: Pardodermix @ 1.5 L ha^-1 as PE fb. Bipyridylic acid @ 30%SC @ 1C mla ha^-1 early PE</td>
<td>50.33</td>
<td>39.33</td>
<td>15.33</td>
<td>36.00</td>
<td>24.00</td>
<td>18.00</td>
</tr>
<tr>
<td>T8: Pyraform @ 10%WPE @ 15 g ha^-1 CE fb. Bipyridylic acid @ 30%SC @ 1C mla ha^-1 early PE</td>
<td>50.20</td>
<td>20.67</td>
<td>14.33</td>
<td>36.33</td>
<td>24.33</td>
<td>18.33</td>
</tr>
<tr>
<td>T9: Prebait formic acid @ 35 g ml ha^-1 of 70%WPE</td>
<td>51.00</td>
<td>20.67</td>
<td>14.00</td>
<td>36.67</td>
<td>24.67</td>
<td>16.67</td>
</tr>
<tr>
<td>T10: Weed Free</td>
<td>51.33</td>
<td>20.00</td>
<td>16.00</td>
<td>38.67</td>
<td>25.00</td>
<td>15.67</td>
</tr>
<tr>
<td>T11: Weedy - check</td>
<td>51.30</td>
<td>20.67</td>
<td>15.33</td>
<td>35.00</td>
<td>24.00</td>
<td>15.67</td>
</tr>
<tr>
<td>S. Empt</td>
<td>0.31</td>
<td>0.33</td>
<td>1.10</td>
<td>0.56</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>CDI @ 5%</td>
<td>0.35</td>
<td>0.91</td>
<td>0.97</td>
<td>3.25</td>
<td>0.56</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Table 3: Soil chemical properties & available soil nutrient status as influenced by weed management practices after harvesting aerobic rice.

<table>
<thead>
<tr>
<th>Weed management practices</th>
<th>pH</th>
<th>EC (dS m⁻¹)</th>
<th>OC (%)</th>
<th>Nitrogen (kg ha⁻¹)</th>
<th>P₂O₅ (kg ha⁻¹)</th>
<th>K₂O (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁: Straw mulch with Dhaincha @ 25 kg ha⁻¹</td>
<td>7.18</td>
<td>0.32</td>
<td>0.55</td>
<td>331.57</td>
<td>24.57</td>
<td>175.40</td>
</tr>
<tr>
<td>T₂: Live mulch with Horsegram @ 50 kg ha⁻¹</td>
<td>7.18</td>
<td>0.29</td>
<td>0.56</td>
<td>333.57</td>
<td>25.33</td>
<td>175.33</td>
</tr>
<tr>
<td>T₃: Preemergent @ 1.5 kg ha⁻¹ as PE + Bipyridyl sodium @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>5.84</td>
<td>0.32</td>
<td>0.47</td>
<td>311.57</td>
<td>29.33</td>
<td>187.00</td>
</tr>
<tr>
<td>T₄: Pyrazosulfuron ethyl 10% WP @ 35 g a.i. ha⁻¹ as PE + Bipyridyl sodium @ 30 ml a.i. ha⁻¹ as early PoE</td>
<td>5.87</td>
<td>0.28</td>
<td>0.46</td>
<td>315.33</td>
<td>30.00</td>
<td>192.67</td>
</tr>
<tr>
<td>T₅: Pyrazosulfuron ethyl 10% WP @ 35 g a.i. ha⁻¹ as PE + one IC as per package of practice (PoF)</td>
<td>5.93</td>
<td>0.31</td>
<td>0.48</td>
<td>314.57</td>
<td>29.57</td>
<td>189.00</td>
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<td>T₆: Weed Free</td>
<td>7.26</td>
<td>0.34</td>
<td>0.56</td>
<td>317.33</td>
<td>32.00</td>
<td>197.33</td>
</tr>
<tr>
<td>T₇: Weedy check</td>
<td>7.12</td>
<td>0.33</td>
<td>0.54</td>
<td>221.00</td>
<td>18.33</td>
<td>138.67</td>
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<tr>
<td>5% Em.</td>
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<tr>
<td>C₀ @ 5%</td>
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<tr>
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Note: NS indicates that the values are not significant.