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Effect of Early Post Emergent Herbicides/ Herbicide Mixtures on Weed Control and Soil Biological Activity in Maize L

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A B S T R A C T

A field experiment was conducted to study the effect of herbicides on weed control and soil microbial activity. The experiment consisted of 12 treatments laid out RCBD. The treatments consisted of herbicides *viz*., atrazine, 2,4-D, tembotrione, topramezone and their tank mixtures sprayed at 16 DAS as early post emergent herbicides, they were checked against recommended weed management practice- atrazine 1.25 kg ha^{-1} (PRE) + 1HW + 1IC, sequential application-atrazine (PRE) *fb* 2,4-D,Weed free and weedy check. The results indicated that significantly lower weed density (7.67 per 0.5 m^{2}), Weed index (7.07 %) was observed with application of topramezone + 2,4-D next to recommended weed management practices. The next best treatment was tembotrione + 2,4-D. The mixtures recorded broad spectrum weed control than sole application of herbicides. Higher biological activity with respect to dehydrogenase activity (8.70 μg TPF g^{-1} soil day^{-1}) was observed in topramezone + 2,4-D. Higher grain yield (5582 kg ha^{-1}) and net returns (53769 □ ha^{-1}) was recorded in topramezone + 2,4-D next to recommended weed management practice. However weedy check was inferior to all other treatments.

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice. The main constraint to production is problem of weed control. Weeds are among the most harmful pests, reducing crop yields, impairing the quality of crop production and causing technical problems during harvests (Oerke, 2006). They can also host other pests such as crop pathogens for example take-all disease of cereals, (Gutteridge *et al.*, 2006). They compete for nutrients, moisture, light, space, harbor many pest and diseases, and eventually affect the growth, yield and quality of crop adversely. Sharma and Thakur (1996) gave a rough estimation on crop-weed competition and noticed 33-50 per cent yield reduction due to weed infestation. Furthermore, high weed infestation increases the cost of cultivation, lowers value of land, and reduces the returns of corn producers. In order to realize the yield potential of corn, weed management becomes indispensable. Weed species infesting the corn crop are a function of complex interactions among soil characteristics, climate, and cultural practices.

The conventional methods of weed control are the age old practices to control weeds. However, these methods are slow, labour consuming and impractical during bad weather. Besides, the labour for weeding during peak periods of cultural operations is not only costly but their availability becomes a problem resulting in delayed weeding and yield loss. In many instances the weed flourishes even after critical period of crop-weed competition and many times it is difficult to control these weeds due to incessant rains by cultural operations. Besides, manual weeding is also difficult under the circumstances of non-availability, inefficient and costly labour. This is especially true when sowing is in progress. Even farmers are unable to complete sowing operation in time due to non availability of labour. Application of pre-emergent herbicides soon after sowing is a remote chance. In order to control the weeds for longer period of the crop growth, there is need for early post-emergent herbicides especially herbicide mixtures for broad spectrum weed control.

Soil enzymes play key biochemical functions in the overall process of organic matter decomposition, nutrient mineralization and transportation in the soil system. The dehydrogenase enzyme activity is commonly used as an indicator of biological activity in soils (Burns, 1978). This enzyme is considered to exist as an integral part of intact cells but does not accumulate extra cellular in the soil. Dehydrogenase enzyme is known to oxidize soil organic matter by transferring protons and electrons from substrates to acceptors. These processes are part of respiration pathways of soil microorganisms and studies on the activities of dehydrogenase enzyme in the soil is very important as it may give indications of the potential of the soil to support biochemical processes which are essential for maintaining soil fertility. Additionally, dehydrogenase enzyme is often used as a measure of any disruption caused by pesticides, trace elements or management practices to the soil (Frank and Malkomes, 1993), as well as a direct measure of soil microbial activity. Generally, higher activities of dehydrogenase have been reported at low doses of pesticides and lower activities of the enzyme at higher doses of pesticides (Baruah and Mishra, 1984).

Materials and Methods

The soil of the experimental site was medium deep black clay soil with pH 7.3. The experiment consisted of 12 treatments laid out in Randomized Complete Block Design. The treatments were T_1-atrazine 1 kg ha^{-1}, T_2-topramezone 25 g ha^{-1}, T_3-2,4-D 1 kg ha^{-1}, T_4-tembotrione 100 g ha^{-1} and their tank mixtures with half of their dosage *i.e.*, T_5-topramezone 12.5 g ha^{-1} + atrazine 500 g ha^{-1}, T_6-topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1}, T_7-tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} and T_8-tembotrione 50 g ha^{-1} + 2,4-D 500 g ha^{-1}, T_9-sequential application of atrazine 1 kg ha^{-1} (PRE) *fb* 2,4-D 500 g ha^{-1} (POST). These treatments were checked against T_{10}-recommended weed management practice *i.e.*, atrazine 1.25 kg ha^{-1} + 1 IC + 1 HW, T_{11}-weed free and T_{12}-weedy check (PRE: Pre – emergent herbicide IC: Intercultivation HW: Hand weeding DAS: Days after sowing RPP: Recommended weed management practice POST: Post - emergent herbicide 2 - 3 leaf stage of weed: 16 DAS).

Weed density was observed at 60 DAS. The number of weeds present in 0.5 m² area in each plot was counted. A quadrant of 0.25 m^2 (0.5 m × 0.5 m) was thrown in a plot at two spots randomly and number of weeds in these quadrants was counted. These weeds were further classified into sedges, grasses and broad-leaf weeds and their population was recorded.

Grain yield of the crop was recorded at harvest. Based on the total yield, weed index was calculated.

Weed index is the reduction in crop yield due to the presence of weeds in comparison with weed free plot expressed as percentage.

$$\text{Weed index (\%)} = \frac{X - Y}{X} \times 100$$

Where,
X = Total yield from the weed free plot
Y = Total yield from the treatment for which weed index has to be calculated.

Economics is calculated in terms of net returns expressed in Indian rupees.

Soil biological activity estimated using dehydrogenase test. Dehydrogenase activity in the soil samples was determined as per the procedure as described by Casida *et al.*, (1964). For this study, soil samples were collected after 7, 14, 21 and 50 days after herbicide spray.

Results and Discussion

Different weed management treatments significantly influenced weed density (grasses, sedges and BLWs) at 60 DAS (Table 1).

Grassy weeds; Significantly lower number of grassy weeds was recorded in recommended weed management practice *viz*., atrazine 1.25 kg ha^{-1} + IC + HW (2.00 0.5 m^{-2}) and with sequential application of atrazine 1 kg ha^{-1} *fb* 2,4-D 500 g ha^{-1} (2.67 0.5 m^{-2}). The treatments receiving tank mixtures topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} (3.00 0.5 m^{-2}) was on par with tembotrione g ha^{-1} + 500 g ha^{-1} (3.33 0.5 m^{-2}), tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (3.33 0.5 m^{-2}), but these two treatments were significantly superior over application of atrazine 1.00 kg ha^{-1} alone and 2,4-D 1 kg ha^{-1} alone (4.33 and 5.7 0.5 m^{-2}, respectively). However, sole application of topramezone 25 g ha^{-1} or tembotrione 100 g ha^{-1} gave good control of grassy weeds similar to tank mixtures (3.33, 3.33 0.5 m^{-2}, respectively).

Sedges; Significantly lower number of sedges was recorded in topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} (2.67 0.5 m^{-2}) which was on par with other mixtures, tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (3.00 0.5 m^{-2}), tembotrione 50 g ha^{-1} + 2,4-D 500 g ha^{-1} (2.67 0.5m^{-2}) and sole application of 2,4-D 1 kg ha^{-1} (3.00 0.5 m^{-2}), and recommended weed management practice *i.e.*, atrazine 1.25 kg ha^{-1} + 1IC + 1HW (2.33 0.5 m^{-2}). The sequential application of atrazine 1 kg *fb* 2,4-D 500 g ha^{-1} (3.67 0.5 m^{-2}) and it was on par with topramezone 12.5 g ha^{-1} + atrazine 500 g ha^{-1} (4.33 0.5 m^{-2}), topramezone 25 g ha^{-1} alone (4.00 0.5 m^{-2}), and tembotrione 100 g ha^{-1} alone (4.00 0.5 m^{-2}).

BLWs; Significantly lower number of BLWs was recorded in recommended weed management practice *viz*., atrazine 1.25 kgha^{-1} + IC + HW (1.33 0.5 m^{-2}), closely followed by application of tank mixture topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} (2.00 0.5 m^{-2}) which was on par with topramezone 12.5 g ha^{-1} + atrazine 500 g ha^{-1} (2.33 0.5 m^{-2}), tembotrione g ha^{-1} + 2,4-D 500 g ha^{-1} (2.33 0.5 m^{-2}), tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (2.33 0.5 m^{-2}) and sequential application of atrazine 1 kg ha^{-1} *fb* 2,4-D 500 g ha^{-1} (2.00 0.5 m^{-2}) but these treatments were significantly superior over application of atrazine 1 kg ha^{-1} alone, tembotrione 100 gha^{-1} alone and topramezone alone 25 g ha^{-1} (3.33,3.33 and 3.00 0.5 m^{-2}, respectively). However, sole application of 2,4-D gave good control of BLWs (2.33 0.5 m^{-2}).

Total weed density was nil in weed free (0.00/0.5 m^{2}) compared to all other treatments. Significantly lower weed density was observed in recommended weed management practice *i.e.,* atrazine 1.25 kg ha^{-1} + IC + HW (5.67 0.5 m^{-2}). The next best treatments was topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} (7.67 0.5 m^{-2}) and which was significantly superior over topramezone 12.5 g ha^{-1} alone (10.33 0.5 m^{-2}), atrazine 1.25 kg ha^{-1} alone (12.67 0.5 m^{-2}), 2,4-D 1 kg ha^{-1} alone (11.00 0.5 m^{-2}) and on par with the other tank mixtures. The total weed density was significantly higher with weedy check (28.00 0.5 m^{-2}).

Grain yield of maize was significantly influenced by different weed management treatments (Table 2). Weed free treatment recorded higher grain yield compared to all other treatments (6,032 kg ha^{-1}). Significantly higher grain yield was recorded with recommended weed management practice *i.e.*, atrazine 1.25 kg ha^{-1} + IC + HW (5,789 kg ha^{-1}) and Tank mixtures topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} (5,582 kg ha^{-1}). The next best treatments were tembotrione 50 g ha^{-1} + 2,4-D 500 g ha^{-1} (5,451 kg ha^{-1}), tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (5,310 kg ha^{-1}) and topramezone 12.5 g ha^{-1} + atrazine 500 g ha^{-1} (5,061 kg ha^{-1}). These treatments recorded significantly higher grain yield compared to topramezone alone (4,494 kg ha^{-1}), 2,4-D alone (4,298 kg ha^{-1}) and (4,455 kg ha^{-1}) respectively. Grain yield of maize was significantly lower in weedy check (3,630 kg ha^{-1}) compared to rest of the treatments. The weed index (Table 2) was significantly lower with treatments receiving atrazine 1.25 kg ha^{-1} + IC + HW 30 DAS (4.03 %) The next best treatment was topramezone 12.5 g ha^{-1} + 2,4-D g ha^{-1} (7.07 %) on par with tembotrione 50 g ha^{-1} + 2,4-D 500 g ha^{-1} (9.5 %) and sequential application of atrazine *fb* 2,4-D (8.25 %). The weed index was significantly higher with weedy check (39.8 %).

Dehydrogenase activity recorded at 7 DAH showed that there was decrease in dehydrogenase activity in all the treatments. Significantly higher dehydrogenase activity was observed in weed free and weedy check (4.28 and 4.26 □ g of TPF formedg^{-1} soil day^{-1}, respectively), followed by application of tank-mixtures topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} and tembotrione 50 g ha^{-1} + 2,4-D g ha^{-1} 500 g ha^{-1} (3.34 and 3.13 □ g of TPF formed g^{-1} soil day^{-1}, respectively). The lower dehydrogenase activity was recorded in atrazine @ 1 kg ha^{-1} (1.60 □ g of TPF formed g^{-1} soil day^{-1}) which was significantly lower compared to all other treatments.

After 14 DAH, application of tank-mixtures topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} and tembotrione atrazine 500 g ha^{-1} (4.59 and 4.57 □ g of TPF formed g^{-1} soil day^{-1}, respectively) recorded significantly higher dehydrogenase activity which was on par weed free and weedy check (5.38,5.56 □ g of TPF formed g^{-1} soil day^{-1}). The lowest dehydrogenase activity was recorded in 2,4-D 1.0 kg ha^{-1} (3.16 □ g of TPF formed g^{-1} soil day^{-1}) and atrazine 1 kg ha^{-1} *fb* 2,4-D 3.29 (2.22 □ g of TPF formed g^{-1} soil day^{-1}) compared to all other treatments. However tank mixtures recorded higher dehydrogenase activity than sole application of atrazine or topramezone or tembotrione or 2,4-D. At 21 DAH, weed free and weedy check recorded higher dehydrogenase activity compared to all other treatments (5.88 and 5.99 □ g of TPF formed g^{-1} soil day^{-1}, respectively). It was closely followed by the application of topramezone 12.5 g ha^{-1} + 2,4-D 500 g ha^{-1} and tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (4.96 and 4.95 □ g of TPF formed g^{-1} soil day^{-1}, respectively) which were on par with each other.

At 50 DAH significant increases in dehydrogenase activity in all the treatments was observed. Significantly higher dehydrogenase activity was found in tank mixture topramezone 12.5 g ha^{-1} + 2,4-D, topramezone + atrazine (8.70 and 8.56 □ g of TPF formed g^{-1} soil day^{-1}, respectively) was on par with weed free and weedy check (8.80 and 9.15 □ g of TPF formed g^{-1} soil day^{-1}, respectively). Significantly lower activity was recorded in sequential application of atrazine *fb* 2,4-D.

Net returns were significantly higher with recommended weed management practice (`55,466 $ha^{-1}$). It was on par with topramezone 12.5 g $ha^{-1}$ + 2,4-D 500 g $ha^{-1}$ (` 55,3769 ha^{-1}), weed free check (` 56,203 $ha^{-1}$) (Table 2). Significantly lower net return was obtained with 2,4-D 500 g $ha^{-1}$ alone (` 38,036 ha^{-1}) and weedy check(` 29,816 ha^{-1}).

Effect of herbicides on weed density, grain yield, weed index

The treatments receiving herbicide mixtures *viz.* topramezone + 2,4-D was significantly superior in terms of weed density (Table 1) over all other herbicide treatments next to recommended weed management practice and weed free condition. All tank mixtures *viz.*, topramezone + atrazine, tembotrione + 2,4-D and tembotrione + atrazine performed better than application of topramezone alone or atrazine alone or 2,4-D alone at 60 DAS. This is due to broad spectrum weed control achieved through herbicide mixtures controlling both grasses and BLWs. In tank mixture topramezone + 2,4-D, topramezone is effective against grassy weeds and BLWs whereas, 2,4-D is effective in controlling BLWs. Similarly in the herbicide mixture topramezone + atrazine, topramezone controls grassy weeds and BLWs effectively and atrazine controls BLWs effectively. In the treatment receiving herbicide mixture tembotrione + 2,4-D has also similar effect on grasses and BLWs, respectively. Hence in the treatments receiving herbicide mixtures *viz.*, topramezone + atrazine, tembotrione + 2,4-D, tembotrione + atrazine and topramezone + 2,4-D, the weed density and total dry weight of weeds was significantly lower.

The herbicide mixture of topramezone + 2,4-D was very effective in controlling the weeds and more interestingly, it was comparable with recommended weed management practice (atrazine + HW + IC), that too with 50 per cent of their recommended doses. Weed free check which received hand weeding at regular intervals, indicated that complete weed control was possible only by local methods (hand weeding). However, this will neither be economical nor possible under scarcity of labour. These results are in conformity with the findings of Hawaldar *et al.*, (2012), and Nadiger *et al.*, (2013).

The value of WI generally does not have a definite range. Weedy check will have the highest value since its yield is likely to be the lowest. In the present investigation, the effective control of weed topramezone + 2,4-D, is due to the fact that topramezone as early post-emergent application controlled all the weeds, particularly grasses and to some extent on BLWs. Whereas, 2,4-D being a post-emergent herbicide controls BLWs effectively and has effect on sedge (*Cyperus rotundus*) also to some extent. Due to broad spectrum weed control, the herbicide mixture topramezone + 2,4-D was able to keep the maize crop free of weeds for a substantial period of time especially during critical crop-weed competition period. WI of Topramezone + 2,4-D (7.07 %) and it was on par with recommended weed management practice *i.e.*, atrazine 1.25 kg ha^{-1} + IC + HW(4.03 %) as timely operations were taken up. The maize crop was weed free in the critical period of crop-weed competition. Subsequently, the weeds were smothered by maize crop during its grand growth stage. By this, the weeds were eliminated for quite long period of time including the critical period. Added to this, there was broad spectrum weed control through herbicide mixture. Because of significantly lower weed density, the grain yields in maize were significantly higher in the herbicide mixtures.

Grain yield of maize differed significantly among various weed management treatments (Table 2). The significantly higher grain yield of maize in topramezone + 2,4-D (5,582 kg ha^{-1}) atrazine 1.25 kg ha^{-1} + IC + HW, sequential application other tank mixtures was mainly due to minimum crop-weed competition throughout the crop growth period which is evident from significantly lower weed density and weed index.

Table.1 Weed density (number of weeds) as influenced by herbicides in maize

Treatments	Weed density (No. 0.5 m^{-2}) at 60DAS			Total number of weeds (No. 0.5 m^{-2}) at 60 DAS
	Grasses	Sedges	Broad leaved weeds	
T_1	60 DAS	2.34 (5.00)	1.96 (3.33)	60 DAS
T_2	2.20 (4.33)	2.12 (4.00)	1.87 (3.00)	3.62 (12.67)
T_3	1.94 (3.33)	1.87 (3.00)	1.68 (2.33)	3.29 (10.33)
T_4	2.48 (5.67)	2.11 (4.00)	1.96 (3.33)	3.40 (11.00)
T_5	1.95 (3.33)	2.20 (4.33)	1.68 (2.33)	3.34 (10.67)
T_6	2.20 (4.33)	1.77 (2.67)	1.58 (2.00)	3.40 (11.00)
T_7	1.87 (3.00)	1.87 (3.00)	1.68 (2.33)	2.86 (7.67)
T_8	1.95 (3.33)	1.78 (2.67)	1.68 (2.33)	3.03 (8.67)
T_9	1.95 (3.33)	2.04 (3.67)	1.58 (2.00)	2.97 (8.33)
T_{10}	1.77 (2.67)	1.68 (2.33)	1.35 (1.33)	2.97 (8.33)
T_{11}	1.58 (2.00)	0.71 (0.00)	0.71 (0.00)	2.48 (5.67)
T_{12}	0.71 (0.00)	3.19 (9.67)	2.97 (8.33)	0.71 (0.00)
S.Em. ±	3.24 (10.00)	0.08	0.07	5.34 (28.0)
C.D. (P=0.05)	0.09	0.24	0.20	0.07

*Transformed values $\sqrt{(x + 0.5)}$, figures in the parenthesis indicate original values.

Table.2 Grain yield, weed index and net returns as affected by herbicides in maize

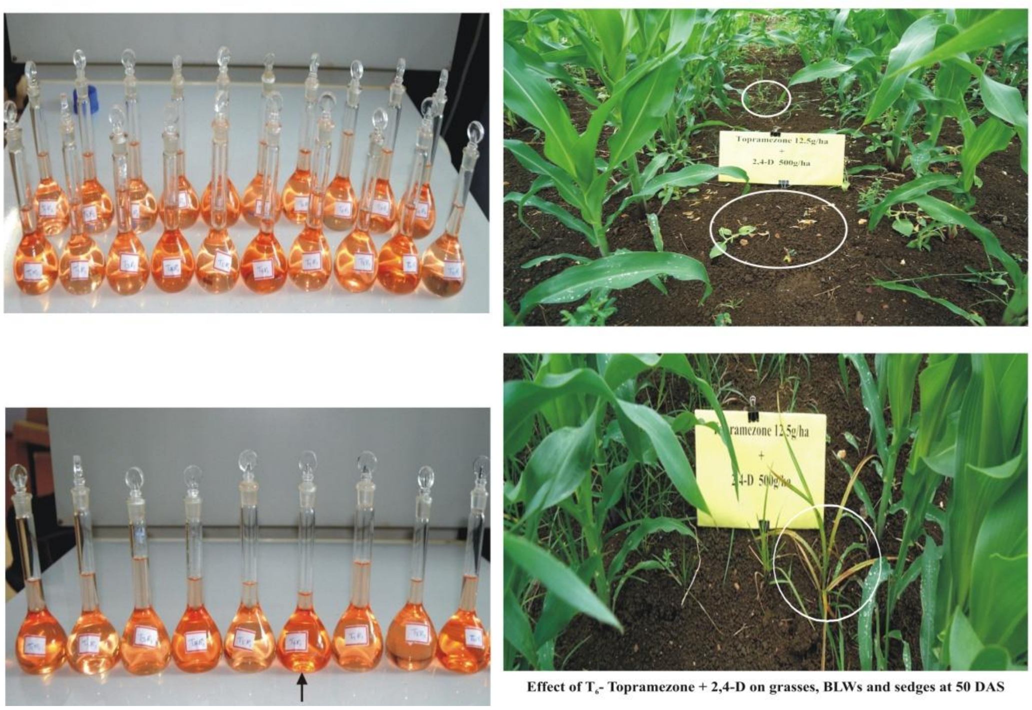
Treatments	Grain yield (kg ha^{-1})	Weed index (%)	Net return (` ha^{-1})
T_1	5,269	12.63	47,015
T_2	4,494	25.45	36,290
T_3	4,298	28.73	38,036
T_4	4,455	26.19	36,921
T_5	5,061	13.99	46,772
T_6	5,582	7.07	53,769
T_7	5,310	11.86	48,363
T_8	5,451	9.53	50,489
T_9	5,535	8.25	53,949
T_{10}	5,789	4.03	55,466
T_{11}	6,032	0.00	56,203
T_{12}	3,630	39.78	29,816
S.Em. ±	64.80	1.00	1,094
C.D. (P=0.05)	190	3.00	3,210

Table.3 Soil dehydrogenase activity as influenced by post-emergent herbicides in maize

Treatments	Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})			
	7 DAH	14DAH	21DAH	50 DAH
T_1	2.44	3.92	4.32	7.99
T_2	2.77	3.97	4.25	8.76
T_3	2.61	3.16	4.17	8.13
T_4	2.88	3.55	4.00	8.54
T_5	2.86	4.05	3.80	8.56
T_6	3.34	4.59	4.96	8.70
T_7	2.41	4.57	4.95	7.39
T_8	3.13	4.04	4.15	7.78
T_9	2.27	3.29	4.27	7.24
T_{10}	2.27	3.50	5.74	7.91
T_{11}	4.28	5.38	5.88	8.80
T_{12}	4.26	5.56	5.99	9.15
S.Em. ±	0.25	0.30	0.20	0.46
C.D. (P=0.05)	0.74	0.90	0.6	1.35

DAH- Days after herbicide spray

Fig.1 dehydrogenase activity at 14DAH and effect of herbicide mixtures on weed at 50 DAS



Effect of T_6- Topramezone + 2,4-D on grasses, BLWs and sedges at 50 DAS

This enabled the crop to utilize nutrients, moisture, light and space to maximum extent and this result is in conformity with the findings of Walia *et al.*, (2007). Among the herbicide mixtures, topramezone + 2,4-D was superior. These results correlate with the findings of Bahirgul (2015). WI is significantly higher in weedy check (39.78 %) that means nearly yield reduction to the tune of about 40 per cent was noticed with weedy check. This resulted in lower maize grain yield in weedy check (3,630 kg ha^{-1}) due to greater competition offered by unchecked weed growth for nutrients, moisture, space and light as indicated by poor growth and yield components (Krishnamurthy *et al.,* 1981).

Effect of herbicides on economics

With regard to net returns, recommended weed management practice, recorded significantly higher net returns (`55,466 ha$^{-1}$). It was superior over the rest of treatments expect weed free check. Among the weed management treatments application of topramezone 12.5 g ha$^{-1}$ + 2,4-D 500 g ha$^{-1}$ has recorded significantly higher net returns (`53,770 ha^{-1}) and it was on par with sequential application of atrazine *fb* 2,4-D (`53,950). The next best treatment was tembotrione 50 g ha$^{-1}$ + 2,4-D 500 g ha$^{-1}$ (`50,489 ha^{-1}) on par with tembotrione 50 g ha^{-1} + atrazine 500 g ha^{-1} (`48,363 ha^{-1}). This is attributed to the significantly higher grain yield in these treatments receiving herbicide mixtures which have controlled all types of weeds very effectively resulting in higher grain and hundred grain yield due to better utilization of natural resources *viz.,* water, sunlight and nutrients. Weedy check recorded significantly lower net income due to lower grain yield. These results are in conformity with the findings of Bahirgul (2015).

Effect of herbicides on soil microbial activities

At 7 DAH there was decrease in dehydrogenase activity in all the treatments due to effect of herbicides on microbial activity. Significantly higher dehydrogenase activity was observed in weed free and weedy check. There was no effect of herbicides on micro flora in weedy check and weed free condition and hence the dehydrogenase activity was more. Similar trend was followed in 14 DAH and 21DAH; dehydrogenase activity was increased due to decrease in effect of herbicides. There was a significant increase in dehydrogenase activity of all the treatments at 50 DAH *i.e.,* peak period of crop growth indicating that microbial activity was increased and effect of herbicides on microbes was decreased (Table 3 and Fig. 1).

In conclusion, early post emergent spray of tank mixtures i.e., topramezone + 2,4-D, tembotrione + 2,4-D and tembotrione + atrazine were superior to sole application of herbicides in terms of weed density, weed index, grain yield and net returns and was comparable with recommended practice. Tank mixtures were found to be more effective than sole application which is a viable alternative for farmers during critical period of labour scarcity. The biological activity of herbicides was high in tank mixtures next to weedy check and weed free check than sole applications. Biological activity increased in all treatments at 50 days after spraying indicating less effect of herbicides on soil micro flora.

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