Soil Enzymes as Influenced by Pre and Post Emergence Herbicide in Sweet Corn Grown in Vertisols

R. K. Rathod, V. P. Bhalerao, P. B. Margal* and R. S. Thakare

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule (Maharashtra), India

*Corresponding author

A B S T R A C T

Field experiment was conducted at Department of Agronomy, College of Agriculture, Dhule during Kharif 2019 to study the effect of pre and post emergence herbicides on soil enzymes in sweet corn. The soil enzymes activity viz. dehydrogenase, urease was significantly influenced due to application of pre and post emergence herbicides. The per cent decrease in the dehydrogenase activity at harvest was 14.79 %, 30.15 % and 32.57 to 35.70 % in weed free treatment (two hand weeding), weedy check (T1) and treatments of pre and post emergence herbicides (T3 to T10), respectively over the initial value of 19.8 µg TPF g⁻¹ soil 24 h⁻¹. The per cent decrease in the urease activity was 4.39 %, 13.56 % and 17.02 to 17.88 % in the weed free treatment (two hand weeding), weedy check (T1) and treatments of pre and post emergence herbicides (T3 to T10), respectively over the initial value of 28.9 mg NH₄-N 100 g soil h⁻¹. Application of tembotrione @ 120 g ha⁻¹ as post emergence herbicide (T₉) showed less adverse effect on soil dehydrogenase and urease activity at harvest than the other herbicides treatments.

Keywords
Dehydrogenase, Urease

Introduction

Sweet corn (Zea mays var. saccharata) also called as “sugar corn”, “pole corn” or simply corn, is a variety of maize with high sugar content. In India, sweet corn is cultivated on very small area to meet the demands of many industries. The demand for eating roasted cobs in cities and towns is increasing day by day. Sweet corn is gaining popularity among the urban masses in terms of nutrition and health consciousness in India. Heavy weed infestation is one of the major constraints that limit the productivity of sweet corn crop. Wider spacing and slow growing nature of the crop during the first 3-4 weeks provide enough opportunity for weeds to invade and offer severe competition resulting in 30-100 % yield reduction (Dey et al., 2017). Weeds emerge fast and grow rapidly competing with the crop for growth viz., nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of sweet corn.

In the modern era of urbanization, labour component in agriculture is becoming scarce, not available at time and prohibitive cost. Chemical weed control is a better supplement
Herbicides are toxic agrochemicals, which have been used to control the weeds in the agricultural farms and gardens. These herbicides are rampantly used to some extent, by farmers without considering the long or short term effects in soil medium. It is evident that most of these herbicides may cause the reduction of sensitive populations of certain groups of biota in soil medium.

The effect of glyphosate, paraquat, trifluralin and atrazine on soil enzymes activities of dehydrogenase, phosphatase and urease was studied by Davies and Greaves, (1981). They reported that when recommended doses were used, enzymes activities were not affected by the herbicides. The wide range of soils used with greatly differing enzyme activities, and varying assay conditions like temperature, pH, and substrate concentrations were responsible for contradictory results on effect of herbicides on soil. So, serious attempts should be made, possibly by judging the effects against those natural stresses or against the background of natural variation for assay of soil enzymes.

Dehydrogenase is the respiration enzyme presents in viable cells and reflects the total range of oxidative activity of soil microflora and may be a good indicator of microbial activity. Dehydrogenase significantly correlated with microbial population and soil organic matter. Optimum and balanced application of nutrients led to significant increase in dehydrogenase activity (Srinivasaraao et al., 2018). The dehydrogenase catalyzes the biological oxidation and dehalogenation of a number of herbicides and other organic compounds (Beller et al., 1996).

Urease catalyses the hydrolysis of urea to CO₂ and NH₄. Higher organic matter level provide a more favourable environment for the accumulation of enzymes in the soil matrix, since soil organic constituent are thought to be important in forming stable complexes with free enzymes (Bansal et al., 2015).

Though lot of information is available concerning the influence of herbicide on soil microflora and fauna, very little information is available concerning their effects on soil soil enzyme activity particularly those enzymes related with soil fertility. Keeping these fact in view, experiment was conducted to study the effect of pre and post emergence herbicides on soil enzymes in sweet corn.

**Materials and Methods**

Field experiment was conducted at Department of Agronomy, College of Agriculture, Dhule during Kharif 2019 to study the effect of pre and post emergence herbicides on soil enzymes in sweet corn. The experiment was laid out in randomized block design with ten treatments replicated three times. Treatments composed of T₁: weedy check, T₂: weed free (two hand weeding), T₃: atrazine @ 1000 g ha⁻¹ (PE) fb halosulfuron methyl @ 90 g ha⁻¹ (PoE), T₄: atrazine @ 1000 g ha⁻¹ (PE) fb 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE), T₅: pendimethalin @ 1000 g ha⁻¹ (PE) fb halosulfuron-methyl @ 90 g ha⁻¹ (PoE), T₆: pendimethalin @ 1000 g ha⁻¹ (PE) fb tembotrione @ 120 g ha⁻¹ (PoE), T₇: pendimethalin @ 1000 g ha⁻¹ (PE) fb 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE), T₈: halosulfuron-methyl @ 90 g ha⁻¹ (PoE), T₉: tembotrione @ 120 g ha⁻¹ (PoE) and T₁₀: 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE). The pre emergence (PE) herbicides were applied on next day after sowing of sweet corn, however, the post emergence (PoE) herbicides were applied 30 days after sowing of sweet corn.

The soil of experimental site was medium black with the following chemical properties:
pH 8.01, electrical conductivity (EC) 0.32 dS m⁻¹, organic carbon (5.60 g kg⁻¹), calcium carbonate (49 g kg⁻¹), available N (202.34 kg ha⁻¹), available (Olsen-P) P (17.32 kg ha⁻¹), available (NH₄OAc-K) K (402.25 kg ha⁻¹), dehydrogenase (19.18 µg TPF g⁻¹ soil 24 h⁻¹) and urease (28.9 mg NH₄-N 100 g⁻¹ h⁻¹).

Representative moistened soil samples were collected from each plot before sowing, at 7, 15, 21, 30 and 45 DAS as well as at harvest. Dehydrogenase activity was determined by spectrophotometric method (Casida et al., 1964). Urease activity was determined by titrimetric method (Tabatabai and Bremner, 1972).

**Results and Discussion**

**Dehydrogenase activity**

The periodical dehydrogenase activity in soil was significantly influenced at 7, 15, 21, 30 and 45 days after application by pre and post emergence herbicides during the field experiment. The weed free (two hand weeding) treatment (T2) recorded significantly higher dehydrogenase activity of 21.61, 23.34, 22.74 and 21.57 µg TPF g⁻¹ soil 24 h⁻¹ at 15, 21, 30 and 45 DAS, respectively, as compared to rest of the treatments. However, reduction (18.93 µg TPF g⁻¹ soil 24 h⁻¹) in dehydrogenase activity at 7 DAS was observed in T2 treatment. The periodical dehydrogenase activity was increased by 12.46 % over the initial value (19.18 µg TPF g⁻¹ soil 24 h⁻¹) at 45 DAS in T2 treatment. The periodical dehydrogenase activity in soil was decreased with advanced period of field experimentation in the treatment of weedy check (T1) and the treatments of pre and post emergence herbicides application (T3 to T10). The periodical dehydrogenase activity at 45 DAS in the treatment of weedy check (T1) was 15.35 µg TPF g⁻¹ soil 24 h⁻¹ with 19.96 % reduction over the initial value (19.18 µg TPF g⁻¹ soil 24 h⁻¹). The periodical dehydrogenase activity at 45 DAS was ranged between 11.74 to 12.81 µg TPF g⁻¹ soil 24 h⁻¹ in the treatments of pre and post emergence herbicides application (T3 to T10) with 33.21 to 38.79 % reduction over the initial value.

The dehydrogenase activity was significantly higher (16.87 µg TPF g⁻¹ soil 24 h⁻¹) in the weed free treatment (two hand weeding) at harvest of sweet corn. It was followed by the treatment of weedy check (T1), which recorded the dehydrogenase activity 13.83 µg TPF g⁻¹ soil 24 h⁻¹. Significantly lower dehydrogenase activity was recorded in the treatment of pendimethalin @ 1000 g ha⁻¹ (PE) fb halosulfuron-methyl @ 90 g ha⁻¹ (PoE), however, this treatment was at par with the treatments of pre and post emergence application of herbicides (T3, T4 and T6 to T10).

The per cent decrease in the dehydrogenase activity at harvest was 14.79 %, 30.15 % and 32.57 to 35.70 % in weed free treatment (two hand weeding), weedy check (T1) and treatments of pre and post emergence herbicides (T3 to T10), respectively over the initial value of 19.8 µg TPF g⁻¹ soil 24 h⁻¹. The decrease in the dehydrogenase activity with the application of pre and post emergence herbicides was also reported by Nadiger et al., (2013), Inalli et al., (2014) and Abbas et al., (2015).

Among the herbicide treatments, the detrimental effect of pre and post emergence herbicides on periodical soil dehydrogenase activity was in the order of pendimethalin (PE) fb 2,4 D ethyl ester (PoE) > atrazine (PE) fb 2,4 D ethyl ester (PoE) > atazine (PE) fb halosulfuron methyl (PoE) > tembotrione (PoE) > pendimethalin (PE) fb halosulfuron-methyl (PoE) = halosulfuron-methyl (PoE) > pendimethalin (PE) fb tembotrione (PoE) > 2,4 D ethyl ester (PoE).
### Table 1. Dehydrogenase activity in soil as influenced by application of herbicides

| Sr. No | Treatments | Dehydrogenase (μg TPF g⁻¹ soil 24 h⁻¹) | 7 DAS | 15 DAS | 21 DAS | 30 DAS | 45 DAS | At harvest |
|--------|------------|-------------------------------------|-------|--------|--------|--------|--------|------------|
| 1.     | Weedy      | 17.58ᵇ 17.49ᵇ 16.49ᵇ 16.42ᵇ 15.35ᵇ 13.83ᵇ |       |        |        |        |        |            |
| 2.     | Weed free (two hand weedings) | 18.93ᵃ 21.61ᵃ 23.34ᵃ 22.74ᵃ 21.57ᵃ 16.87ᵃ |       |        |        |        |        |            |
| 3.     | Atrazine @ 1000 g ha⁻¹ (PE) f/halosulfuron methyl @ 90 g ha⁻¹ (PoE) | 17.65ᵇ 16.88ᶜ 13.73ᶜ 13.13ᶜ 12.17ᶜ 12.97ᵇᶜ |       |        |        |        |        |            |
| 4.     | Atrazine @ 1000 g ha⁻¹ (PE) f/b 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 17.73ᵇ 16.83ᶜ 13.52ᶜ 13.09ᶜ 12.06ᶜ 13.03ᵇᶜ |       |        |        |        |        |            |
| 5.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b halosulfuron-methyl @ 90 g ha⁻¹ (PoE) | 17.75ᵇ 16.62ᶜ 13.66ᶜ 13.15ᶜ 12.43ᶜ 12.73ᶜ |       |        |        |        |        |            |
| 6.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b tembotrione @ 120 g ha⁻¹ (PoE) | 17.77ᵇ 16.62ᶜ 14.13ᶜ 13.49ᶜ 12.62ᶜ 12.74ᶜ |       |        |        |        |        |            |
| 7.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 17.95ᵇ 16.64ᶜ 13.94ᶜ 12.93ᶜ 11.74ᶜ 12.75ᶜ |       |        |        |        |        |            |
| 8.     | Halosulfuron-methyl @ 90 g ha⁻¹ (PoE) | 17.97ᵇ 17.72ᵇᶜ 14.99ᵇᶜ 14.55ᶜ 12.43ᶜ 13.10ᵇᶜ |       |        |        |        |        |            |
| 9.     | Tembotrione @ 120 g ha⁻¹ (PoE) | 17.96ᵇ 18.02ᵇ 15.40ᵇᶜ 14.45ᶜ 12.18ᶜ 13.35ᵇᶜ |       |        |        |        |        |            |
| 10.    | 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 18.11ᵇ 17.91ᵇᶜ 14.75ᶜ 14.30ᶜ 12.81ᶜ 13.25ᵇᶜ |       |        |        |        |        |            |

### Table 2. Urease activity in soil as influenced by application of herbicides

| Sr. No | Treatments | Urease activity (mg NH₄-N 100 g soil h⁻¹) | 7 DAS | 15 DAS | 21 DAS | 30 DAS | 45 DAS | At harvest |
|--------|------------|------------------------------------------|-------|--------|--------|--------|--------|------------|
| 1.     | Weedy      | 28.29ᶜ 27.17ᶜ 25.21ᵇ 27.75ᵇ 27.41ᵇ 24.98ᵇ |       |        |        |        |        |            |
| 2.     | Weed free (two hand weedings) | 29.66ᵃ 31.27ᵃ 31.49ᵃ 33.38ᵃ 33.31ᵃ 27.63ᵃ |       |        |        |        |        |            |
| 3.     | Atrazine @ 1000 g ha⁻¹ (PE) f/halosulfuron methyl @ 90 g ha⁻¹ (PoE) | 28.48ᵇᶜ 26.46ᶜ 22.42ᶜᵈ 24.49ᶜᵈ 24.13ᶜ 23.73ᶜ |       |        |        |        |        |            |
| 4.     | Atrazine @ 1000 g ha⁻¹ (PE) f/b 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 28.48ᵇᶜ 26.51ᶜ 22.26ᵈ 24.40ᵈ 24.09ᵈ 23.74ᶜ |       |        |        |        |        |            |
| 5.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b halosulfuron-methyl @ 90 g ha⁻¹ (PoE) | 28.47ᵇᶜ 26.38ᶜ 22.36ᶜᵈ 24.50ᶜᵈ 24.05ᵈ 23.60ᶠ |       |        |        |        |        |            |
| 6.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b tembotrione @ 120 g ha⁻¹ (PoE) | 28.47ᵇᶜ 26.32ᶜ 22.64ᶜᵈ 24.72ᶜᵈ 24.01ᵈ 23.57ᶜ |       |        |        |        |        |            |
| 7.     | Pendimethalin @ 1000 g ha⁻¹ (PE) f/b 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 28.48ᵇᶜ 26.31ᶜ 22.61ᶜᵈ 24.69ᶜᵈ 24.10ᶜᵈ 23.49ᶜ |       |        |        |        |        |            |
| 8.     | Halosulfuron-methyl @ 90 g ha⁻¹ (PoE) | 28.92ᵇ 27.74ᵇ 23.66ᶜ 25.75ᶜᵈ 25.17ᶜᵈ 23.93ˢ |       |        |        |        |        |            |
| 9.     | Tembotrione @ 120 g ha⁻¹ (PoE) | 28.85ᵇ 27.71ᵇ 23.89ᵇᶜ 25.92ᶜ 25.25ᶜ 23.98ˢ |       |        |        |        |        |            |
| 10.    | 2,4 D ethyl ester @ 1000 g ha⁻¹ (PoE) | 28.87ᵇ 27.71ᵇ 23.29ᶜᵈ 25.70ᶜᵈ 25.17ᶜᵈ 23.95ˢ |       |        |        |        |        |            |

SE(m)+: 0.18 0.36 0.52 0.53 0.46 0.35
CD at 5%: 0.56 1.08 1.57 1.60 1.39 1.06

SE(m)+: Standard error mean
CD at 5%: Critical difference at 5% level
The decrease in soil dehydrogenase enzyme activity might be associated with an inhibition of microbial population which was one of the source of soil dehydrogenase enzyme on disintegration of microbial cells. Similarly, there might be binding of active site of dehydrogenase enzyme with pre and post emergence herbicides (Latha and Gopal 2010, Nadiger et al., 2013).

**Urease activity**

The periodical urease activity in soil was significantly influenced at 7, 15, 21, 30 and 45 days after application by pre and post emergence herbicides during the field experiment. Significantly higher urease activity of 29. 66, 31. 37, 31. 49, 33. 38 and 33. 31 mg NH₄-N 100 g soil h⁻¹ was recorded in the weed free (two hand weeding) treatment (T₂) at 7, 15, 21, 30 and 45 DAS, respectively, as compared to rest of the treatments. The increase of 15. 25 % at 45 DAS was observed in the periodical urease activity in T₂ treatment.

The periodical urease activity in soil was decreased with advanced period of field experimentation in the treatment of weedy check (T₁) and the treatments of pre and post emergence herbicides application (T₃ to T₁₀) except at 7 DAS the periodical urease activity was maintained as initial value in the treatment of halosulfuron-methyl @ 90 g ha⁻¹ as a post emergence (T₈). The periodical urease activity at 45 DAS in the treatment of weedy check (T₁) was 27. 41 mg NH₄-N 100 g soil h⁻¹ with 5. 15 % reduction over the initial value (28. 9 mg NH₄-N 100 g soil h⁻¹). The periodical urease activity at 45 DAS was ranged between 24. 01 to 25. 25 mg NH₄-N 100 g soil h⁻¹ in the treatments of pre and post emergence herbicides application (T₃ to T₁₀) with 12. 62 to 16. 92 % reduction over the initial value.

The urease activity was significantly higher (27. 63 mg NH₄-N 100 g soil h⁻¹) in the weed free treatment (two hand weeding) at harvest of sweet corn. It was followed by the treatment of weedy check (T₁), which recorded the urease activity 24. 98 mg NH₄-N 100 g soil h⁻¹. The per cent decrease in the urease activity was 4. 39 %, 13. 56 % and 17. 02 to 17. 88 % in the weed free treatment (two hand weeding), weedy check (T₁) and treatments of pre and post emergence herbicides (T₃ to T₁₀), respectively over the initial value of 28. 9 mg NH₄-N 100 g soil h⁻¹. The decrease in urease activity with the application of pre and post emergence herbicides was also reported by Sireesha et al., (2012), Abbas et al., (2014) and Abbas et al., (2015).

The results revealed that an application of tembotrione @ 120 g ha⁻¹ as post emergence herbicide (T₉) has less adverse effect on periodical urease activity in soil than the other herbicides treatments under study. However, the treatment T₉ was statistically at par with treatment atrazine @ 1000 g ha⁻¹ as pre emergence (T₉), pendimethalin @ 1000 g ha⁻¹ as pre emergence (T₉), Halosulfuron-methyl @ 90 g ha⁻¹ as post emergence (T₈) and 2, 4 D ethyl ester @ 1000 g ha⁻¹ as post emergence (T₁₀).

The decreased urease enzyme activity with an application of pre and post emergence herbicides might be associated with the increased application of herbicides leads to increased chemical concentrations in soil, altered soil reactions, adverse effects on non target organisms, alter the biological equilibrium in the soil, lower the microbial population and hence lower enzyme activity. The results are in conformity with the findings of Latha and Gopal (2010), Kavitha et al., (2011) and Abbas et al., (2015).
It is concluded that, among the herbicide treatments, the minimum detrimental effect of herbicides on dehydrogenase and urease activity was observed in the treatment of tembotrione @ 120 g ha\(^{-1}\) as post emergence herbicide (T\(_9\)) at 7, 15, 21, 30, 45 DAS and at harvest.

Acknowledgement

The authors are grateful to the I/c. Professor, Department of Agronomy, College of Agriculture, Dhule for providing necessary facilities for conduct of the experiment.

References

Abbas, Z., Akmal, M., Khan, K. S. and Hassan, F. (2014) Effect of Bructril Super (Bromoxynil) herbicide on soil microbial biomass and bacterial population. *Brazilian Archives of Biology and Technology* 57(1), 9-14.

Abbas, Z., Akmal, M., Khan, K. S. and Hassan, F. (2015) Response of soil microorganisms and enzyme activity to application of bromoxynil under rainfed condition. *International Journal of Agriculture Biology* 17, 305-312.

Bansal, O. P. (2015) Long term effects of organic manures (FYM, sewage sludge) amendments on soil enzymatic activities in an alluvial soil of Aligarh district: A 20 year study. *Journal of Scientific Research in Allied Science* 1, 135-145.

Beller, H.R., Spormann, A.M., Sharma, P.K., Cole, J.R. and Reinhard, M. (1996) Isolation and characterization of a novel toluene-degrading, sulfate-reducing bacterium. *Applied and Environmental Microbiology* 62, 1188-1196.

Casida, L.; Klein, D. and Santoro, T., (1964) Soil dehydrogenase activity. *Soil Science* 98, 371- 376.

Dey, P., Pratap, T., Singh V.P., Singh, R. and Singh, S.P. (2017) Weed management options for spring sweet corn. ISWS Golden Jubilee International Conference on "Weeds and Society: Challenges and Opportunities", ICAR-Directorate of Weed Research, Jabalpur, India during 21-24 November 2018: 297.

Davies, H.A and Greaves, M.P. (1981) Effects of some herbicides on soil enzyme activities. *Weed Research* 21, 205-209.

Inalli, K., Aravindakumar, B. N., Geeta, G. S. and Babu, R. (2014) Effect of tank mixture herbicides on phytotoxicity, soil dehydrogenase activity and nutrient uptake by weeds in Maize. *Trends in Biosciences* 7(14), 1839-1842.

Kavitha, M. P., Ganesaraja, V., Paulpand, V.K. and Subramanian, R. B. (2011) Rhizosphere enzyme activities as influenced by age of seedlings, weed management practices and humic acid application under system of rice intensification. *Indian Journal of Agriculture Research* 45(2), 151-155.

Latha, P. C. and Gopal, H. (2010) Effect of herbicides on soil micro-organisms. *Indian Journal of Weed Science*, 42(3 & 4), 217-222.

Nadiger, S., Baboo, R. and Arvindkumar, B. N. (2013) Bioefficacy of pre emergence herbicides on weed management in maize. *Karnataka Journal of Agriculture Science* 26(1), 17-19.

Sireesha, A., Rao, P. C., Ramalaxmi, C. S. and Swapna, G. (2012) Effect of pendimethalin and oxyfluorfen on soil enzyme activity. *Journal of Crop and Weed* 8(1), 124-128.

Srinivasarao, C., Kundu, S., Grover, M., Manjunath, M., Sudhanshu, S. K., Patel, J. J., Singh, S. R., Singh, R. P., Patel, M. M., Ayyandar, A., and Soam, S. K. (2018) Effect of long term application of organic and inorganic fertilizers on soil microbial activities in semi-arid and sub-humid rainfed agricultural systems. *Tropical Ecology* 59(1), 99-108.

Tabatabai, M.A. and Bremner, J.M. (1972) Assay of Urease activity in soil. *Soil Biology Biochemistry* 4, 479-487.
How to cite this article:

Rathod, R. K., V. P. Bhalerao, P. B. Margal and Thakare, R. S. 2021. Soil Enzymes as Influenced by Pre and Post Emergence Herbicide in Sweet Corn Grown in Vertisols. *Int.J.Curr.Microbiol.App.Sci.* 10(01): 2787-2793. 
doi: [https://doi.org/10.20546/ijcmas.2021.1001.322](https://doi.org/10.20546/ijcmas.2021.1001.322)