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

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ABSTRACT

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 (T_1) and treatments of pre and post emergence herbicides (T_3 to T_{10}), 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 (T_1) and treatments of pre and post emergence herbicides (T_3 to T_{10}), respectively over the initial value of 28.9 mg NH_4-N 100 g soil h^{-1}.Application of tembotrione @ 120 g ha^{-1} as post emergence herbicide (T_9) showed less adverse effect on soil dehydrogenase and urease activity at harvest than the other herbicides treatments.

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 to conventional methods and forms an integral part of the modern crop production. Herbicides are toxic agrochemicals, which have being 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 (Srinivasarao *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 CO_2 and NH_4. 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 micro flora 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 T_1: weedy check, T_2: weed free (two hand weeding), T_3: atrazine @ 1000 g ha^{-1} (PE) *fb* halosulfuron methyl @ 90 g ha^{-1} (PoE), T_4: atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE), T_5: pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE), T_6: pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE), T_7: pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE), T_8: halosulfuron-methyl @ 90 g ha^{-1} (PoE), T_9: tembotrione @ 120 g ha^{-1} (PoE) and T_{10}: 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) hebicides 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. 32dS 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 (NH_4OAc-K) K (402. 25 kg ha^{-1}), dehydrogenase (19. 18 µg TPF g^{-1} soil 24 h^{-1}) and urease(28. 9 mg NH_4 -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 (T_2) 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 T_2 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 T_2 treatment. The periodical dehydrogenase activity in soil was decreased with advanced period of field experimentation in the treatment of weedy check (T_1) and the treatments of pre and post emergence herbicides application (T_3 to T_{10}). The periodical dehydrogenase activity at 45 DAS in the treatment of weedy check (T_1) 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 (T_3 to T_{10}) 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 (T_1), 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 (T_3, $T_4$and T_6 to T_{10}).

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 (T_1) and treatments of pre and post emergence herbicides (T_3 to T_{10}), 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 periodiocal 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	17.58^{b}	17.49^{bc}	16.49^{b}	16.42^{b}	15.35^{b}	13.83^{b}
2.	Weed free (two hand weedings)	18.93^{a}	21.61^{a}	23.34^{a}	22.74^{a}	21.57^{a}	16.87^{a}
3.	Atrazine @ 1000 g ha^{-1} (PE) *fb*halosulfuron methyl @ 90 g ha^{-1} (PoE)	17.65^{b}	16.88^{c}	13.73^{c}	13.13^{c}	12.17^{c}	12.97^{bc}
4.	Atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	17.73^{b}	16.83^{c}	13.52^{c}	13.09^{c}	12.06^{c}	13.03^{bc}
5.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE)	17.75^{b}	16.62^{c}	13.66^{c}	13.15^{c}	12.43^{c}	12.73^{c}
6.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE)	17.77^{b}	16.62^{c}	14.13^{c}	13.49^{c}	12.62^{c}	12.74^{c}
7.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	17.95^{b}	16.64^{c}	13.94^{c}	12.93^{c}	11.74^{c}	12.75^{c}
8.	Halosulfuron-methyl @ 90 g ha^{-1} (PoE)	17.97^{b}	17.72^{bc}	14.99^{bc}	14.55^{c}	12.43^{c}	13.10^{bc}
9.	Tembotrione @ 120 g ha^{-1} (PoE)	17.96^{b}	18.02^{b}	15.40^{bc}	14.45^{c}	12.18^{c}	13.35^{bc}
10.	2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	18.11^{b}	17.91^{bc}	14.75^{c}	14.30^{c}	12.81^{c}	13.25^{bc}
	SE(m)$\pm$	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

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

Sr. No.	Treatments	Urease activity (mg NH_4-N 100 g soil h^{-1})					
		7 DAS	15 DAS	21 DAS	30 DAS	45 DAS	At harvest
1.	Weedy	28.29^{c}	27.17^{bc}	25.21^{b}	27.75^{b}	27.41^{b}	24.98^{b}
2.	Weed free (two hand weedings)	29.66^{a}	31.27^{a}	31.49^{a}	33.38^{a}	33.31^{a}	27.63^{a}
3.	Atrazine @ 1000 g ha^{-1} (PE) *fb*halosulfuron methyl @ 90 g ha^{-1} (PoE)	28.48^{bc}	26.46^{c}	22.42^{cd}	24.49^{cd}	24.13^{c}	23.73^{c}
4.	Atrazine @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	28.48^{bc}	26.51^{c}	22.26^{d}	24.40^{d}	24.09^{d}	23.74^{c}
5.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* halosulfuron-methyl @ 90 g ha^{-1} (PoE)	28.47^{bc}	26.38^{c}	22.36^{cd}	24.50^{cd}	24.05^{d}	23.60^{c}
6.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* tembotrione @ 120 g ha^{-1} (PoE)	28.47^{bc}	26.32^{c}	22.64^{cd}	24.72^{cd}	24.01^{d}	23.57^{c}
7.	Pendimethalin @ 1000 g ha^{-1} (PE) *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	28.48^{bc}	26.31^{c}	22.61^{cd}	24.69^{cd}	24.10^{cd}	23.49^{c}
8.	Halosulfuron-methyl @ 90 g ha^{-1} (PoE)	28.92^{b}	27.74^{b}	23.66^{c}	25.75^{cd}	25.17^{cd}	23.93^{c}
9.	Tembotrione @ 120 g ha^{-1} (PoE)	28.85^{b}	27.71^{b}	23.89^{bc}	25.92^{c}	25.25^{c}	23.98^{c}
10.	2,4 D ethyl ester @ 1000 g ha^{-1} (PoE)	28.87^{b}	27.71^{b}	23.29^{cd}	25.70^{cd}	25.17^{cd}	23.95^{c}
	SE(m)$\pm$	0.18	0.33	0.46	0.48	0.38	0.23
	CD at 5 %	0.55	1.00	1.38	1.43	1.15	0.71

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 NH_4-N 100 g soil h^{-1} was recorded in the weed free (two hand weeding) treatment (T_2) 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 T_2 treatment.

The periodical urease activity in soil was decreased with advanced period of field experimentation in the treatment of weedy check (T_1) and the treatments of pre and post emergence herbicides application (T_3 to T_{10}) 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 (T_8). The periodical urease activity at 45 DAS in the treatment of weedy check (T_1) was 27. 41 mg NH_4-N 100 g soil h^{-1} with 5. 15 % reduction over the initial value (28. 9 mg NH_4-N 100 g soil h^{-1}). The periodical urease activity at 45 DAS was ranged between 24. 01 to 25. 25 mg NH_4-N 100 g soil h^{-1}in the treatments of pre and post emergence herbicides application (T_3 to T_{10}) with 12. 62 to 16. 92 % reduction over the initial value.

The urease activity was significantly higher (27. 63 mg NH_4-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 (T_1), which recorded the urease activity 24. 98 mg NH_4-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 (T_1) and treatments of pre and post emergence herbicides (T_3 to T_{10}), respectively over the initial value of 28. 9 mg NH_4-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 (T_9) has less adverse effect on periodical urease activity in soil than the other herbicides treatments under study. However, the treatment T_9 was statistically at par with treatment atrazine @ 1000 g ha^{-1} as pre emergence *fb*halosulfuron methyl @ 90 g ha^{-1} as post emergence(T_3), pendimethalin @ 1000 g ha^{-1} as pre emergence *fb* 2,4 D ethyl ester @ 1000 g ha^{-1} as post emergence (T_7), Halosulfuron-methyl @ 90 g ha^{-1} as post emergence (T_8) and 2,4 D ethyl ester @ 1000 g ha^{-1} as post emergence (T_{10}).

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.

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