Effect of herbicides on the activity of soil enzymes urease in maize crop

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ABSTRACT
A field experiment was conducted to study the effect of pre-emergence, post emergence and combination of atrazine with post emergence herbicides on soil enzyme urease activity (expressed as µg of NH$_4^+$ released g$^{-1}$ soil h$^{-1}$) at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, India during kharif 2014. The experiment was laid out in randomized block design (RBD) using six herbicide treatments un weeded control and hand weeding at 20 and 40 DAS with three replications. Maize was sown as test crop (variety – DHM-117). The soil samples were collected at 15 days intervals ie: 0, 15, 30, 45, 60, 75 and 90 days, to assay the enzyme activity. The pre-emergence herbicides were sprayed at zero days after sowing where post- emergence herbicides were sprayed after 15 days after sowing. The enzyme activity in the control increased from 0 days to 60 days and then decreased but the activity in the pre- emergence herbicide pendimethalin showed the same phase as that of control and showed higher activity over the control at each stage where as atrazine showed decrease in activity at 0 days (8.71) and latter it revoked the activity and reached maximum at 60 days (12.35). When compare to pendimethalin the activity was less at each and every stage. In case of post – emergence herbicides the activity showed mixed responses to at different stages Tembotrione showed higher activity when compare to Topramezone. In combination of Tembotrione and Topramezone with atrazine showed mixed responses.

Key words: Atrazine, Pendimethalin, Pre-emergence, Post- emergence, Urease, Tembotrione Topramezone.

INTRODUCTION
In developing countries, the greatest challenge is improving and sustaining agricultural productivity to enable the country to become self-sufficient in food production and improving economy of country. Hence arable land is often amended with agrochemicals to increase agricultural productivity. In transforming the natural ecosystems into agricultural ecosystems characterized by a low biodiversity, as well as the intensive development of farming systems, resulted in a large-scale application of crop protection chemicals especially pesticides, fungicides and herbicides. Sustainable agriculture involves optimizing agricultural resources and at the same time maintaining the quality of environment and sustaining natural resources and the need for substantial increase in agricultural production is an urgent problem particularly in the less developed areas of the world and further increase in agrochemical use can be foreseen. Various pesticides and other agricultural chemicals have been studied with a view of ascertaining their effect on soil microorganisms and enzyme activities and discussions concerning the nature and properties of the selected enzyme activities are rarely reported. Herbicides are used in large quantities in modern agriculture to control undesirable plant species within a field. The increased application of herbicides leads to increased chemical concentrations in soil, altered soil reactions and potential adverse effect on non-target organisms. Repeated application of herbicides may involve a risk of reduced or altered soil microbial activities.

Herbicides are biologically active compounds and an unintended consequence of its application may lead to significant changes in microbial populations and activities influencing microbial ecological balance affecting soil fertility as microbial community plays crucial role in carbon flow, nutrient cycling and litter decomposition, which in turn affect soil fertility and plant growth (Tripathi et al., 2006, Pandey et al., 2007), and hence occupy a unique position in biological cycles in terrestrial habitat. On the other hand any action of the chemicals altering the life functions of soil organisms could indirectly affect soil enzyme activity. Agrochemicals often stimulate or decrease the growth of soil microbial population and thus may alter the enzyme activity. Also these chemicals may exert some physiological effect on living organisms. An agrochemical may also modify the inter relationship between the particular group of organisms and thus influence the amount and type of enzyme produced. When agrochemicals are released into the environment about 1 per cent reaches the target organism while remaining 0.99 per cent interferes with local metabolism or enzymes activities (Ramudu et al. 2011). 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.

Maize is the world's third most important cereal crop after wheat and rice and is grown for grain and fodder. Maize is also known as “Queen of Cereals”. During 2013-14 the worldwide area of maize was 177 M ha with production and productivity of 899 Mt and 5.5 t ha⁻¹ respectively. It accounts for about 64 per cent of coarse grain and 27.1 per cent of total cereal production (Commodity profile on maize, 2014). Maize is highly productive crop with diversified uses, mainly as food and feed for livestock, many value added products such as maize flakes, maize popcorn and recently it is also being used as a biofuel.

Farmers usually give prime importance to few cultural practices and neglect other practices like weed control. Maize crop gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 28 to 100 per cent and even total crop failure (Patel et al., 2006). Keeping this in view an experiment on the effect of herbicides on soil urease enzyme activity in kharif season with maize (Zea mays L.) as test crop was conducted at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad.

**MATERIALS AND METHODS**

A field experiment was carried out during kharif, 2014 at College Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar. The experimental site experiences semi-arid climate. The crop growth period i.e from 8.07.2014 to 20.10.2014. Initial soil samples were analyzed for physico-chemical and chemical properties by following standard procedures. Mechanical analysis Bouyoucos Hydrometer (Bouyoucos 1962) chemical analysis pH(Jackson, 1973), EC (Jackson, 1973), Organic carbon (Walkley and Black Method 1934). Available nitrogen alkaline permanganate method (Subbaiah and Asija, 1956), available phosphorus Olsen’s method (Olsen et al., 1954) and available potassium neutral normal ammonium acetate method using Flame Photometer (Jackson, 1979). The pH of the experimental field was 7.68, EC 0.19 dSm⁻¹, CEC (c mol (p+)+ kg⁻¹) 39.38 and organic carbon was 0.20. The N status of the experimental field was low (255.4 kg ha⁻¹), available P (25.1 kg ha⁻¹) and available K status was in higher

### Table 1: Statical Analysis

| Herbicides | SE(m)  | C.D. |
|------------|-------|------|
| Herbicides | 0.058 | 0.162|
| Urease     | 0.061 | 0.172|
| Herbicide X Urease | 0.174 | 0.488|

**RESULTS AND DISCUSSION**

The activity of urease (expressed as µg of NH₄⁺ released g⁻¹ soil h⁻¹) as influenced by the herbicide treatments is presented Fig (1 & 2). In case of pre-emergence treatments with herbicides atrazine, pendimethalin the enzyme activity of urease (expressed as µg of NH₄⁺ released g⁻¹ soil h⁻¹) was observed to increase from at 0 DAT to 60 DAT. At 0 DAT the Urease activity for atrazine was (8.71), pendimethalin (9.70), hand weeding (9.72) and control (9.72). At 60 DAT the urease activity for atrazine was (12.35), pendimethalin (12.62), hand weeding (11.84) and control (11.98) and then decreased till harvest. The highest enzyme activity was observed at 60 DAT for all the four treatments. However at the initial stages i.e., 0 to 15 DAT inhibition was observed in the activity at these

![Fig 1: Effect of Pre-emergence Herbicides on soil Urease activity](image-url)
action of herbicide as the incubation time increases the opinion that the soil enzymes are protected against inhibition. Similar results have been reported by different treatment can be grouped under three categories i.e., stimulation or inhibition. Based on the overall enzyme activity they can be only stimulation or only inhibition and both stimulation and inhibition. The partial degradation of the herbicide with time in soil may also be another factor for decrease in inhibition. The recovery from inhibition may also be due to enzyme secreted by plant themselves. The detracting effect of herbicides towards all microbes and enzyme activities decreased with time and this may also be due to microbial population and enzyme activities after initial inhibition due to microbial adaptation to these chemicals or due to their degradation. Latha and Gopal, (2010) studied the effects of herbicides and found an inhibition in the enzyme activity particularly due to application of substituted urea herbicides. Kavitha et al. (2011) observed that application of herbicide disturbs and alters the biological equilibrium in the soil, at the initial stages, that is, 20 days after transplanting of rice, the pre-emergent application of pretillachlor @ 0.75 kg ai ha\(^{-1}\) lower the microbial population and hence enzyme activity. But at later stages, enzyme activity and microbial population was increased and minimum enzyme activity was observed for unweeded control at all the growth stages. Vandana et al., (2012) reported that soil enzyme activities increased from 0 to 60 days after transplanting of the crop irrespective of the treatment to the soil as the root volume increases the production of soil enzymes increase. Sireesha et al., (2012) reported that level of herbicide application increased enzyme activity and vice versa. Abbas et al., (2015) reported that there was 30% reduction in urease activity, 36% inhibition in dehydrogenase activity and 34% decline in alkaline phosphatase activity with bromoxynil herbicide application due to decrease in microbial population. Baboo et al., (2013) reported that the enzyme activities of amylase, invertase, protease, urease and dehydrogenase were affected by the herbicides butachlor, pyrazosulfuran, paraquat and glyphosate over a period of four weeks, the herbicides caused transient impact on microbial populations and enzyme activities associated with the type of herbicides at recommended field application. Rasool and Reshi, (2010), reported that pesticide application affects activities of different soil enzymes differently while the activities of urease and asparaginase were inhibited and the activities of dehydrogenase, protease and amidase activities were stimulated in response to pesticide treatments on the other hand phosphatase exhibited a highly variable response to different concentration of pesticide as the phosphatase activity was influenced by pH. Weaver et al. (2004) reported inactivation of most soil enzymes, because of herbicide attachment on the active site of enzyme and thus preventing two stages the enzyme activity was lower than that of control, however the activity was recovered in the later stages. The decreasing order of urease activity was pendimethalin (12.62) > atrazine (12.35) > control (11.98) > hand weeding (11.84).

The enzyme activity observed in case of post emergence herbicides Tembotrione is as follows, the activity increased from 0 DAT (11.45) to 45 DAT (14.15) and there after decreased till harvest the activity was higher than that of control at each stage. On the other hand the activity of the enzyme in case of Topramezone the increased from 0 to 15 DAT and later decreased during the process of decrease, the activity was lower than that of control. In the combined form of application the Topramezone and atrazine the activity decreased from 0 to 30 DAT and then increased till 45 DAT later decreased till harvest. In case of Tembotrione and atrazine the enzyme activity increased from 0 to 15 DAT and decreased lower till harvest.

A close perusal of data indicates that significant difference exist between different herbicide treatments and periods of study. Among the treatments there was significant difference, from the data the activity of the enzymes under different treatment can be grouped under three categories i.e., only stimulation or only inhibition and both stimulation and inhibition. Based on the overall enzyme activity they can be further classified broadly into two classes i.e., stimulation or inhibition. Similar results have been reported by Balaabramanayen et al. (1970) for simazine, Karanth et al. (1975) for dexam, Voets et al. (1974) for atrazine and Cerevelli et al. (1975) for substituted urea herbicides. They were of the opinion that the soil enzymes are protected against inhibition action of herbicide as the incubation time increases the inhibition activity decreases. The inhibition, of enzyme activity by the herbicide could be the direct effect of herbicide on urease activity and also due to competitive and non-competitive inhibition. The increased enzyme activity in these treatments at latter stages with time may be due to different reasons i.e., the herbicide effect on microbial population may get stabilized after some time and the herbicides themselves are adsorbed irreversibly on soil colloids with increase in time resulting in decreased inhibition. The recovery from inhibition may also be due to enzyme secreted by plant themselves. The detrimental effect of herbicides towards all microbes and enzyme activities decreased with time and this may also be due to microbial population and enzyme activities after initial inhibition due to microbial adaptation to these chemicals or due to their degradation. Latha and Gopal, (2010) studied the effects of herbicides and found an inhibition in the enzyme activity particularly due to application of substituted urea herbicides. Kavitha et al. (2011) observed that application of herbicide disturbs and alters the biological equilibrium in the soil, at the initial stages, that is, 20 days after transplanting of rice, the pre-emergent application of pretillachlor @ 0.75 kg ai ha\(^{-1}\) lower the microbial population and hence enzyme activity. But at later stages, enzyme activity and microbial population was increased and minimum enzyme activity was observed for unweeded control at all the growth stages. Vandana et al., (2012) reported that soil enzyme activities increased from 0 to 60 days after transplanting of the crop irrespective of the treatment to the soil as the root volume increases the production of soil enzymes increase. Sireesha et al., (2012) reported that lower level of herbicide application increased enzyme activity and vice versa. Abbas et al., (2015) reported that there was 30% reduction in urease activity, 36% inhibition in dehydrogenase activity and 34% decline in alkaline phosphatase activity with bromoxynil herbicide application due to decrease in microbial population. Baboo et al., (2013) reported that the enzyme activities of amylase, invertase, protease, urease and dehydrogenase were affected by the herbicides butachlor, pyrazosulfuran, paraquat and glyphosate over a period of four weeks, the herbicides caused transient impact on microbial populations and enzyme activities associated with the type of herbicides at recommended field application. Rasool and Reshi, (2010), reported that pesticide application affects activities of different soil enzymes differently while the activities of urease and asparaginase were inhibited and the activities of dehydrogenase, protease and amidase activities were stimulated in response to pesticide treatments on the other hand phosphatase exhibited a highly variable response to different concentration of pesticide as the phosphatase activity was influenced by pH. Weaver et al. (2004) reported inactivation of most soil enzymes, because of herbicide attachment on the active site of enzyme and thus preventing...