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Effect of atrazine and nutrient resources on soil quality under fodder sorghum

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ABSTRACT

A study was conducted at IGFRI, Jhansi to evaluate the soil quality through analysis of alkaline monophosphatase activity as affected by pre-emergence application of atrazine @ 1.5 kg a.i. ha^{-1} and supplementation with farmyard manure in fodder sorghum (cv PC-6) during two consecutive kharif seasons. It was observed that atrazine had some inhibitory effect on soil enzyme activity during initial phases of crop growth, but the effect was not much pronounced and the activity was restored to a considerable extent. Introduction of FYM showed positive effect on soil quality and correlation of organic matter with enzyme activity in sub-surface soil samples. No phytotoxicity was observed in the crop at the used rate of atrazine application

***Key Words**:* Atrazine, fodder sorghum, FYM, phosphatases, soil enzymes and soil quality

Pesticides have become an indispensable component of sound agriculture system. Atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine), belongs to a group of pesticides that are moderately persistent and moderately mobile in soil. The half-life of atrazine varies between several days and several month. Sorghum for forage [*Sorghum bicolor* (L.) Moench] occupies 2.93 million ha area in semi-arid regions of India. Being a rainy season crop, it faces the problem of heavy infestation of weeds. Therefore weed management in forage sorghum is an important aspect to check the nutrient, water loss and to increase the fodder yield.

Measurements of enzyme activities can be used as an index of soil fertility (Perucci, 1992). For example, the measurement of intracellular dehydrogenase activity in soil is a common method of estimating potential soil microbial activity (Beyer *et al*., 1993) and has been used as a basis for empirical indexes of soil biology or fertility (Dick, 1994). Phosphatase is, a hydrolytic enzyme of agricultural interest. Closely involved with the P cycle, this enzyme is capable of hydrolyzing organic phosphate esters (Alef *et al*., 1995) to inorganic phosphorus, which can then be absorbed by plants.

Active substances found in many herbicides may hamper the rate of a series of biochemical processes, interfering with the soil enzymatic activity and microbial growth. Modifications in the count and activity of microorganisms may lead to upsetting the biological equilibrium of soil, which in turn affects its fertility. All these considerations emphasise the importance of studies on the effect of pesticides on the biological activity of soil Braschi *et. al.* 2000), and particularly on soil enzymes, which can serve as a good indicator of the impact of pesticides on soil metabolism.

MATERIALS AND METHODS

The experiment was conducted at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi during *kharif* seasons of 2006 and 2007. The soil characteristic of the experimental area is described in table 1. Sorghum (var PC-6) was taken as the kharif crop and plant nutrient (nitrogen) was applied through completely inorganic source (urea) or 50% of it replaced by organic (FYM). There were four treatment combinations in total – sole inorganic nutrient with no herbicide (T_1), sole inorganic nutrient with pre-emergence application of atrazine @ 1.5 kg a.i. ha^{-1} (T_2), 50:50 inorganic-organic nutrient with no herbicide (T_3) and 50:50 inorganic-organic nutrient with pre-emergence application of atrazine @ 1.5 kg a.i. ha^{-1} (T_4). The size of each experimental plot was 4 × 3m with 0.75 m channels in between the plots. The experiment was laid out in Completely Randomized Block design with four replications. The recommended dose of nutrient for fodder sorghum (90 kg N, 40 kg P ha^{-1}) was used. The treatment plots created in the first year were kept undisturbed and continued for the same treatments in the next year. Both the years were affected by drought condition in the region (average annual rainfall ~ 450 mm). After sowing and imposition of treatments, soil samples were collected from all the replication plots from two depths – surface region (0-15 cm) and sub-surface region (15-30 cm). The sampling was done at periodic intervals and the soil samples were partially air-dried before passing through 2 mm sieve. The sieved samples were subjected to laboratory analysis for determination of alkaline monophosphatase activity following standard spectrophotometric method and using *p*-nitrophenyl phosphate as substrate and measurement of absorbance at 400 nm (Tabatabai and Bremner, 1969). During 2006, the changes in soil phosphatase activity within a month were studied. But in the next year, i.e., 2007, the interval was made wider to study the trend in changes of soil phosphatase activity in different treatments till the harvest of fodder sorghum

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Table 1. Initial soil properties of experimental field.

Soil parameters	Analyzed result
pH	7.19
EC	0.14 dSm^{-1}
BD	1.35 g cc^{-1}
Water holding capacity (Max)	34.3 %
Texture	Clay
Organic carbon	0.52 %
Total nitrogen	0.080%
Available nitrogen	57.8 ppm
Available phosphorus	5.52 ppm
Available potassium	118.3 ppm
Available sulphur	2.97 ppm

RESULTS AND DISCUSSION

The results of analysis of soil enzyme activities are presented in tables 2 to 5. The soil monophosphatase activity was determined in moist soil and results were expressed in oven dry weight basis. In the years 2006 and 2007, after the initial (0 day) subsequent intervals of sampling were kept separate to cover a wider time zone of study as a whole. The enzyme activity in soil was improved in 2007 in comparison to 2006. In 2006, there was depression of phosphatase activity caused by pre-emergence application of atrazine and this effect continued till the last sampling, *i.e*., 30 days after sowing/spraying (DAS) though with a declining trend (Table 2). However, the alkaline monophosphatase activity was enhanced when 50% of the total recommended dose of nitrogen was applied through organic source (FYM). During kharif 2007, when the same study was continued in same experimental plots but with a longer sampling period, atrazine again expressed its inhibitory effect on phosphatase and the effect was significantly high in the surface soil samples from 10 DAS (Table 3). The examination of the analysed values revealed that not only the organic nutrient application resulted in enhanced phosphatase activity, but also played a role in restoring the enzyme activity in the herbicide treated soil. This phenomenon was supported from the laboratory results, on comparison of the phosphatase activities between T_1 and T_2 on 10 and 73 DAS and thereafter compared the enzyme activities between T_3 and T_4 at the same time intervals. The subsurface (15-30 cm) soil samples were also analysed for alkaline monophosphatase activity (Table 4 and 5). The results showed that the phosphatase activity in the lower horizon of the soil was much lower than the surface zone where the organic matter content was more. Several reports have compared phosphatase activity with soil depth (Kiss *et al.* 1974, Arutyunyan and Galstyan 1975). Phosphatase activity decreases with soil depth and corresponds to the distribution of microorganisms in the soil profiles (Khazirev and Burangulova 1965) and organic matter content (Arutyunyan and Galstyan 1974).Phosphatse activity is directly related with the soil organic matter and it has been reported by many authors (Beyer *et. al*. 1992). All pesticides, including herbicides, play an important role in the environment by modifying the enzymatic activity of soils (Furczak and Gostkowska 1982, Nowak 1983). Enzyme activities decrease after decreasing total organic carbon (Beyer *et al*. 1999) as can be seen in different intensively cultivated agricultural soils. Organic carbon content was found to correlate with total nitrogen content. There was a positive correlation between this element and phosphatase activity, which corresponds with the data reported by Speir (1978) and Bonmati *et al*. (1991), Aon and Colaneri (2001) described strong relationships between organic carbon and total nitrogen with enzymatic activities including acid and alkaline phosphatases.

The green forage yield of sorghum was taken in both the years and the result is presented in figure 1. In both the years, the yield variation amongst different treatments was not significant. One of the reasons may be because of the drought situation, weed problem was not severe and so effect of herbicide could not be properly translated in yield increase. Secondly the effect of organic manure was also not expressed fully as those were the initial years of experimentation. However, it was clear from the result that atrazine, at its applied dose, did not have any detrimental effect on the growth of sorghum.

Table 2: Effect of atrazine on soil alkaline monophosphatase activity during 2006

Treatments	Alkaline monophosphatase activity (mg PNP g^{-1} soil hr^{-1})				
	0 day	**3 days**	**7 days**	**15 days**	**30 days**
T_1	0.103	0.097	0.111	0.120	0.122
T_2	0.083	0.067	0.091	0.101	0.109
T_3	0.142	0.145	0.163	0.170	0.171
T_4	0.131	0.123	0.130	0.145	0.160
SEm (±)	**0.006**	**0.014**	**0.010**	**0.012**	**-**

Table 3: **Effect of atrazine on soil alkaline monophosphatase activity during 2007**

Treatments	Alkaline monophosphatase activity (mg PNP g^{-1} soil hr^{-1})				
	0 day	**10 days**	**21 days**	**46 days**	**73 days**
T_1	0.265	0.332	0.171	0.193	0.255
T_2	0.227	0.157	0.135	0.146	0.189
T_3	0.289	0.318	0.217	0.248	0.285
T_4	0.243	0.175	0.175	0.194	0.224
SEm (±)	**0.009**	**0.018**	**0.010**	**0.008**	**0.009**

Table 4: Effect of atrazine on soil alkaline monophosphatase activity during 2006

Treatments	Alkaline monophosphatase activity (mg PNP g^{-1} soil hr^{-1})				
	0 day	**3 days**	**7 days**	**15 days**	**30 days**
T_1	0.067	0.065	0.070	0.096	0.092
T_2	0.045	0.033	0.057	0.062	0.089
T_3	0.093	0.106	0.110	0.115	0.109
T_4	0.087	0.075	0.087	0.098	0.100
SEm (±)	**0.003**	**0.009**	**0.008**	**0.010**	**-**

Table 5: **Effect of atrazine on soil alkaline monophosphatase activity during 2007**

Treatments	Alkaline monophosphatase activity (mg PNP g^{-1} soil hr^{-1})				
	0 day	**10 days**	**21 days**	**46 days**	**73 days**
T_1	0.146	0.157	0.093	0.166	0.244
T_2	0.180	0.127	0.099	0.088	0.156
T_3	0.247	0.154	0.100	0.199	0.207
T_4	0.244	0.117	0.094	0.107	0.129
SEm (±)	**0.005**	**0.008**	**0.004**	**0.006**	**0.009**

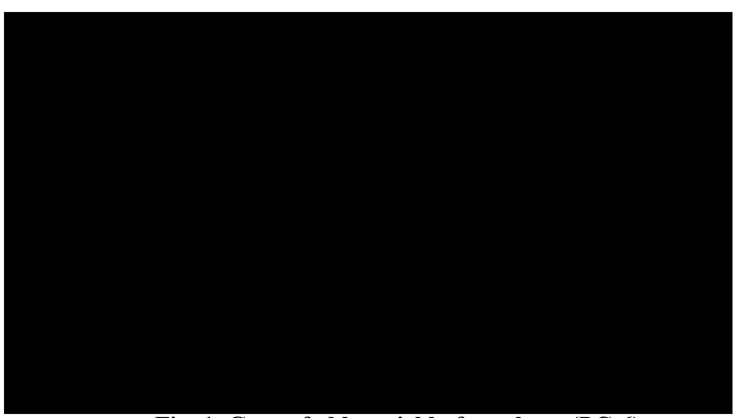

Fig. 1: **Green fodder yield of sorghum (PC-6)**

It is concluded from the study that though atrazine causes an initial depression of alkaline monophosphatase activity in surface soil, this was recovered in the later stages of crop growth. Integration of organic resources in nutrient management enhances phosphatase activity and also reduces the effect of herbicide on phosphatase. Therefore, application of organic improves soil quality and health and atrazine, when applied at recommended dose did not show any detrimental effect on soil quality at the end of the crop season.

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