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Effect of different post-emergent herbicides on soil enzyme activity in cluster bean

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Abstract
A field experiment was conducted during *Kharif*, 2016 at College of agriculture, Rajendranagar, Hyderabad, Telangana. The soil of the experimental site was sandy loam with pH, 8.02 and electrical conductivity, 0.35 dS m^{-1}. The soil has low organic carbon (0.41%), available N (294 kg N ha^{-1}), available P (30 kg P_2O_5 ha^{-1}) and available K (204 kg K_2O ha^{-1}). The experiment was laid out in randomized block design with seven treatments replicated thrice. The treatments are T_1: Pendimethalin (30% EC) @ 1.0 kg ha^{-1} (PE) followed by hand weeding twice at 20 and 40 DAS, T_2: Pendimethalin (30% EC) 1.0 kg ha^{-1} (PE) followed by Imazethapyr (10% SL) 100 g ha^{-1} as post-emergence spray at 20-25 DAS, T_3: Pendimethalin (30% EC) 1.0 kg ha^{-1} (PE) followed by Acifluorfen + Clodinafop propargyl (16.5 + 8% EC) 165 + 80 g ha^{-1} as post-emergence spray at 20-25 DAS, T_4: Pendimethalin (30% EC) @ 1.0 kg ha^{-1} (PE) followed by Propaquizafop 2.5% + Imazethapyr 3.75% ME 50 g + 75 g ha^{-1} as post-emergence spray at 20-25 DAS, T_5: Pendimethalin (30% EC) 1.0 kg ha^{-1} (PE) followed by Imazethapyr + Imazamox (70% WDG) 70 g (35 g + 35 g) ha^{-1} as post-emergence spray at 20-25 DAS, T_6: Hand weeding (twice at 20 and 40 DAS) and T_7: Control (unweeded).
Soil samples were assayed for soil enzyme activity (dehydrogenase, urease, acid and alkaline phosphatase) at different intervals of observation *viz.*, 1(24), 3(26), 8(31), 15(38) and 30(53 DAS) DAA. Soil enzyme activity was affected from 1DAA (24 DAS) to 15 DAA (38 DAS) due to the influence of herbicides but they recovered to normal from 15 DAA in post-emergence herbicide treatments. However they showed on par relation with hand weeded and controlled treatments.

Keywords: Post-emergent herbicides, soil enzyme activity, cluster bean

Introduction
Soil enzyme activity which is an indication of the biological activity and an important factor of productivity from agricultural and ecological stand point and sensitive indicator of anthropogenic impact. All biological reactions are catalysed by the enzymes which are proteins with catalytic properties towards specific substance (Quastel and Scholefield, 1951) [8]. Soil contain group of enzymes that determine metabolic processes which in turn depend on physical, chemical, microbiological and biochemical properties of soil. Soil enzymes play an essential role in soil processes such as nutrient cycling and energy transformation by catalyzing numerous chemical, physiological and biological reactions. Enzymes are constantly synthesized, accumulated, inactivated or decomposed in soil and play an important role in agriculture (Tabatabai, 1994) [12]. They may also be present in dead cells or cell debris and also adsorbed by clay or incorporated in humic substances.
As discussed above enzymes play very crucial role in nutrient cycling it is important to know the effect of herbicides and their impact on the enzyme activity. As it is necessary to use herbicides effectively and efficiently this study was conducted to know the effect of different herbicides in combination.

Methods and Materials
The soil samples were collected at 1, 3, 8, 15 and 30 days after post emergence herbicide application were assessed for the enzyme activities *viz*., dehydrogenase, urease and phosphatase. Urease activity was assayed by quantifying the rate of release of NH^{4+}-N from hydrolysis of urea as described by Tabatabai and Bremner (1972) [11]. The method involved in determination of dehydrogenase activity in the soil was spectrophotometry of Tri Phenyl Formazon (TPF) produced when soil is treated with Triphenyl Tetrazolium Chloride (TTC), given by Cassida *et al*., (1964) [2]. Likewise the acid and alkaline phosphatase activity was assayed by quantifying the amount of *p*-nitrophenol released and expressed as µg of *p*-nitrophenol released g^{-1} soil h^{-1} as described by Tabatabai and Bremner (1972) [11].

Results and Discussion

Effect of herbicide treatments on enzyme activity in the soil

To evaluate the influence of herbicides on soil biological health, the three enzymes which are released by microorganisms during the decomposition and have a bearing on soil nutrient transformations were chosen for the study. The effect of different treatments on activity of three soil enzymes *viz*., dehydrogenase, urease and phosphatase (acid and alkaline phosphatase) activity was evaluated at 1, 3, 8, 15 and 30 days after application (DAA), which means 24, 26, 31, 38 and 53 DAS.

Effect of herbicides on soil dehydrogenase activity

Dehydrogenases are generally present in surface layers of soil. Dehydrogenases are respiratory chain enzymes and play the major role in the energy production of organisms. They oxidise organic compounds by transferring two hydrogen atoms. These are essential components of the enzyme systems of microorganisms. Dehydrogenase activity can be used as an indicator of biological redox systems and as a measure of microbial activity in soil, which in turn influences the nutrient availability to plants. The effect of different treatments on activity of soil dehydogenase enzyme (mg of TPF released g^{-1} soil 24 h^{-1}) at various days after herbicide application in cluster bean was presented in table1.

In all the treatments, the dehydrogenase activity showed an increasing trend with the age of the crop. Highest dehydrogenase activity was recorded in T_7 (unweeded), T_6 (hand weeding) and T_1 (pendimethalin fb hand weeding). In general, the dehydrogenase activity decreased significantly over hand weeded and unweeded check in all other treatments (with application of post emergence herbicides) at all intervals up to 15 DAA (38 DAS). Highest activity in T_1, T_6 and T_7 due to healthy rhizosphere growth as there was no herbicide application in T_6 and T_7 and no post-emergent herbicide application in T_1 after emergence of crop. Lower dehydrogenase activity in other treatments was due to toxic effects of herbicides applied which led to inhibition of microorganisms involved in nutrient breakdown (Hazel and Greases, 1981) [3].

However, the decrease in activity with post emergent herbicides existed only up to 15 DAA (31 DAS). Later the activity of dehydrogenase regained from 15 DAA (31 DAS) to 30 DAA (53DAS) and non-significant differences was recorded as microbes used the applied herbicides as carbon source resulting an increase in the enzymatic activity (Latha and Gopal, 2010) [5].

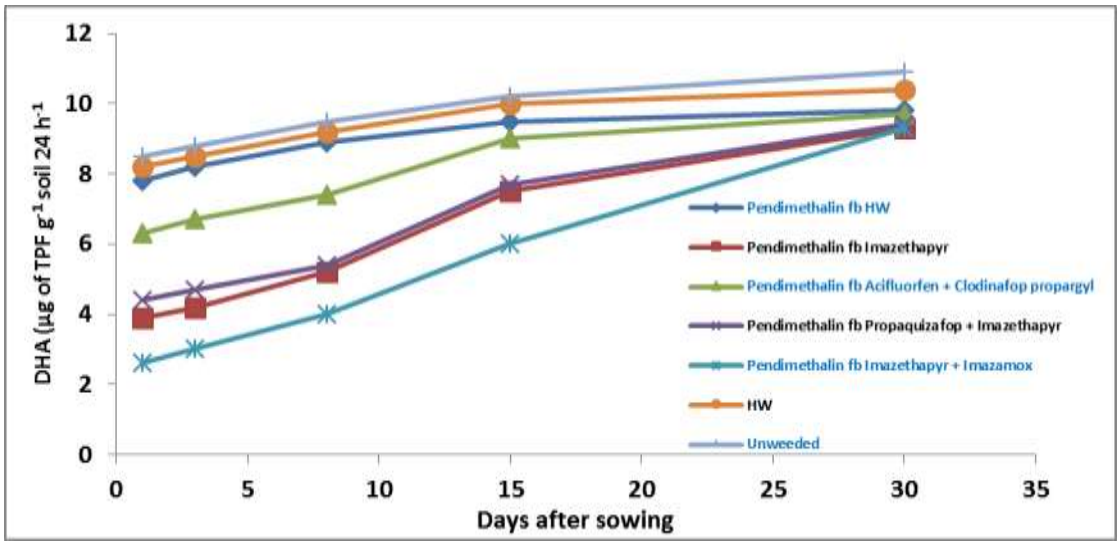
Effect of herbicides on soil urease activity

Urease is unique among soil enzymes, catalyses the hydrolysis of urea to carbon dioxide and NH_4^+ and thus greatly affects the fate and performance of urea.

The effect of different treatments on activity of soil urease (µg NH_4^+-N released g^{-1} soil h^{-1}) at different days after application is presented in table 2 and depicted in fig 2. In all the treatments, the urease activity showed an increasing trend with increasing crop age.

Table 1: Effect of herbicides on dehydrogenase activity (µg of TPF released g^{-1} soil 24 h^{-1})

Trt. No.	Treatment	24 DAS	26 DAS	31 DAS	38 DAS	53 DAS
T_1	Pendimethalin fb HW at 20 and 40 DAS	7.8	8.2	8.9	9.5	9.8
T_2	Pendimethalin fb Imazethapyr	3.9	4.2	5.2	7.5	9.3
T_3	Pendimethalin fb Acifluorfen + Clodinafop propargyl	6.3	6.7	7.4	9.0	9.7
T_4	Pendimethalin fb Propaquizafop + Imazethapyr	4.4	4.7	5.4	7.7	9.4
T_5	Pendimethalin fb Imazethapyr + Imazamox	2.6	3.0	4.0	6.0	9.3
T_6	Hand weeding at 20 and 40 DAS	8.2	8.5	9.2	10.0	10.4
T_7	Unweeded	8.5	8.8	9.5	10.2	10.9
	S. Em. (±)	0.47	0.30	0.31	0.39	0.59
	CD (0.05)	1.47	0.93	0.97	1.21	NS

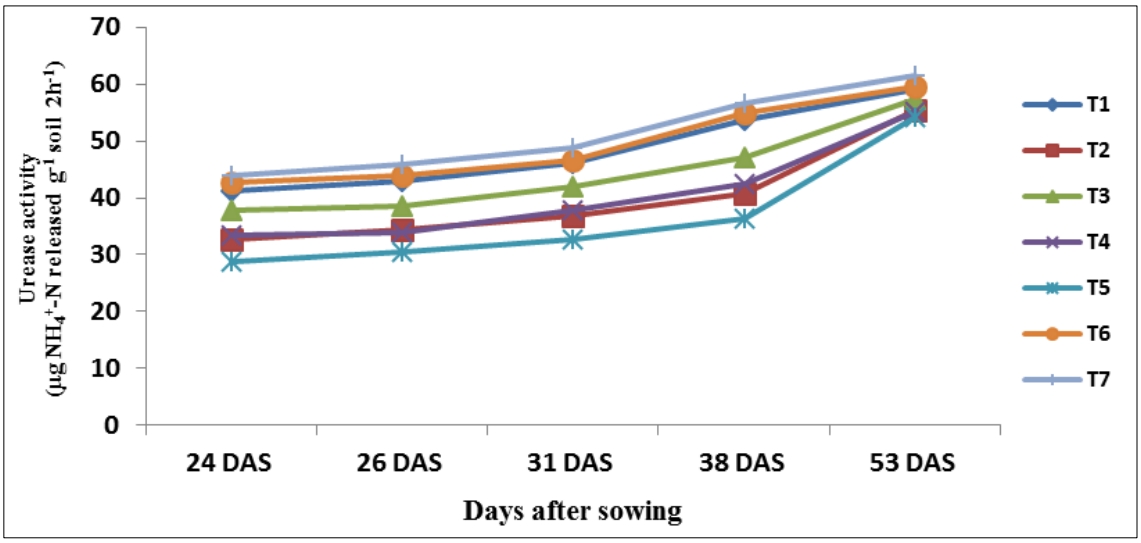


T_1: Pendimethalin fb HW at 20 and 40 DAS; T_2: Pendimethalin fb Imazethapyr; T_3: Pendimethalin fb Acifluorfen + Clodinafop propargyl; T_4: Pendimethalin fb Propaquizafop + Imazethapyr; T_5: Pendimethalin fb Imazethapyr + Imazamox; T_6: Hand weeding at 20 and 40 DAS; T_7: Unweeded

Fig 1: Effect of herbicides on dehydrogenase activity (µg of TPF released g^{-1} soil 24 h^{-1})

Table 2: Effect of herbicides on urease activity (µg NH_4^+-N released g^{-1} soil $2h^{-1}$)

Trt. No.	Treatment	24 DAS	26 DAS	31 DAS	38 DAS	53 DAS
T_1	Pendimethalin fb HW at 20 and 40 DAS	41.3	43.0	46.0	53.7	59.1
T_2	Pendimethalin fb Imazethapyr	32.8	34.3	36.9	40.8	55.3
T_3	Pendimethalin fb Acifluorfen + Clodinafop propargyl	37.7	38.5	41.9	47.1	57.3
T_4	Pendimethalin fb Propaquizafop + Imazethapyr	33.4	33.9	37.7	42.4	55.1
T_5	Pendimethalin fb Imazethapyr + Imazamox	28.8	30.5	32.8	36.3	54.3
T_6	Hand weeding at 20 and 40 DAS	42.6	44.0	46.7	54.9	59.6
T_7	Unweeded	43.8	45.8	48.9	56.7	61.5
	S. Em. (±)	1.09	1.11	1.20	1.49	2.24
	CD (0.05)	3.38	3.45	3.71	4.61	NS



T_1: Pendimethalin fb HW at 20 and 40 DAS; T_2: Pendimethalin fb Imazethapyr; T_3: Pendimethalin fb Acifluorfen + Clodinafop propargyl; T_4: Pendimethalin fb Propaquizafop + Imazethapyr; T_5: Pendimethalin fb Imazethapyr + Imazamox; T_6: Hand weeding at 20 and 40 DAS; T_7: Unweeded

Fig 2: Effect of herbicides on urease activity (µg NH_4^+-N released g^{-1} soil $2h^{-1}$)

At all the intervals, highest urease activity was found in treatment T_7 (weedy check) which was on par with T_6 (Hand weeded at 20 & 40 DAS) and T_1 (pendimethalin PE fb hand weeded twice at 20 & 40 DAS). In all the treatments of PoE herbicide application (T_2, T_3, T_4 & T_5), significant reduction in urease activity was noticed up to 15 DAA over non PoE herbicidal treatments (T_7, T_6 & T_1). However, the urease activity was restored later at 30 DAA in the herbicidal treatments and they were similar results were also reported by Bacmaga *et al*. (2014) [1], Rao *et al*. (2012) [9]. That, there is reduction of urease activity in initial stages with herbicide application, the on par in all the treatments with each other. Lowest urease activity was recorded in T_5 (pendimethalin PE fb imazethapyr + imazamox PoE) from 24 DAS to 38 DAS which was on par with T_2 (pendimethalin PE fb imazethapyr PoE) application of recommended dose of herbicides will not affect the enzyme activity in long run due to degradation of herbicides by microbial population in soil.

Effect of herbicides on phosphatase activity in soil

Soil phosphomonoesterases *i.e*., acid and alkaline phosphatases are a broad group of enzymes that are capable of catalyzing hydrolysis of esters and anhydrides of phosphoric acid. They play an important role in phosphorous nutrition of plants as these enzymes are involved in mineralization of organically bound phosphates to inorganic phosphate in soil. In soil ecosystems, phophatases are believed to play a vital role in P cycles (Speir and Ross, 1978) [10].

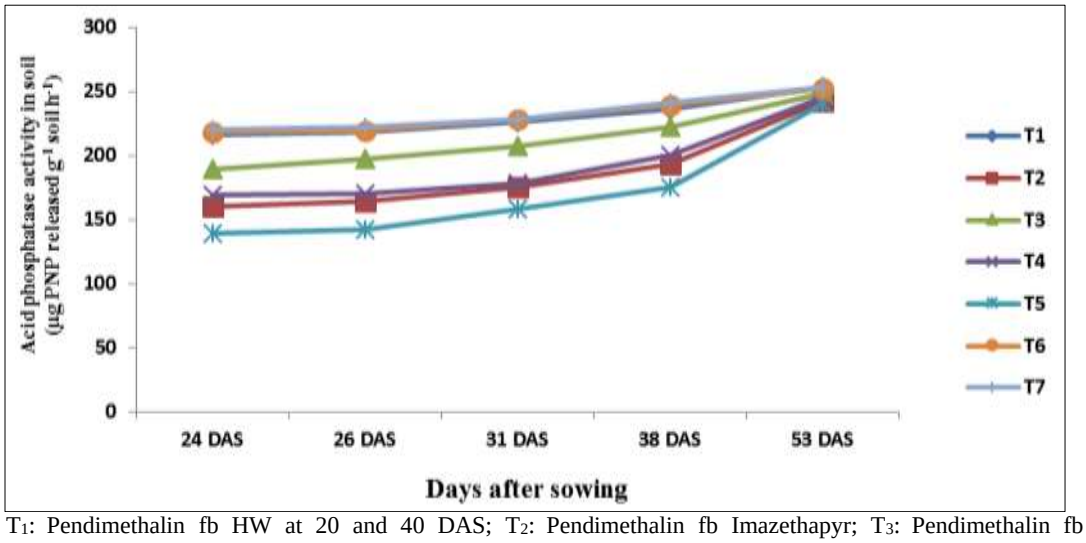
Effect of herbicides on acid phosphatase activity in soil

The acid phosphatase activity (Table 3) was significantly higher in treatments which did not received post emergent herbicides (T_7, T_6 and T_1) than the treatments which received PoE herbicides (T_2, T_3, T_4 and T_5) at all growth stages after their application up to 15 DAA (38 DAS). However at 30 DAA (53 DAS), the activity was on par in all the treatments indicating restoration of acid phosphatase activity in treatments that received PoE herbicides. Results were depicted in fig 3.1. The acid phosphatase activity was least in T_5 at all the intervals after application of post emergence herbicides upto 38 DAS (15 DAA). Rao, P.C. *et al*. (2012) [9] also stated that increase in enzyme activity was due to change in variables of microflora and increase in availability of substrate.

Table 3: Effect of herbicides on acid phosphatase activity in soil (µg PNP released g^{-1} soil h^{-1})

Trt. No.	Treatment	24 DAS	26 DAS	31 DAS	38 DAS	53 DAS
T_1	Pendimethalin fb HW at 20 and 40 DAS	215.8	217.8	226.5	236.3	252.9
T_2	Pendimethalin fb Imazethapyr	160.4	164.6	175.5	193.5	242.1
T_3	Pendimethalin fb Acifluorfen + Clodinafop propargyl	189.1	197	207.2	222.1	247.7
T_4	Pendimethalin fb Propaquizafop + Imazethapyr	168.8	170	177.8	200.4	245.5
T_5	Pendimethalin fb Imazethapyr + Imazamox	139.7	142.0	158.2	175.0	240.3
T_6	Hand weeding at 20 and 40 DAS	218.3	219.3	227.7	239.2	252.5

T_7	Unweeded	220.5	222.5	228.2	241.5	253.4
	S. Em. (±)	6.19	5.35	7.65	5.52	4.93
	CD (0.05)	19.0	16.4	23.5	17.0	NS

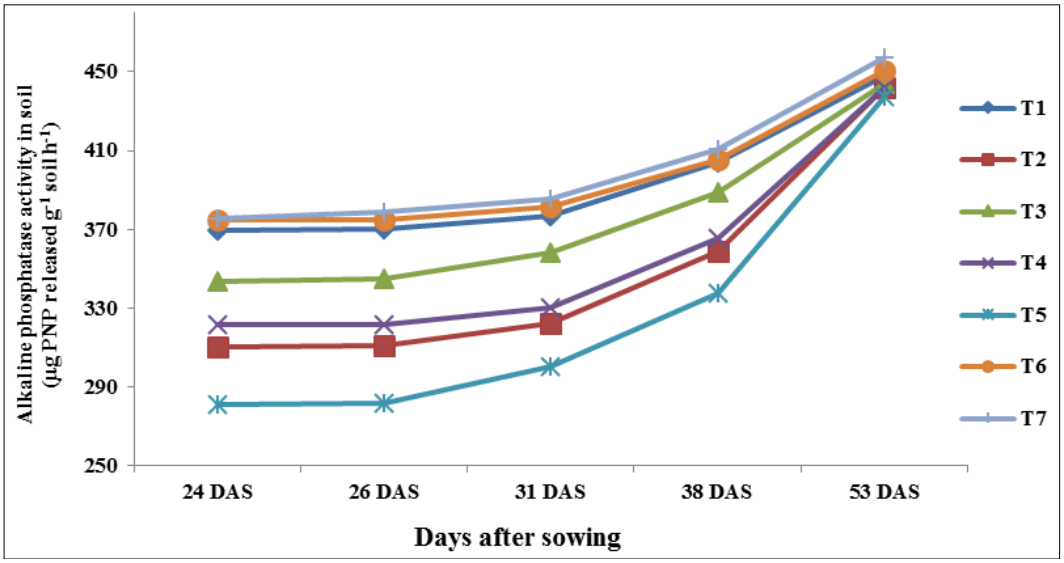


T_1: Pendimethalin fb HW at 20 and 40 DAS; T_2: Pendimethalin fb Imazethapyr; T_3: Pendimethalin fb Acifluorfen + Clodinafop propargyl; T_4: Pendimethalin fb Propaquizafop + Imazethapyr; T_5: Pendimethalin fb Imazethapyr + Imazamox; T_6: Hand weeding at 20 and 40 DAS; T_7: Unweeded.

Fig 3.1: Influence of herbicides on acid phosphatase activity in soil (µg PNP released g^{-1} soil h^{-1})

Table 4: Effect of herbicides on alkaline phosphatase activity in soil (µg PNP released g^{-1} soil h^{-1})

Trt. No.	Treatment	24 DAS	26 DAS	31 DAS	38 DAS	53 DAS
T_1	Pendimethalin fb HW at 20 and 40 DAS	369.3	370.4	376.5	403.8	447.8
T_2	Pendimethalin fb Imazethapyr	310.4	311.2	322.4	358.9	442.2
T_3	Pendimethalin fb Acifluorfen + Clodinafop propargyl	343.7	345.2	358.2	389.0	444.0
T_4	Pendimethalin fb Propaquizafop + Imazethapyr	321.8	322.0	330.3	365.4	441.6
T_5	Pendimethalin fb Imazethapyr + Imazamox	281.4	281.6	300.7	337.5	437.5
T_6	Hand weeding at 20 and 40 DAS	374.5	375.1	381.8	405.5	450.5
T_7	Unweeded	375.7	378.6	385.3	410.4	457.1
	S. Em. (±)	4.55	3.55	5.80	6.57	8.47
	CD (0.05)	14.0	10.9	17.8	20.2	NS



T_1: Pendimethalin fb HW at 20 and 40 DAS; T_2: Pendimethalin fb Imazethapyr; T_3: Pendimethalin fb Acifluorfen + Clodinafop propargyl; T_4: Pendimethalin fb Propaquizafop + Imazethapyr; T_5: Pendimethalin fb Imazethapyr + Imazamox; T_6: Hand weeding at 20 and 40 DAS; T_7: Unweeded.

Fig 3.2: Influence of herbicides on alkaline phosphatase activity in soil (µg PNP released g^{-1} soil h^{-1})

Effect of herbicides on alkaline phosphatase activity in soil

Alkaline phosphatase activity (Table 3.2), depicted in fig 4 was highest in unweeded check (T_7) which was on par with T_1 and T_6. Lowest activity at all the intervals was recorded in T_5 (pendimethalin PE fb imazethapyr + imazamox PoE). The alkaline phosphatase activity was significantly lower with PoE herbicide application (T_2, T_3, T_4 and T_5) than treatments without PoE herbicide application (T_7, T_6 and T_1) up to 15

DAA (38 DAS). At 30 DAA (53 DAS), the activity restoration resulted in on par alkaline phosphatase activity in all the treatments.

Majumdar *et al*. (2010) [6] also reported that the weedy check and hand weeded treatments recorded significantly higher activity of phosphatases than herbicide treatment. Kumar, S. *et al*. (2015) [4] stated that the influence of herbicides mitigated within two weeks after application.

Conclusion

Soil enzyme activity was affected from 1DAA (24 DAS) to 15 DAA (38 DAS) due to the influence of herbicides but they recovered to normal from 15 DAA in post-emergence herbicide treatments. Hence in the present scenario of advancement in technology and unavailability of labour herbicides can be used safely with recommended dosage as there was no negative impact.

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