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Effect of Crop Cover and Stage of Crop Growth on Soil L-glutaminase, Acid and Alkaline Phosphatase Activity in an Alfisol

G. Pavani, P. Chandrasekhar Rao, G. Padmaja, Sameena Khathoon

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Abstract A pot culture experiment was conducted on an Alfisol in the vegetable production unit to study the influence of crop cover on soil enzyme activity. The experiment was undertaken with three cereals—rice, sorghum and maize, two oil seeds—groundnut and sesame, two vegetables—bhendi and spinach and two pulses–greengram and blackgram. The experiment was conducted using crops as treatments in completely randomized block design with three replications along with the uncropped control. The results obtained with regard to the effect of these crops on soil enzyme activity showed that there was an increase in enzyme activity with age of the crop and it varied with plant species grown. The increase in L-glutaminase activity (expressed as µg of NH_4^+ released g^{-1} soil $2h^{-1}$) varied in groundnut (*Arachis hypogea*) from 5.7 to 13.4, blackgram (*Vigna mungo*)) from 5.7 to 12.9, green gram (*Vigna radiata*) from 5.6 to 12.7, sesamum (*Sesamum indicum*) from 4.8 to 11.8, rice (*Oryza sativa*) from 4.7 to 11.3, maize (*Zea mays*) from 4.3 to 10.2, sorghum (*Sorghum vulgare*) from 3.1 to 10.7, spinach (*Spinacea oleracea*) from 3.8 to 9.5 and bhendi (*Abelmoschus esculentus*) from 2.4 to 8.4. The activity of L-glutaminase, Acid and Alkaline phosphatase under different crop coverages followed the order groundnut > blackgram > greengram > sesame > maize > sorghum > spinach > bhendi. The presence of plants and the type of plants grown on a soil have shown a marked effect on enzyme activities.

Keywords L-glutaminase, Crop cover, Organic carbon, Acid, Alkaline phosphatase.

G. Pavani*, P. Chandrasekhar Rao, G. Padmaja, S. Khathoon
Department of Soil Science and Agriculture Chemistry, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad 500030, India
e-mail: pawanigolla@gmail.com
*Correspondence

Introduction

Soil enzymes play a major role in nutrient availability. In soils, enzymes may be associated with viable cells, dead cells (abiontic enzymes), cell debris and immobilized enzymes in the soil matrix. In the soil, enzymes can be stabilized either being adsorbed to internal or external clay surfaces, or complexed with humic colloids by adsorption and cross-linking, microencapsulation. The presence of crops and the type of crops grown on a soil have a marked effect on its enzyme activities. The effect is either direct or indirect. The direct contribution is by way of plant enzymes. In addition to endoenzymes contained in plant residues, extracellular enzymes secreted by living roots make a significant contribution to the total activity. The indirect effect is caused by many factors, basically, however, changes in enzyme activities are related to changes in soil organic matter content and microbial population brought about by the plants [1]. Mummy et al. [2] indicated that crop cover plays a central role

Table 1. Effect of crop cover on soil L-glutaminase activity (μg of NH_4^+ released g^{-1} soil 2 h^{-1}).

Treatments	Days after sowing					
	0 days	30 days	60 days	90 days	At harvest	Mean
Rice	4.7	5.2	11.3	10.4	4.4	7.20
Maize	4.3	4.8	10.2	9.7	3.9	6.58
Sorghum	3.1	4.4	10.7	9.2	3.7	6.22
Groundnut	5.8	6.9	13.4	12.8	5.7	8.92
Sesamum	4.8	5.7	11.8	10.9	4.7	7.58
Greengram	5.6	6.3	12.7	11.2	5.2	8.20
Blackgram	5.7	6.8	12.9	11.6	5.3	8.46
Bhendi	2.4	3.5	8.4	8.1	2.2	4.92
Spinach	3.8	4.2	9.5	8.5	2.5	5.70
Control	2.3	3.2	5.5	4.3	3.1	3.68
Mean	4.25	5.10	10.64	9.67	4.07	
Analysis of variance		CD		SE (m)±		
Crop cover		0.327		0.116		
Days after sowing		0.231		0.082		
Cropcover × Days after sowing		0.732		0.260		

in establishing heterogeneity and regulating ecological processes such as carbon and N mineralization and immobilization. Nearly 25% of the photosynthates are exuded through roots in the rhizosphere. As the nature of photosynthates varies from crop to crop the microbial community in the rhizosphere also differs. After harvest of the crop, the dead microbial cells and / or transformation products of root exudates can also provide adsorption site for enzyme and may thus influence enzyme stability. The crops contribute to soil heterogeneity by their effects on soil moisture, aeration, pH and by the litret distribution. All these factors can affect enzyme synthesis in microbes and enzyme survival outside the microbial cells. The amount of research on the effect of crop cover and the stage of crop on soil enzyme activity is scanty.

Table 2. Effect of crop cover on soil acid phosphatase activity (μg of 4 nitrophenol released g^{-1} soil h^{-1}).

Treatments	Days after sowing					
	0 days	30 days	60 days	90 days	At harvest	Mean
Rice	16	26.5	43.1	26.9	15.8	25.66
Maize	15.8	25.4	38.3	25.5	15.4	24.08
Sorghum	15.6	23.2	33.2	23.3	15.2	22.1
Groundnut	17.8	38.2	54.2	29.3	18.0	31.5
Sesamum	16.4	27.9	44.6	27.2	16.2	26.46
Greengram	16.3	29.4	45.2	28.3	16.4	27.12
Blackgram	16.8	37.7	49.5	28.9	17.5	30.08
Bhendi	14.5	20.4	27.3	20.9	14.5	19.52
Spinach	14.9	22.8	29.8	22.8	14.8	21.02
Control	12.4	13.4	15.7	14.2	13.0	13.74
Mean	15.65	26.49	38.09	24.73	15.68	
Analysis of variance		CD		SE (m)±		
Crop cover		0.8196		0.2921		
Days after sowing		0.5796		0.2065		
Cropcover × Days after sowing		1.8328		0.6532		

Table 3. Effect of crop cover on soil alkaline phosphatase activity (µg of 4-nitrophenol released g^{-1} soil h^{-1}).

	Days after sowing					
Treatments	0 days	30 days	60 days	90 days	At harvest	Mean
Rice	27.6	45.1	98.7	38.0	27.5	47.38
Maize	26.9	43.2	86.4	37.9	26.3	44.14
Sorghum	26.6	41.8	82.2	34.3	24.9	41.96
Groundnut	32.4	47.6	108.6	59.6	34.8	56.6
Sesamum	27.8	45.5	98.6	43.1	29.4	48.88
Greengram	28.5	46.2	99.6	45.9	29.8	50
Blackgram	29.8	46.7	100.7	48.1	32.4	51.54
Bhendi	25.0	41.9	70.5	29.8	20.4	37.52
Spinach	26.0	42.2	79.3	35.1	21.6	40.84
Control	28.5	29.3	31.4	26.8	23.3	27.86
Mean	27.91	42.95	85.6	39.86	27.04	
Analysis of variance		CD		SE (m)±		
Crop cover		1.222		0.435		
Days after sowing		0.864		0.308		
Cropcover × Days after sowing		2.734		0.974		

Hence the present study was undertaken to study the effect of crop cover and stage of crop growth on soil L-glutaminase, acid and alkaline phosphatase activity.

Materials and Methods

A pot culture experiment was conducted in the Vegetable production unit of Department of Horticulture, College of Agriculture, Rajendranagar, Hyderabad during the year 2014 on an Alfisol collected from vegetable production unit. The experiment was undertaken with three cereals–rice (*Oryza sativa*), sorghum (*Sorghum vulgare*), and maize (*Zea mays*), two oilseeds–groundnut (*Arachis hypogea*) and sesame (*Sesamum indicum*), two vegetables–bhendi (*Abelmoschus esculentus*) and spinach (*Spinacea oleracea*) and two pulses–greengram (*Vigna radiata*) and blackgram (*Vigna mungo*). The experiment was conducted using crops as treatments in completely randomized block design with three replications along with the uncropped control. The crops received normal recommended agricultural practices during crop growth. The initial soil samples were taken on the date of sowing and subsequence samples were collected at thirty days interval till harvest. The effect of crop cover and stage of crop growth on L-glutaminase [3] acid phosphatase [4] and alkaline phosphatase [5] activity were studied.

Results and Discussion

The results obtained with regard to the effect of crop cover and stage of crop growth on L-glutaminase activity are presented in Table 1. The L-glutaminase activity in soils collected under these different crops varied with the crops grown. The enzyme activity was consistently higher in soils covered with groundnut, blackgram, greengram, sesamum, rice, maize, sorghum, spinach, bhendi. The L-glutaminase activity increased with the age of crop and increase recorded at each stage of crop growth was significantly higher over previous crop stage up to 60 days after sowing and decreased at harvest. The increase in enzyme activity varied in groundnut from 5.7 to 13.4, blackgram from 5.7 to 12.9, greengram from 5.6 to 12.7, sesamum from 4.8 to 11.8, rice from 4.7 to 11.3, maize from 4.3 to 10.2, sorghum from 3.1 to 10.7, spinach from 3.8 to 9.5 and bhendi from 2.4 to 8.4 µg of NH_4^+ released g^{-1} soil $2h^{-1}$. The L-glutaminase activity of soils under different crop cover follows the order Groundnut > blackgram > greengram > sesamum > rice > maize > sorghum > spinach > bhendi.

The acid phosphatase activity (expressed µg of

4-nitrophenol released g^{-1} soil h^{-1}) value for groundnut ranged from 17.8 to 54.2, blackgram from 16.8 to 49.5, greengram from 16.3 to 45.2, sesamum from 16.4 to 44.6, rice from 16 to 43.1, maize from 15.8 to 38.3, sorghum from 15.6 to 33.2, spinach from 14.9 to 29.8 and bhendi from 14.5 to 27.3 (Table 2). Enzyme activity of the soils under different crop coverages followed the same order as that for L-glutaminase. A close observation of data indicated significant differences between the crops and stages of crop growth and their interactions. The activity of acid phosphatase in uncropped control was least variant with time which ranged from 12.4 to 15.7 µg of 4-nitrophenol released g^{-1} soil h^{-1} and their level increased gradually till 60 days after sowing then decreased at harvest. In cropped pots soil acid phosphatase activity rose sharply from 0 to 60 days after sowing and decreased thereafter to practically 0 day level at harvest.

Data indicated that the alkaline phosphatase activity (expressed µg of 4-nitrophenol released g^{-1} soil h^{-1}) value for groundnut ranged from 32.4 to 108.6, blackgram from 29.8 to 100.7, greengram from 28.5 to 99.6, sesamum from 27.8 to 98.6, rice from 27.6 to 98.7, maize from 26.9 to 86.4, sorghum from 26.6 to 82.2, spinach from 26.0 to 79.3 and bhendi from 25.0 to 70.5 (Table 3). The activity increased sharply up to 60 days after sowing and thereafter declined gradually to 0 day level for all the cropped pots. In uncropped control alkaline phosphatase in all the soils was least variant with time and ranged from 2.5 to 31.4. These results are in conformity with the trends reported in literature by various workers [6—8].

All the enzymes studied including L-glutaminase, phosphatase were significantly activated to different degrees in cropped sites than control, reflecting the response of greater organic matter input to soil, which increased carbon turn over and nutrient availability. All the enzymes increased in proportion to the rate of crop residue addition especially with inclusion of legumes in the system due to N substrates in the crop residues.

In this experiment the groundnut has shown highest activity compared to other crops this is because among the crops studied groundnut has shown least insect attack, less wilting and study growth rate. Hence, the root growth and extracellular enzymes secreted by roots affecting the microcosm of soil rhizosphere also high further the crop cover increased all the biochemical variables like substrates and increasing all hydrolytic enzymes of soils, specially L-glutaminases due to increased carbon turnover and nutrient availability. Here, the higher emzyme activity was observed at 60 days after sowing which was the stage at which most of the crop species posses their flowering stage. At this stage they secrete most of the root exudates, which inturn increase the enzyme activity.

In a study conducted by Dinesh et al. [6] the phosphomonoesterase activity ranged from 12.5 to 14.9 µmol -nitrophenol g^{-1} h^{-1} under cover crops and 7.3 µmol P-nitrophenol g^{-1} h^{-1} (42 to 51%) in control. The activities of urease were significantly lower (41 to 44%) in control than the respective activity in cover cropped sites. Leguminous plants have the potential for biological nitrogen fixation and this could have stimulated the increased activity of enzymes (urease and phosphatase) involved in nitrogen cycle.

Cropping significantly increase the activity of acid and alkaline phosphatase in the soil compared to their activity in soils of fallow lands. Higher alkaline phosphatase activity was reported for legumes than under cereals [7]. Similar findings were also reported by Srinivas et al. [9] that the activity of acid and alkaline phosphatase exhibited significant variations due to differences in plant species and their growth stages. The activities were higher in soils having groundnut and cowpea followed by gingelly, maize and greengram. A significant increase in the activities of both the enzymes was observed from 0 to 45 DAS in all crops and subsequent decrease approaching to initial levels at harvest. Various factors like rhizosphere effect, age of vegetation, nature of present and past crops and weeds influence the level of enzymes in soils.

Vandana et al. [8] also observed that the activities of urease and phosphatase were significantly related to different degrees in cropped sites than in uncropped control. This was mainly due to greater addition of organic matter input to the soil. Khorsandi

and Nourbakhs [10] found that for residue-amended soils, inorganic N decreased in the first 2 weeks of incubation by 50 to 86%, followed by a gradual increase. This is due to the application of corn residues which control the flush of inorganic nitrogen and reduce the potential of nitrate leaching in manure-applied soils. Furthermore, manure application at the highest rate increased the activity of urease by 47%, L-asparaginase by 70%, L-glutaminase by 60% and β-glucosidase by 78%. β -glucosidase increased due to corn shoot application which may provide more C and energy sources for proliferating soil microorganisms, which are partially responsible for enzyme production in soil and demonstrated that manure application has a promoting effect on catalytic activity of soils. The higher enzyme activities of the manured soils can be attributed to the higher enzyme content of the soils. The higher humic material in manured soils can increase the capacity of the soils to protect extracellular pools of the soil enzymes against proteolytic activities and hence, provide more functional enzyme molecules in soil.

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