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Changes in Enzymatic Activity and Microbial Count During Vermicomposting of *Solanum melongena* Stem

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***Solanum melongena* is a vegetable plant but its stem has no economic use and generally burnt in fields. Present study is an attempt to convert it into vermicompost through the activities of *Eisenia foetida*. The study was focused on changes occurred in activities of various enzymes and in microbial count during the vermicomposting process. Vermicompost was prepared in pits of (45 × 45 × 21) cm (l × b × h) size prepared on cemented floor. Four treatments were laid out in triplicates viz. Control: Buffalo dung + *Eisenia foetida*, T_1: Buffalo dung + *Solanum melongena* stem, T_2: Buffalo dung + *Solanum melongena* stem + *Eisenia foetida* and T_3: *Solanum melongena* stem + *Eisenia foetida*. Vermicomposting materials were analyzed at monthly interval for the activities of CMCase, β-glucosidase, FPase, amylase, xylanase, acid and alkaline phosphatase and the count of bacteria, azatobacter, phosphate solubilizer, yeast, fungi and actinomycetes. Results show that the activities of all the enzymes and counts of all the microbial species increased progressively with time but urease activity shows the reverse trend and decreased with time. Statistically the effect of treatments for all these parameters was significant at 5% level of significance except for the counts of yeast and actinomycetes.**

Key words: Brinjal stem, decomposition, earthworms, microbial count, enzyme assay.

Solanum melongena, commonly known as Brinjal, provides low calories and fats and contain many minerals, water, some protein, fiber, carbohydrates, vitamins etc. After harvesting of crop the stem is burnt in field or used as fuel in house. Vermicomposting may be a technique to convert this waste into a valuable product because earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard and derive their nourishment from microorganisms which grow upon them[1,2]. During vermicomposting the degradation of material is carried out by a number of microorganisms including bacteria, actinomycetes, fungi [3,4,5] and cellulose-degrading bacteria[5]. These microorganisms produce a variety of extra- or intra- cellular enzymes. Gut of earthworms also secrets many enzymes which degrades the material during their passing through it.

In present study activities of variety of enzymes responsible for degradation of raw material was checked along with the number of important degrading microorganisms at various time intervals.

MATERIALS AND METHODS

Solanum melongena stem, buffalo dung and *Eisenia foetida* were used for the experiment which were arranged locally. Four treatment combinations were used viz. Control: Buffalo dung + *Eisenia foetida*, T_1: Buffalo dung +*Solanum melongena* stem, T_2: Buffalo dung + *Solanum melongena* stem + *Eisenia foetida* and

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T_3: *Solanum melongena* stem + *Eisenia foetida*. The experiment was laid down in triplicates in pits of (45×45×21) cm (l×b×h) size constructed on cemented floor. The material was filled in layers in pits. The first layer was of buffalo dung (3kg) followed by one layer of small pieces (1 inch length) of stem (1kg) and top layer of buffalo dung (2kg). In control only buffalo dung was added. The material was mixed thoroughly and watered upto nearly 70% moisture. The whole material was turned at 7 days interval. After 15 days of experimentation, earthworms were added to the pits @ 18g per pit. Again the material was mixed and watered. Weekly turning and regular watering was done upto maturity of vermicompost i.e. 90 days.

Enzymatic and microbial characteristics of vermicomposting of *Solanum melongena*

During vermicomposting the samples were withdrawn monthly and analyzed for their enzymatic activities (CMCase, β-glucosidase, FPase, amylase, xylanase, urease, acid and alkaline phosphatase) and microbial counts (bacteria, azatobacter, phosphate solubilizer, yeast, fungi, actinomycetes) [6,7].

Statistical analysis

Results of the study were analyzed statistically following CRD (Completely Randomized Design) to find out the significance of experimental treatments at 5% level of significance (Gomez and Gomez, 1984)[8].

RESULTS AND DISCUSSION

Changes in enzymatic activity during vermicomposting of *Solanum melongena* stem

Agricultural material consists of various compounds like cellulose, xylan, celldextrin, starch, nitrogen, phosphorus etc which breaks down during vermicomposting by a number of enzymes produced by microorganisms and earthworm's gut. Cellulose is decomposed by the activities of CMCase and β-glucosidase; cellulose, xylan, celldextrin by xylanase and Fpase; nirogen by urease and phosphorus by acid and alkaline phosphatase; and starch is degraded by amylase. Therefore activities of these enzymes were checked during various stages of vermicomposting. Results shows that except urease the activities of all other enzymes (CMCase, β-glucosidase, FPase, amylase, xylanase, acid and alkaline phosphatase) continuously increased significantly with time which shows that the material is being degraded (Table- 1 and 2).

The activities of CMCase, β-glucosidase, FPase, amylase, xylanase, acid and alkaline phosphatase were increased at maturity of vermicompost compared to their initial values in order of $T_2>T_3>T_1>$control, $T_2>T_3>$control$>T_1$, $T_2>T_1>T_3>$control, $T_2>T_3>T_1>$control, $T_2>T_3>$control$>T_1$, $T_2>T_3>$control$>T_1$, $T_2>T_3>$control$>T_1$, respectively whereas the activity of urease enzyme was decreased during vermicomposting in order of $T_1>$control$>T_3>T_2$. The extracellular β-glucosidase may form complexes with the humic substances and thus increases the resistance of enzyme to the inhibition[9, 10, 11]. Therefore, these enzymes remain active in soil and perform decomposition of complex organic composition. Our results are in tune with previous studies concluded increased enzyme activity during vermicomposting[10, 12, 13, 14, 15]. The urease activity was decreased during vermicomposting because the atomic hydrocarbon inhibits the enzymes[16, 17, 18].

Changes in microbial number during vermicomposting of *Solanum melongena*

Microorganisms play important role in degradation of agricultural waste (*Solanum melongena*) during vermicomposting (90 days). The numbers of bacteria, fungi, yeast, actinomycetes, azatobacter and phosphate solubilizing bacteria also increased during vermicomposting compared to initial numbers of microorganisms in materials in order of control$>T_2>T_1>T_3$, $T_2>T_3>$control$>T_1$, $T_2>T_1>$control$>T_3$, $T_2>T_1>$control$>T_3$, $T_2>T_1>T_3>$control, $T_3>$control$>T_2>T_1$, respectively (Table 3 and 4) and statistically the effect of treatments was found significant at 5% level of significance at maturity for all the microbial species except yeast and actinomycetes.

Easily degradable carbohydrates and pectins are utilized by microorganisms at initial stage whereas more stable material such as lignin was being oxidized in prolonged thermophilic phase[19]. Fungi play an important role in degrading complex organics such as cellulose, lignin and

Table 1. Changes in contents of β-glucosidase, FPase, CMCase, xylanase activity at various stages (0, 30, 60 and 90 days) of vermicomposting of *Solanum melongena*

Treatments	β- glucosidase (IU/mL)				Fpase (IU/mL)				CMCase (IU/mL)				Xylanase (IU/mL)			
	0	30	60	90	0	30	60	90	0	30	60	90	0	30	60	90
Control	4.02[a]	4.68[a]	6.54[a]	7.39[a]	2.67[a]	2.79[a]	3.29[a]	4.12[a]	52.63[a]	66.36[a]	69.31[a]	78.25[a]	2.47[a]	2.74[a]	3.22[a]	3.95[a]
T_1	3.13[b]	3.69[b]	4.26[b]	5.26[b]	3.99[b]	4.18[b]	4.96[b]	5.32[b]	82.33[b]	96.23[b]	103.30[b]	112.40[b]	2.30[a]	2.46[b]	2.69[b]	3.14[b]
T_2	6.70[c]	7.96[c]	10.30[c]	13.30[c]	3.93[b]	4.15[b]	4.89[b]	6.16[c]	215.70[c]	273.60[c]	289.00[c]	354.20[c]	4.36[b]	4.96[c]	5.63[c]	7.29[c]
T_3	7.47[d]	9.38[d]	10.40[c]	12.40[d]	3.90[b]	4.09[b]	4.41[c]	5.24[b]	114.00[d]	138.30[d]	156.30[d]	185.30[d]	3.23[c]	3.69[d]	4.45[d]	4.93[d]
SEM (±)	0.099	0.083	0.088	0.075	0.79	0.062	0.073	0.063	1.63	0.083	3.26	0.085	0.082	0.082	0.059	0.117
CD5%	0.23	0.19	0.20	0.172	0.182	0.143	0.169	0.146	3.77	0.191	7.53	0.196	0.188	0.189	0.136	0.269

Alphabet a,b,c,d shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant

Table 2. Changes in contents of amylase, urease, acidic phosphatase and alkaline phosphatase activity at various stages (0, 30, 60 and 90 days) of vermicomposting of *Solanum melongena*

Treatments	Amylase (IU/mL)				Acidic Phosphatase (µg/g)				Alkaline Phosphatase (µg/g)				Urease (µg/g)			
	0	30	60	90	0	30	60	90	0	30	60	90	0	30	60	90
Control	1.10[a]	1.22[a]	1.36[a]	1.42[a]	17.86[a]	22.23[a]	22.64[a]	66.63[a]	90.63[a]	61.72[a]	46.27[a]	20.56[a]	90.63[a]	61.72[a]	46.27[a]	20.56[a]
T_1	1.14[a]	1.34[a]	1.42[a]	1.52[a]	15.06[b]	23.45[b]	21.14[b]	42.35[b]	76.10[b]	63.44[b]	43.34[b]	21.53[b]	76.10[b]	63.44[b]	43.34[b]	21.53[b]
T_2	1.96[b]	2.31[b]	2.49[b]	2.64[b]	27.69[c]	29.91[c]	27.19[c]	83.86[c]	79.14[c]	67.01[c]	43.42[b]	12.83[c]	79.14[c]	67.01[c]	43.42[b]	12.83[c]
T_3	1.90[b]	2.14[b]	2.21[c]	2.30[c]	21.31[d]	21.73[d]	27.39[d]	68.16[d]	86.77[d]	59.37[d]	43.91[c]	16.73[d]	86.77[d]	59.37[d]	43.91[c]	16.73[d]
SEM (±)	0.087	0.085	0.100	0.073	0.115	0.085	0.084	0.097	0.089	0.109	0.131	0.106	0.089	0.114	0.101	0.095
CD5%	0.201	0.195	0.231	0.169	0.266	0.196	0.194	0.223	0.207	0.252	0.301	0.244	0.206	0.262	0.232	0.220

Alphabet a,b,c,d shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant

Table 3. Effect of different treatments on counts of bacteria, fungi and yeast at various stages (0, 30, 60 and 90 days) of vermicomposting of *Solanum melongena* ($\times 10^{13}$)

Treatments	Bacteria (CFU/mL)				Fungi (CFU/mL)				Yeast (CFU/mL)			
	0	30	60	90	0	30	60	90	0	30	60	90
Control	4.07	1.27[a]	1.39[a]	1.64[a]	4.30	2.30[a]	2.80[a]	3.10[a]	2.70[a]	3.20[a]	3.90	4.40
T_1	7.8	8.8[c]	9.20[b]	3.91[a]	3.20	1.90[a]	2.30[a]	2.40[a]	5.60[b]	6.70[b]	7.30	8.20
T_2	8.9	3.82[a,b]	1.35[a]	1.54[a]	3.60	5.60[b]	6.10[b]	7.10[b]	7.30[b]	9.10[c]	6.33	3.91
T_3	5.5	6.1[b,c]	7.50[c]	8.90[b]	2.00	2.60[a]	3.30[a]	3.60[a]	2.20[a]	2.90[a]	3.30	4.10
SEM (±)	8.37	8.03	7.19	9.64	7.22	7.79	8.68	8.15	8.03	6.73	8.79	8.46
CD5%	NS	4.64	1.14	4.77	NS	1.80	2.0	1.88	1.85	1.55	NS	NS

Alphabet [a,b,c] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant

Table 4. Counts of actinomycetes, azatobacter and phosphate solubilizer bacteria at various stages (0, 30, 60 and 90 days) of vermicomposting of *Solanum melongena* ($\times 10^{13}$)

Treatments	Bacteria (CFU/mL)				Fungi (CFU/mL)				Yeast (CFU/mL)			
	0	30	60	90	0	30	60	90	0	30	60	90
Control	7.40[a]	8.10[a]	6.44	3.82	5.20[a]	6.40[a]	7.80	8.50[a]	5.20[a]	5.60	6.70[a]	8.10[a]
T_1	7.53[a]	8.30[a]	6.39	4.02	8.20[b]	8.90[b]	9.10	3.50[a,b]	3.10[b]	3.50	3.90[b]	4.60[b]
T_2	7.50[a]	7.90[a]	6.34	1.15	8.40[b]	8.90[b]	3.56	1.33[b]	2.70[b]	3.20	4.40[b]	5.20[b]
T_3	4.60[b]	4.90[b]	5.60	6.60	8.10[b]	8.50[b]	5.84	6.11[a,b]	8.10[c]	6.41	1.09[c]	1.21[c]
SEM (±)	8.07	7.92	8.36	20.82	8.59	7.42	8.27	8.00	6.22	7.40	6.78	5.77
CD5%	2.08	10.3	NS	NS	1.98	4.66	NS	1.18	1.43	NS	1.39	1.18

Alphabet [a,b,c] shows significance and non-significance of treatments at 5% level of significance. Treatments with same alphabet are non-significant and with different alphabet are significant

protein [20, 21]. The highest fungal growth was found in the early stage of vermicomposting[12]. The fungi penetrate throughout the composting material, decomposing both chemically and mechanically the more recalcitrant organic matter fraction such as lignin and cellulose. The fungi recommended breaking down the organic raw materials. The numbers of yeast and actinomycetes were also affected the degradation of raw manure. But yeast and actinomycetes are growing slowly than most bacteria and fungi. Actinomycetes easily degraded organic matter. The early thermophilic attack by actinomycetes that easily converts degradable substrates such as sugars and proteins, whereas fungi are the major microorganisms in the following part of the process when cellulose, hemicellulose and lignin are available substrates and humification takes place[22]. Several findings showed increase in total viable counts of actinomycetes and bacteria in the worm treated compost [23, 24]. The increase of microbial population may be due to the congenial condition for the growth of microbes within the digestive tract of earthworm and by the ingestion of nutrient rich organic wastes which provide energy and also act as a substrate for the growth of microorganisms[25]. The phosphate solubilizing bacteria cause significant effect on the available phosphate content in vermicompost[26]. Phosphates activity by microorganism leads to increase in amount of phosphorus and P_2O_5 which support the phosphate availability in cast and help drive biological nitrogen fixation.

CONCLUSION

From the above experiment it can be concluded that *Solanum melongena* stem can be degraded by the activities of *Eisenia foetida* and during this process the number of bacteria, fungi, yeast, actinomycetes, azatobacter and phosphate solubilizing bacteria and the activities of CMCase,

β-glucosidase, FPase, amylase, xylanase, acid and alkaline phosphatase increase whereas the activities of urease decreased. The effect of treatments was significant at maturity of vermicompost at 5% level of significance for all the parameters except counts of yeast and actinomycetes.

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