

Results and Discussion

CHAPTER – IV

RESULTS AND DISCUSSION

The results and discussion pertaining to the decomposition of solid waste using activated Effective Microorganisms (EM) and the effect of EM-SW compost on the test crop, Lady's finger [*Abelmoschus esculentus* (L.) Moench] and Cow pea [*Vigna unguiculata* (L.) Walp.] are presented in this chapter.

4.1 BIOCHEMICAL ANALYSIS OF FRESH SW AND EM-SW COMPOST **(Table – 2)**

4.1.1 Cellulose Content

A decreasing trend in cellulose content was observed in EM-SW compost over 60 days of decomposition. The cellulose content in raw SW was found to be 43.01 per cent and after decomposition with activated EM, it was decreased to 29.14 per cent.

The significant decrease in cellulose content of EM-SW compost ($P < 0.01 = 0.79$) during 60 days of decomposition might be attributed to the presence of lactic acid bacteria present in EM solution which promoted the degradation of lignin and cellulose and fermented these materials thereby removing undesirable effects of undecomposed organic matter.

According to Knowes and Carthy (1987), the decomposition of cellulose to soluble sugars requires the cooperative action of a number of enzymes.

The present finding is on par with the finding of Tamilarasi (2006) who also obtained a significant reduction in cellulose content of Kitchen waste

from 34.71 to 10.93 percent ($P<0.01$) after 60 days of activated EM treatment.

4.1.2 Organic Carbon Content

The organic carbon content in raw solid waste was 29.43 per cent and it gradually decreased to 19.35 per cent after 60 days of decomposition of solid waste with EM.

Statistical analysis of the data proved a significant reduction in organic carbon ($P<0.01=1.93$) after 60 days of decomposition of solid waste by EM and it might be due to the higher mineralization of organic matter by micro flora present in EM.

TABLE - 2
BIOCHEMICAL PARAMETERS OF RAW AND COMPOSTED EM-SW

Biochemical parameters	Raw	Days of observation				SED	CD (P< 0.01)
		15	30	45	60		
Cellulose (%)	43.01	39.95	39.94	33.36	29.14	0.25	0.79
Organic carbon (%)	29.43	26.31	24.05	21.32	19.35	0.61	1.93
Total nitrogen (%)	0.57	0.73	0.96	1.02	1.26	0.05	0.16
C / N ratio	52 : 1	36 : 1	25 : 1	21 : 1	15 : 1		
Total phenol (mg g ⁻¹)	2.85	1.85	1.37	0.91	0.62	0.10	0.31
Total soluble sugars (mg g ⁻¹)	1.60	1.33	1.17	0.93	0.83	0.02	0.05
Reducing sugar (mg g ⁻¹)	0.97	0.85	0.76	0.62	0.55	0.02	0.05
Non-reducing sugars (mg g ⁻¹)	0.63	0.48	0.41	0.31	0.28	0.01	0.04
Catalase*	3.76	6.78	8.23	11.82	13.42	0.10	0.32
Peroxidase**	14.0	37.8	54.2	68.1	71.8	0.74	2.3
Dehydrogenase* **	56.8	40.8	37.6	35.9	30.5	0.64	2.10
pH	6.3	6.6	6.8	7.2	7.5	0.30	0.96

* Enzyme units(Ul⁻¹) equivalent to 1 ml of 0.01N potassium permanganate min⁻¹ mg⁻¹ enzyme protein.

** μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein

*** μ mol of TTC formed g⁻¹ sample mg⁻¹ enzyme protein

Similar result was obtained by Sekaran *et al.* (2005), who found that there was a reduction in organic carbon content from 32.16 per cent to 30.08 per cent in EM-solid waste compost (from canteen and hostel).

The present finding is in accordance with the result of Tamilarasi (2006) who also obtained a significant reduction in organic carbon content from 28.30 to 19.08 percent ($P < 0.01$) during 60 days of decomposition of kitchen waste with activated EM.

4.1.3 Total Nitrogen Content

A steady increase in nitrogen content of EM-SW compost was noticed from 0 to 60 days of decomposition with activated EM which ranged from 0.57 per cent to 1.26 per cent.

The significant increase in total nitrogen ($P < 0.01 = 0.16$) in EM-SW compost might be due to the mineralization of organic matter by microorganisms. The increase in total nitrogen content adds agricultural significance to EM-SW compost because organic manure with high nitrogen content is a welcoming trait for enhancing the yield of agriculture crops.

This result coincides with the result of Damodharan *et al.* (2005) who also observed that during composting, the N, P and K values were on the increase after the experimentation period.

Sekaran *et al.* (2005) also found that the nitrogen content of EM-SW compost increased from 0.98 per cent to 1.21 per cent in the process of composting (within 30 days). This was due to the increased microbial activity in the casts that resulted in an increased mineralization rate of organic nitrogen.

4.1.4 C : N RATIO

C: N ratio of EM-SW compost was narrowed down drastically from 52: 1 to 15 : 1 after 60 days of decomposition of solid waste with EM.

The reduction in C : N ratio of EM – SW compost was due to activated EM treatment which contained efficient decomposing organisms and it enhanced carbon oxidation and mineralization. The C: N ratio of 15: 1 indicates compost maturity and the manural value of the decomposed EM-SW compost.

Cappart et al (1976) recommended that a C:N ratio of 25:1 to 35:1 should be optimum for composted organic matter

The result is on par with the result of Damodharan *et al.* (2005) who found that during composting of solid waste, the C/N ratio was narrowed from 52 : 1 to 25 : 1. Sekaran *et al.* (2005) in his study on evaluation of Effective micro-organisms (EM) in solid waste management established that the carbon and nitrogen (C:N) ratio measurement provided an indication of the degree of decomposition. Enhanced organic matter decomposition in the presence of Effective Micro-organisms (EM) resulted in lowering the C:N ratio from 28 : 1 (fresh waste) to 26 : 1 (composted waste).

. Similar drastic reduction in C:N ratio of 16:1 from 49:1 was obtained by Tamilarasi (2006) during the study on decomposition of kitchen waste by activated EM.

4.1.5 Total Phenol Content

A marked reduction in total phenol content was observed in EM-SW compost, which was 0.62 mg g⁻¹ from 2.85 mg g⁻¹ over 60 days of decomposition with activated EM.

It may be inferred from the statistical data that the reduction in total phenol ($P < 0.01 = 0.31$) after 60 days of decomposition of SW by EM may be indicative of the anti toxicity nature of composted EM-SW for application to crops.

According to Nagarajan *et al.* (1985), the raw crop residue contained high levels of free phenols 8 – 12 per cent and is toxic to many crop plants.

Similar result was obtained by Tamilarasi (2006). A significant reduction in total phenolic content of 1.83 to 0.67 mg g⁻¹ was obtained after 60 days of decomposition of kitchen waste by effective microorganism treatment.

4.1.6 Total Soluble, Reducing and Non-Reducing Sugars

There was a gradual reduction in total soluble, reducing and non-reducing sugar content of EM-SW compost from 0 to 60 days of decomposition with activated EM.

The total soluble, reducing and non-reducing sugar content in raw solid waste were 1.60 mg g⁻¹, 0.97 mg g⁻¹ and 0.63 mg g⁻¹ and it gradually decreased to 0.83 mg g⁻¹, 0.55 mg g⁻¹ and 0.28 mg g⁻¹.

The reduction may be due to the action of microorganisms that partake in the degradation process which utilizes sugar as their carbon source.

4.2 ENZYME ACTIVITY IN FRESH SW AND EM-SW COMPOST

4.2.1 Catalase

It is elucidated from Table – 2, that there was a significantly gradual increase in catalase enzyme activity from 3.76 to 13.42 U l⁻¹ min⁻¹

mg⁻¹ enzyme protein during 60 days of decomposition of solid waste by activated EM ($P<0.01=0.32$).

The oxidative enzymes like catalase and peroxidase play an important role in decomposition process.

The present finding is in accordance with the findings of Gil *et al.* (2000). They reported that MSW compost (80 t ha⁻¹) increased the catalase activity by 200 per cent.

4.2.2 Peroxidase (Table - 2)

The peroxidase enzyme activity in raw SW was 14.0 μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein and as decomposition proceeded, it significantly increased to 71.8 μ mol of pyrogallol oxidized min⁻¹ mg enzyme protein ($P<0.01=2.3$).

4.2.3 Dehydrogenase (Table - 2)

Dehydrogenase enzyme activity in raw SW was 56.8 μ moles of TTC formed g⁻¹ soil mg⁻¹ enzyme protein and it was gradually decreased to 30.5 μ moles of TTC formed g⁻¹ soil mg⁻¹ enzyme protein during 60 days of SW decomposition with activated EM ($P<0.01=2.10$).

The increase in dehydrogenase activity to a certain period (60 days) might be indicating an increase in microbial metabolism in the soil as a result of the mineralization of biodegradable carbon fractions found in the EM-SW compost.

The result is in accordance with the result of Crecchio *et al.* (2004). They reported that the municipal solid waste compost significantly increased the dehydrogenase enzyme activity to 9.6 per cent.

4.2.4 pH and Temperature Profile in EM-SW Compost (Table -2 and Figure -2)

There was a significant increase in pH from 6.3 to 7.5 during 60 days of decomposition of SW by activated EM ($P < 0.01 = 0.96$).

A pH between 6.0 to 8.0 is considered optimum. The compost with this pH might have improved the structure, aeration, water retaining and nutrient collecting ability of soil.

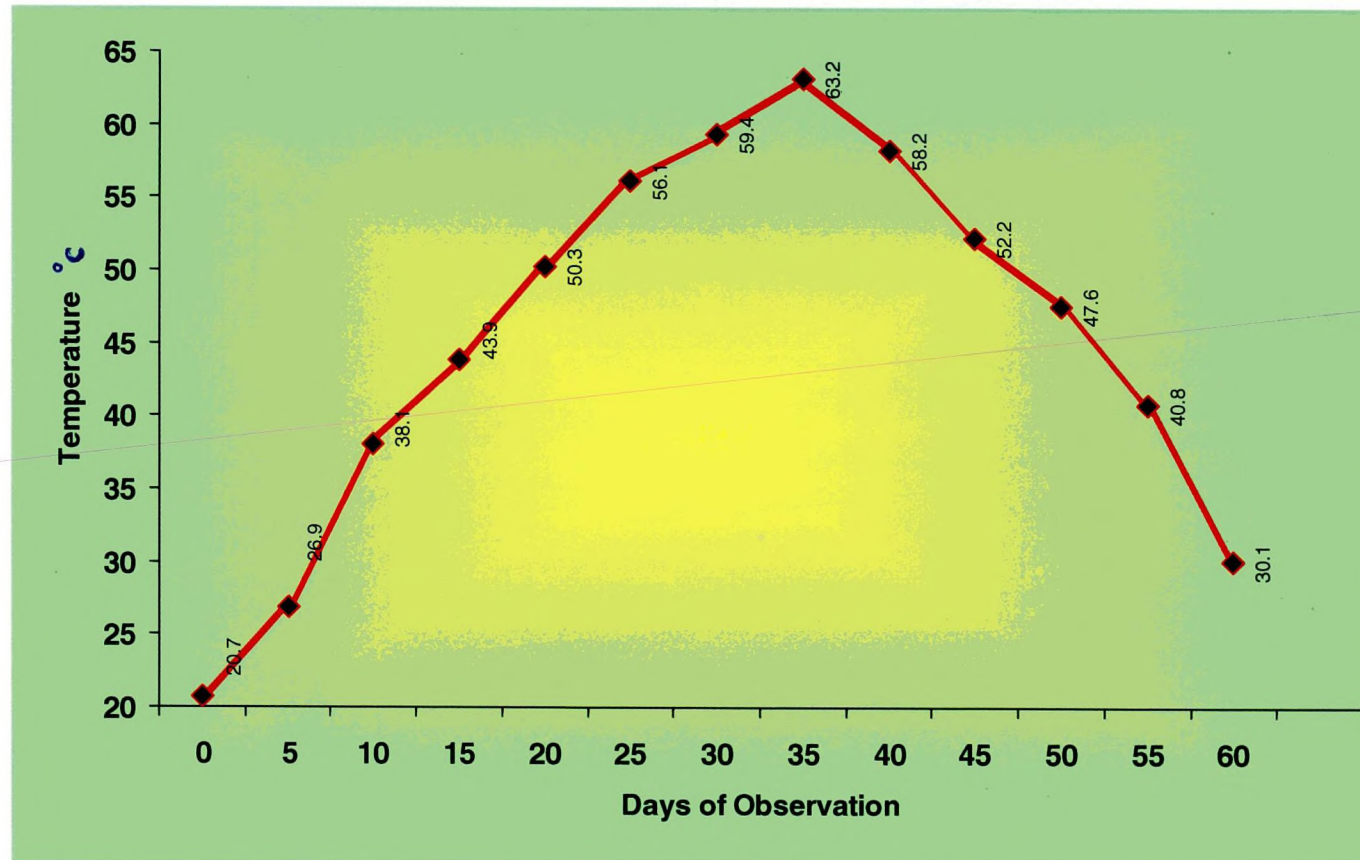
The increase in pH of the EM-SW compost may be attributed to the generation of ammonia from ammonification and mineralization of organic nitrogen through microbial activities.

The result is in conformity with the result of Sekeran *et al.* (2005). They have observed an increase in pH from 7.4 to 8.4 during solid waste composting by EM. They also reported that the occurrence of acidic conditions may be attributed to the bioconversion of organic materials into various intermediate types of organic acids and higher mineralization of the nitrogen and phosphorus into nitrites / nitrates and orthophosphates respectively.

Similar result was obtained by Jeyapriya and Saseetharan (2007). They have obtained a pH of 7.66 in MSW-biocompost.

The temperature profile during 60 days of decomposition of SW by activated EM showed a gradual increase from 20.7°C to 61.3°C upto 40 days and it represented mesophilic and thermophilic phases and decrease in temperature from 61.3°C to 30.1°C which represented cooling (mesophilic and maturation) phase. The elevated temperature of 50 to 61°C encouraged the microbial decomposition and biomass formation of EM-SW compost.

FIGURE - 2
TEMPERATURE PROFILE DURING EM-SW COMPOSTING



In the present study, the temperature of the compost pile in the pit was the highest in the center and decreasing towards the outer zones.

Similar finding was observed by Barrena *et al.* (2006). They observed during their study on prediction of temperature and thermal insertion effect in the maturation stage and stock piling of a large composting mass, that the center of compost mass showed higher temperature than the outer surface (ranging from 15 to 40°C). Thermophilic temperature of 60 to 50 ° C indicated the quick establishment of microbial activities associated with respiratory metabolism in the composting process.

Similar trend was observed by Fogarty and Tuovinen (1995). They divided the composting process into 4 phases based on temperature as mesophilic, thermophilic, cooling and maturation phase.

The increase in temperature in the thermophilic phase might be due to the enzymatic degradation of the complex organic compound found in SW compost into smaller compounds, CO₂ and H₂O by a plethora of microorganisms present in activated EM solution. During this oxidative process heat is also generated as a byproduct.

4.3 POT CULTURE EXPERIMENTS OF TEST PLANTS

The various biometric observations, yield parameters and biochemical analysis recorded at different stages during the growth of Lady's finger [*Abelmoschus esculentus* (L.) Moench.] and Cow pea [*Vigna unguiculata* (L.) Walp.] plants as influenced by different treatments at different intervals 30, 60 and 90 DAS (Days After Sowing) were statistically analysed.

During the three stages (30, 60 and 90 DAS), the biometric parameters like plant height, root volume, number of root nodules per plant, number of leaves per plant, fresh and dry weight of plant, number of flowers per plant and yield parameters like number of pods per plant, length of the pod, number of seeds per pod and 100 seed weight were analysed (Plate – V).

4.4 BIOMETRIC PARAMETERS

4.4.1 Plant height

There was a gradual increase in plant height in all the treatments (T₁ to T₄) from 30 to 90 DAS (Table 3 and Figure 3).

The treatment T₃ (EM – SW compost 80 t ha⁻¹) recorded a significant increase in plant height in both the test plants, Lady's finger and Cow pea which ranged from 33.40 to 102.40 cm and from 27.47 to 65.83 cm over the control T₁ (from 17.53 to 35.53 cm in Lady's finger and 14.10 to 32.20 cm in Cow pea).

Statistical analysis of the data also revealed that the treatment T₃ (EM – SW compost 80 t ha⁻¹), resulted in significantly maximum plant height in the test crops, Lady's finger and Cow pea, than the other treatments [(P<0.01) = 0.54 and 0.35].

Increase in the plant height may be due to greater fixation of atmospheric nitrogen by *Rhizobium* and also by photosynthetic bacteria present in activated EM solution. They synthesize amino acids, nucleic acids, sugars etc., which promoted growth and development of plant.

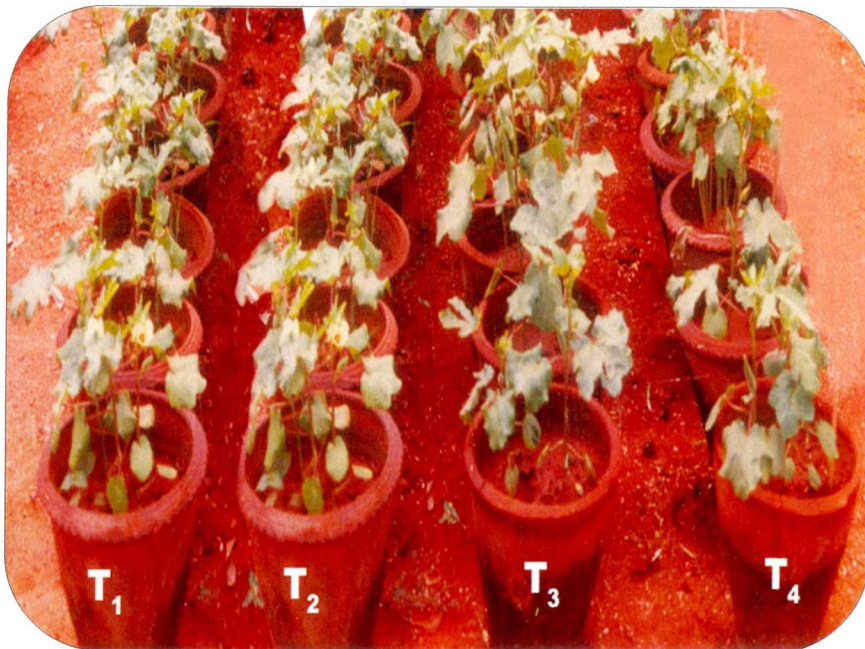
This result is on line with the result of Thananusont (1996) who reported that in a pot culture experiment of soybean, the growth and yield were significantly increased by EM inoculation. Bruggenwert

(2005) in his study found out that EM had a positive effect on the growth of plants.

The result is also in confirmity with the result of Ho and Hwan (2006), who also reported that the EM inoculation to the soil enhanced plant height in rice, maize and Chinese cabbage which were 19.7 cm, 31.8 cm and 18.2 cm respectively over the control.

PLATE V

Overall Pot Culture view of
Abelmoschus esculentus (L.) Moench



Overall Pot Culture view of
Vigna unguiculata (L.) Walp



TABLE - 3
EFFECT OF EM-SW COMPOST ON PLANT HEIGHT (cm)
OF THE TEST PLANTS

Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	17.53	25.80	35.53	14.10	27.03	32.20
T ₂	24.23	37.20	67.63	20.37	34.10	59.20
T ₃	33.40	68.43	102.40	27.47	39.20	65.83
T ₄	27.40	55.87	85.26	19.27	32.40	53.10
SED	0.19			0.12		
CD	0.54			0.35		
(P < 0.01)						

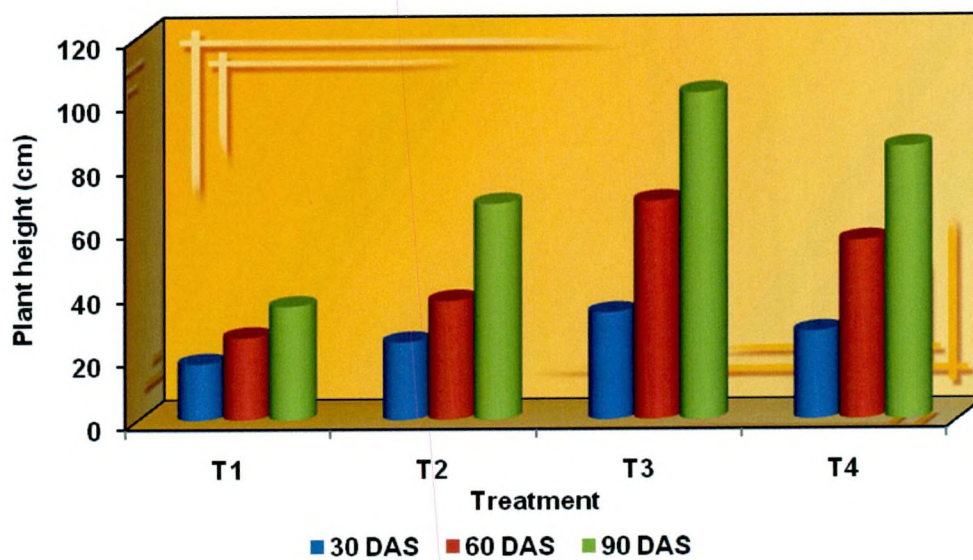
(Data represent the mean of three replications)

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

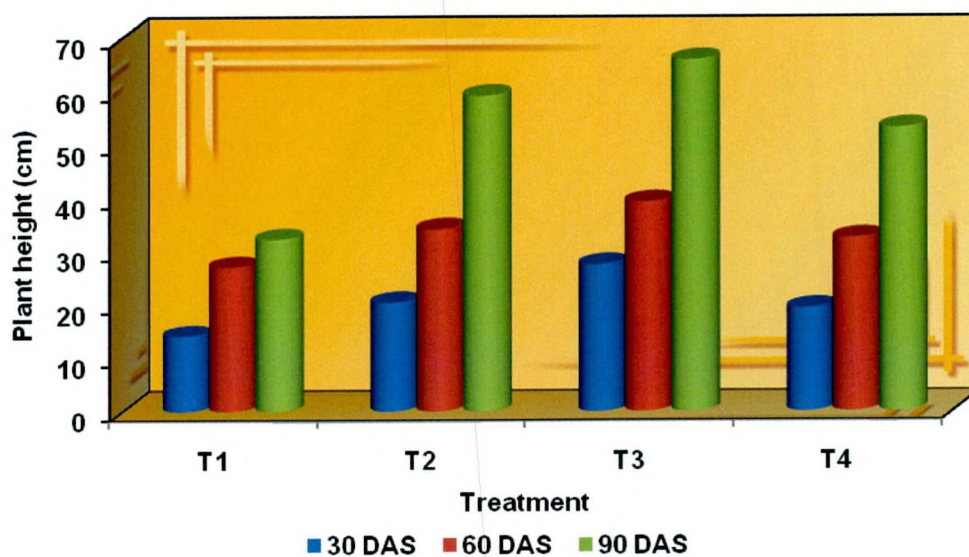
FIGURE - 3

EFFECT OF EM-SW COMPOST ON PLANT HEIGHT (cm) OF THE TEST PLANTS

Lady's finger



Cow pea



- T₁ - Control (Untreated)
 T₂ - EM - SW compost (20 t ha⁻¹)
 T₃ - EM - SW compost (80 t ha⁻¹)
 T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

4.4.2 Root volume

Root volume registered a sharp increase in all treatments (T_1 to T_4) from 30 to 90 DAS (Table 4 and Figure 4).

A significant increase in root volume was observed in T_3 treatments of Lady's finger and Cow pea. The increase was from 0.79 to 5.15 cu.cm in Lady's finger whereas in Cow pea the root volume values ranged from 0.47 to 4.98 cu. cm. than the control T_1 from 0.38 to 2.08 cu. cm. in Lady's finger and 0.19 to 2.06 cu. cm in Cow pea.

The statistical scrutiny of the data showed that T_3 (EM – SW compost 80 t ha⁻¹) registered the maximum root volume in both Lady's finger and Cow pea when compared with other treatments [($P < 0.01$) = 0.022] and it may be due to the role of microflora present in activated EM which supplied essential nutrients, hormones and amino acids by continuous mineralization of EM-SW compost.

According to Ho and Hwan (2006), the solution of EM contained many hormones, and so it promoted root growth in rice, corn and Chinese cabbage significantly. Similar result was obtained by Hossain *et al.* (2006) who also observed that the application of EM solution at different concentration (0.1 %, 0.5 %, 1 %, 2 %, 5 % and 10 %) into the soil increased the shoot and root growth of *Albizia saman* significantly.

4.4.3 Number of Root Nodules / Plant (Cow pea)

There was a significant increase in number of root nodules from 30 to 90 DAS in Cow pea which ranged from 14.0 to 20.6 in T_3 treatment (EM – SW compost 80 t ha⁻¹) followed by T_2 , (EM – SW compost 20 t ha⁻¹) which ranged from 7.0 to 19.0 than the control, T_1 from 1.6 to 7.6 (Table 5 and Plate – VI).

Statistical analysis of the data showed that the maximum number of nodules/plant was recorded in T₃ (EM – SW compost 80 t ha⁻¹) compared to other treatments [(P<0.01) = 4.80].

The increase in number of nodules may be due to positive influence of *Rhizobium* treatment to Cow pea seeds. The photosynthetic bacteria present in EM enhanced the ability of nodulation, more nitrogen fixation and nutrient uptake.

TABLE - 4
EFFECT OF EM-SW COMPOST ON ROOT VOLUME (cu.cm)
OF THE TEST PLANTS

Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	0.38	0.45	2.08	0.19	1.80	2.06
T ₂	0.49	0.62	3.51	0.41	2.11	4.13
T ₃	0.79	1.85	5.15	0.47	2.95	4.98
T ₄	0.55	0.76	3.93	0.36	2.61	3.57
SED	0.008			0.008		
CD	0.022			0.22		
(P < 0.01)						

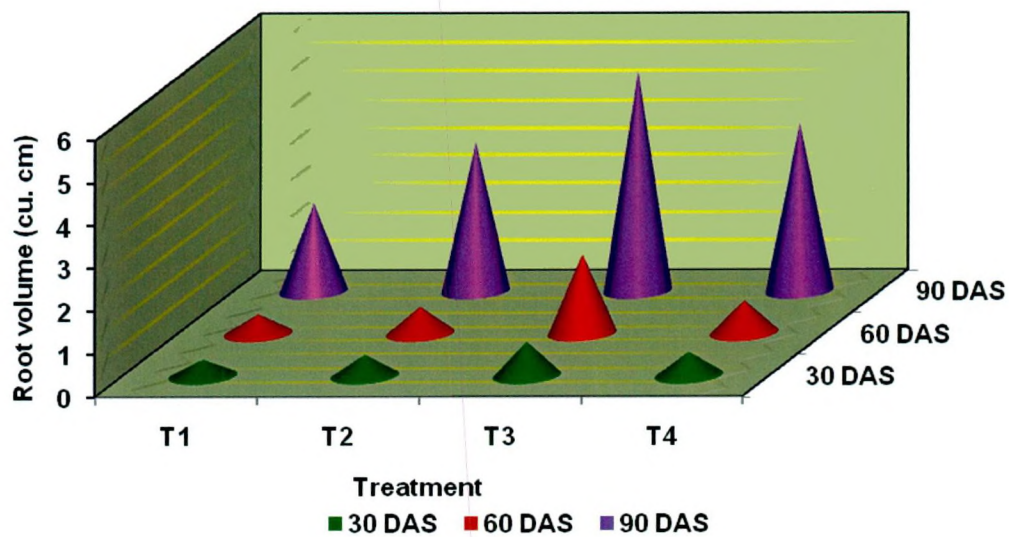
(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

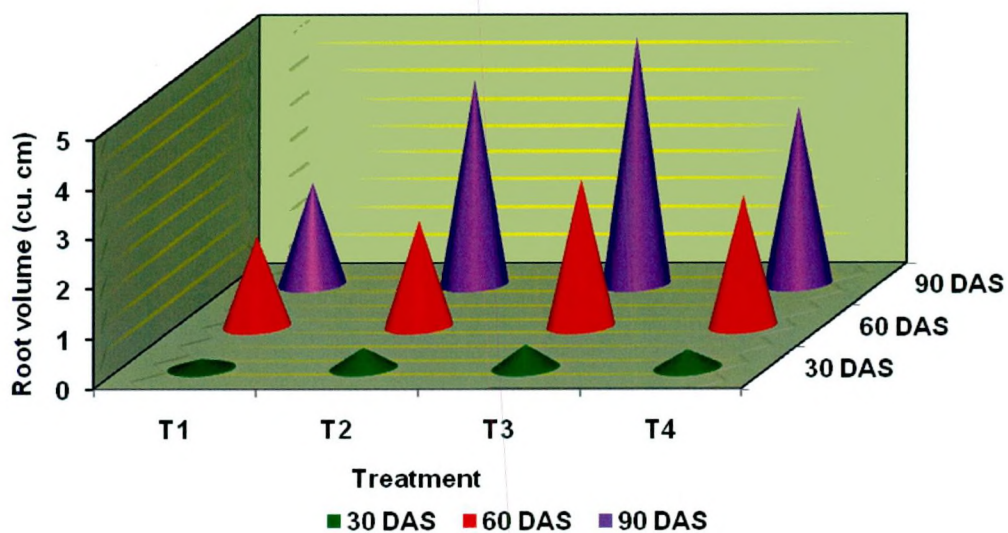
FIGURE - 4

EFFECT OF EM-SW COMPOST ON ROOT VOLUME (cu.cm)
OF THE TEST PLANTS

Lady's finger



Cow pea



- T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

TABLE - 5
EFFECT OF EM-SW COMPOST ON NUMBER OF
ROOT NODULES OF COW PEA

Treatment	Cow pea		
	30 DAS	60 DAS	90 DAS
T ₁	1.6	4.6	7.6
T ₂	7.0	12.0	19.0
T ₃	14.0	13.3	20.6
T ₄	5.6	11.3	16.0
SED	1.70		
CD	4.80		
(P < 0.01)			

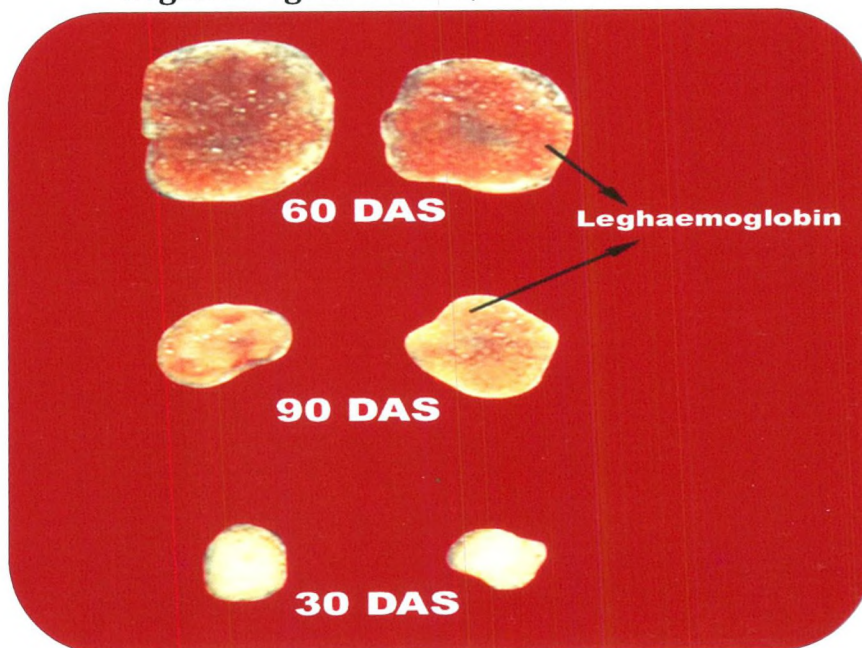
(Data represent the mean of three replications)

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

PLATE VI
Root Nodules of Cow Pea



**C.S. of Nodules of Cow Pea Showing
Leghaemoglobin at 30, 60 and 90 DAS**



The result is in accordance with the result of Jat *et al.* (1996) who found that *Rhizobium* inoculation to soybean resulted in 46 per cent increase in mean nodule count and 61 per cent increase in mean nodule dry weight over the control (un inoculated).

4.4.4 Number of leaves / plant

A substantial increase in the number of leaves / plant was registered in all treatments (T_1 to T_4) from 30 to 90 DAS (Table 6 and Figure 5).

Among the treatments, T_3 (EM – SW compost 80 t ha⁻¹) registered maximum number of leaves. In Lady's finger, the number varied from 4.4 to 8.1 and in Cow pea from 14.2 to 46.8 over the control T_1 (the increase was from 1.3 to 4.4 in Lady's finger and from 8.2 to 20.2 in Cow pea) (Plate – VII).

It may be inferred from the statistical investigation of the data that the treatment T_3 (EM – SW compost 80 t ha⁻¹) registered a significant increase in the number of leaves/plant than the other treatments in both Lady's Finger and Cow Pea [($P < 0.01$) = 0.22 and 0.25].

The increase in number of leaves / plant signifies, that it had an efficient photosynthetic apparatus which could be more effectively utilized for its high production and it was also due to the efficacy of photosynthetic bacteria present in activated EM solution.

Similar result was reported by Tabora *et al.* (2000). They found that the banana plants treated with 23 kg of EM-bokashi / plant produced five per cent longer and seven per cent wider leaves than those of the control. Yadav (2000) reported that the compactness of cabbage

heads was better in EM applied (foliar spray) plots than the control (without foliar spray).

The result coincides with the result of Quang *et al.* (2005). They observed that the application of 2T-EM Bokashi + NPK (25: 75: 50 kg ha⁻¹) enhanced the number of leaves / plant to 10.5 in soyabean CR 206 than the control 8T FYM + NPK (50 : 150 : 100 kg ha⁻¹) which was 9.2.

TABLE - 6

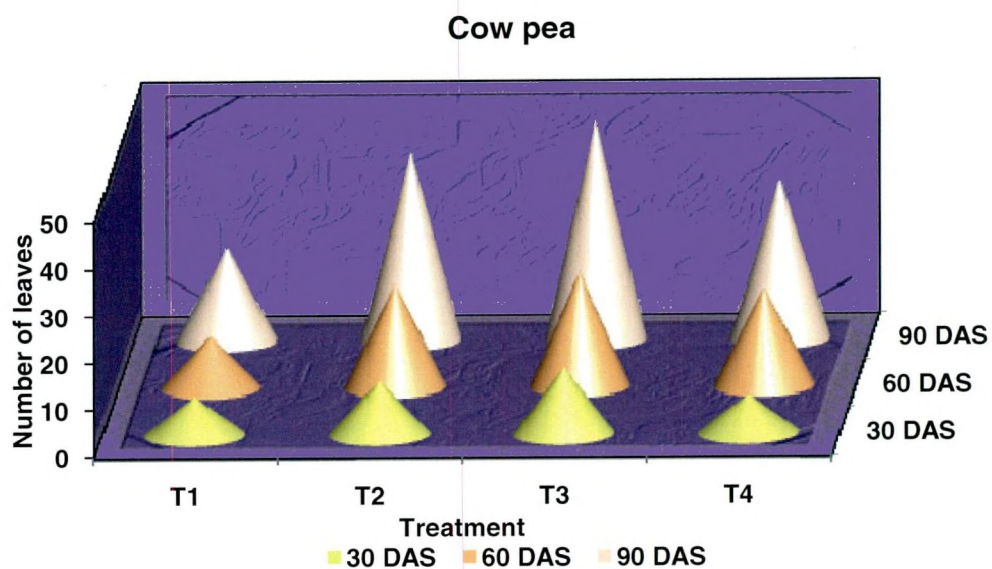
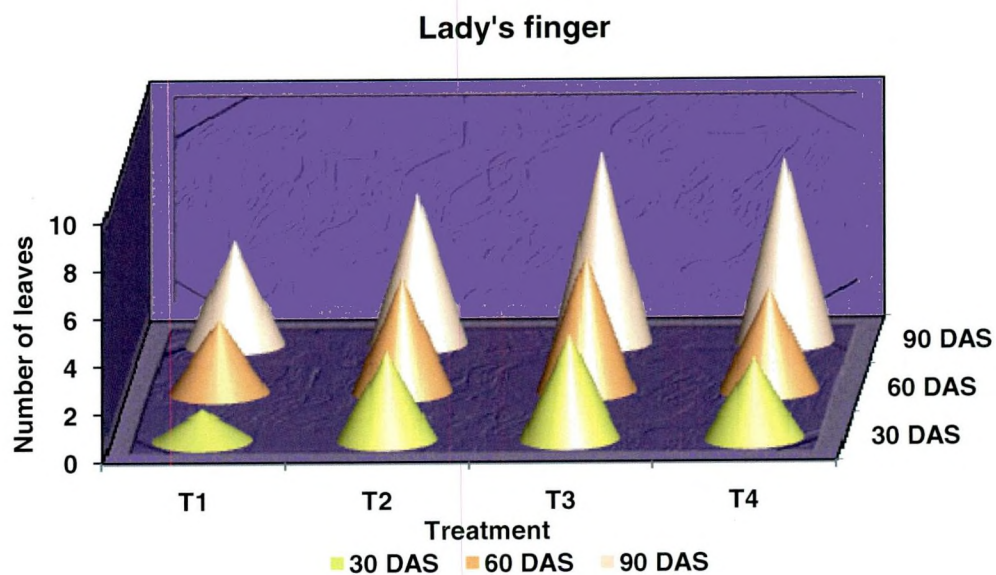
**EFFECT OF EM-SW COMPOST ON NUMBER OF LEAVES / PLANT
OF THE TEST PLANTS**

Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	1.3	3.1	4.4	8.2	11.1	20.2
T ₂	3.7	4.8	6.3	11.5	22.4	40.2
T ₃	4.4	5.7	8.1	14.2	24.4	46.8
T ₄	3.4	4.3	7.8	8.3	21.2	34.3
SED	0.08			0.09		
CD (P < 0.01)	0.22			0.25		

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

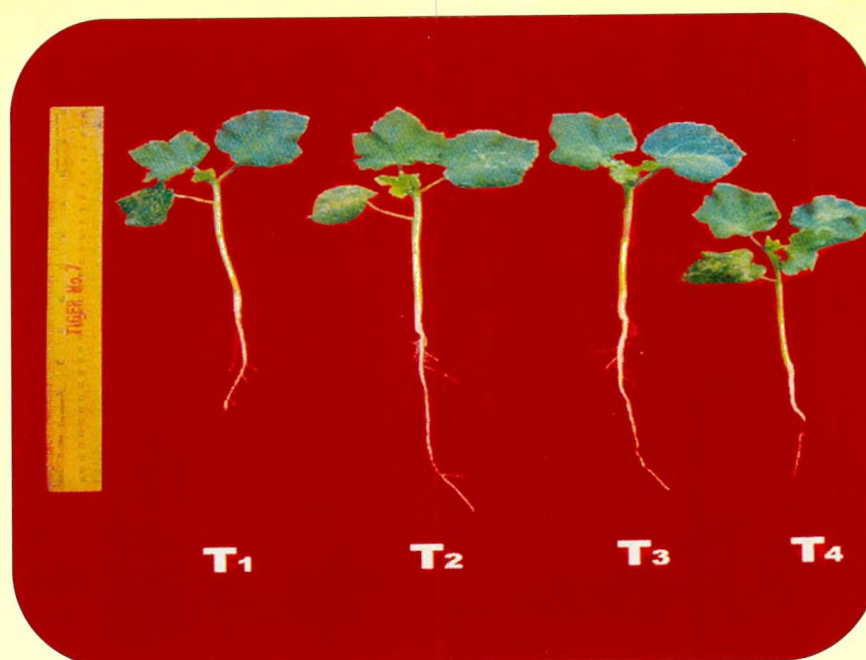
FIGURE - 5
EFFECT OF EM-SW COMPOST ON NUMBER OF LEAVES / PLANT
OF THE TEST PLANTS



- T₁ - Control (Untreated)**
- T₂ - EM - SW compost (20 t ha⁻¹)**
- T₃ - EM - SW compost (80 t ha⁻¹)**
- T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)**

PLATE VII

Effect of EM-SW Compost
on Lady's Finger 30 DAS



Effect of EM-SW Compost
on Cow Pea 30 DAS



4.4.5 Fresh and dry weight of plant

There had been an appreciable influence on the fresh and dry weight of plant in all treatments ($T_2 - T_4$) over absolute control T_1 from 30 to 90 DAS (Table 7 and Figure 6).

Fresh and dry weight of plant showed a remarkable increase in T_3 treatment which varied from 5.08 to 92.80 g and from 2.70 to 22.40 g in Lady's finger and from 6.40 to 34.80 g and from 2.40 to 16.40 g in Cow pea when compared to control, T_1 which ranged from 2.52 to 21.50 g and 0.50 to 1.80 g in lady's finger and from 1.80 to 15.10 g and 0.80 to 7.30 g in Cow pea.

Statistical analysis of the data revealed that the significant increase in fresh and dry weight of the plant in T_3 may be due to the positive influence of microbial population present in EM solution that has resulted in the increase in the humus content of the soil [($P < 0.01$)=0.22, 0.23 (lady's finger) & ($P < 0.01$)=0.23, 0.24 (cow pea)].

Similar result was observed by Okereke *et al.* (2002). They found that the growth performance of rice grown on organic manure prepared from cowpea residue incorporated plots showed enhanced tiller number and shoot dry weight and total nitrogen were also significantly increased.

4.4.6 Number of Flowers / Plant

A remarkable increase in the number of flowers/plant was observed in all treatments T_2 to T_4 when compared to control T_1 , from 30 to 60 DAS (Table 8 and Figure 7).

Maximum number of flowers/plant was registered in T_3 which varied from 1.3 to 3.6 in Lady's finger and from 5.0 to 8.3 in Cow pea. The

treatment T₁ recorded minimum number of flowers which varied from 0.6 to 1.3 in Lady's finger and from 0.9 to 4.0 in Cow pea (Plate – VIII).

It may be deduced from the statistical data that the number of flowers/plant were found to be significantly maximum in T₃ treatment of lady's finger and cow pea compared to others [(P<0.01) = 1.08 and 3.30].

TABLE - 7
EFFECT OF EM-SW COMPOST ON FRESH AND DRY WEIGHT (g)
OF THE TEST PLANTS

Treatment	Lady's finger						Cow pea					
	30 DAS		60 DAS		90 DAS		30 DAS		60 DAS		90 DAS	
	FW	DW	FW	DW	FW	DW	FW	DW	FW	DW	FW	DW
T ₁	2.52	0.50	10.80	1.80	21.50	1.80	1.80	0.80	4.70	2.10	15.10	7.30
T ₂	3.31	1.30	15.80	4.80	55.70	10.50	3.20	1.50	7.63	3.10	31.50	15.13
T ₃	5.08	2.70	26.70	7.70	92.80	22.40	6.40	2.40	13.50	6.10	34.80	16.40
T ₄	3.13	0.80	16.70	4.60	69.30	5.60	3.00	1.23	6.30	2.60	30.70	14.30
SED	Fresh Weight : 0.78 Dry Weight : 0.082						Fresh Weight : 0.083 Dry Weight : 0.084					
CD (P < 0.01)	Fresh Weight : 0.22 Dry Weight : 0.23						Fresh Weight : 0.23 Dry Weight : 0.24					

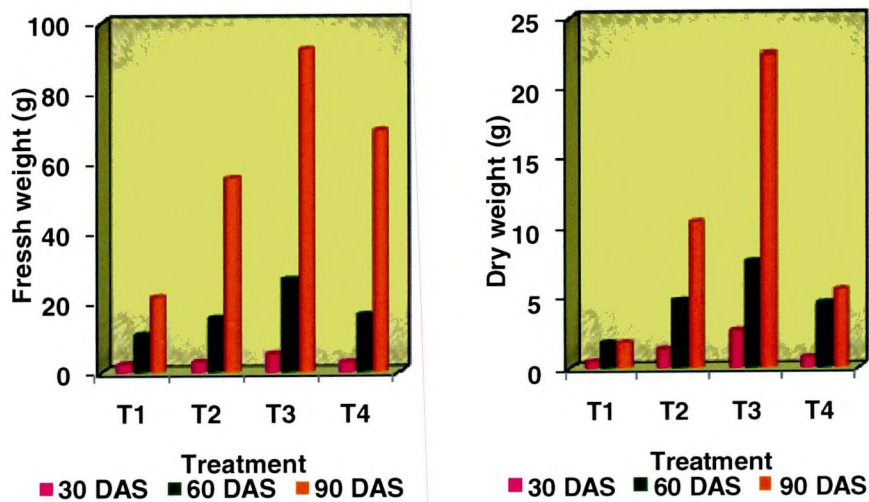
(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK(N-0.45 g, P-1.31 g and K-0.12 g)

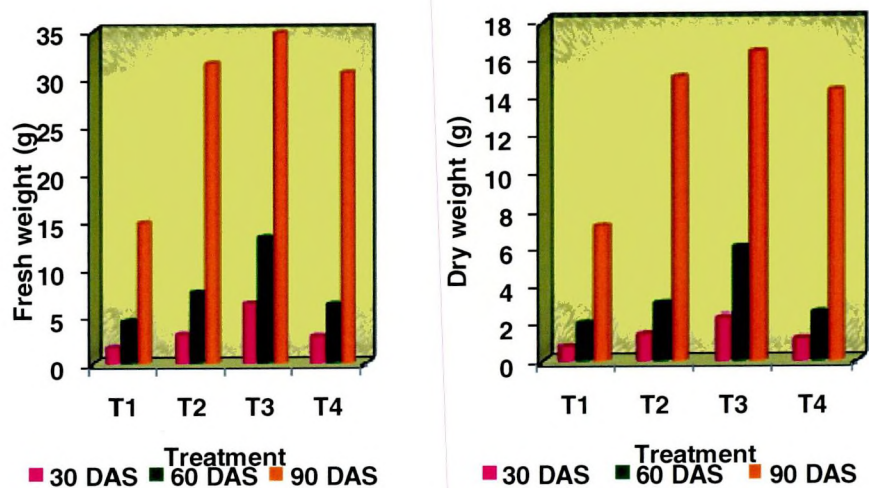
FIGURE - 6

EFFECT OF EM-SW COMPOST ON FRESH AND DRY WEIGHT (g)
OF THE TEST PLANTS

Lady's finger



Cow pea



- T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

TABLE - 8
EFFECT OF EM-SW COMPOST ON NUMBER OF FLOWERS / PLANT
OF THE TEST PLANTS

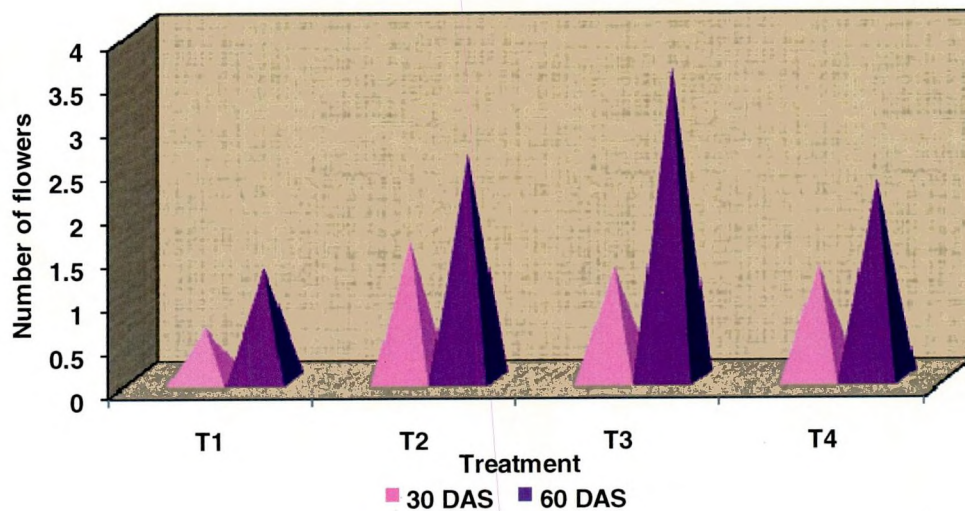
Treatment	Lady's finger		Cow pea	
	30 DAS	60 DAS	30 DAS	60 DAS
T ₁	0.6	1.3	0.9	4.0
T ₂	1.6	2.6	2.3	5.0
T ₃	1.3	3.6	5.0	8.3
T ₄	1.3	2.3	2.3	6.2
SED	0.38		1.13	
CD	1.08		3.30	
(P < 0.01)				

(Data represent the mean of three replications)

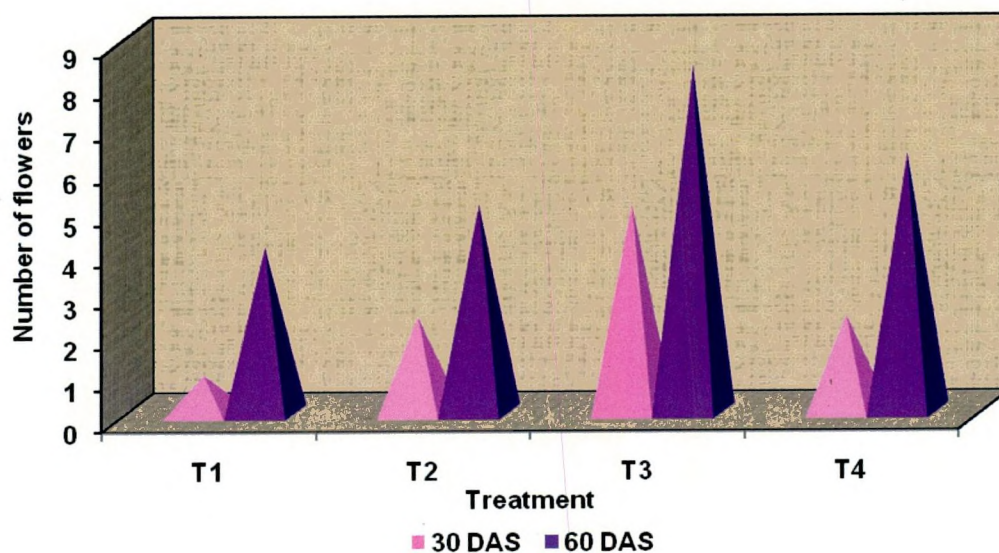
- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 7
EFFECT OF EM-SW COMPOST ON NUMBER OF FLOWERS / PLANT
OF THE TEST PLANTS

Lady's finger



Cow pea



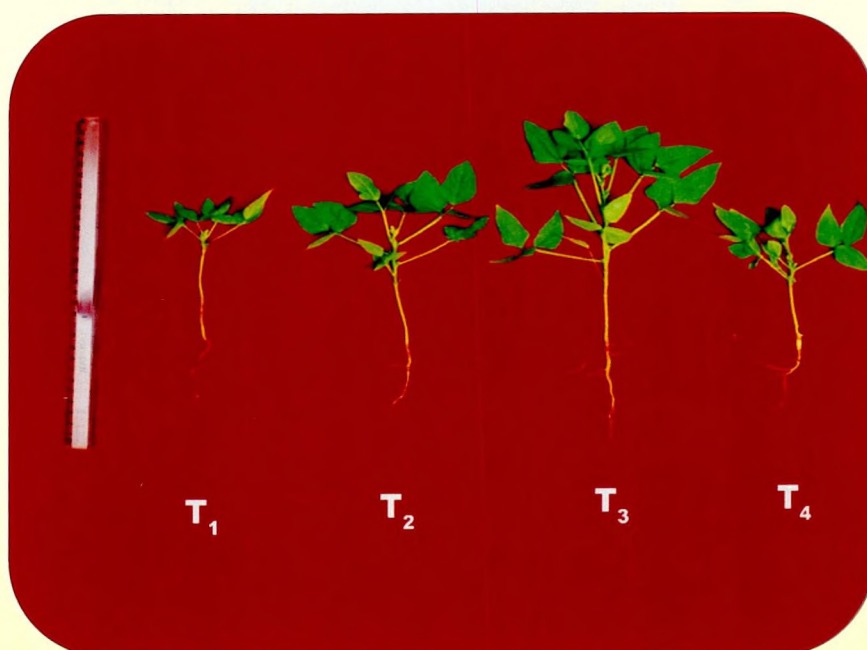
- T₁ - Control (Untreated)**
- T₂ - EM - SW compost (20 t ha⁻¹)**
- T₃ - EM - SW compost (80 t ha⁻¹)**
- T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)**

PLATE VIII

Effect of EM-SW Compost
on Lady's Finger 60 DAS



Effect of EM-SW Compost
on Cow Pea 60 DAS



4.5 YIELD PARAMETERS

4.5.1 Number of pods / plant

There was a gradual increase in the number of pods / plant in all the treatments at harvest (90 DAS). (Table 9, Figure 8 and Plate-IX).

Maximum number of pods / plant observed in Lady's finger, T₃ (EM – SW compost 80 t ha⁻¹) was 4.3. The values of T₂ (EM-SW compost 20 t ha⁻¹) and T₄ (NPK) were on par with each other (3.3). Minimum number of pods / plant was recorded in control, T₁ (1.3).

In Cow pea, the maximum number registered was 14.0 in T₃ treatment followed by 12.0 in T₂ (EM – SW compost 20 t ha⁻¹) over the T₁, control which was 3.0.

Statistical scrutiny of the data revealed that the treatment T₃ was found to be significantly superior over other treatments in both lady's finger and cow pea [(P<0.01) = 2.53 and 3.34].

The result coincides with the result of Reddy *et al.* (2000) who showed that the application of garbage waste compost at 15, 20 and 25t ha⁻¹ gave highest yields in brinjals, bhendi, beet root, radish and carrot.

The present investigation is on par with the result of Daniel (2005) who also reported that EM compost application and EM soil spray resulted in higher yields compared to locally recommended fertilizer application in onion and chickpea. According to Yadav (2005) EM applied at 0.2 percent (at 15 days interval) produced highest yield of 36.30 kg in cabbage and 16.20 kg in radish.

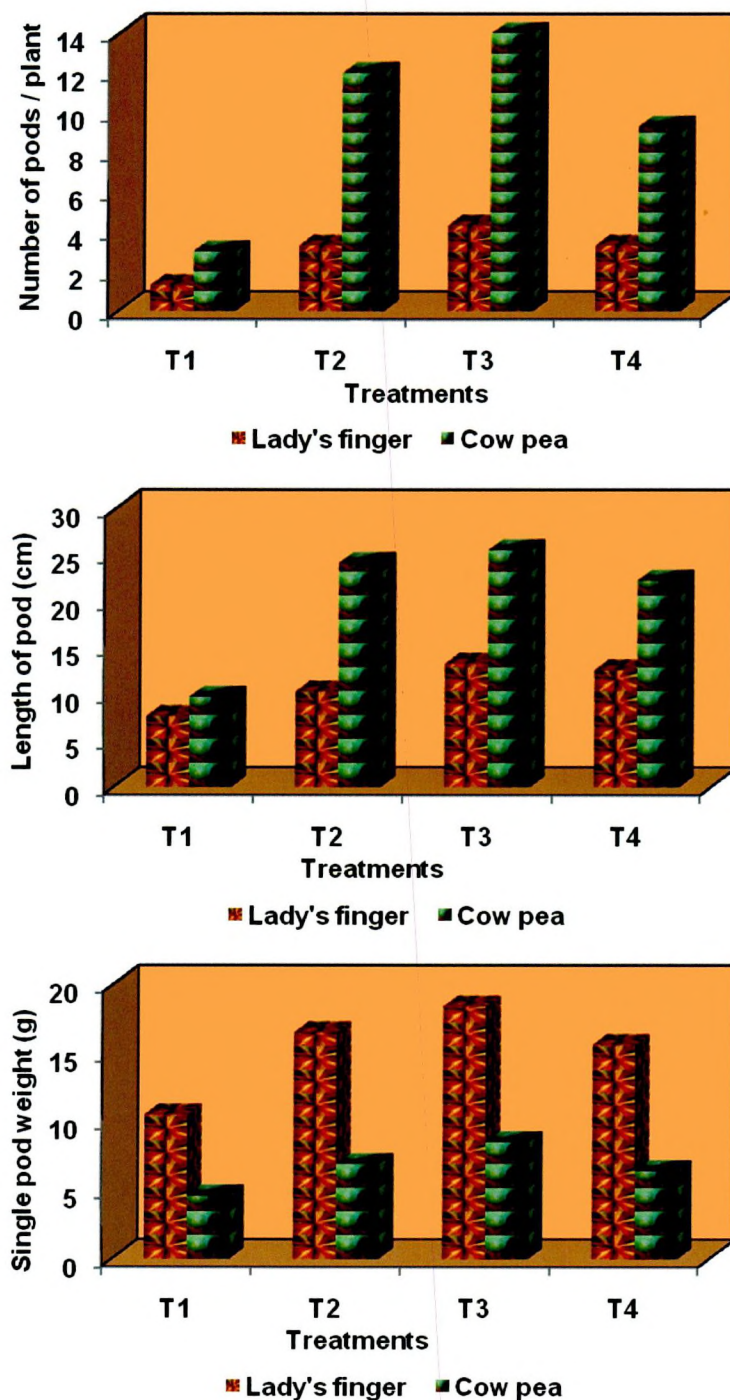
TABLE - 9
EFFECT OF EM-SW COMPOST
OF THE TEST PLANTS AT HARVEST (90 DAS)

Treatment	Lady's finger			Cow pea		
	No. of pods / plant	Length of pod (cm)	Single pod weight (g)	No. of pods / plant	Length of pod (cm)	Single pod weight (g)
T ₁	1.3	7.6	10.5	3.0	9.7	4.6
T ₂	3.3	10.3	16.5	12.0	24.2	6.9
T ₃	4.3	13.3	18.4	14.0	25.6	8.5
T ₄	3.3	12.6	15.6	9.3	22.3	6.4
SED	0.87	1.45	0.40	1.14	0.48	0.29
CD	2.53	4.24	1.17	3.34	1.40	0.83
(P < 0.01)						

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 8
EFFECT OF EM-SW COMPOST AT HARVEST (90 DAS) OF THE TEST
PLANTS



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

PLATE IX

Effect of EM-SW Compost on Lady's Finger 90 DAS



Effect of EM-SW Compost on Cow Pea 90 DAS

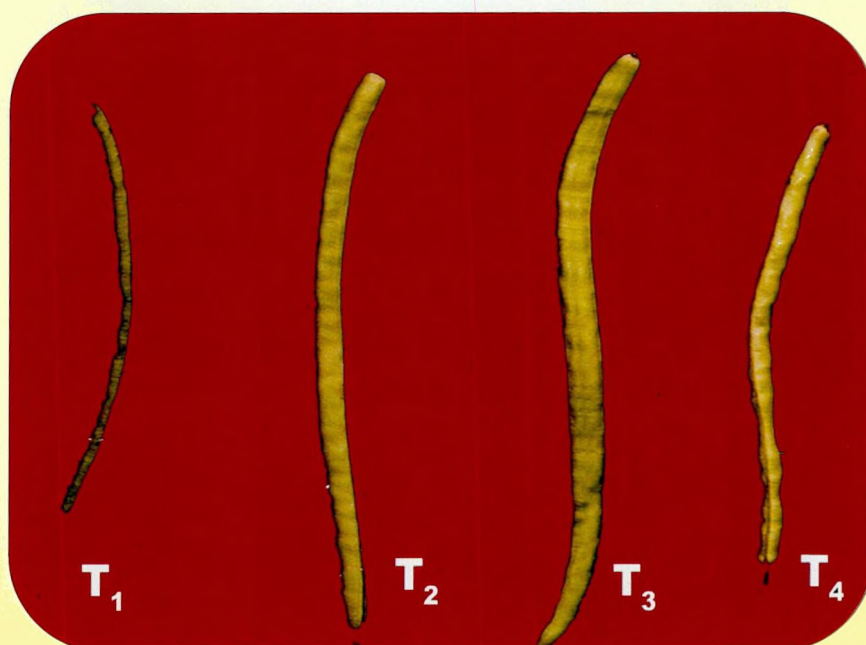


PLATE X

Pods of Lady's Finger 90 DAS



Pods of Cow Pea 90 DAS



4.5.4 Number of seeds / Pod

The data from Table 10, Figure - 9 and Plate - XI showed that the maximum number of seeds / pod registered was in T₃ treatment (EM-SW compost 80 t ha⁻¹). In Lady's finger the maximum number registered was 38.0 and in Cow pea, it was 12.0 compared to control, T₁ (22.0 in Lady's finger and 8.3 in Cow pea) .

Statistical analysis of the data showed that the treatment T₃ recorded significantly more number of seeds/pod in both lady's finger and cow pea [(P<0.01) = 9.5 and 3.68].

The increase in the number of seeds in T₃ treatment of Lady's finger and Cow pea could be due to better supply of amino acids, enzymes, micro and macro nutrients by EM SW compost incorporation into the soil which induced photosynthetic efficiency, regulation of water into cells, conducive physical environment leading to better aeration, root activity and microbial population.

The increase in number of seeds was due to the rhizobium inoculation and carbon mineralization of EM-SW compost by microbial population. Prinsloo *et al.*, (2005) also showed a significant difference between EM treated and chemically fertilized flood irrigated plots and they found that EM treated plots produced higher yields.

4.5.6 100 Seed Weight

It is elucidated from Table 10 and Figure -9, that 100 seed weight registered was maximum in T₃ (EM - SW compost 80 t ha⁻¹) treatment in Lady's finger (4.5 g) and in Cow pea (10.0 g), than the control, T₁ (2.3 g in Lady's finger and 6.50 g in Cow pea).

It may be inferred from the statistical analysis, that the 100 seed weight was maximum in T₃ and is found to be superior over other treatments in both lady's finger and cow pea [CD (P<0.01) = 0.96 and 0.74].

The use of activated EM solution into the SW enhanced the humus content and improved soil conditions resulting in greater yield, healthier and more nutritious plants.

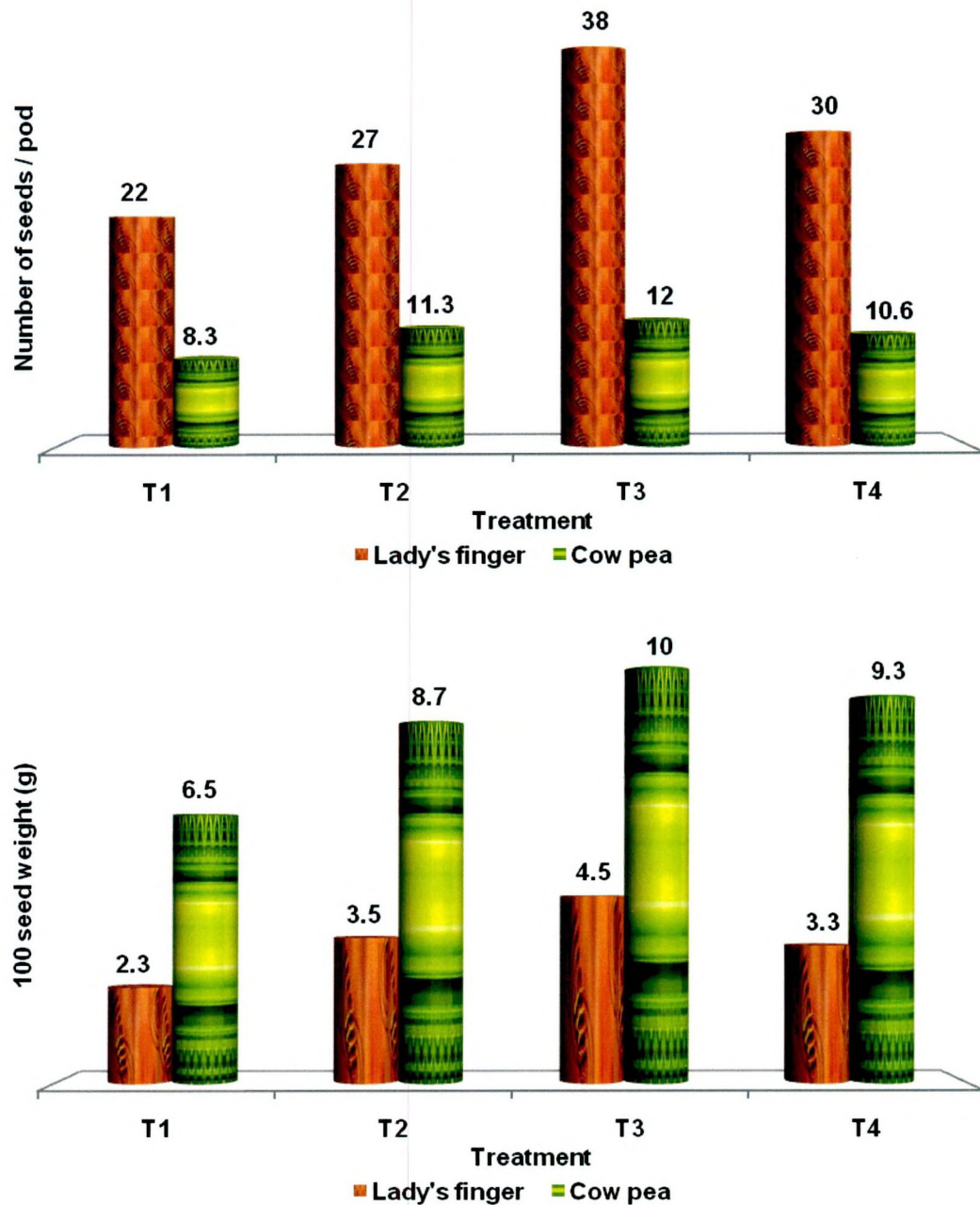
TABLE - 10
EFFECT OF EM-SW COMPOST
ON THE TEST PLANTS - AT HARVEST (90 DAS)

Treatment	Lady's finger		Cow pea	
	No. of seeds / pod	100 seed weight (g)	No. of seeds / pod	100 seed weight (g)
T ₁	22.0	2.3	8.3	6.5
T ₂	27.0	3.5	11.3	8.7
T ₃	38.0	4.5	12.0	10.0
T ₄	30.0	3.3	10.6	9.3
SED	2.8	0.33	1.25	0.25
CD (P < 0.01)	9.5	0.96	3.68	0.74

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 9
EFFECT OF EM-SW COMPOST AT HARVEST (90 DAS)
OF THE TEST PLANTS



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

TABLE - 11
EFFECT OF EM-SW COMPOST ON LEGHAEMOGLOBIN
CONTENT (mg g⁻¹nodule weight) OF ROOT NODULES OF COW PEA

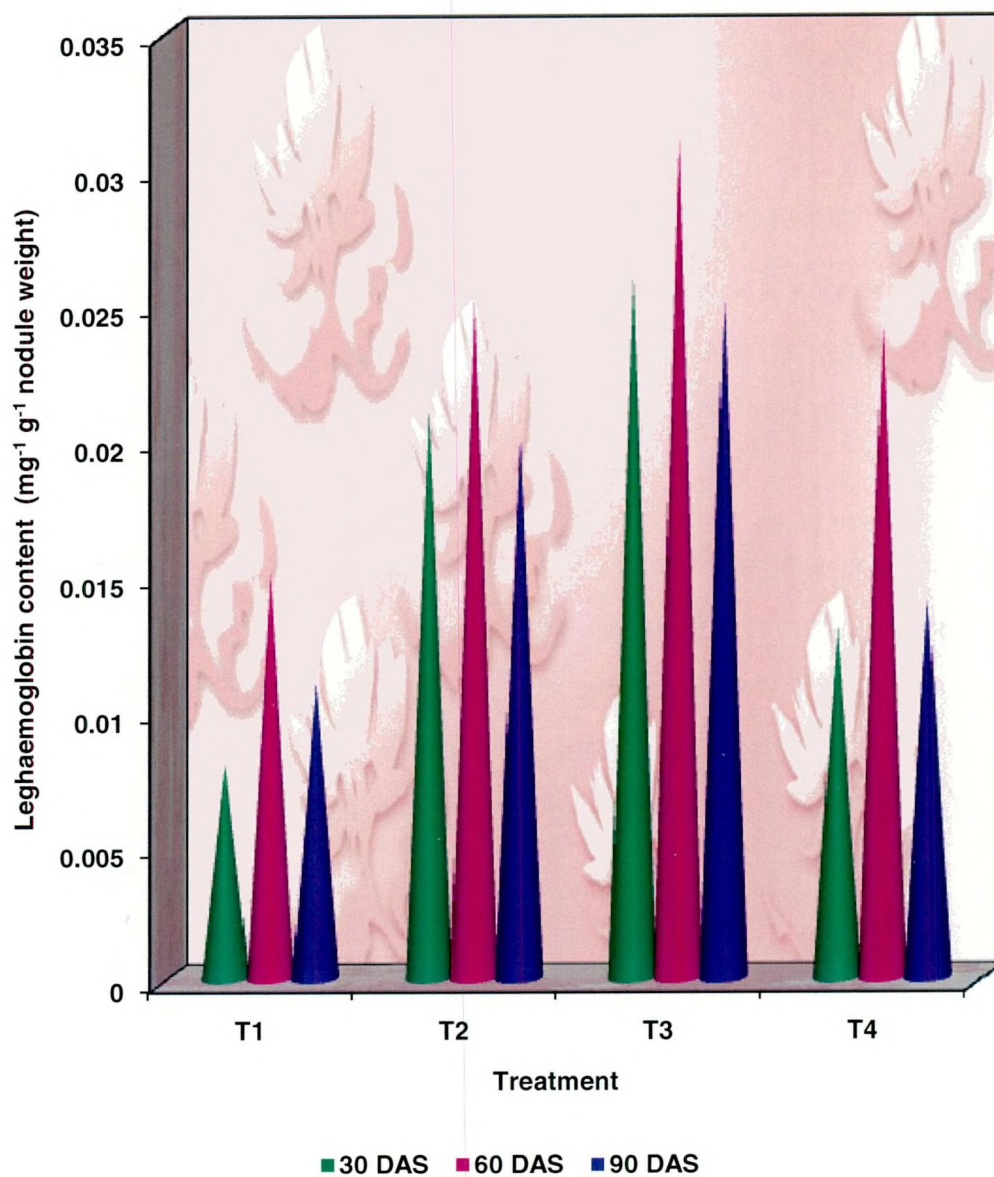
Treatment	Cow pea		
	30 DAS	60 DAS	90 DAS
T ₁	0.008	0.015	0.011
T ₂	0.021	0.025	0.020
T ₃	0.026	0.031	0.025
T ₄	0.013	0.024	0.014
SED	0.0008		
CD (P < 0.01)	0.0021		

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE – 10

EFFECT OF EM-SW COMPOST ON LEGHAEMOGLOBIN CONTENT (mg g⁻¹ NODULE WEIGHT) OF ROOT NODULES OF COW PEA



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

4.6 BIOCHEMICAL PARAMETERS OF TEST PLANTS

The biochemical traits like total protein content, carbohydrate content and chlorophyll content (chl. a, b and total chlorophyll), leghaemoglobin, and non-enzymic antioxidants like ascorbic acid, tocopherol and enzymic antioxidants like catalase and peroxidase in the plants of lady's finger and cow pea as influenced by the various treatments are presented below :

4.6.1 Leghaemoglobin Content (Table 11 and Figure 10)

The leghaemoglobin content was analysed in the root nodules of leguminous plant, Cow pea which increased from 0.026 to 0.031 mg g⁻¹ nodule weight in T₃ treatment and declined to 0.025 mg g⁻¹ nodule weight in 90 DAS.

Statistical analysis of the data showed that the treatment T₃ registered a significant increase in the leghaemoglobin content which may be due to enhancement in nitrogenase activity by rhizobium inoculation. It also enhanced nodule formation resulting in increased nitrogen fixation through legume-bacteria symbiotic associations [(P<0.01) =0.0021].

The result is in accordance with the findings of Abira (2005), who analysed that the leghaemoglobin content increased profoundly from 30 to 60 DAS in the T₆ (fruit waste compost + *Pseudomonas fluorescens* + phosphobacter) recording 0.0098 to 0.0256 mg g⁻¹ nodule weight and declined to 0.0186 mg g⁻¹ nodule weight in 90 DAS.

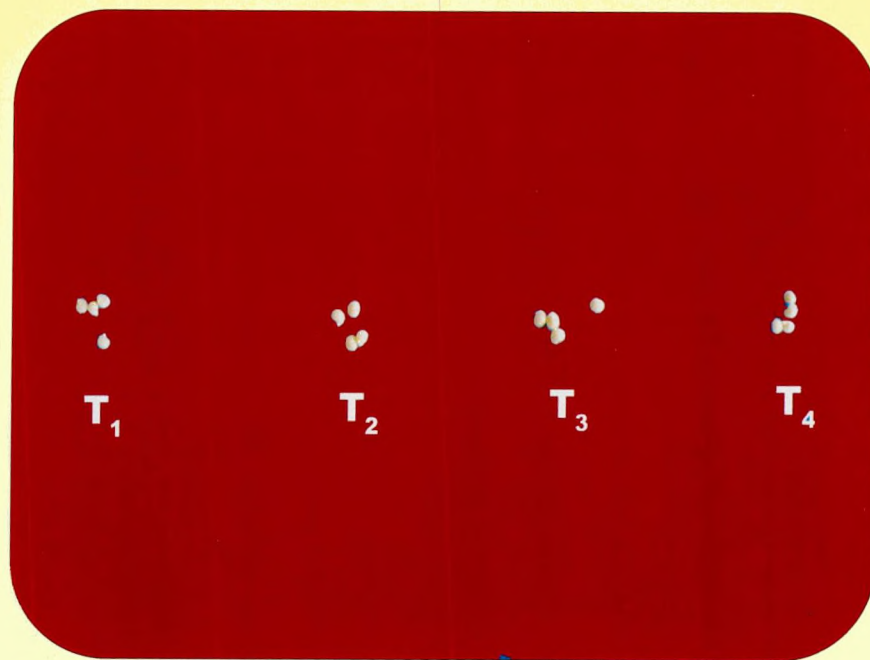
4.6.2 Total Protein Content

The total protein content in T₂ to T₄ increased significantly from 30 to 60 DAS and gradually decreased in 90 DAS over the control, T₁ (Table

12 and Figure 11). Statistical analysis of the data showed that the total protein content of the leaves of lady's finger and cow pea was significant in T₃ when compared with other treatments [(P<0.01) = 0.04 and 0.023].

The increase in protein content upto 60 DAS may be due to the release of CO₂, nitrification and dehydrogenase activities of microbial populations present in the EM-SW compost and its incorporation into the soil and decrease at 90 DAS may be due to the utilization of protein for flower and fruit formation.

PLATE XI
Seeds of Lady's Finger



Seeds of Cow Pea

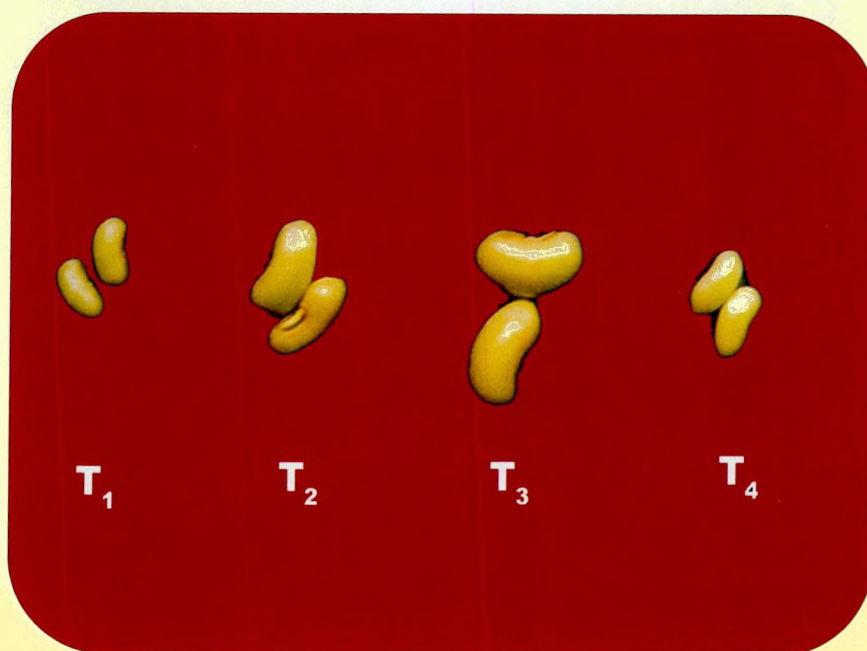


TABLE - 12
EFFECT OF EM-SW COMPOST ON TOTAL PROTEIN CONTENT (mg g⁻¹)
OF THE TEST PLANTS

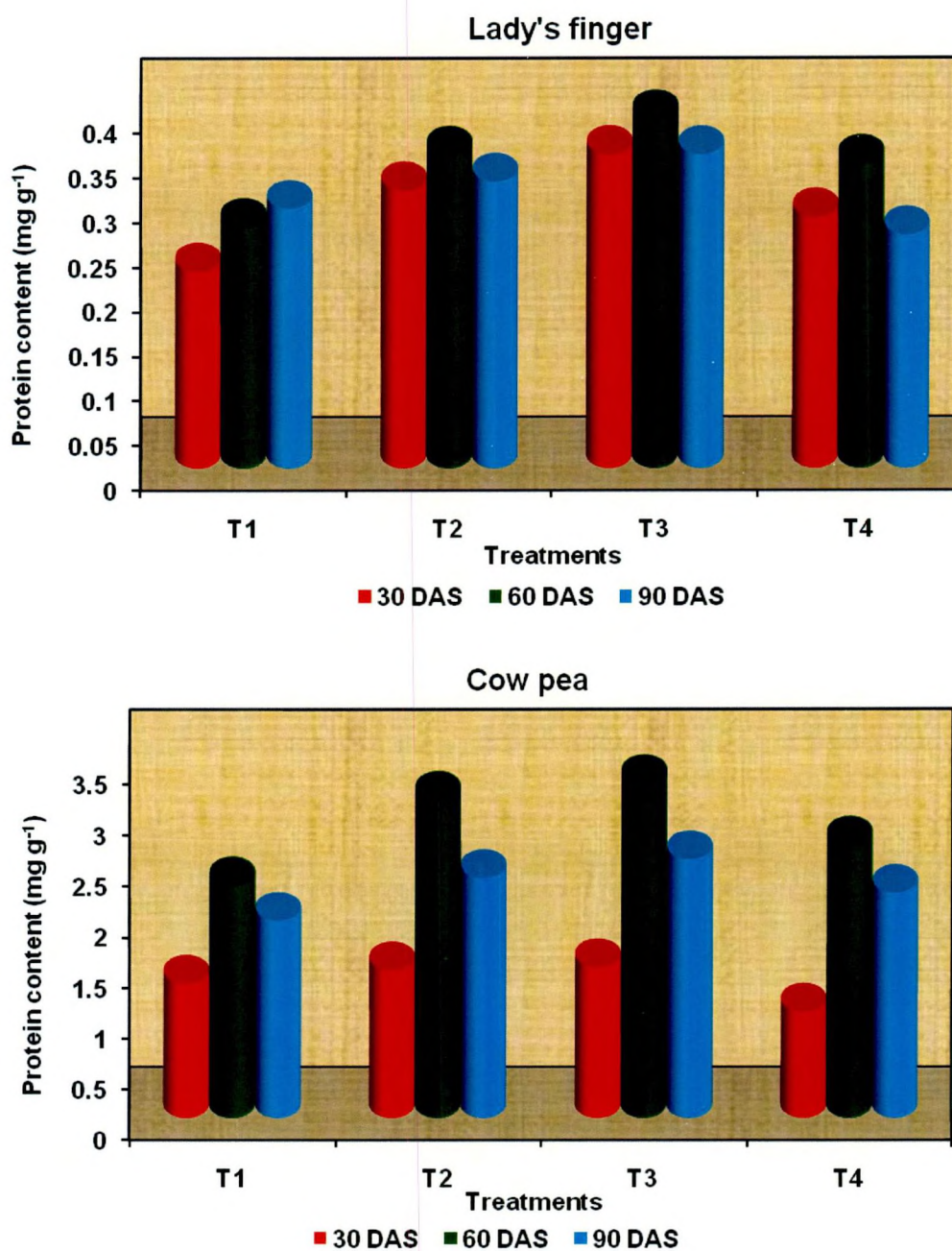
Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	0.22	0.29	0.27	1.32	2.29	1.94
T ₂	0.31	0.35	0.32	1.45	3.12	2.36
T ₃	0.35	0.39	0.35	1.48	3.28	2.54
T ₄	0.28	0.34	0.26	1.04	2.68	2.21
SED	0.03			0.008		
CD	0.04			0.023		
(P < 0.01)						

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 11

EFFECT OF EM-SW COMPOST ON TOTAL PROTEIN CONTENT (mg g^{-1}) OF THE TEST PLANTS



T₁ - Control (Untreated)

T₂ - EM - SW compost (20 t ha⁻¹)

T₃ - EM - SW compost (80 t ha⁻¹)

T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

There was a significant increase in protein content of T₃ treatments (EM-SW compost 80 t ha⁻¹) from 30 to 60 DAS in Lady's finger which ranged from 0.35 to 0.39 mg g⁻¹ tissue and in Cow pea, the increase was from 1.48 to 3.28 mg g⁻¹ and decreased to 0.35 mg g⁻¹ tissue in Lady's finger and 2.54 mg g⁻¹ tissue in Cow pea than the control, T₁.

This finding is in accordance with the observation of Quang *et al.* (2005). They found that the application of 2T – EM Bokashi + NPK (25 : 75 : 50 kg ha⁻¹) increased the protein content of soybean CR 206 to 28.94 per cent than the control (8T – FYM + NPK (50 : 150 : 100 kg ha⁻¹)) which was 24.15 per cent.

4.6.3 Total Carbohydrate

A gradual increase in total carbohydrate content was observed in all the treatments T₂ to T₄ upto 60 DAS against the control T₁ (Table 13 and Figure 12).

A significant increase in total carbohydrate content was registered in T₃ treatment from 30 to 60 DAS in Lady's finger and Cow pea which ranged from 10.80 mg g⁻¹ to 16.66 mg g⁻¹ and from 10.05 mg g⁻¹ to 19.83 mg g⁻¹ and it gradually decreased to 15.16 mg g⁻¹ and 16.60 mg g⁻¹ when compared to the absolute control T₁.

It may be deduced from the statistical analysis of the data that the treatment T₃ registered significant values in the carbohydrate content of the leaves of both lady's finger and cow pea [(P<0.01) = 0.20 and 0.23].

Carbohydrate is an important storage and structural component of plant and is utilized for pod formation at harvest stage, hence the decrease at harvest (90 DAS).

TABLE - 13
EFFECT OF EM-SW COMPOST ON TOTAL CARBOHYDRATE
CONTENT (mg g⁻¹) OF THE TEST PLANTS

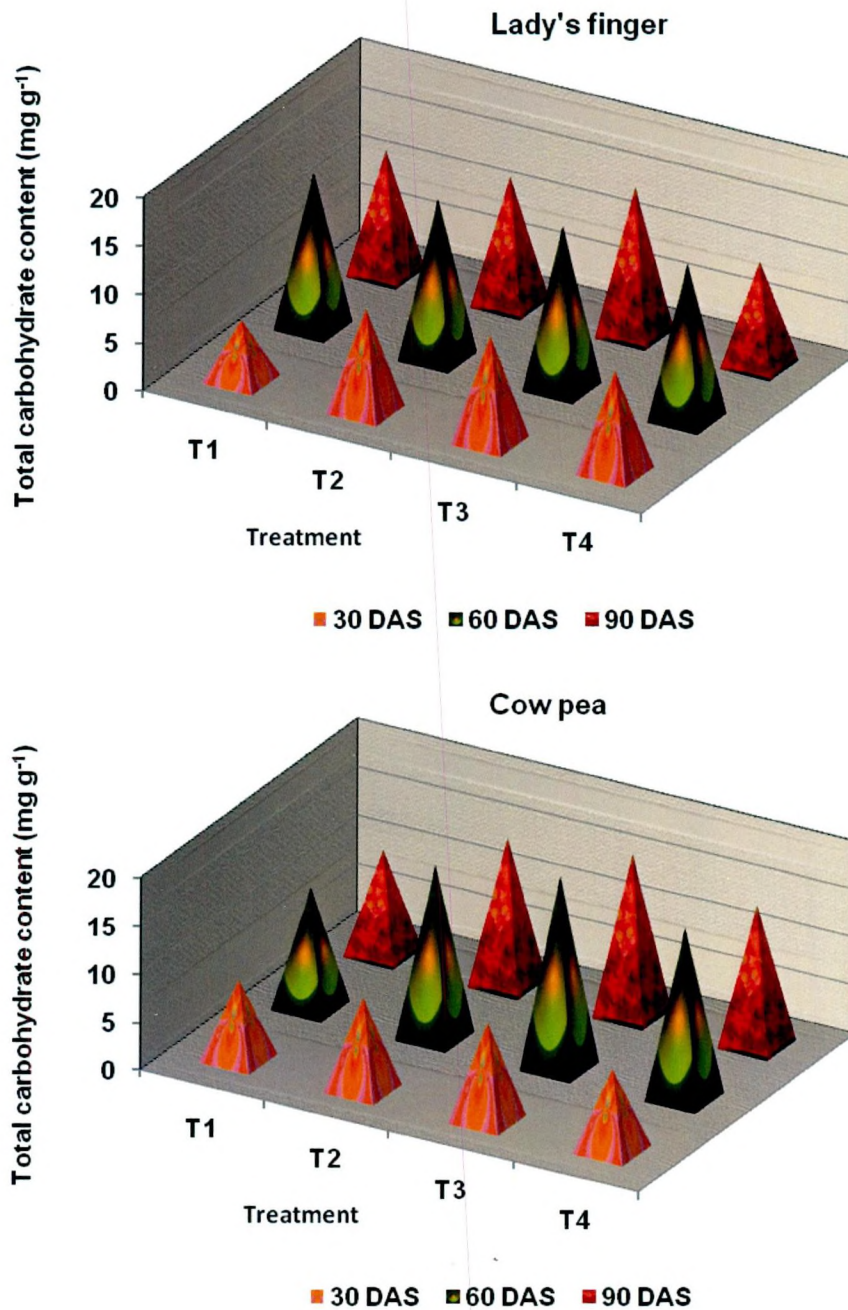
Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	6.10	15.80	12.70	8.12	12.20	10.70
T ₂	10.40	16.30	13.10	9.47	17.80	15.10
T ₃	10.80	16.66	15.16	10.05	19.83	16.60
T ₄	10.36	15.93	10.63	8.43	17.60	14.40
SED	0.07			0.082		
CD	0.20			0.233		
(P < 0.01)						

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 12

EFFECT OF EM-SW COMPOST ON TOTAL CARBOHYDRATE CONTENT (mg g^{-1}) OF THE TEST PLANTS



- T₁ - Control (Untreated)
 T₂ - EM - SW compost (20 t ha^{-1})
 T₃ - EM - SW compost (80 t ha^{-1})
 T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

This result is in accordance with a result of Manonmani and Anand (2002) who also observed an increase in biochemical constituents such as carbohydrate in leaf tissue of lady's finger upto 60 DAS by the application of vermicompost.

4.6.4 Chlorophyll Content

Chlorophyll content (a, b and total) increased gradually from 30 DAS to 60 DAS in all the treatments, (T₂ to T₄) and decreased at 90 DAS over the absolute control, T₁ (Tables 14 and 15 and Figures 13 and 14).

Out of the four treatments, T₃ showed remarkable increase in chlorophyll a, b and total from 30 to 60 DAS in Lady's finger and Cow pea, which ranged from 0.016 to 0.057 mg g⁻¹ and 0.055 to 0.058 mg g⁻¹ tissue (a), 0.016 to 0.072 mg g⁻¹ and 0.053 to 0.060 mg g⁻¹ tissue (b) and 0.029 to 0.129 mg g⁻¹ and 0.108 to 0.119 mg g⁻¹ tissue (total) respectively than the control T₁ and thereafter declined gradually to 0.044 mg g⁻¹ and 0.056 mg g⁻¹ tissue (a), 0.051 and 0.041 mg g⁻¹ tissue (b), 0.099 and 0.097 mg g⁻¹ tissue (total) respectively in 90 DAS.

Statistical scrutiny of the data revealed that the chlorophyll (a, b and total) content of the leaves of the test crops was significant in T₃ over other treatments [(P<0.01) = 0.004,0.004,0.009 (lady's finger) and (P<0.01)=0.0022,0.003,0.004 (cow pea)].

The increase in chlorophyll content in the leaves of Lady's finger and cow pea may be due to the incorporation of EM-SW compost into the soil which enhanced organic matter, nitrogen, amino acids and proteins. The decline in chlorophyll content was due to slow cell lysis of photosynthetic bacteria present in activated EM solution that resulted in breakdown of protein and ageing of the leaves.

According to Ghosh and Das (1998), the relative increase in chlorophyll content was due to organic manure which supplies higher nutrients especially nitrogen to the growing tissues which leads to the synthesis of more chlorophyll.

TABLE - 14
EFFECT OF EM-SW COMPOST ON
CHLOROPHYLL CONTENT (mg g⁻¹ TISSUE) OF LADY'S FINGER

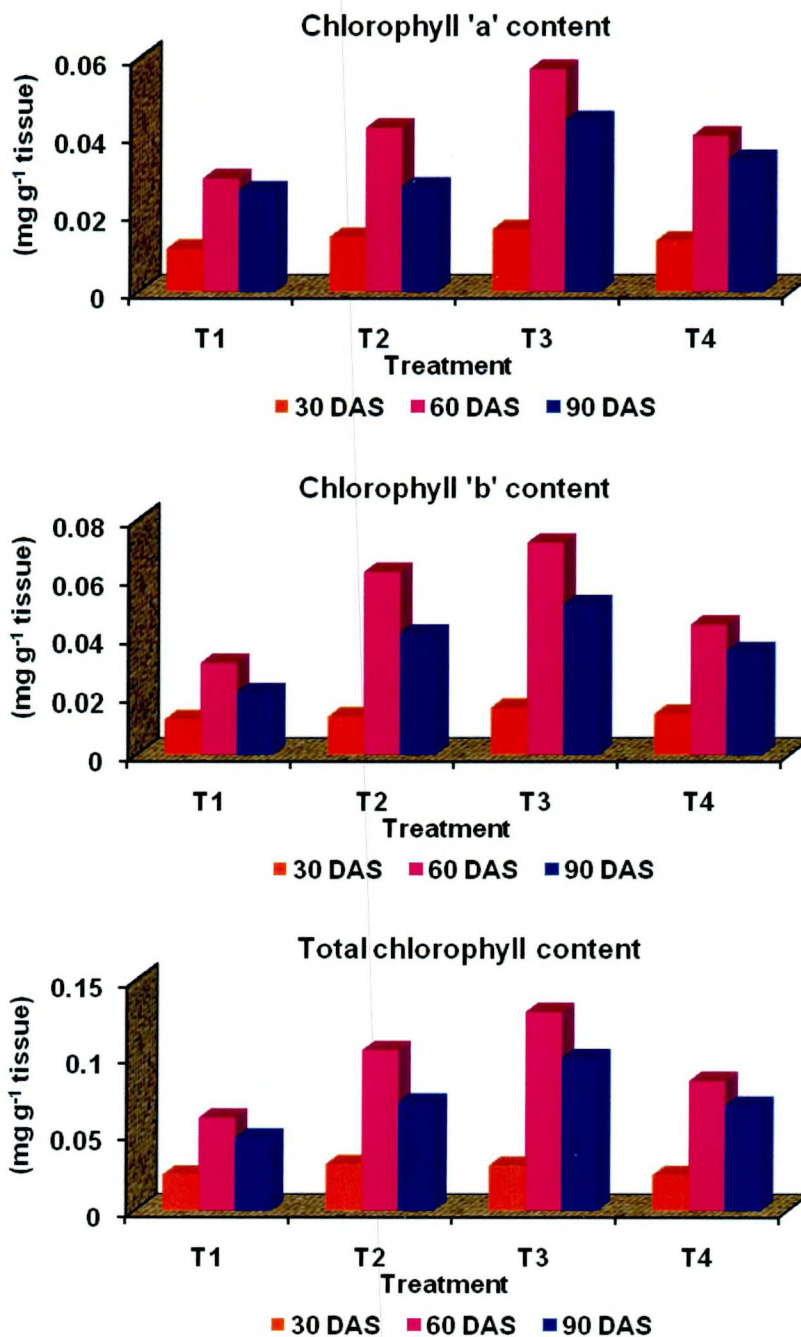
Treatment	Chlorophyll								
	a			b			Total		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	0.011	0.029	0.026	0.012	0.031	0.021	0.023	0.060	0.047
T ₂	0.014	0.042	0.027	0.013	0.062	0.041	0.030	0.104	0.070
T ₃	0.016	0.057	0.044	0.016	0.072	0.051	0.029	0.129	0.099
T ₄	0.013	0.040	0.034	0.014	0.044	0.035	0.023	0.084	0.068
SED	0.001			0.001			0.003		
CD	0.004			0.004			0.009		
(P < 0.01)									

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 13

EFFECT OF EM-SW COMPOST ON CHLOROPHYLL
CONTENT (mg g^{-1} TISSUE) OF LADY'S FINGER



T₁ - Control (Untreated)

T₂ - EM - SW compost (20 t ha⁻¹)

T₃ - EM - SW compost (80 t ha⁻¹)

T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

TABLE - 15

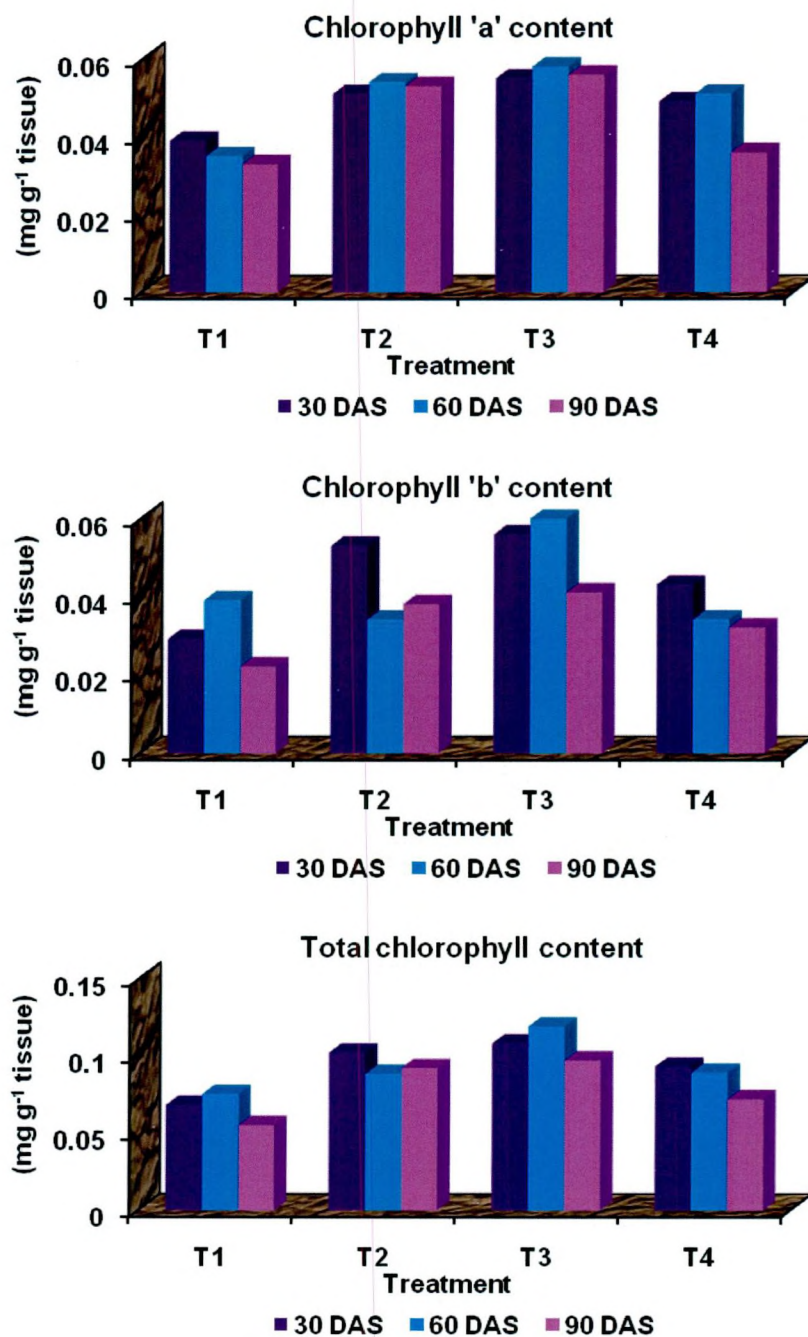
**EFFECT OF EM-SW COMPOST ON
CHLOROPHYLL CONTENT (mg g⁻¹ TISSUE) OF COW PEA**

Treatment	Chlorophyll								
	a			b			Total		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	0.039	0.035	0.033	0.029	0.039	0.022	0.068	0.075	0.055
T ₂	0.051	0.054	0.053	0.051	0.034	0.038	0.102	0.088	0.092
T ₃	0.055	0.058	0.056	0.053	0.060	0.041	0.108	0.119	0.097
T ₄	0.049	0.051	0.036	0.043	0.034	0.032	0.093	0.089	0.072
SED	0.0007			0.001			0.002		
CD	0.0022			0.003			0.004		
(P < 0.01)									

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 14
EFFECT OF EM-SW COMPOST ON CHLOROPHYLL
CONTENT (mg g^{-1} TISSUE) OF COW PEA



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

Similar result was observed by Hossain, *et al.* (2006), who also showed that there were higher amount of pigments like chl. a, b and carotenoid in the leaves of the EM treated seedlings of *Albizia saman* than the control.

4.7 NON-ENZYMIC ANTIOXIDANT

4.7.1 Ascorbic Acid

The data from Table 16 revealed that there was a steady increase in ascorbic acid content in all the treatments (T₁ to T₄) from 30 to 90 DAS (Figure 15).

TABLE - 16
EFFECT OF EM-SW COMPOST ON ASCORBIC ACID CONTENT (mg g⁻¹)
OF THE TEST PLANTS

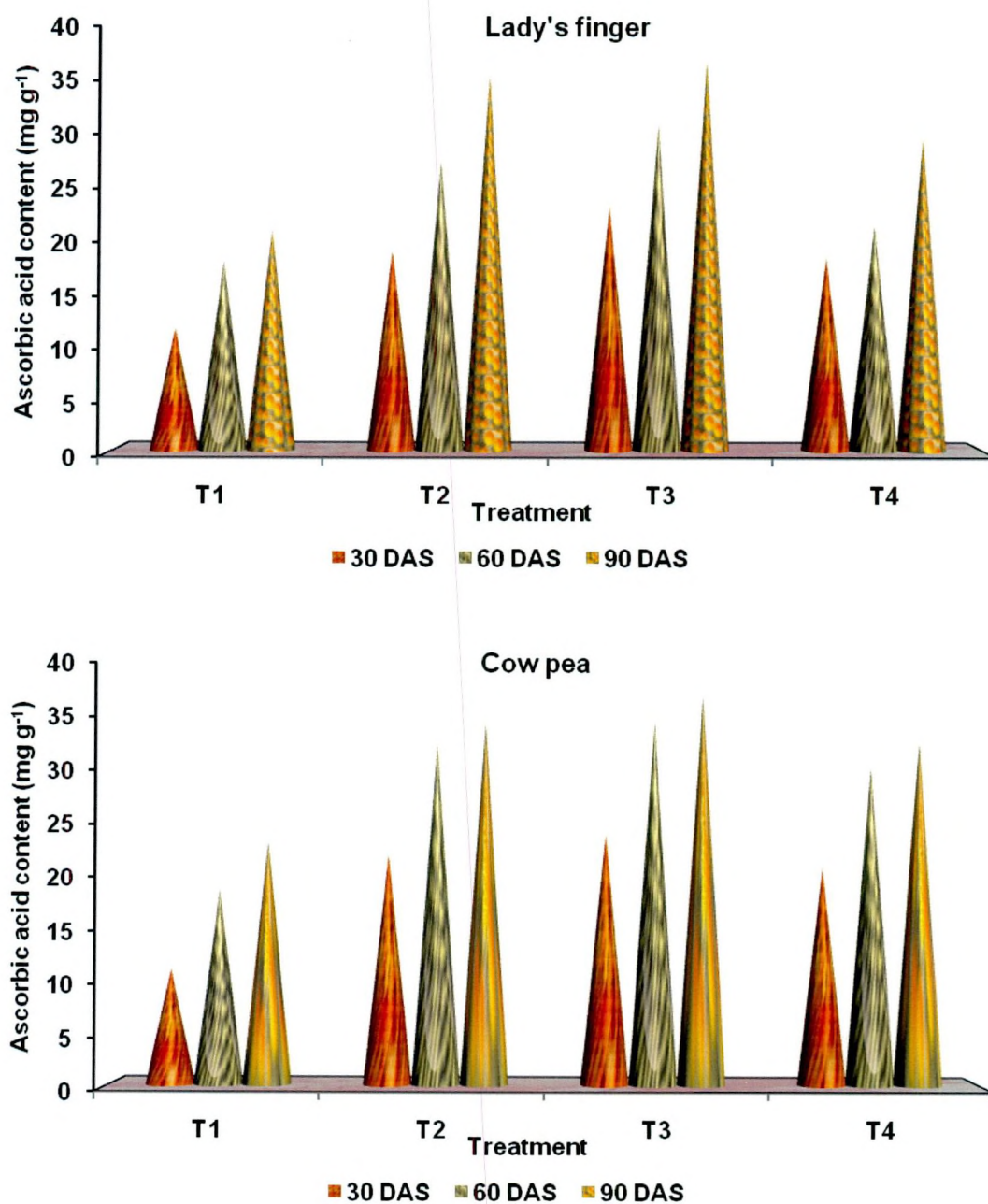
Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	11.7	18.2	21.2	11.1	18.8	23.5
T ₂	19.2	27.8	36.0	22.2	32.9	34.9
T ₃	23.4	31.2	37.5	24.2	35.0	37.6
T ₄	18.5	21.6	30.0	21.0	30.7	33.2
SED	0.55			0.53		
CD	1.55			1.48		
(P < 0.01)						

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 15

EFFECT OF EM-SW COMPOST ON ASCORBIC ACID CONTENT (mg g^{-1}) OF THE TEST PLANTS



- T₁ - Control (Untreated)
 T₂ - EM - SW compost (20 t ha⁻¹)
 T₃ - EM - SW compost (80 t ha⁻¹)
 T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

Ascorbic acid content showed a significant increase in T₃ treatment (EM – SW compost 80 t ha⁻¹) and T₂ (EM – SW compost 20 t ha⁻¹) which varied from 23.4 to 37.5 mg g⁻¹ and from 19.2 to 36.0 mg g⁻¹ in Lady's finger. In Cow pea, the increase in ascorbic content in T₃ was from 24.2 to 37.6 mg g⁻¹ while in T₂ and T₄ (NPK) the ascorbic content values were on par with each other (22.2 to 34.9 mg g⁻¹ and 21.0 to 33.2 mg g⁻¹) over the control T₁ from 11.7 to 21.2 mg g⁻¹ in Lady's finger and from 11.1 to 23.5 mg g⁻¹ in Cow pea.

It may be inferred from the statistical analysis of the data that the treatment T₃ registered significant values in the ascorbic acid content in the leaves of both lady's finger and cow pea [(P<0.01) = 1.55 and 1.48].

According to Lee and Kader (2000) ascorbic acid plays a protective role against reactive O₂ that are formed from photosynthetic and respiratory processes. It is linked to cell growth and other mechanism of plant growth.

The result is on line with the result in Lian *et al.* (2001). They reported that the application of EM-Bokashi inoculated organic manure to the soil increased the ascorbic acid concentration in tomato fruit.

4.7.2 Tocopherol

It may be deduced from the Table -17 and Figure -16, that all the treatments (T₁ to T₅) showed a gradual increase in tocopherol content from 30 to 60 DAS and declined gradually after that.

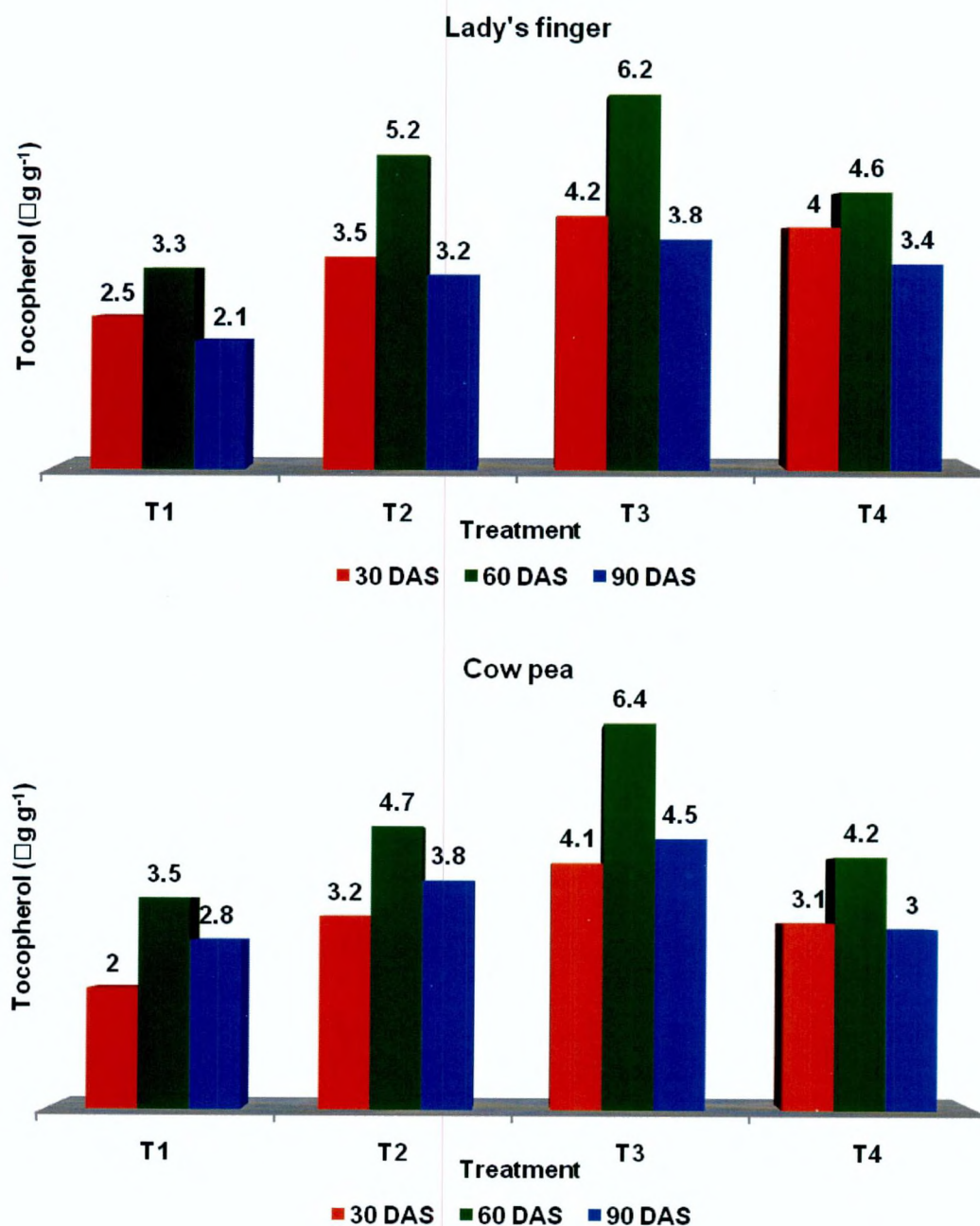
TABLE - 17
EFFECT OF EM-SW COMPOST ON TOCOPHEROL ($\mu\text{g g}^{-1}$)
OF THE TEST PLANTS

Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	2.5	3.3	2.1	2.0	3.5	2.8
T ₂	3.5	5.2	3.2	3.2	4.7	3.8
T ₃	4.2	6.2	3.8	4.1	6.4	4.5
T ₄	4.0	4.6	3.4	3.1	4.2	3.0
SED	0.25			0.12		
CD	0.70			0.35		
(P < 0.01)						

(Data represent the mean of three replications)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 16
EFFECT OF EM-SW COMPOST ON TOCOPHEROL ($\mu\text{g g}^{-1}$) CONTENT
OF THE TEST PLANTS



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

Tocopherol content was very much pronounced in the leaves of T₃ and it increased from 4.2 to 6.2 $\mu\text{g g}^{-1}$ in Lady's finger and from 4.1 to 6.4 $\mu\text{g g}^{-1}$ in Cow pea upto 60 DAS compared to control which varied from 2.5 to 3.3 $\mu\text{g g}^{-1}$ and from 2.0 to 3.5 $\mu\text{g g}^{-1}$ upto 60 DAS and declined gradually to 3.8 $\mu\text{g g}^{-1}$ and 4.5 $\mu\text{g g}^{-1}$ than the control T₁ (2.1 $\mu\text{g g}^{-1}$ and 2.8 $\mu\text{g g}^{-1}$ respectively).

It may be inferred from the statistical analysis of the data that the treatment T₃ registered significant values in the tocopherol content of the leaves of both lady's finger and cow pea [(P<0.01) = 0.70 and 0.35].

4.8 ENZYMIC ANTIOXIDANTS

4.8.1 Catalase Activity

It may be elucidated from Table -18 and Figure -17 that there was a gradual increase in catalase enzyme activity in all the treatments from 30 to 90 DAS.

The treatment T₃ (EM-SW compost 80 t ha⁻¹) exhibited maximum increase in catalase enzyme activity in Lady's finger and Cow pea which varied from 0.62 to 4.4 $\text{U l}^{-1} \text{ min}^{-1} \text{ mg}^{-1}$ enzyme protein and 1.4 to 2.7 $\text{U l}^{-1} \text{ min}^{-1} \text{ mg}^{-1}$ enzyme protein compared to the control, T₁ (from 0.19 to 2.4 $\text{U l}^{-1} \text{ min}^{-1} \text{ mg}^{-1}$ enzyme protein and 0.25 to 1.2 $\text{U l}^{-1} \text{ min}^{-1} \text{ mg}^{-1}$ enzyme protein).

It may be inferred from the statistical analysis of the data that the treatment T₃ registered significant values in the catalase activity in the leaves of both lady's finger and cow pea [(P<0.01) = 0.50 and 0.39]. The increase in oxido reductase enzyme catalase and peroxidase activity might be due to increase in microbial metabolism in the soil as a result of

the mineralization of biodegradable C fractions contained in EM-SW compost.

4.8.2 Peroxidase Activity

The data from the Table -19 indicate that the peroxidase activity increased gradually from 30 to 90 DAS in all the treatments (Figure -18).

TABLE - 18
EFFECT OF EM-SW COMPOST ON CATALASE ACTIVITY*
OF THE TEST PLANTS

Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	0.19	2.03	2.4	0.25	1.1	1.2
T ₂	0.52	3.5	3.9	0.98	2.4	2.6
T ₃	0.62	4.3	4.4	1.43	2.6	2.7
T ₄	0.19	2.2	2.4	0.69	1.4	2.1
SED	0.16			0.14		
CD	0.50			0.39		
(P < 0.01)						

(Data represent the mean of three replications)

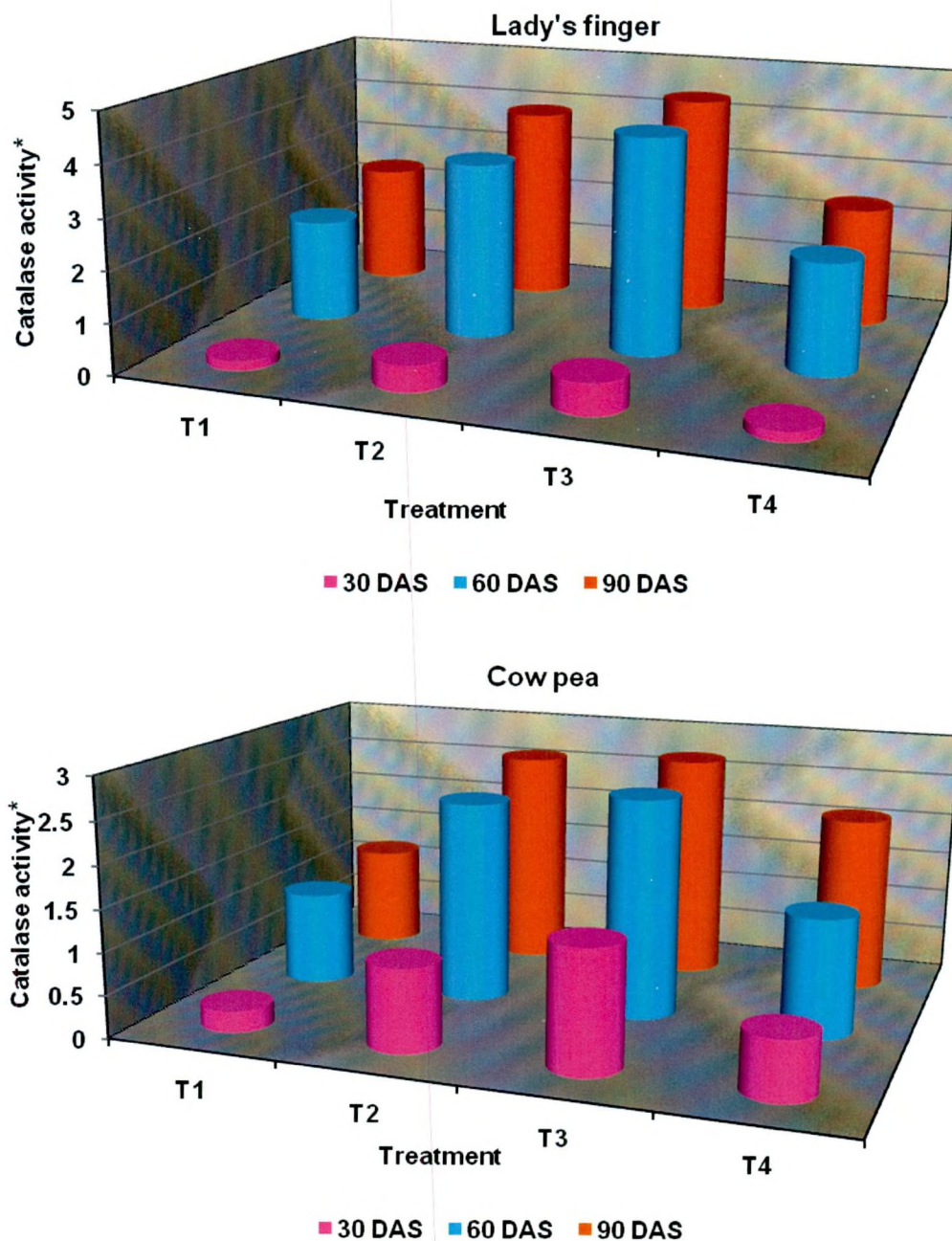
* Activity expressed in units (UI⁻¹)

(One unit is equivalent to 1 ml of 0.01 N potassium permanganate min⁻¹ mg⁻¹ enzyme protein)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 17

EFFECT OF EM-SW COMPOST ON CATALASE ACTIVITY*
OF THE TEST PLANTS



* Activity expressed in units. (one unit is equivalent to 1 ml of 0.01 N potassium permanganate min⁻¹ mg⁻¹ enzyme protein)

T₁ - Control (Untreated)

T₂ - EM - SW compost (20 t ha⁻¹)

T₃ - EM - SW compost (80 t ha⁻¹)

T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

TABLE - 19
EFFECT OF EM-SW COMPOST ON PEROXIDASE ACTIVITY*
OF THE TEST PLANTS

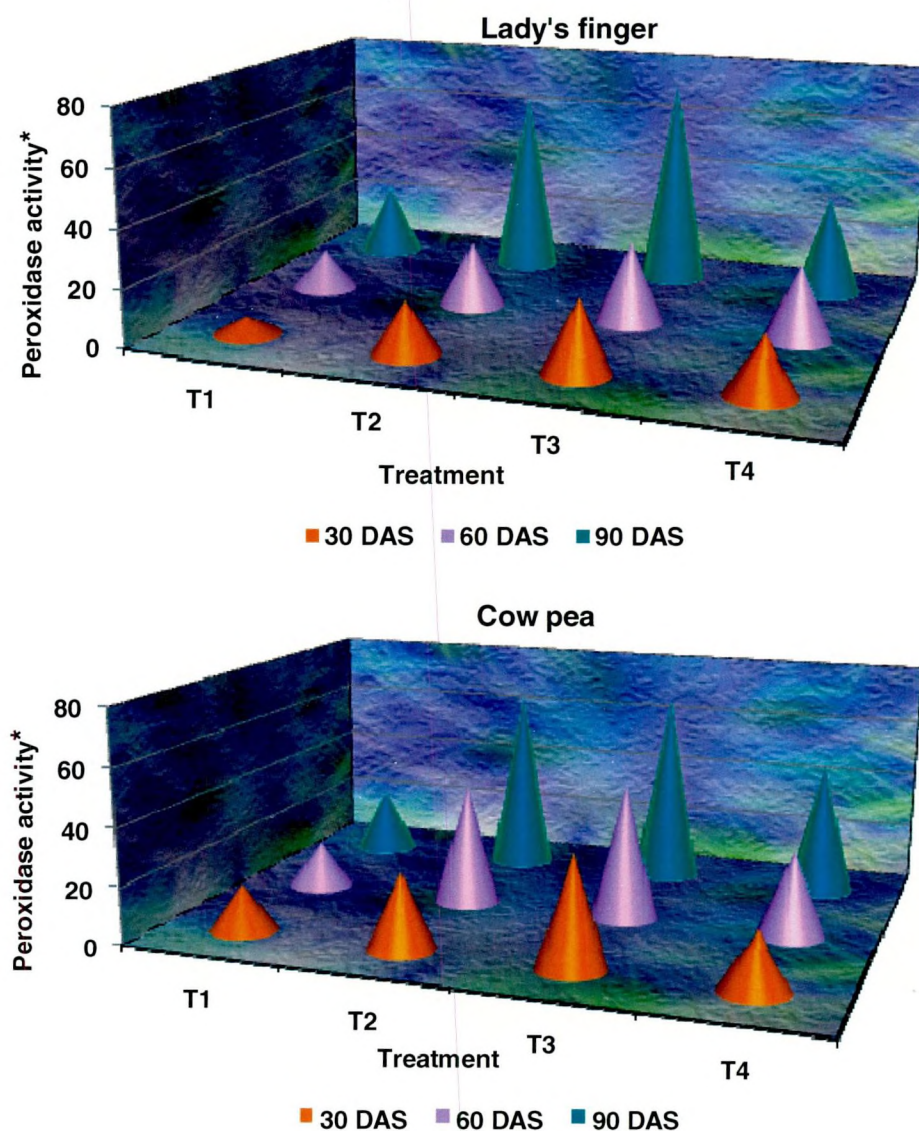
Treatment	Lady's finger			Cow pea		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T ₁	6.1	14.3	25.2	16.3	16.3	22.6
T ₂	18.1	22.1	64.3	26.2	42.4	65.2
T ₃	25.1	28.0	72.3	39.2	48.2	67.2
T ₄	20.6	26.1	35.3	20.3	30.06	46.4
SED	0.30			2.11		
CD	0.84			5.44		
(P < 0.01)						

(Data represent the mean of three replications)

* Activity expressed in μ mol of pyrogallol oxidized $\text{min}^{-1} \text{mg}^{-1}$ enzyme protein

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 18
EFFECT OF EM-SW COMPOST ON PEROXIDASE ACTIVITY*
OF THE TEST PLANTS



* Activity expressed in μ mol of pyrogallol oxidized $\text{min}^{-1} \text{mg}^{-1}$ enzyme protein

- T₁ - Control (Untreated)
- T₂ - EM - SW compost (20 t ha⁻¹)
- T₃ - EM - SW compost (80 t ha⁻¹)
- T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

A significantly higher peroxidase activity was recorded in T₃ (EM – SW compost 80 t ha⁻¹) which ranged from 25.1 to 72.3 μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein in Lady's finger and in Cow pea from 39.2 to 67.2 μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein than the control, T₁ (from 6.1 to 25.2 μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein and 16.3 to 22.6 μ mol of pyrogallol oxidized min⁻¹ mg⁻¹ enzyme protein).

The statistical scrutiny of the data revealed that the soil peroxidase enzyme activity was found to be significantly enhanced in T₃ compared to other treatments [(P<0.01) = 0.84 and 5.44].

Similar results were obtained by Ruth (2002) who found that peroxidase activity was found to be higher in F₁ hybrids of chilli.

The present result is in accordance with the result of Sathyamurthy (2002). He conducted a study on the development of F₁ hybrids in chilli to analyze the enzyme activity. The results of the study revealed that a significantly higher peroxidase activity of 788.58 min⁻¹ mg⁻¹ fresh weight was obtained in green fruit at 45 days after flowering in Ujala XP X in F₁ hybrid variety.

4.9 ENZYME ACTIVITY IN INITIAL AND EXPERIMENTAL SOIL OF TEST PLANTS

4.9.1 Dehydrogenase Enzyme activity

The data from Table -20 and Figure- 19 revealed that there was a gradual increase in dehydrogenase enzyme activity upto 60 DAS and after that it declined gradually in all the treatments (T₁ to T₄) of test plants.

The dehydrogenase enzyme activity increased maximally in T₃ (EM – SW compost 80 t ha⁻¹) from 19.7 to 57.5 µ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein in Lady's finger compared to control T₁, from 14.9 to 37.2 µ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein upto 60 DAS and it decreased gradually to 47.1 µ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein in Lady's finger and 18.7 µ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein in T₁ (control).

TABLE - 20
INITIAL AND EXPERIMENTAL SOIL ANALYSIS - DEHYDROGENASE*
ENZYME ACTIVITY

Treatments	Lady's finger				Cow pea			
	Initial	30 DAS	60 DAS	90 DAS	Initial	30 DAS	60 DAS	90 DAS
T ₁	14.9	24.2	37.2	18.7	25.6	31.2	38.2	35.3
T ₂	18.3	32.4	45.0	45.0	62.0	75.4	95.6	83.7
T ₃	19.7	44.2	57.5	47.1	94.3	124.9	140.1	123.7
T ₄	17.3	36.2	45.6	41.1	78.3	82.3	92.1	72.7
SEd	1.56				1.03			
CD (P < 0.01)	4.37				2.83			

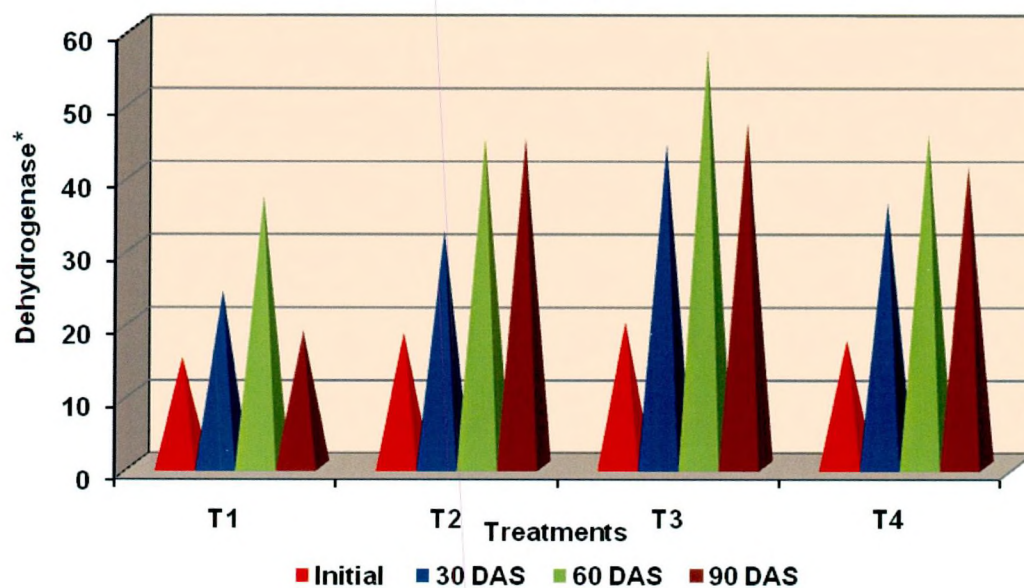
* Enzyme activity expressed in μ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein

- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

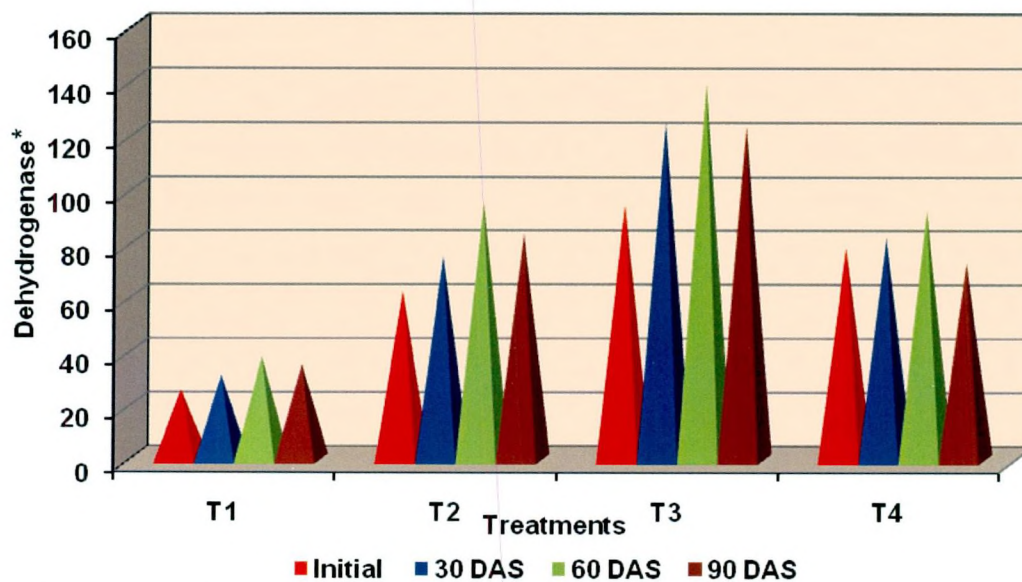
FIGURE - 19

INITIAL AND EXPERIMENTAL SOIL ANALYSIS - DEHYDROGENASE*
ENZYME ACTIVITY

Lady's finger



Cow pea



* Enzyme activity expressed in μ mol of TTC formed g^{-1} soil mg^{-1} enzyme protein

T₁ - Control (Untreated)

T₂ - EM - SW compost (20 t ha⁻¹)

T₃ - EM - SW compost (80 t ha⁻¹)

The dehydrogenase enzyme activity was pronounced significantly in T₃ treatment of Cow pea. The increase was from 94.3 to 140.1 μ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein upto 60 days compared to the control, T₁ (from 25.6 to 38.2 μ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein) and it gradually declined to 123.7 μ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein and in T₁, control to 35.3 μ mol of TTC formed g⁻¹ soil mg⁻¹ enzyme protein.

The statistical scrutiny of the data revealed that the soil dehydrogenase enzyme activity was found to be significantly enhanced in T₃ over other treatments [(P<0.01) = 4.37 and 2.83]. The increase in dehydrogenase enzyme activity upto 60 DAS may be indicative of high microbial activity.

The result is in accordance with the result of Gil *et al.* (2000). They found that solid waste compost applied at 80 t ha⁻¹ showed a higher dehydrogenase activity (200 per cent).

Similar result was reported by Jothimani (2002) during the experiments on solid waste compost application to maize. Highest dehydrogenase activity obtained was 125.3 μ g TTC formed g⁻¹ of soil and the lowest activity was 73.7 μ g TTC formed g⁻¹ of soil, in NPK applied soil.

4.9.2 Urease activity in Soil

It is observed from Table 21 and Figure -20 that the urease enzyme activity increased significantly upto 60 DAS and declined gradually after that in all the treatments (T₁-T₄). The increase in urease enzyme activity upto 60 DAS may be attributed to the production of ammonia and also due to the progressive utilization of organic acids by microbial populations present in the soil as well as in the activated EM solution.

TABLE - 21
INITIAL AND EXPERIMENTAL SOIL ANALYSIS - UREASE*
ENZYME ACTIVITY

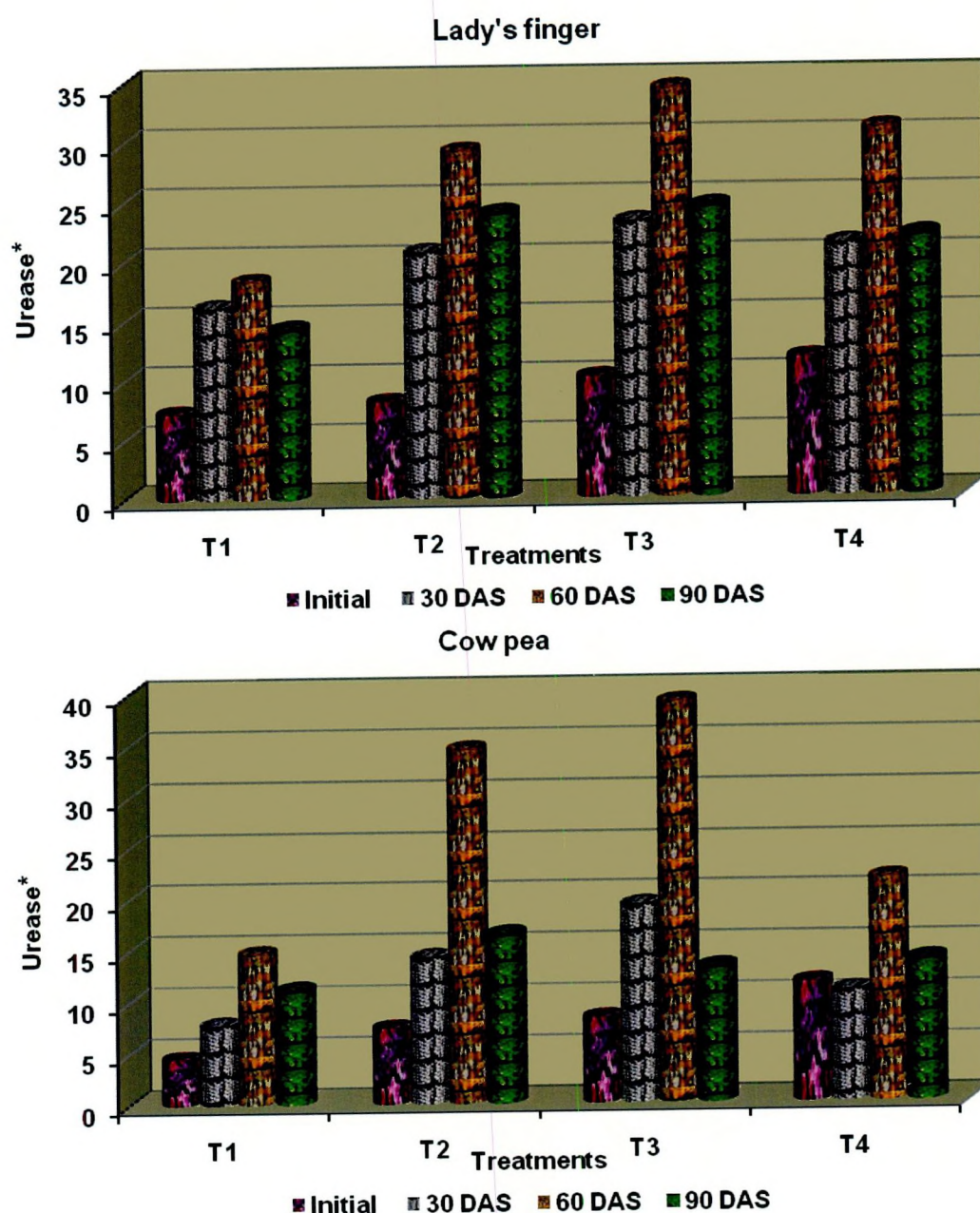
Treatments	Lady's finger				Cow pea			
	Initial	30 DAS	60 DAS	90 DAS	Initial	30 DAS	60 DAS	90 DAS
T ₁	7.3	16.2	18.4	14.4	4.5	7.8	14.7	11.2
T ₂	8.2	20.8	29.3	24.1	7.4	14.3	34.6	16.5
T ₃	10.2	23.3	34.5	24.6	8.3	19.3	39.1	13.2
T ₄	11.7	21.3	31.0	22.0	11.6	10.8	21.7	13.8
SEd	0.58				0.24			
CD (P < 0.01)	1.46				0.76			

* Enzyme activity expressed in (μ mol of ammonia formed mg^{-1} enzyme protein)

- T₁ - Control (Untreated)
T₂ - EM – SW compost (20 t ha⁻¹)
T₃ - EM – SW compost (80 t ha⁻¹)
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 20

INITIAL AND EXPERIMENTAL SOIL ANALYSIS - UREASE* ENZYME ACTIVITY



* Enzyme activity expressed in μ mol of TTC formed g^{-1} soil mg^{-1} enzyme protein

- T₁ - Control (Untreated)
- T₂ - EM - SW compost (20 t ha⁻¹)
- T₃ - EM - SW compost (80 t ha⁻¹)
- T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

There was a significant increase in T₃ (EM – SW compost 80 t ha⁻¹) and T₂ (NPK) treatments in both Lady's finger and Cow pea plants. The increase in urease activity in Lady's finger, T₃ treatment was from 10.2 to 34.5 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein and in T₄ treatment (NPK) from 11.7 to 31.0 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein upto 60 DAS and gradually declined to 24.6 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein in T₃ and 22.0 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein in T₄ compared to the control, T₁.

The increase in urease activity in T₃ and T₂ treatments (EM-SW compost 80 and 20 t ha⁻¹) in Cow pea varied from 8.3 to 39.1 and 7.4 to 34.6 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein and decreased gradually to 13.2 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein in T₃ and 16.5 μ mol of Ammonia formed min⁻¹ mg⁻¹ enzyme protein in T₂ compared to the control, T₁.

It may be inferred from the statistical analysis of the data that the treatment T₃ registered significant values in the urease enzyme activity in the leaves of both lady's finger and cow pea [(P<0.01) = 1.46 and 0.76].

The result coincided with the findings of Chang *et al.* (2007). They observed during their study on different application rates of compost that the populations of bacteria, fungi and actinomycetes as well as soil enzyme activities like urease and phosphatases increased significantly in the compost treated soils compared with chemical fertilizer treated soil.

Similar result was obtained by Nogales and Benitez (2007). They conducted an incubation experiment to ascertain the effects organic

amendments (fresh, composted and vermicomposted olive cake). They inferred from the study that the application of compost and vermicompost significantly increased humic acid in soils and it stimulated dehydrogenase and urease activities initially upto certain period and showed decreased activity later on.

4.10 INITIAL AND EXPERIMENTAL SOIL ANALYSIS OF TEST PLANTS

4.10.1 pH, EC AND NPK

The initial and experimental soil samples of all the treatments were assessed for their characteristics. The texture of the soil sample was red sandy loam. The soil analysis showed the following data (Tables 22 and 23 and Figures 21 and 22).

TABLE - 22

INITIAL AND EXPERIMENTAL SOIL ANALYSIS (LADY'S FINGER)

	pH	EC dSm ⁻¹	Available nutrients (kg ha ⁻¹)		
			N	P	K
Initial	7.5	0.09	70	11.1	162
T ₁	8.2	0.22	128	18.6	245
T ₂	8.4	0.27	168	24.8	523
T ₃	8.7	0.43	217	31.6	587
T ₄	8.4	0.33	189	27.4	567

T₁ - Control (Untreated)

T₂ - EM – SW compost (20 t ha⁻¹)

T₃ - EM – SW compost (80 t ha⁻¹)

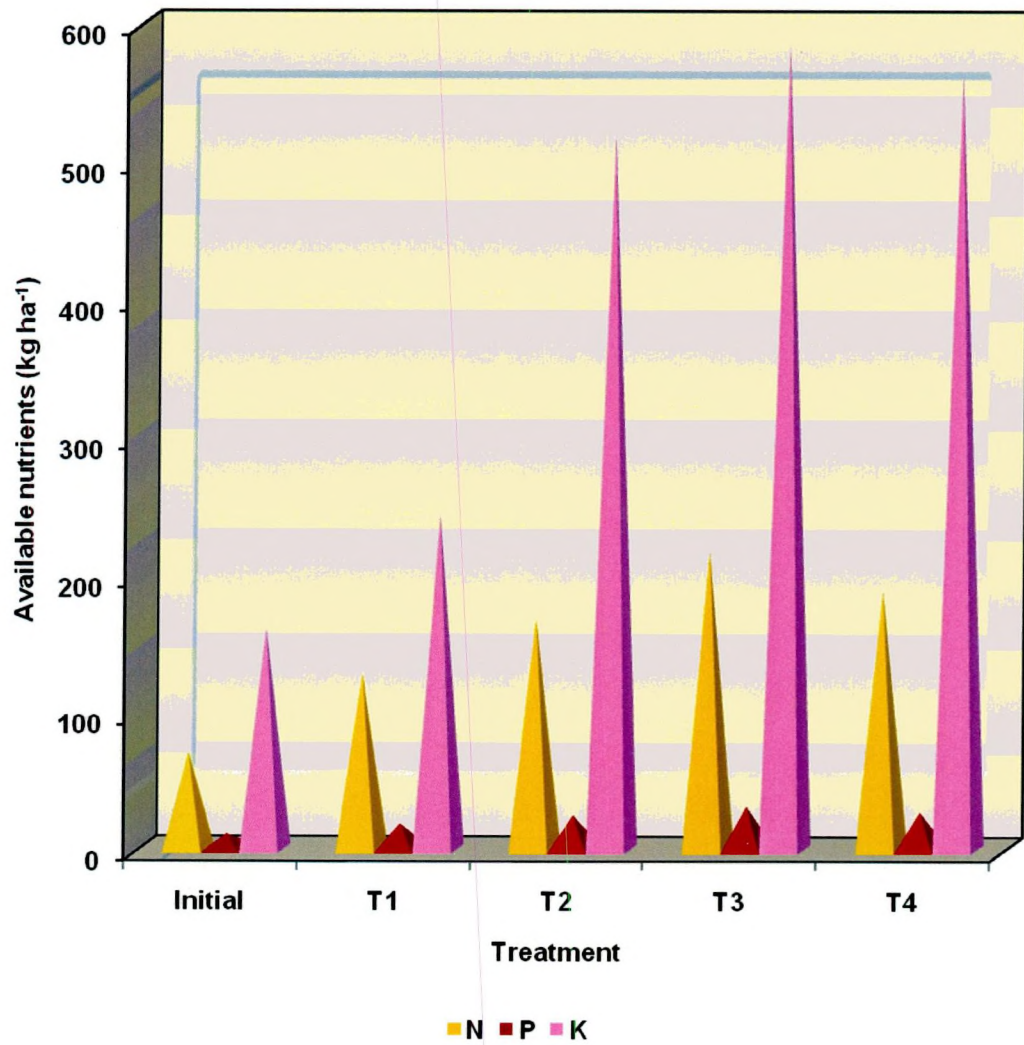
T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

TABLE - 23
INITIAL AND EXPERIMENTAL SOIL ANALYSIS (COW PEA)

	pH	EC dSm ⁻¹	Available nutrients (kg ha ⁻¹)		
			N	P	K
Initial	7.5	0.153	70.0	2.5	105.0
T ₁	8.5	0.167	76.0	3.0	112.0
T ₂	8.6	0.174	101.0	4.0	185.0
T ₃	8.7	0.176	109.0	6.5	245.0
T ₄	8.6	0.168	91.0	5.5	210.0

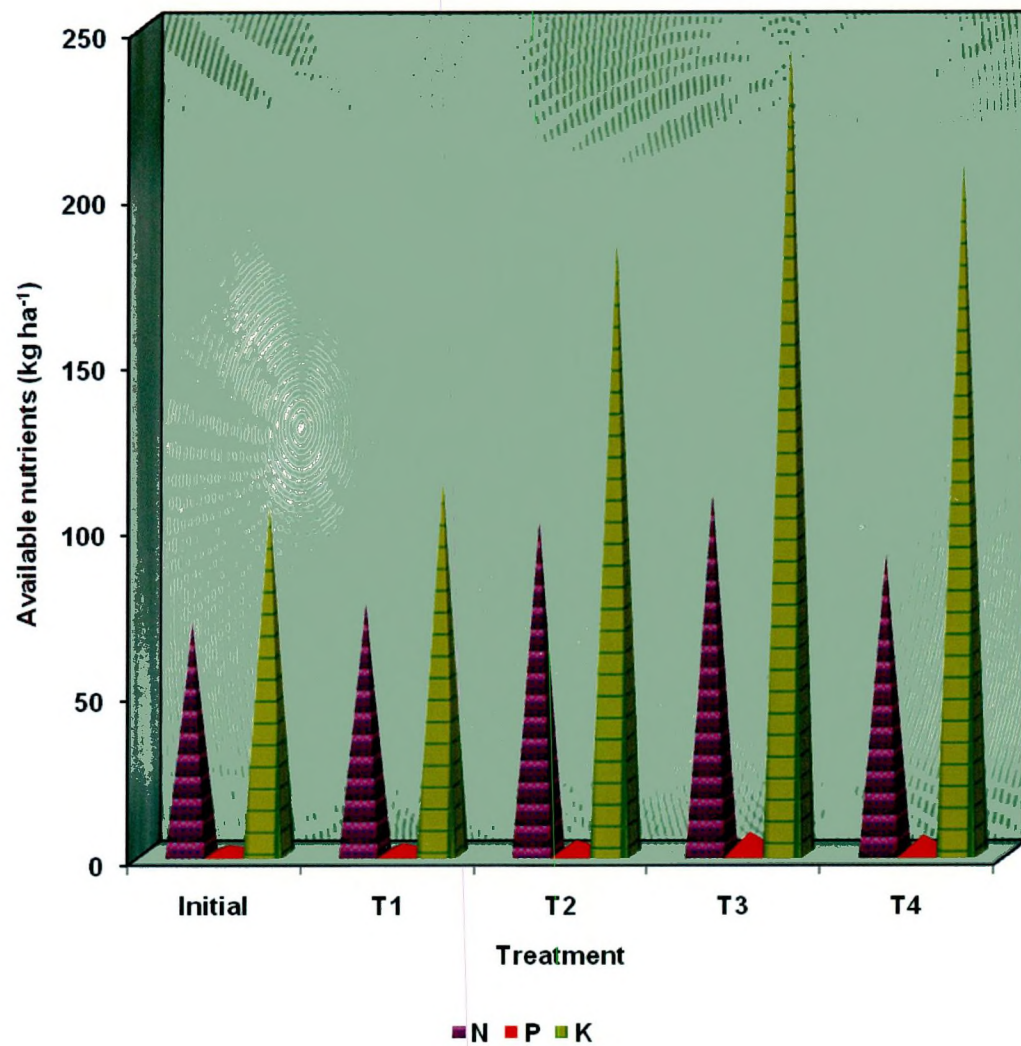
- T₁ - Control (Untreated)
- T₂ - EM – SW compost (20 t ha⁻¹)
- T₃ - EM – SW compost (80 t ha⁻¹)
- T₄ - NPK (N-0.45 g, P-1.31 g and K-0.12 g)

FIGURE - 21
INITIAL AND EXPERIMENTAL SOIL ANALYSIS (LADY'S FINGER)



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

FIGURE - 22
INITIAL AND EXPERIMENTAL SOIL ANALYSIS (COW PEA)



T₁ - Control (Untreated)
T₂ - EM - SW compost (20 t ha⁻¹)
T₃ - EM - SW compost (80 t ha⁻¹)
T₄ - NPK (N - 0.45 g, P - 1.31 g and K - 0.12 g)

The experimental soil analysis (Lady's finger) showed maximum pH of 8.7 in T₃ (EM-SW compost 80 t ha⁻¹), compared to the initial soil pH of 7.5. Soil pH values in T₂ (EM – SW compost 20 t ha⁻¹) and T₄ (NPK) were on par with each other (8.4). EC is maximum in T₃ (0.43 dSm⁻¹) followed by T₄ (0.33 dSm⁻¹) when compared to the initial soil (0.09 dSm⁻¹). NPK amount varied from 70 to 217 kg ha⁻¹, 11.1 to 31.6 kg ha⁻¹, 162 to 587 kg ha⁻¹ respectively in T₃.

Among the treatments of experimental soil analysis in Cow pea, the soil pH was 8.7 in T₃ followed by 8.6 in T₂ and T₄ and EC was 0.176 dSm⁻¹ in T₃ followed by T₂, 0.174 dSm⁻¹. The available nutrients increased from 70.0 to 109 kg ha⁻¹ (N), from 2.5 to 6.5 kg ha⁻¹ (P) and from 105 to 245 kg ha⁻¹ respectively in T₃ treatment.

The increase in pH, EC and available NPK levels were probably due to the production of NH₄ during proteolysis by microbes and also due to progressive increase in mineral constituents of EM-SW compost incorporation into the soil.

The result coincides with the findings of Yadav (2000) who reported that Effective Micro-organisms (EM) has the ability to breakdown organic matter, thereby providing plant nutrients and enhancing physical and chemical properties of the soil.

The result is on par with the result of Arul (2002). He inferred that the marigold plants performed better in solid waste than the FYM in all aspects and increased pH, EC and NPK of soil.

According to Zamanov *et al* (2002) only the organic fertilizers can raise the humus maintenance in soil. They are a source of carbon for

reproducing humus loses, improving the physical properties of soil and promoting the mineralization of organic matter.

Similar result was reported by Guerini *et al.* (2006). They cultivated maize plants in solid waste compost, cattle manure and usual minerals and found that the pH, EC and NPK were higher in solid waste compost applied soil than the other treatments.