Results and Discussion

The treatments were as follows:

C- *Azospirillum* + *Phosphobacteria* + 100% recommended dose of N and K

T_1- *Azospirillum* + 50% recommended dose of N and K

T_2 – *Phosphobacteria* + 50% recommended dose of N and K

T_3- *Azophos* + 50% recommended dose of N and K

T_4- *Azophosmet* + 50% recommended dose of N and K

T_5- *Azospirillum* + 25% recommended dose of N and K

T_6- *Phosphobacteria* + 25% recommended dose of N and K

T_7- *Azophos* + 25% recommended dose of N and K

T_8- *Azophosmet* + 25% recommended dose of N and K

The 100% recommended dose of N is 75 kg ha^{-1} and that of K is 25 kg ha^{-1}. The control group has the carrier based inoculum with the microbial population of about $18x10^6$ cells of *Azospirillum*/g and $15x10^5$ cells of *Phosphobacteria*/g. The treatment T_1 to T_8 consists of liquid biofertilizers with the microbial population of about $12x10^7$cells of *Azospirillum*/ml, $9x10^7$ cells of *Phosphobacteria*/ml and $3x10^6$ cells of *Azophosmet*/ml.

The results obtained in the present study are discussed under the following headings:

4.1. Biometric observations

4.1.1. Root length, Shoot length and Number of leaves

4.1.2. Fresh weight and Dry weight

4.2. Biochemical analysis

4.2.1. Chlorophyll and Carotenoid

4.2.2. Protein, Total phenol and Reducing sugar

4.2.3. Phosphorus, Iron and Total free aminoacid

4.3. Antioxidant status

4.3.1. Catalase, Peroxidase and Superoxide dismutase

4.3.2. Glutathione-S- transferase and Glutathione peroxidase

4.4. Soil enzyme analysis

4.4.1. Amylase, Cellulase, Dehydrogenase, Phosphatase and Urease

4.5. Soil analysis at the initial and at the post harvesting stage

4.6. Vermicompost analysis

4.1. Biometric observations

The biometric observations such as root length, shoot length, number of leaves, fresh weight and dry weight of *Hibiscus surattensis* (L.) were observed on the 30^{th} and 45^{th} day of growth.

4.1.1. Root length, Shoot length and Number of leaves

Table II illustrates the root length, shoot length and number of leaves of *Hibiscus surattensis* (L.) on the two different stages of growth.

TABLE II

THE ROOT LENGTH, SHOOT LENGTH AND NUMBER OF LEAVES OF *Hibiscus surattensis* (L.)

Treatments	Root length (cm)		Shoot length (cm)		Number of leaves	
	Days after sowing		Days after sowing		Days after sowing	
	30	45	30	45	30	45
C	7.93	10.60	25.80	40.06	7	11
T_1	8.33	10.86	28.16	34.70	8	10
T_2	6.20	08.46	27.66	39.60	7	14
T_3	9.90	14.26	30.63	39.60	9	11
T_4	7.63	08.73	24.43	34.43	7	12
T_5	7.70	09.43	27.76	32.00	7	12
T_6	7.00	12.43	28.10	41.13	8	11
T_7	9.00	11.16	28.33	36.83	8	8
T_8	6.70	11.16	29.90	41.66	8	10
CD(0.05)	4.40		5.38		3.00	

Values are mean of triplicates

Root length

From the Table II the maximum root length was exhibited by T_3 on the 30^{th} day of growth, followed by T_7 and T_1 whereas on the 45^{th} day of growth T_3 registered the maximum root length. This was followed by T_6, T_7 and T_8.

This correlates with the study of Datta *et al.* (2009) in yellow sarson (*Brassica campestries* cv.B9). A significant increase in the root length of cotton plant inoculated with the *Phosphobacteria* was reported by Ramalaksmi and Raj (2008).

Engqvist *et al.* (2006) also stated that bio-inoculation with PGPR in the form of seed coating induced the bacterial and fungal population which enhanced the plant growth in terms of root and shoot length in barley. *Azospirillum* sp. inoculation had improved the root growth and later enhanced mineral and water uptake in both maize and rice plants (Tilak *et al.*, 2005).

Shoot length

Among the treatments, T_3 recorded the maximum shoot length on the 30^{th} day of growth. This was followed by T_8 and T_7 respectively. The treatment, T_8 registered the highest shoot length on the 45^{th} day followed by T_6.

Mia *et al.* (2010) showed that the effect of PGPR inoculation resulted in more shoot growth compared to un-inoculated control plants. A study by Suthar (2009) had also shown that the application of vermicompost (15t/ha) + 50 % NPK had increased the shoot length in garlic (*Allium stivum* L.).

The maximum plant height was observed in the treatment involving the combination of biofertilizers (*Azospirillum* + PSB) + vermicompost (1:1:1) + inorganic water soluble fertilizers in *Dianthus carpohyllus* (Bhalla *et al.*, 2007). Ribaudo *et al.* (2006) indicated that the inoculation of tomato seedlings with *Azospirillum brasilense* promote the development of plants, as reveled by increased shoot and root biomass, shoot height and total root surface.

Number of leaves

The maximum number of leaves was recorded in T_3, whereas the treatments T_1, T_6, T_7 and T_8 recorded a similar number of leaves on the 30^{th} day after sowing. T_2 showed the highest number of leaves on the 45^{th} day after sowing. This was followed by T_4 and T_5 with similar number of leaves.

This study in accordance with the study of Warade *et al.* (2007) that the combined treatment of vermicompost and PSB significantly increased the height of the plant and number of leaves in Dahlia. Reddy and Ohkura, (2004) also stated that the application of vermicompost had increased the plant height, shoot biomass, root length, root biomass, leaf number and leaf area in the sorghum plants. The compost at 10t/ha along with recommended dose of N, P and K recorded maximum number of leaves per plant in maize (*Zea mays L*) as reported by Baig *et al.* (2001).

4.1.2. Fresh weight and Dry weight

The fresh and dry weight of *Hibiscus surattensis* (L.) on the 30th and on the 45th day of growth were represented in Table III.

TABLE III

THE FRESH AND DRY WEIGHT OF *Hibiscus surattensis* (L.)

Treatments	Fresh weight (g/plant)		Dry weight(g/plant)	
	Days after sowing		Days after sowing	
	30	45	30	45
C	0.78	1.89	0.54	0.91
T_1	0.77	0.96	0.57	0.86
T_2	0.79	0.94	0.43	0.74
T_3	0.98	2.28	0.63	0.84
T_4	0.98	1.95	0.61	0.85
T_5	0.95	1.85	0.84	0.75
T_6	0.64	2.19	0.47	0.94
T_7	0.78	1.52	0.41	0.98
T_8	0.84	1.94	0.73	0.88
CD(0.05)	**0.019**		**0.050**	

Values are mean of triplicates

Fresh weight

It was clear from the Table III that the treatment, T_3 and T_4 had tremendously increased the fresh weight of the plants which was followed by T_5 on the 30^{th} day of growth, whereas the plant fresh weight was found to be significantly ($P < 0.05$) higher in T_3 on the 45^{th} day of growth. This was followed by T_6, T_4 and T_8 respectively.

Vijayananthan *et al.* (2007) also had shown that the inoculation of vermicompost : sand : red soil in the ratio of 1:1:1 had induced the significant improvement in shoot fresh and dry weight compared to the control as well as the other vermiproduct application. Dashti *et al.* (2007) stated that the inoculation of *Azospirillum* had increased the dry weight of tomato plants.

Dry weight

The dry weight of the treatment, T_5 were found to be higher on the 30^{th} day after sowing, which was followed by T_8, T_3 and T_4 respectively. Among the treatments, T_7 recorded a significantly higher dry weight on the 45^{th} day of growth, followed by T_6.

The inoculation of plant growth promoting *Rhizobacteria* significantly increased the shoot length, root length and dry matter production of shoot and root seedlings of *Cicer arietinum* (Mishra *et al.*, 2010).

Bhaskara Rao and Charyulu (2005) also reported that the inoculation of foxtail millet with the strains of *Azospirillum lipoferum* either alone or in combination with nitrogen fertilizer increased the plant height, dry weight of shoot and root and total N content of shoot, root and grain.

This study was also in agreement with Saniz *et al.* (2004) that the amendment of soil with 10 or 50% vermicompost significantly increased the dry matter yields of red clover and cucumber plants.

4.2. Biochemical analysis

The plants were plugged on the 30^{th} and 45^{th} day of growth and subjected to analysis of biochemical parameters such as chlorophyll, carotenoid, protein, total phenol, reducing sugar, phosphorous, iron and total free aminoacid.

4.2.1. Chlorophyll and Carotenoid

Table IV and figure 1 and 2 depicts the chlorophyll and carotenoid content of *Hibiscus surattensis* (L.) on the two different stages of growth.

TABLE IV

CHLOROPHYLL AND CAROTENOID CONTENT IN *Hibiscus surattensis* (L.)

Treatments	Chlorophyll (mg/g)		Carotenoid (mg/g)	
	Days after sowing		Days after sowing	
	30	45	30	45
C	1.30	1.56	1.52	2.72
T_1	1.07	1.94	1.46	1.65
T_2	1.16	2.09	4.45	4.47
T_3	1.42	2.20	2.09	3.85
T_4	1.31	1.49	0.55	1.20
T_5	1.24	1.31	0.80	2.37
T_6	0.85	1.06	1.82	1.82
T_7	1.02	1.18	4.43	4.73
T_8	0.83	1.55	1.70	4.21
CD(0.05)	0.17		0.14	

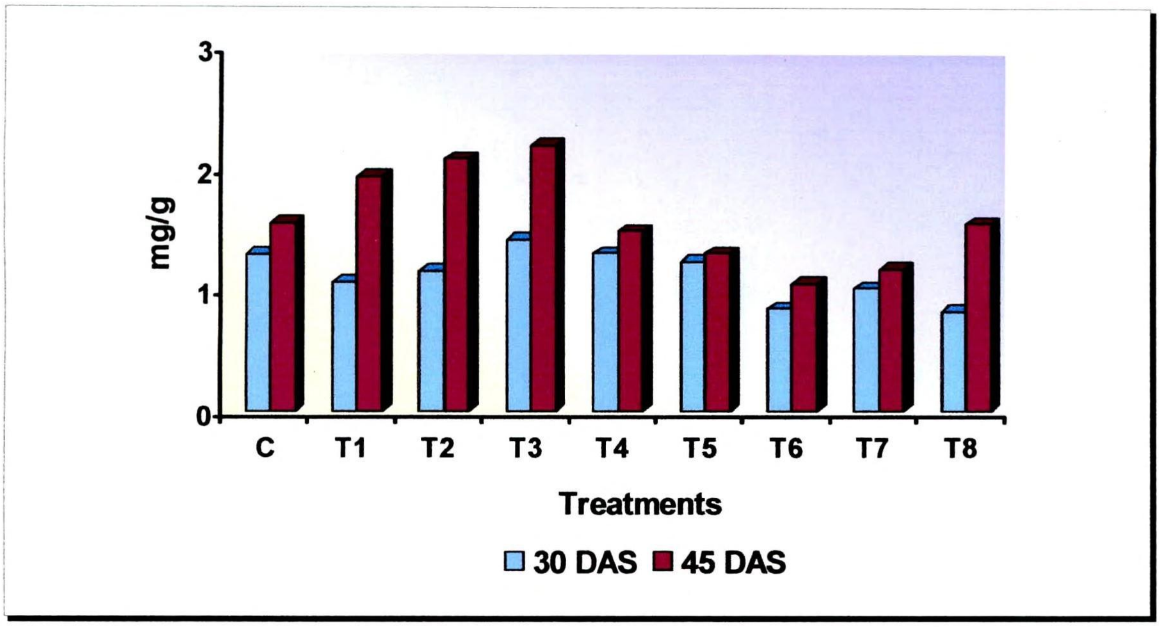
Values are mean of triplicates

Chlorophyll

Photosynthesis is the process, which can harvest solar energy to convert it into chemical energy (glucose) in plants. The key molecule for photosynthesis is chlorophyll, which absorbs photon, goes to the excited state and transfer the energy to the other pigment molecules, which are in close proximity and in the perfect orientation via some membrane protein complex. These are the prior requirements to funnel the energy (Manna *et al.*, 2009).

FIGURE 1

CHLOROPHYLL CONTENT IN *Hibiscus surattensis* (L.)



Among the treatments T_3 exhibited the highest chlorophyll content on the 30th as well as on the 45th day of growth which was found to be statistically significant. This was followed by T_4 on the 30th day and T_2 on the 45th day of growth.

The photosynthetic pigments such as chlorophyll *a*, *b*, total chlorophyll and carotenoid contents were increased in the plant *Lycopersicum esculentum* with increasing concentrations of *Azotobacter* and *Phosphobacterium* (Selvarathi *et al.*, 2010).

Velmurugan *et al.* (2008) also reported that the total chlorophyll content was maximum by the application of *Azospirillum* and *Phosphobacteria* as seedling dip plus foliar spraying of panchakavya to cauliflower. Shanthi and Vijayakumari (2005) observed that the application of NPK in combination with vermicompost increased the chlorophyll content in Bendhi (*Abelmoschus esculentus).*

Carotenoid

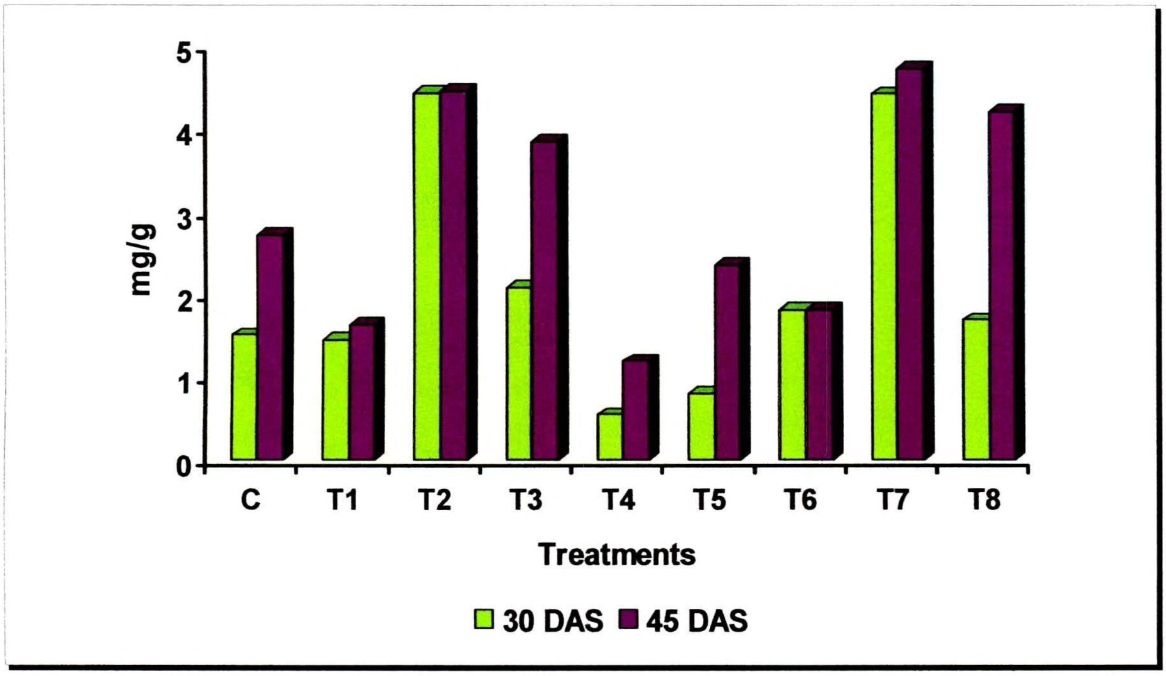
Carotenoids are C40 isoprenoid polyene compounds that form lipid-soluble yellow, orange and red pigments. In higher plants, carotenoid plays an essential role including light-harvesting and protecting photosynthetic apparatus from excess light energy in green tissues (Ji *et al.,* 2009).

Carotenoids are known to exist in many organisms including bacteria, fungi, higher plants and animals and play an important role in those organisms. In photosynthetic organisms, the most remarkable function of carotenoids is as accessory pigments for absorption of light energy and protection of photosystems against photo-oxidation (Suzuki *et al.*, 2007).

Carotenoids play essential functions in plants, like roles in phytohormone precursor action and environmental adaptation through modulation of the photosynthetic apparatus. In addition, some carotenoid pigments like α-carotene and β - carotene are important for human health and nutrition (Cuevas *et al.*, 2008).

FIGURE 2

CAROTENOID CONTENT IN ***Hibiscus surattensis*** **(L.)**



The treatment T_2 recorded the highest carotenoid content on the 30^{th} day of growth, which was followed by T_7. T_7 also showed a maximum carotenoid content on the 45^{th} day of growth and was followed by T_2 and T_8 respectively.

A study by Upadhyay *et al.* (2007) had shown the maximum total carotenoid content in the combination involving FYM, *Azospirillum* and PSM in cabbage (*Brassica oleracea* L.var. *capitata)*. Seadh *et al.* (2006) also showed that the total chlorophyll and carotenoids were significantly increased with increasing nitrogen levels in Sugar beet (*Beta vulgaris L*).

4.2.2. Protein, Total phenol and Reducing sugar

Protein, total phenol and reducing sugar content of *Hibiscus surattensis* (L.) were given in Table V and figure 3, 4 and 5 respectively.

TABLE V

PROTEIN, TOTAL PHENOL AND REDUCING SUGAR CONTENT IN *Hibiscus surattensis* (L.)

Treatments	Protein (mg/g)		Total phenol (mg/g)		Reducing sugar (mg/g)	
	Days after sowing		Days after sowing		Days after sowing	
	30	45	30	45	30	45
C	4.34	12.74	3.79	3.90	0.23	1.67
T_1	4.31	10.50	3.52	4.54	0.43	2.40
T_2	3.67	14.56	3.74	3.94	0.90	1.14
T_3	8.97	18.55	3.80	4.62	2.52	2.53
T_4	7.85	09.22	4.55	5.26	0.50	0.93
T_5	4.59	13.98	4.18	4.57	1.23	1.47
T_6	5.81	11.11	1.75	4.71	0.54	1.09
T_7	7.53	12.23	4.55	4.59	0.38	0.41
T_8	6.86	16.28	4.48	4.57	0.51	0.54
CD(0.05)	3.12		0.35		0.76	

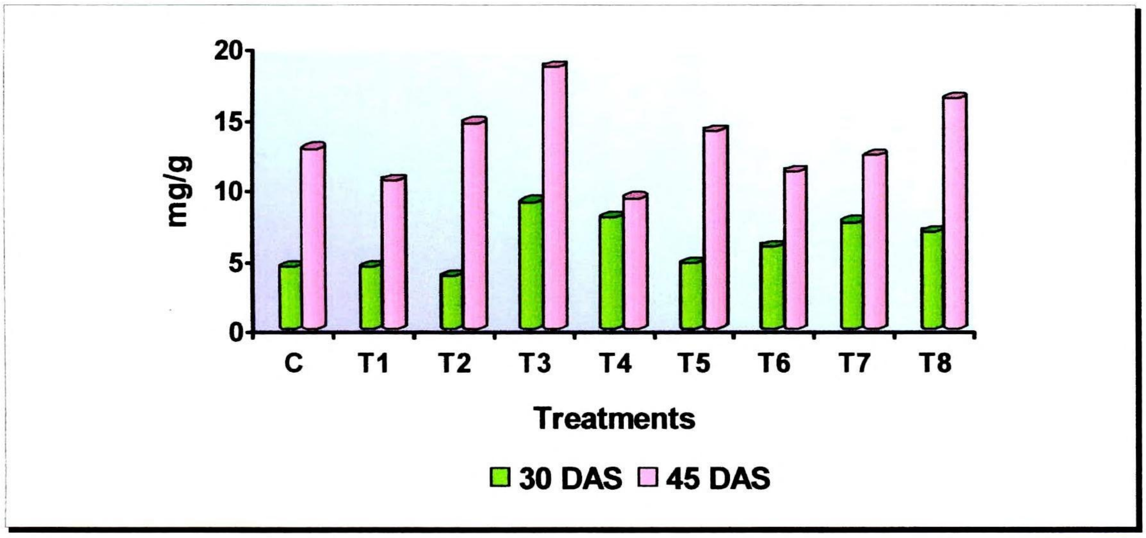
Values are mean of triplicates

Protein

Proteins are important class of biological macromolecules found in all organisms. They are made from elements such as carbon, hydrogen, oxygen, nitrogen and sulphur. Proteins are vital body nutrients, just as fats and carbohydrates, vitamins and minerals. However, proteins, together with dietary fats, are required by the body in larger amounts than vitamins and minerals because they are the primary body building block sources for new tissue. Leafy vegetable protein constitutes about half the vegetable protein content in the human diet and probably contributes more to the total protein than do fish, although less attention is given to it (Ghaly and Alkoaik, 2010).

FIGURE 3

PROTEIN CONTENT IN ***Hibiscus surattensis*** **(L.)**



The treatment T_3 showed an increased protein content over the rest of the treatments on the 30^{th} day of growth, this was followed by T_4, T_7 and T_8 respectively. T_3 was also found to be superior with the maximum protein content on the 45^{th} day of growth, followed by T_8, T_2 and T_5 respectively.

The application of 120kg N ha^{-1} resulted in significantly higher protein content in rabi maize was reported by Meena *et al.* (2007). The crude protein content and yield were higher due to application of *Azotobacter* + *Phosphobacteria* and half the amount of recommended dose of fertilizers in sorghum (*Sorghum bicolor L.*) as shown by the study of Ramanjaneyulu *et al.* (2006).

Vasanthi and Subramanian (2004) also stated that the application of vermicompost / farmyard manure with N, P and K showed the maximum crude protein content in Black gram *(Vigna mungo).*

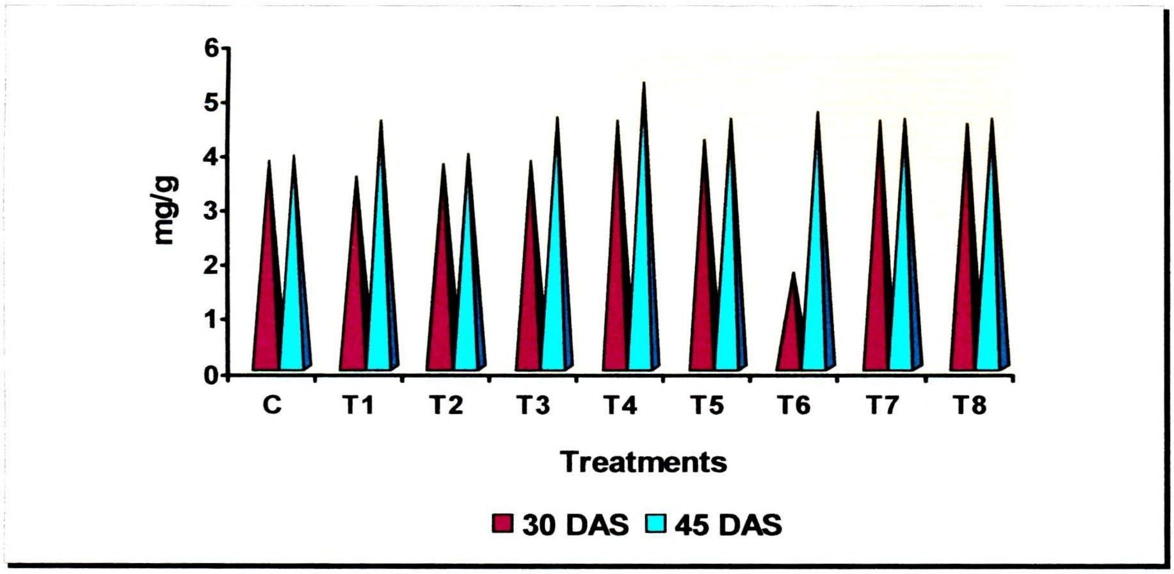
Total phenol

Polyphenols are an important class of defense antioxidants. These compounds are widespread in virtually all plants, often at high level and include phenols, phenolic acids, flavonoids, tannins and lignans (Boussaada *et al.,* 2008).

Phenolics have become the focus of current nutritional and therapeutic interest. The antioxidant activity of the dietary phenolics is considered to be superior to that of the essential vitamins and is ascribed to its high redox potential which allows them to interrupt free radical mediated reactions by donating hydrogen from the phenolic hydroxyl groups. Moreover, these natural antioxidants have easy and unlimited access to metabolic processes in the body and produce virtually none of the side effects associated with synthetic antioxidants (Beevi *et al.*, 2010).

FIGURE 4

TOTAL PHENOL CONTENT IN *Hibiscus surattensis* (L.)



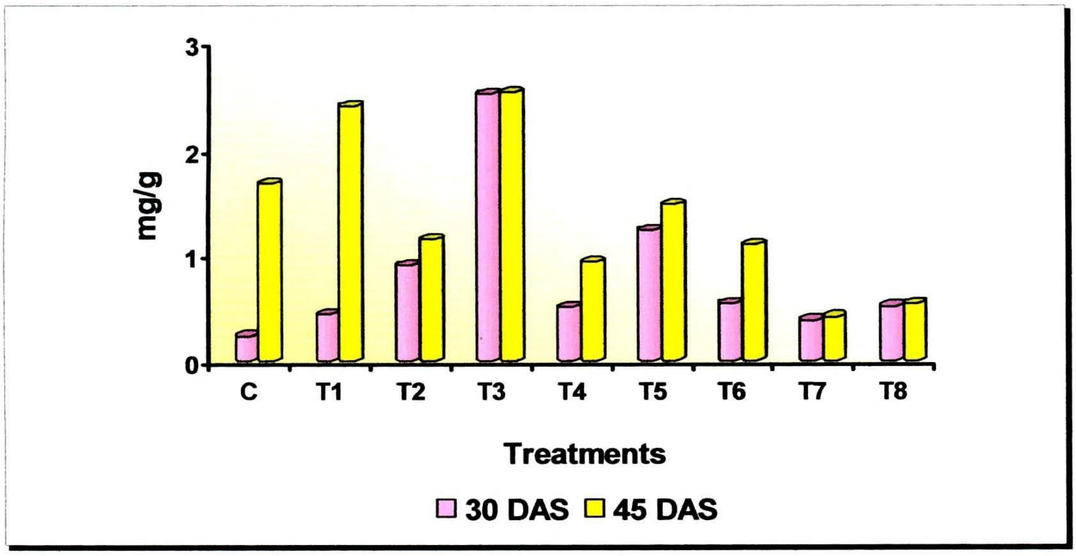
The phenolic content of leaves in the treatment T_4 and T_7 was found to be similar and higher on the 30th day of growth which was followed by T_8, whereas on the 45th day of growth, the highest phenolic content was exhibited by the treatment, T_4 and was followed by T_6.

Taie *et al.* (2008) reported that the addition of multi-biofertilizers including *Bacillus megaterium* var., *phosphaticum Azospirillum* spp., *Pseudomonas* spp and *Bradyrhizobium japonicum* to 50 or 75% compost resulted in great enhancement effect on total phenolics in soyabean. A similar study by Vijayakumari and Janardhanan (2003) reported that the maximum phenol content was seen in silk cotton by the application of VAM, *Phosphobacteria* and *Azospirillum.*

Reducing sugar

Photosynthesis provides plant with sugars that play a central role in the plant life cycle as energy sources, storage molecules, structural components or intermediates for the synthesis of other organic molecules. Next to these metabolic functions, sugars act as signaling molecules with hormone like properties (Schuurmans and Smeekens, 2008).

FIGURE 5
REDUCING SUGAR CONTENT IN ***Hibiscus surattensis*** **(L.)**



Among the treatments, T_3 exhibited the highest reducing sugar content on the 30th as well as on the 45th day of growth followed by T_5 on the 30th day and T_1 on the 45th day of growth.

This is in accordance with the study of Vijaya and Mouli (2010) reported that the inoculation of VAM+PSB+AZO had significantly increased the reducing and non- reducing sugar content in *Stevia rebaudiana* (BERT). Chandrasekar *et al.* (2005) also showed that the inoculation of *Azospirillum* and *Azotobacter* fairly increased the amount of reducing sugars in banana.

4.2.3. Phosphorus, Iron and Total free aminoacid

Table VI and figure 6, 7 and 8 depicts the phosphorus, iron and total free amino acid content of *Hibiscus surattensis* (L.) on the two different stages of growth.

TABLE VI

PHOSPHORUS, IRON AND TOTAL FREE AMINOACID CONTENT IN *Hibiscus surattensis* (L.)

Treatments	Phosphorus (mg/g)		Iron (mg/g)		Total free amino acid (mg/g)	
	Days after sowing		Days after sowing		Days after sowing	
	30	45	30	45	30	45
C	0.07	0.21	0.014	0.033	2.60	3.97
T_1	0.06	0.14	0.026	0.035	2.48	3.89
T_2	0.05	0.22	0.019	0.022	0.99	2.47
T_3	0.10	0.36	0.023	0.037	4.19	5.95
T_4	0.03	0.16	0.018	0.036	4.10	4.69
T_5	0.05	0.22	0.020	0.025	1.38	4.48
T_6	0.11	0.21	0.024	0.026	1.65	3.76
T_7	0.04	0.28	0.009	0.017	2.50	3.32
T_8	0.09	0.12	0.010	0.032	2.56	4.75
CD(0.05)	0.032		0.006		0.48	

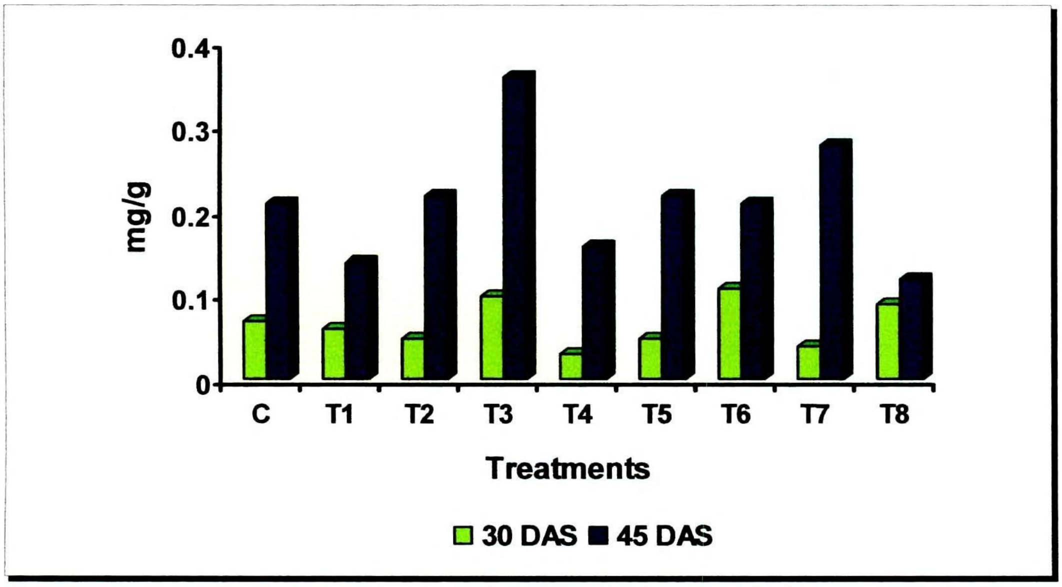
Values are mean of triplicates

Phosphorus

Next to nitrogen, phosphorus has become a major constraint in Indian agriculture because of its gradual negative balance in the soil and higher fertilizer prices. However, this omni deficient nutrient plays a major role in the existence of all living creatures on the earth. It ensures the transfer and storage of energy and permits the conservation and transmission of genetic characteristics in plants as well as in man and animals (Reddy, 2004). Phosphorus performs a numerous normal physiological functions including skeletal development, mineral metabolism, energy transfer through mitochondrial metabolism, cell membrane phospholipid content and function, cell signaling and even platelet aggregation (Moe, 2008).

FIGURE 6

PHOSPHORUS CONTENT IN *Hibiscus surattensis* (L.)



Among the treatments, T_3 and T_6 were recorded the highest and similar phosphorus content on the 30th day of growth. T_3 had also shown significantly higher phosphorus content on the 45th day of growth which was followed by T_7.

Velmurugan *et al.* (2007) also reported that the application of FYM, *Azospirillum, Phosphobacteria* and VAM enhanced the greater uptake of phosphorus in turmeric. The application of *Phosphate Solubilizing Microorganisms* (PSM) and *Arbuscular Mycorrhizal*

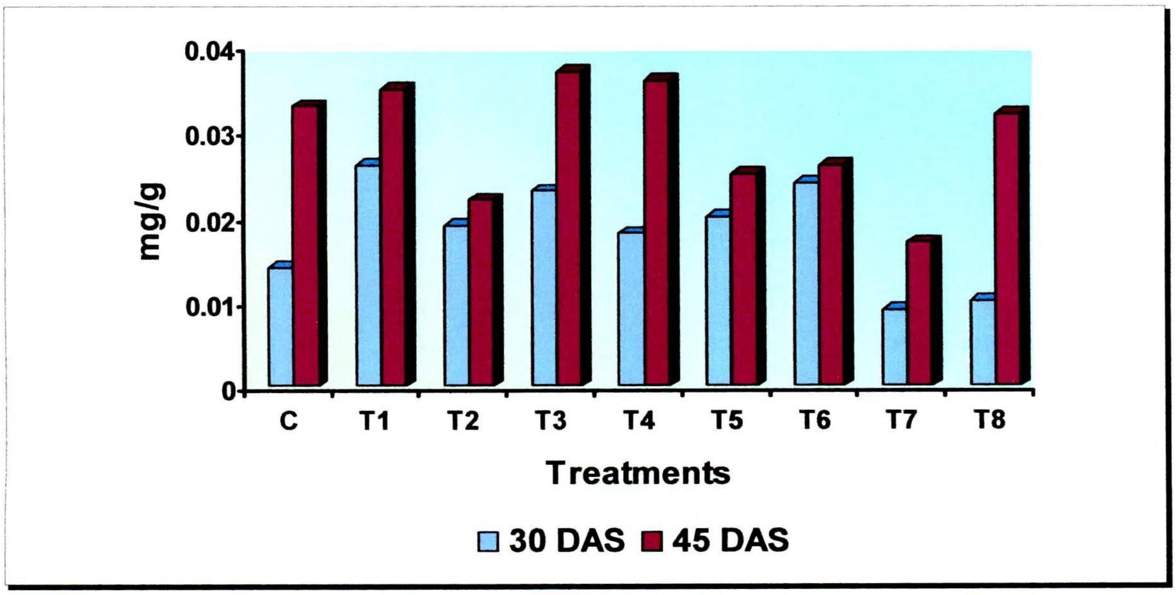
Fungi (AMF) had significantly increased the total phosphorus content in the cow pea plants (Mathew and Hammes, 2002).

Iron

Iron is an essential mineral and an important component of proteins involved in oxygen transport and metabolism. Iron is also an essential cofactor in the synthesis of neurotransmitters such as dopamine, norepinephrine and serotonin. About 15% of the body's iron is stored for future needs and mobilized when dietary intake is inadequate. Sources of iron include dried fruit, peas, asparagus, leafy greens, strawberries and nuts as well as non-heme and heme iron which include beans, lentils, flours, cereals and grain products (Aberoumand and Deokule, 2009).

FIGURE 7

IRON CONTENT IN *Hibiscus surattensis* (L.)



The treatments, T_1, T_3 and T_6 recorded significantly higher iron content on the 30th day of growth when compared to all the other treatments. Whereas the treatments, T_3, T_4 and T_1 were shown a comparable and higher iron content on the 45th day of growth which was also found to be statistically significant ($P<0.05$) when compared to other treatments.

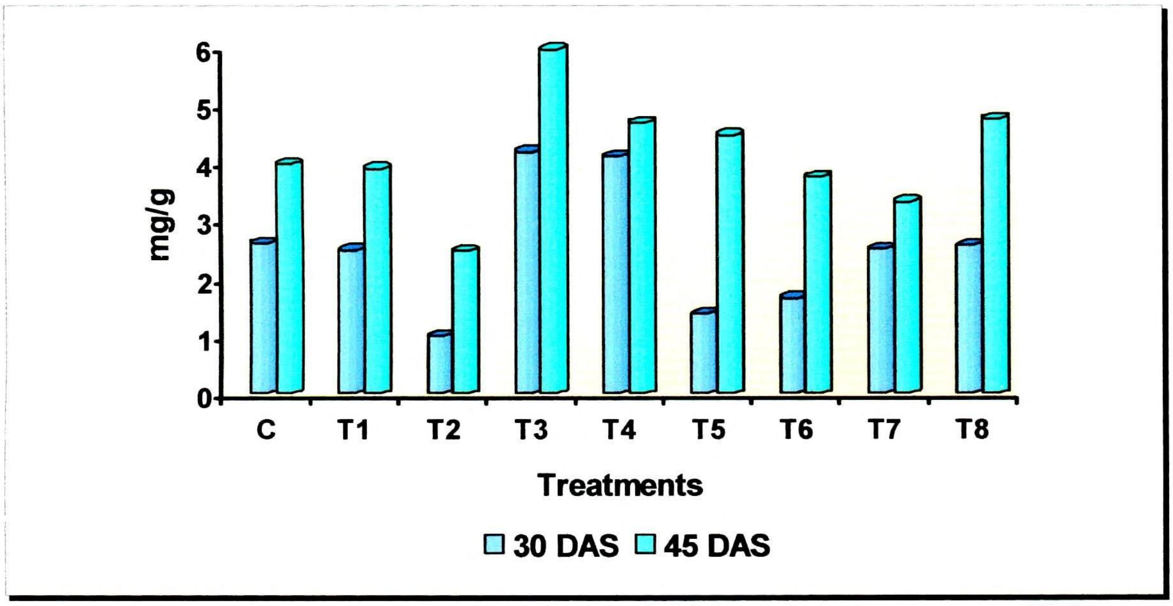
The application of *Bacillus subtilis* (OSU- 142) which is a strain of plant growth promoting rhizobacteria resulted in the highest Mg and Fe contents in the apple leaves was reported by Karakurt and Aslantas in 2010. A similar study by Ouda and Mahadeen (2008) that the application of organic manure and inorganic fertilizers had significantly increased the leaf mineral content (Fe, Mn & Zn) in Broccoli (*Brassica oleracea*). Reddy and Bhatt (2001) also observed that the iron content in the green leafy vegetables was found to be remarkably increased when grown in soil fortified with NPK fertilizer.

Total free aminoacid

Amino acids are molecules containing an amino group, a carboxyl group and a side chain that varies for different amino acids. Amino acids are essential to life and have many functions in metabolism. They are the building block of proteins and every protein is defined by its unique sequence of amino acid residues. Amino acids are linked together in varying sequences to form a vast variety of proteins (Chaing *et al.*, 2007).

FIGURE 8

TOTAL FREE AMINOACID CONTENT IN ***Hibiscus surattensis*** **(L.)**



The total free amino acid content of leaves in the treatment, T_3 and T_4 were found to be significantly higher on the 30th day of growth when compared to the other treatments. Whereas on the 45th day, T_3 recorded the maximum amino acid content which was followed by T_8, T_4 and T_5 respectively.

This was in agreement with the study of Bauer *et al.* (2004) that the foliar application of nitrogen had increased the free amino acid content in red pine (*Pinus resinosa Ait).*

4.3. Assessment of antioxidant status

Antioxidants are compounds that inhibit or delay the oxidation process by blocking the initiation or propagation of oxidizing chain reactions. They may function as free radical scavengers, complexes of pro-oxidant metals, reducing agents and quenchers of singlet oxygen formation (Ozen and Kinalioglu, 2008). In order to survive under stress conditions, plants are equipped with oxygen radical detoxifying enzymes (Jaleel *et al.*, 2007). The level of ROS in plant tissue is controlled by enzymatic and non enzymatic components of antioxidative system (Gajewska and Sklodowska, 2005).

4.3.1. Enzymic antioxidants

A highly efficient antioxidant defense system is present in the plant cells for ROS detoxification including either the non-enzymatic constituents or the enzymatic constituents like catalase, superoxide dismutase, glutathione peroxidase, ascorbate peroxidase and glutathione reductase (Basu *et al.*, 2010).

4.3.1.1. Catalase, Peroxidase and Superoxide dismutase

Table VII indicates the activities of enzymic antioxidants such as catalase, peroxidase and superoxide dismutase in the leaves of *Hibiscus surattensis* (L.) on the 30^{th} and 45^{th} day of growth. Figure 9, 10 and 11 represents the same.

Catalase

Catalase is an important scavenging enzyme against ROS, as it removes hydrogen peroxide produced during metabolic processes. The enzyme is localized in the cytosol and peroxisomes of cells (Bloch *et al.*, 2007).

The maximum catalase activity was exhibited by the treatment T_3 on the 30^{th} as well as on the 45^{th} day of growth followed by T_7 on the 30^{th} day of growth and T_4 on the 45^{th} day of growth. The increase in activity of the above treatments were also found to be statistically significant ($P<0.05$) when compared to the rest of the treatments.

TABLE VII

ACTIVITES OF CATALASE, PEROXIDASE AND SUPEROXIDE DISMUTASE IN *Hibiscus surattensis* (L.)

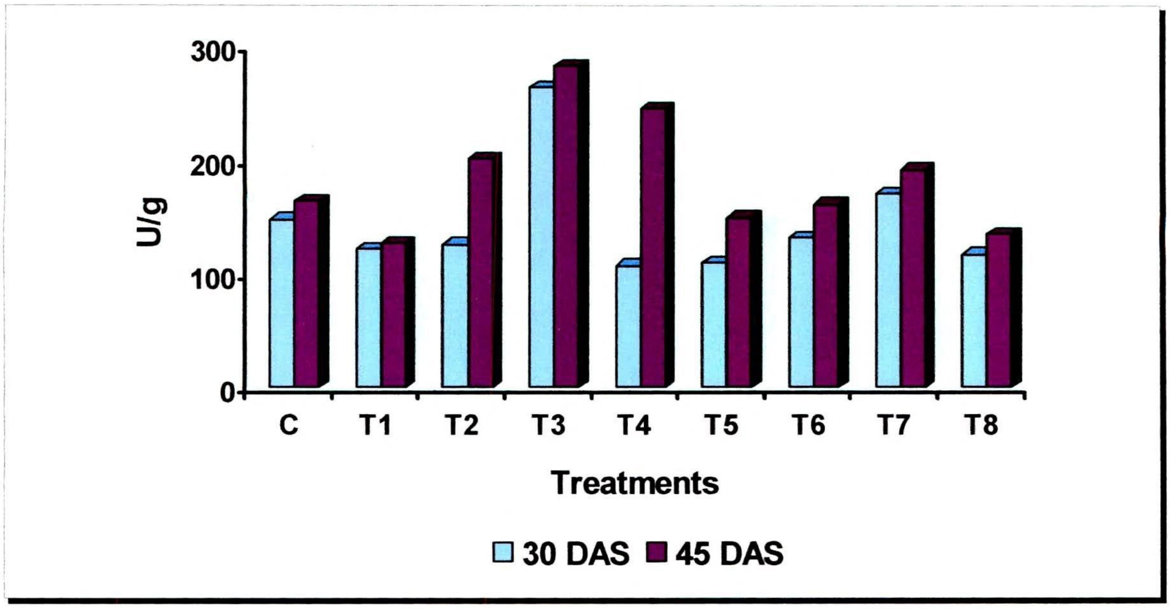
Treatments	Catalase (U/g)$		Peroxidase (U/g)*		Superoxide dismutase (U/g) #	
	Days after sowing		Days after sowing		Days after sowing	
	30	45	30	45	30	45
C	148.40	164.15	1.50	2.57	75.04	77.44
T_1	121.72	126.97	1.25	2.67	76.00	78.72
T_2	125.92	201.47	0.96	2.40	74.18	76.58
T_3	264.44	283.33	2.52	5.96	76.93	78.93
T_4	107.78	245.55	2.08	4.64	76.90	76.98
T_5	109.89	149.90	1.65	3.95	76.20	78.24
T_6	132.21	161.90	1.30	4.43	74.18	77.01
T_7	171.49	192.48	1.04	3.68	73.01	77.41
T_8	117.52	135.08	1.10	3.33	73.28	78.40
CD(0.05)	39.96		0.75		0.84	

Values are mean of triplicates

$ - Amount of enzyme required to decrease the optical density by 0.05 units
*** - 1µmole of pyrogallol oxidized/min**
 # - Amount that causes 50% reduction in the extent of NBT oxidation

FIGURE 9

CATALASE ACTIVTY IN *Hibiscus surattensis* (L.)



This was supported by the study of Devi and Reddy (2004) that the application of *VAM fungs* and *Rhizobium* increased the activity of catalase and peroxidase enzymes in groundnut *(Arachis hypogeae L).*

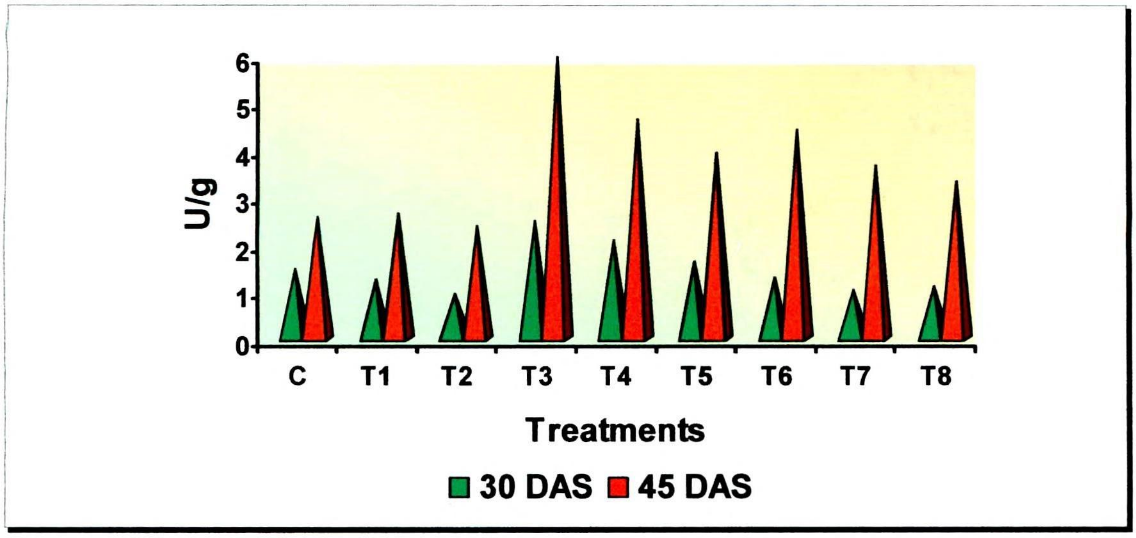
Peroxidase

Peroxidase is an important enzyme, able to scavenge hydrogen peroxide, which is a major substance degraded by SOD (Liu *et al.*, 2009). Peroxidase is connected with cell wall stiffening and lignification (Patykowski, 2006). Peroxidase catalyses the oxidation of phenoilc compounds and certain other closely related substances using oxygen derived from H_2O_2 (Uma and Thirupathiala, 2010).

Among the treatments, T_3 was found to be superior, registering the maximum activity peroxidase on the 30^{th} as well as on the 45^{th} day of growth, which was followed by T_4 and T_6 respectively.

FIGURE 10

PEROXIDASE ACTIVTY IN *Hibiscus surattensis* (L.)



A study by Mahmood (2010) reported that the application of *Rhizobacteria Bacillus sphaericus* UPMB10 significantly increased the peroxidase activity in the leaves of banana plants. Kina and Nikitina (2009) also stated that the application of *Azospirillum brasilense* Sp7 stimulated rapid formation of hydrogen peroxide, associated with an increase in the activities of oxalate oxidase and peroxidase in the roots of wheat seedlings.

Superoxide dismutase

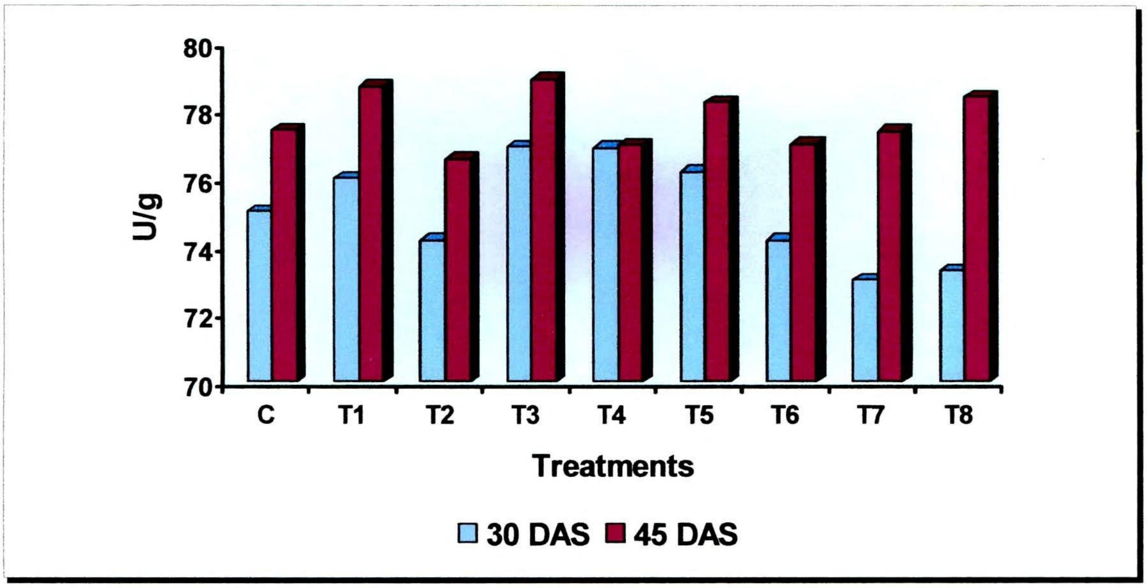
Superoxide dismutase (SOD) is a metallo enzyme whose active center is occupied by copper and zinc, occasionally manganese or iron. SOD plays an important role in the protection of all aerobic life system against oxygen toxicity and the free radicals derived from oxygen. As an enzyme, SOD has particular value as an antioxidant that can help to protect against cell destruction. It has the clear ability to neutralize superoxide, one of the most damaging free radical substances in nature (Kim *et al.*, 2008).

Superoxide dismutase (SOD) is one of the crucial enzyme that protect cells against oxidative damages, which is the key enzyme to diminish the concentration of ROS. SOD catalyses the redundant superoxide radicals to yield molecular oxygen and hydrogen peroxide. SOD is usually considered to be first line of defense against oxidative stress (Nan *et al.,* 2006).

FIGURE 11

SUPEROXIDE DISMUTASE ACTIVTY IN

Hibiscus surattensis (L.)



Among the treatments, T_3 and T_4 exhibited the maximum level of superoxide dismutase activity on the 30^{th} day of growth which was found to be on par with each other. Whereas T_3 and T_1 had shown the maximum level of superoxide dismutase activity on the 45^{th} day of growth and was followed by T_8 and T_5 respectively.

A study by Karthikeyan *et al.* (2007) reported that the application of *Azospirillum* and *Azotobacter* resulted in increased SOD activity in the *Catharanthus roseus* plant. A similar study by Chaparzadeh *et al.* (2004) was in agreement with the above results that the application of *Azospirillum* and *Azotobacter* influenced the SOD activity in *Calendula officinalis.*

4.3.1.2. Glutathione-S- transferase and Glutathione peroxidase

The activities of Glutathione-S- transferase and Glutathione peroxidase in the leaves of *Hibiscus surattensis* (L.) were shown in the Table VIII and figure 12 and 13 respectively.

TABLE VIII

ACTIVITIES OF GLUTATHIONE-S- TRANSFERASE AND GLUTATHIONE PEROXIDASE IN *Hibiscus surattensis* (L.)

Treatments	Glutathione-S- transferase (U/g)@		Glutathione peroxidase (U/g)#	
	Days after sowing		Days after sowing	
	30	45	30	45
C	0.025	0.032	15.59	18.13
T_1	0.027	0.030	10.62	22.73
T_2	0.019	0.025	09.01	23.58
T_3	0.029	0.048	14.74	25.79
T_4	0.016	0.023	18.28	34.40
T_5	0.013	0.019	08.61	11.44
T_6	0.010	0.020	10.64	12.82
T_7	0.020	0.024	03.91	05.24
T_8	0.014	0.028	08.57	09.38
CD(0.05)	0.034		0.41	

Values are mean of triplicates

@ - µmoles of CDNB-GSH conjugated/min/g of sample

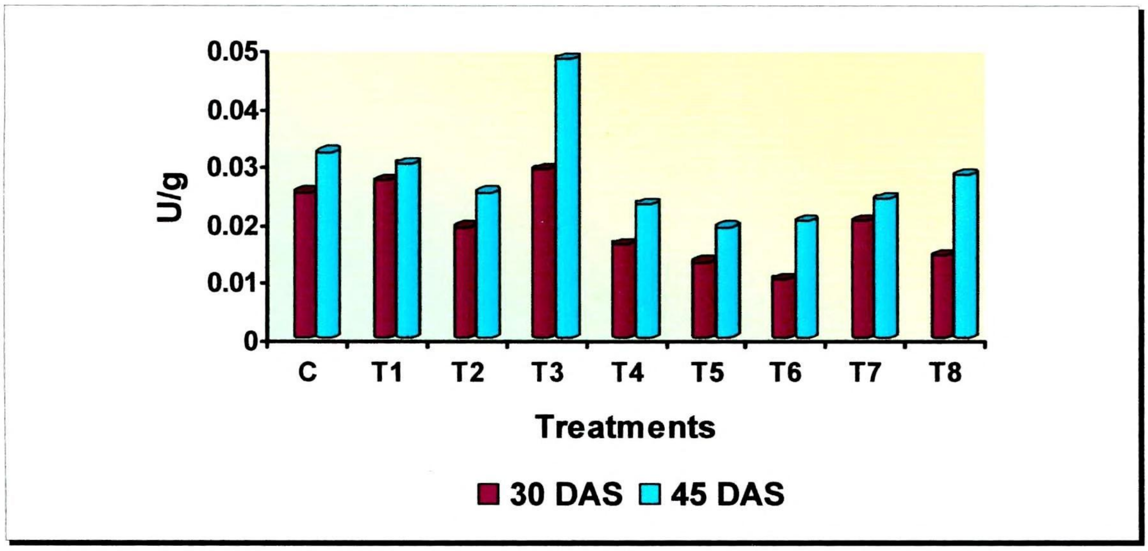
 # - µmoles of GSH consumed/min/g of sample

Glutathione –S- transferase

Glutathione S-transferase (GST) enzymes are a family of detoxification enzymes that catalyze the conjugation of glutathione (GSH) with various endogenous and xenobiotic electrophiles. Due to their primary role in drug metabolism and identification as a potential drug target for antischistosomal, antimalarial, and antifilarial drug development, GSTs have been the recent focus of research as a drug target (Srinivasan *et al.,* 2009)

FIGURE 12

GLUTATHIONE-S- TRANSFERASE ACTIVITY
IN *Hibiscus surattensis* (L.)



It was clear from the Table VIII and Figure 12 that the maximum Glutathione-S-transferase activity was exhibited by the treatment T_3 on both the stages of growth. The rest of the treatments did not influence the glutathione –S- transferase activity very much.

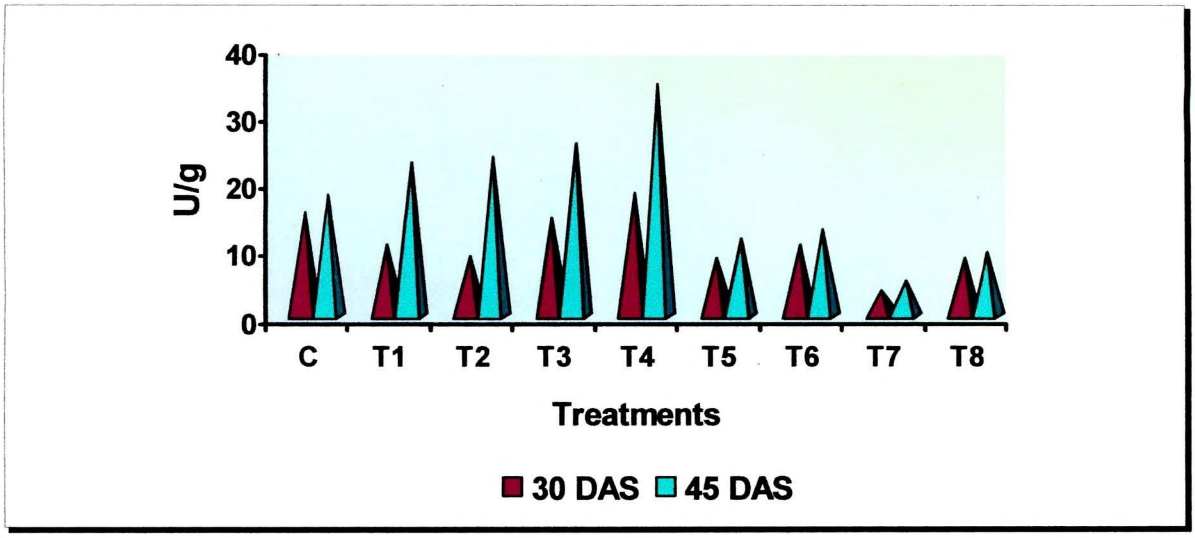
Han and Lee (2005) had reported that the application of PGPR increased the activity of glutathione –S- transferase activity in lettuce.

Glutathione peroxidase

Glutathione peroxidase is a well known selenoenzyme which catalyzes the reduction of harmful ROOH by glutathione (GSH) and protects the lipid membranes and other cellular components against oxidative damage (Lv *et al.,* 2008). Glutathione peroxidase is one of the body's major protectors against free radicals. Glutathione peroxidase may be responsible for scavenging hydrogen peroxide, catalyzing the peroxidation of reduced glutathione and forming the oxidized disulfide form of glutathione as a product (Wang and Fordham, 2007).

FIGURE 13

GLUTATHIONE PEROXIDASE ACTIVITY
IN *Hibiscus surattensis* (L.)



The treatment T_4 had recorded the highest glutathione peroxidase activity when compared to all the other treatments both on the 30th as well as on the 45th day of growth, which was followed by T_3, T_2 and T_1 respectively on the 45th day of growth.

4.3.2. Non- enzymic antioxidants

Plants have developed enzymatic and non-enzymatic protection mechanisms against irradiance stress. The non-enzymatic ROS scavenging mechanism includes major redox buffers such as gluthatione, tocopherol, flavonoids, alkaloids, and carotenoids (Marchese *et al.*, 2008).

4.3.2.1. Ascorbic acid, Tocopherol and Reduced glutathione

Table IX and Figure 14 – 16 depict the levels of non- enzymic antioxidants such as ascorbic acid, tocopherol and reduced Glutathione.

Ascorbic acid

Ascorbic acid is an essential nutrient for higher primates and a small number of other species. The presence of ascorbic is required for a range of essential metabolic reactions in all animals and in plants and is made internally by almost all organisms except human being.

Vitamin C is also present in many other biological systems and multivitamin preparation, which are commonly used to supplement inadequate dietary intake. Nevertheless, it is widely used in foods as an antioxidant for the stabilization of color and aroma with subsequent extension of the storage time of the products (Ardakani *et al.*, 2009).

TABLE IX

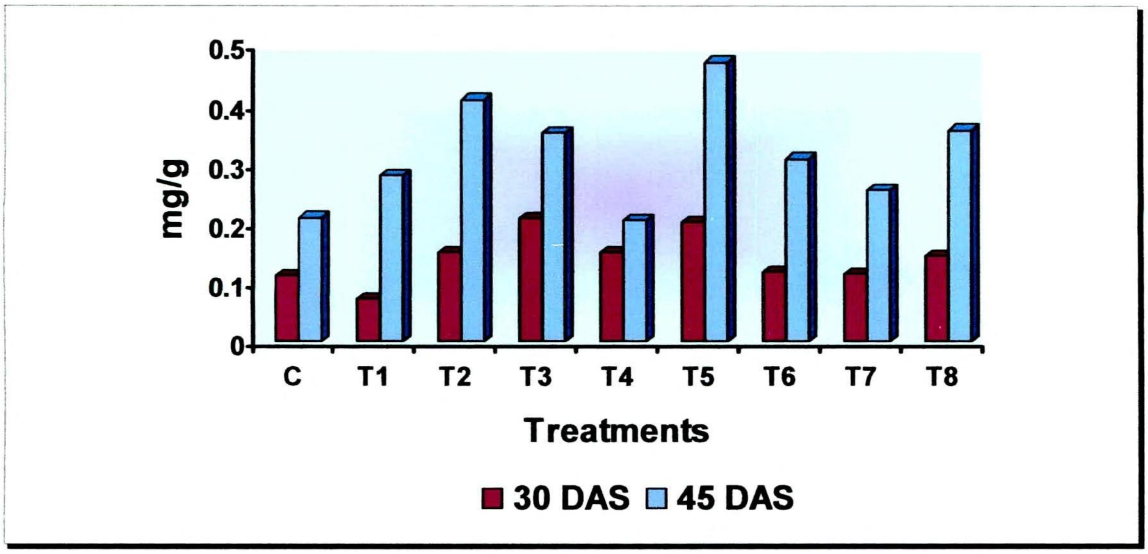
LEVELS OF ASCORBIC ACID, TOCOPHEROL AND REDUCED GLUTATHIONE IN *Hibiscus surattensis* (L.)

Treatments	Ascorbic acid (mg/g)		Tocopherol (mg/g)		Reduced glutathione (mg/g)	
	Days after sowing		Days after sowing		Days after sowing	
	30	45	30	45	30	45
C	0.113	0.211	0.077	0.430	0.300	0.637
T_1	0.074	0.282	0.093	0.154	0.285	0.341
T_2	0.151	0.410	0.164	0.457	0.387	0.407
T_3	0.210	0.354	0.204	0.501	0.524	0.657
T_4	0.151	0.206	0.260	0.566	0.443	0.637
T_5	0.203	0.473	0.036	0.150	0.316	0.494
T_6	0.118	0.310	0.212	0.326	0.331	0.438
T_7	0.115	0.257	0.164	0.262	0.336	0.606
T_8	0.145	0.359	0.055	0.173	0.361	0.412
CD(0.05)	**0.027**		**0.063**		**0.115**	

Values are mean of triplicates

FIGURE 14

LEVEL OF ASCORBIC ACID IN *Hibiscus surattensis* (L.)



Among the treatments, T_3 exhibited the maximum level of ascorbic acid on the 30th day of growth followed by T_5. Whereas T_5 had shown the maximum level of ascorbic acid on 45th day of growth, which was followed by T_2, T_8 and T_3 respectively.

A study by Sudhakar and purushotam (2008) showed that the application of recommended dose of fertilizers + phosphate solubilizing bacteria at 5kg ha^{-1} significantly increased the fruit size and ascorbic acid content in tomato (*Solanum lycoperiscum*).

Application of large amount of nitrogen to leek leaves (*Allium porrum* L.) elevated the vitamin C content (Karic *et al.,* 2005). Kipkosgei, *et al.* (2003) also reported that the application of farm yard manure significantly increased the ascorbic acid content in *Solanum villosum (*Black nightshade) plants.

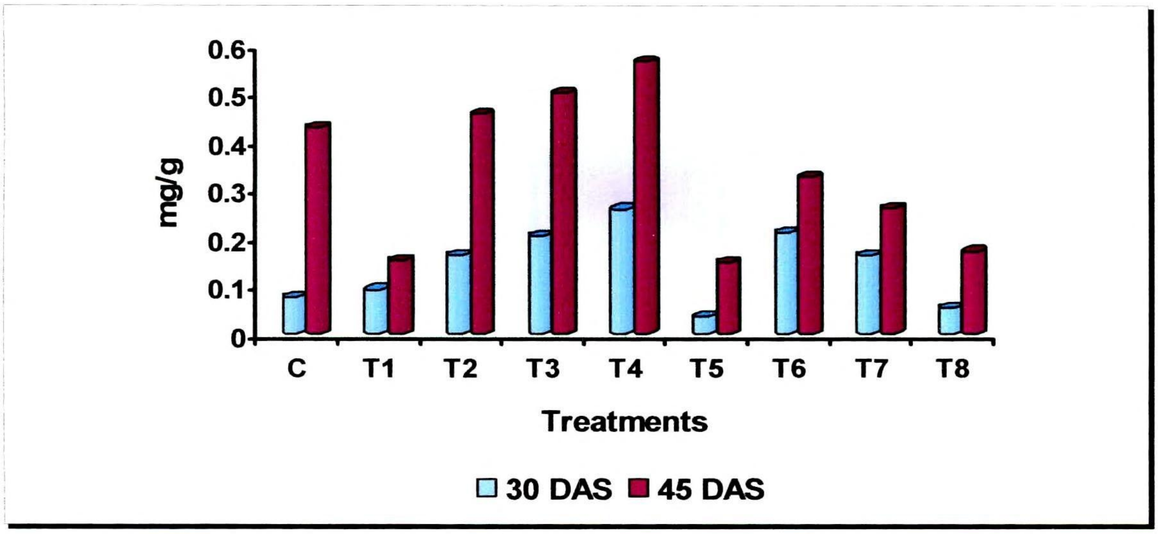
Tocopherol

Tocopherols occur widely in plants, but the form of tocopherol often differs in the leaves and seeds of the same species. α-tocopherol is the primary form of tocopherols in leaves of plants (Hunter *et al.,* 2007).

The plant seeds contain tocopherols and tocotrienols, which are used as natural antioxidants and a source of vitamin E. In nature four different derivatives of tocopherols and tocotrienols (α, β, γ and δ) can be found, which differ in the methylation of the chroman ring. The antioxidant activity increases for tocopherols and tocotrienols in the order α to δ, whereas the biological activity is inversely proportional to the antioxidant activity (Mariod *et al.,* 2010). The main function of α-tocopherol is that a radical chain breaking antioxidant in membranes and lipoproteins as well as in foods (Haq *et al.*, 2008).

FIGURE 15

LEVEL OF TOCOPHEROL IN *Hibiscus surattensis* (L.)



The tocopherol content of leaves in the treatment T_4 was found to be greater on the 30th day of growth, which was followed by T_6 and T_3. Whereas on the 45th day of growth, the highest tocopherol content was exhibited by the treatment T_4 which was followed by T_3. The elevated tocopherol content was found to be statistically significant ($P<0.05$).

The results are in agreement with the study of Prabha (2007) that the level of vitamin A, E and C were found to be increased significantly and reached the maximum on the 45th day of composting by *Eudrilus eugeniae* and *Eisenia fetida.*

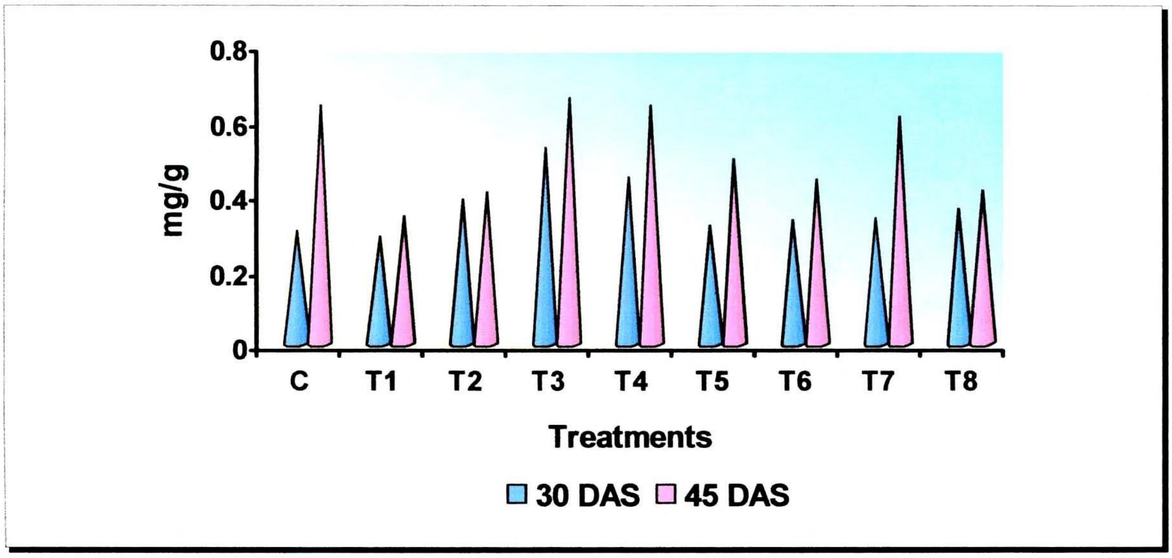
Reduced Glutathione

Glutathione is the most abundant low-molecular weight thiol in most biological systems and functions primarily as a reductant to maintain-SH groups in a reduced state. Reduced glutathione (GSH) and its oxidized form (GSSG) have been shown to participate in a variety of diverse physiological events in both animals and plants (Shohael *et al.*, 2007).

The glutathione is a non-enzymic mode of defense against free radicals. Glutathione reduced the formation of toxic lipid peroxide and hydrogen peroxide in biological system by acting as substrate for glutathione peroxidase. Glutathione reacts chemically with singlet oxygen, superoxide and hydroxyl radical and therefore function as a free radical scavenger (Srinivasan and Suhanya, 2008).

FIGURE 16

LEVEL OF REDUCED GLUTATHIONE IN ***Hibiscus surattensis*** **(L.)**



It was clear from the Table IX and Figure 16, that the maximum Glutathione content was exhibited by the treatments, T_3 and T_4 on the two stages of growth, which was followed by T_2 and T_8 on the 30^{th} day of growth. The rest of the treatments have registered comparable values of glutathione.

4.4. Soil enzyme analysis

Each soil has a characteristic pattern of enzymes because all biochemical actions are dependent on or related to their presence. Soil enzyme assays are indicators of determining the potential of the soil to degrade or to transform substrates. Enzyme activities are closely related to important soil quality parameters and can begin to change much sooner than other properties. Several enzymes are known to be present in the soil which catalyze organic matter turnover (Onet, 2007).

4.4.1. α- Amylase, Cellulase, Dehydrogenase, Phosphatase and Urease

Table X and Figure 17 - 20 depicts the soil amylase, cellulase, dehydrogenase, phosphatase and urease activities in soil.

TABLE X

ACTIVITIES OF α- AMYLASE, CELLULASE, DEHYDROGENASE, PHOSPHATASE AND UREASE IN SOIL

Treatments	α- Amylase µg of maltose	Cellulase µg of glucose	Dehydrogenase µg of TPF	Phosphatase µg of PNPP	Urease µg of ammonia
C	73.17	65.94	0.68	1.27	0.34
T_1	63.75	69.19	0.74	1.24	0.22
T_2	54.16	86.41	0.58	1.35	0.27
T_3	85.67	105.79	0.60	1.22	0.20
T_4	65.00	75.59	0.65	2.33	0.50
T_5	43.33	68.27	0.55	2.22	0.23
T_6	74.00	75.07	0.64	1.31	0.32
T_7	64.58	90.71	0.69	1.33	0.16
T_8	34.27	66.38	0.52	1.52	0.30
CD(0.05)	**0.0049**	**3.4618**	**0.01**	**0.08**	**0.01**

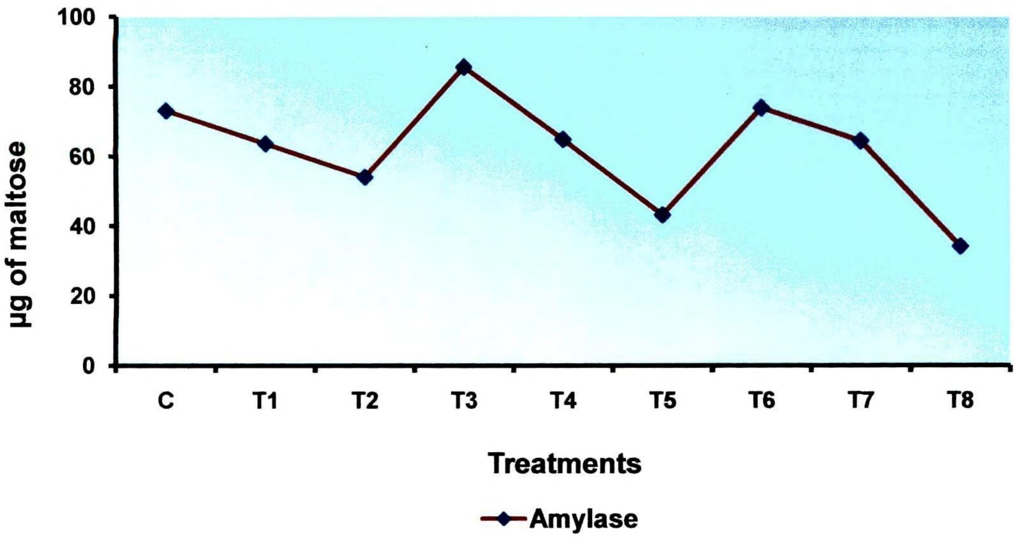
Values are mean of triplicates

Amylase

Amylases are enzymes that break down starch or glycogen. It is produced by a variety of living organisms ranging from bacteria, fungi to plants and humans (Kani *et al.*, 2010). Amylase is commercially an important enzyme in the starch bioprocessing and brewing industries. Amylase has received a great deal of attention because of their benefits. Tremendous research efforts have been made on the applications of amylase for the conversion of starch to sugars (Oshoma *et al.,* 2010).

FIGURE 17

α- AMYLASE ACTIVITY IN SOIL



Highest activity of α-amylase was seen in the soil treated with (T_3) Azophos in combination with 50% N and K and vermicompost was found to be significantly higher ($P<0.05$) over the control. Whereas the treatment, (T_8) *Azophosmet* in combination with 25% N and K and Vermicompost showed the minimum amylase activity in the soil.

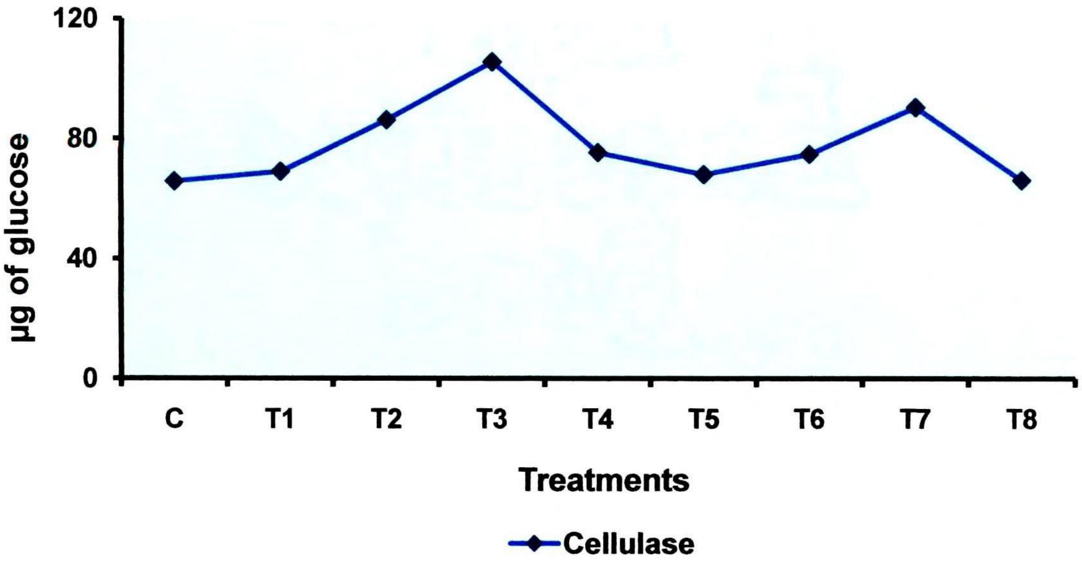
Devi *et al.* (2009) studied that a higher level of amylase activity was observed in the soil treated with vermicompost than the soil treated with normal compost.

Cellulase

Cellualses are a group of hydrolyzing enzymes capable of hydrolyzing cellulose to simple sugar components like glucose units. cellulolytic enzymes play an important role in natural biodegradation processes, where plant lignocellulosic material are efficiently degraded by cellulolytic fungi and bacteria (Ghanbary *et al.,*2010). Cellulases have enormous potential applications in industries and are used in food, beverages, textile, laundry, paper and pulp industries etc (Jahangeer *et al.,* 2005).

FIGURE 18

CELLULASE ACTIVITY IN SOIL



Among the treatments, T_3 (*Azophos* + 50% N and K + Vermicompost) exhibited the maximum level of cellulase activity followed by T_7 (*Azophos*+ 25% N and K + Vermicompost) and T_2 (*Phosphobacteria*+ 50% N and K + Vermicompost) respectively.

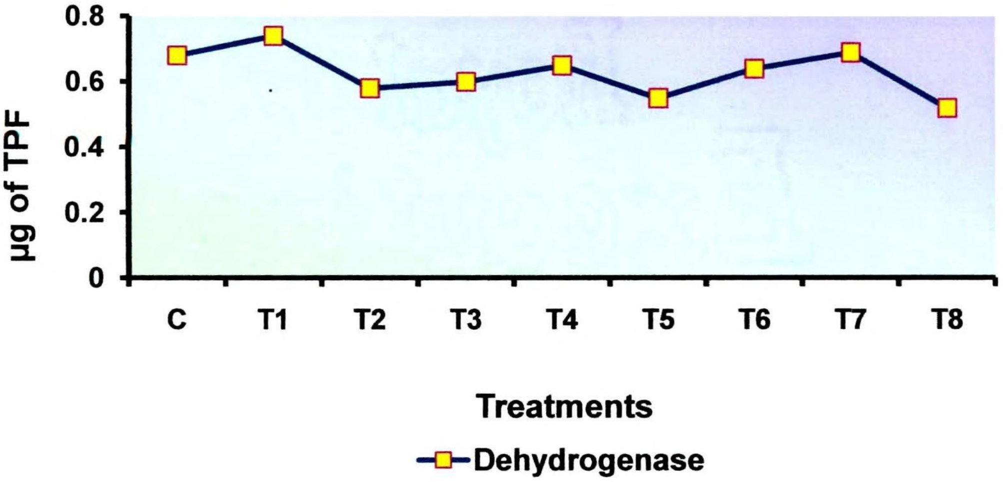
A study by Balakrishnan *et al.* (2007) showed that the halophytic compost increased the cellulase activity when compared to unmanured soil.

Dehydrogenase

Dehydrogenase is a wide group of endocellular enzymes, which are present in all living cells and are essential in catalyzing the biological oxidation of organic compounds. They transfer hydrogen and electrons through a chain of intermediate electron carriers to oxygen as a final electron acceptor, which then combine with them and form water (Ghaly and Mahmoud, 2006).

FIGURE 19

DEHYDROGENASE ACTIVITY IN SOIL



The maximum dehydrogenase activity was recorded in the treatment, T_1 which was followed by T_7 and T_4 respectively. Among the treatments, T_8 showed the minimum dehydrogenase activity in the soil.

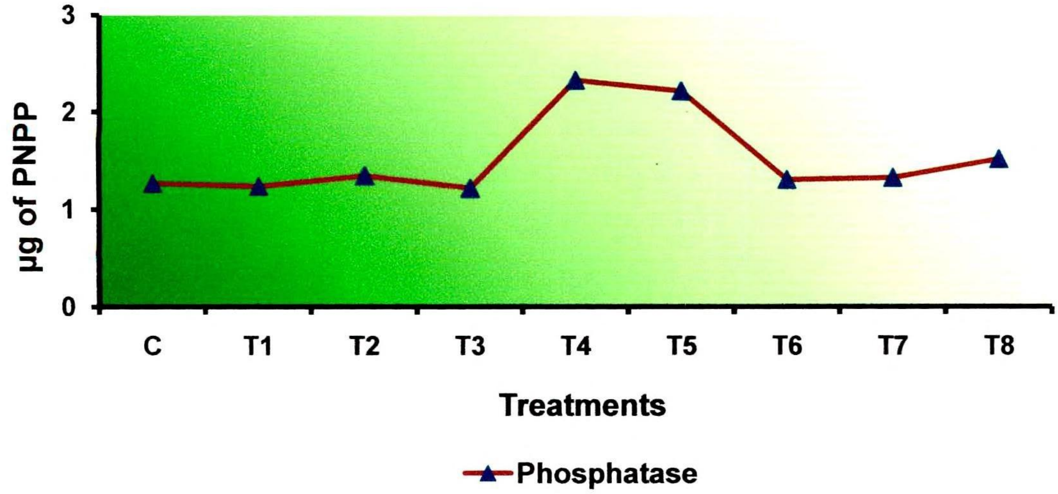
Marinari *et al.* (2000) reported that a higher level of dehydrogenase activity was observed in soil treated with vermicompost and manure compared with soil treated with mineral fertilizer.

Phosphatase

Organic phosphorus (P) is abundant in the soil and can contribute to the phosphorus nutrition of plants and microbes following hydrolysis and the release of free phosphate. This process is catalysed by phosphatase enzymes, which are actively secreted into the soil by many plants and microbes in response to a demand for P, or passively released from decaying cells (Turner and Haygarth, 2005).

FIGURE 20

PHOSPHATASE ACTIVITY IN SOIL



The Phosphatase activity in the soil of the treatment, T_4 and T_5 alone were increased significantly ($P<0.05$) when compared to the control. This was followed by T_8 and T_2 respectively. The rest of the treatments did not influence the soil phosphatase activity very much.

Higher phosphatase activity in the soil resulted from higher organic C content in the soil (Dodor and Tabatabai, 2003).

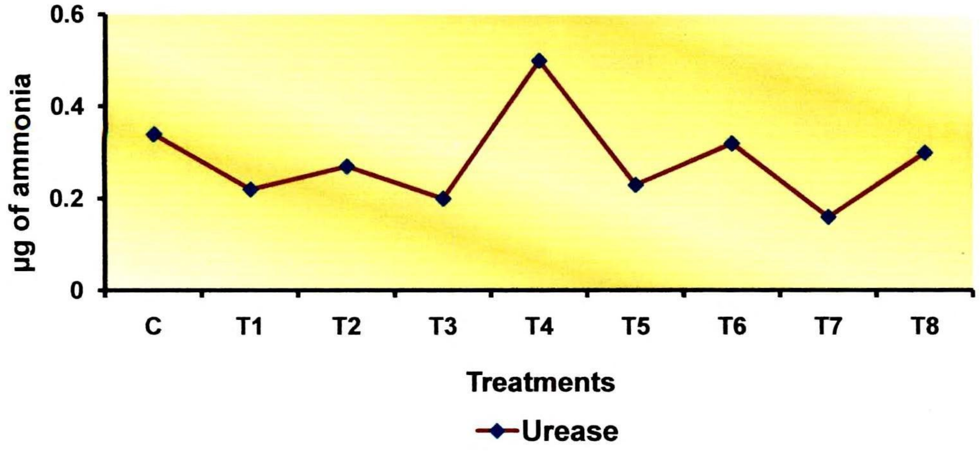
Urease

Urease is a constitutive intracellular enzyme with three subunits of α, ß and γ and two nickel ions. Urease catalyzes the hydrolysis of urea and amides to carbon dioxide and ammonia. It acts on carbon-nitrogen (C-N) bonds other than peptide linkage (Kakhki *et al.,* 2008).

It was clear from the Table X and Figure 21, that the maximum urease activity was exhibited by the treatment, T_4. Whereas the treatment, T_7 showed the minimum urease activity in the soil.

FIGURE 21

UREASE ACTIVITY IN SOIL



A study by Shanwad *et al.* (2001) also reveled that the application of Tunisia rock phosphate TRP (100%) +VC+ *Phosphobacteria* (*Bacillus megaterium* var. *phosphatium*) recorded the maximum urease activity in cotton and blackgram.

4.5. Soil analysis at the initial and at the post harvesting stage

The soil used for the study was analyzed for pH electrical conductivity, N, P and K at the initial stage and at the end of the 45th day of growth, to see the effect of liquid biofertilizer, chemical fertilizer and vermicompost applications on the above characteristics. Table XI gives the pH, electrical conductivity, N, P and K contents of the soil at the initial and at the post harvesting stage.

pH

Initially the pH of the soil was found to be 8.11. There was only a slight variation in the soil pH, after the application of liquid biofertilizers, chemical fertilizer and vermicompost. The pH of all the treatments were also found to be lower at the post harvesting stage when compared to the initial stage of analysis.

Sanwal *et al.* (2007) reported that the application of FYM, poultry manure and pig manure considerably reduced the soil acidity, while it is increased with the addition of inorganic chemical fertilizers

TABLE XI

PHYSICOCHEMICAL PROPERTIES OF SOIL AT THE INITIAL AND AT THE POST HARVESTING STAGE

Treatments	pH	Electrical conductivity (d Sm^{-1})	Nitrogen Kg ha^{-1}	Phosphorus Kg ha^{-1}	Potassium Kg ha^{-1}
Initial	8.11	0.25	143	13.3	194
Post harvesting stage					
T_1	8.09	0.51	137	13.1	174
T_2	8.04	0.65	154	14.4	171
T_3	8.06	0.80	160	15.2	193
T_4	8.08	0.85	168	17.2	204
T_5	7.96	0.42	143	12.9	165
T_6	8.01	0.30	125	12.2	154
T_7	8.14	0.29	130	12.4	143
T_8	8.04	0.20	133	11.9	129

Electrical conductivity

From the electrical conductivity of the soil at the initial and post harvesting stage, it was clear that the saline content of the soil was found to be very low at the initial stage. But the saline content of the soil of all the treatments were improved very much except by the treatment T_8.

Nitrogen

The nitrogen, which is one of the essential elements, is absorbed in great quantities by the plants, need to be available at high concentration in the soil. The nitrogen rate utilized for cultures vary according to the organic matter content of the soil, the previous culture and the utilized cultivar. In the current agriculture, nitrogen is a limited nutrient for growth and consequently to the yield. Nitrogen is found in the gaseous form, constituting approximately 78% of the gases that form the atmospheric air, hence plants and animals donot use nitrogen in this form for their metabolism (Santa *et al.*, 2004).

Among the treatments, T_4 (*Azophos* + 50% N and K + vermicompost) recorded a higher nitrogen content (168 kg ha^{-1}) which was followed by T_3 (160 kg ha^{-1}) and T_2 (154 kg ha^{-1}). Whereas the other treatments recorded a lower nitrogen content when compared to the initial stage.

Das *et al.* (2008) observed that the combined application of PSB+VAM+AZO influenced the available N, P and K contents in soil as well as in plant. Kannan *et al.* (2005) reported that the application of 75 per cent vermicompost with *Azospirillum* recorded the highest available N over the 100 per cent N as urea.

The increase in nitrogen content during vermicomposting might be due to the nitrogen release by earthworm's metabolic products and dead tissues (Araujo *et al.*, 2004). Significantly high nitrogen content was also recorded in vermicompost amended soil (Arancon *et al.*, 2003).

Phosphorus

Phosphorus (P) is an essential macronutrient for plant growth and function (Tsvetkova and Georgiev, 2003). The soil phosphorus cycle is a dynamic process involving the transformation of phosphorus by geochemical and biological processes. Plant available P occurs in the soil solution as orthophosphate anions, predominantly $H_2PO_4^-$ and HPO_2 (Arcand and Schneider, 2006).

The phosphorus level was found to be higher in the treatment T_4 followed by T_3. Among the treatments, T_8 showed the minimum phosphorus content in the soil. Ramalakshmi *et al.* (2008) observed that the co-inoculation of mycorrhiza and *Phosphobacteria* had increased the available phosphorus in black cotton soil. Sanwal *et al.* (2007) also stated that the application of organics influenced the higher available phosphorus and potassium rather than direct addition through inorganic sources.

Potassium

Potassium (K) is one of the sixteen essential nutrients required for plant growth and reproduction. It is classified as a macronutrient, as are nitrogen (N) and phosphorus (P). K is necessary to many plant functions, including carbohydrate metabolism, enzyme activation, osmotic regulation and efficient use of water, N uptake, protein synthesis and translocation of assimilates. It also plays a role in decreasing certain plant diseases and in improving tuber quality (Gunadi, 2009).

It was clear from the Table XI that the T_4 treatment recorded the maximum potassium content compared to the initial stage of the soil. The rest of the treatments did not influence the potassium content of the soil.

The application of compost and vermicompost increased the concentrations of P, K, Ca and Mg in the shoot of corn (Kalantari *et al.*, 2010). Mamatha *et al.* (2006) also reported that the application of 100% RDN (Recommended dose of Nitrogen) along with FYM and vermicompost significantly increased the potassium content in onion (*Allium cepa* L.)

4.6. Vermicompost analysis

The vermicompost used for the study was analyzed for the Organic carbon, Calcium and Magnesium. The values are given in Table XII.

Organic carbon

Carbon storage in the soil is particularly important because soil is the largest reservoir of organic carbon. The terrestrial ecosystems, contains 3 times more carbon than the vegetation they support (Rasse *et al.*, 2005).

TABLE XII

BIOCHEMICAL CONSTITUENTS OF VERMICOMPOST

Nutrients	Vermicompost (%)
Organic carbon	7.92
Calcium	145.00
Magnesium	96.00

Chauhan *et al.* (2008) showed that the application of RDN along with organic nitrogen through biocompost at 33%N, 50%N, and 75%N, significantly increased the organic carbon per cent i.e. 41.1%, 48.07% and 50.0% respectively.

Azarmi *et al.* (2008) showed that that addition of vermicompost at rate of (15 t ha^{-1})significantly ($P < 0.05$) increased the total organic carbon, total N, P, K, Ca, Zn and Mn contents of soil.

Calcium

Umamaheswari and Vijayalakhsmi (2003) found that the macronutrients NPK and micronutrients Ca and Fe were more in vermicompost treated soil. The enriched vermicompost was the better treatment for enhancing the uptake of N,P,K,Ca, and Mg by cowpea (Kumari and Ushakumari, 2002).

Magnesium

Magnesium is the second most abundant intracellular cation. It plays an essential physiological role in many functions of the body. Magnesium has the ability to compete with calcium for binding sites on proteins and membranes (Misra *et al.,* 2008).

Sailajakumari and Ushakumari (2002) found that enriched VC showed its superiority not only on yield of cowpea grains but also on the uptake of major nutrients like N,P,K,Ca and Mg.

From the results it was clear that the application of *Azophos* + 50% N and K + Vermicompost had exhibited higher root length, shoot length, number of leaves, fresh weight, chlorophyll, protein, reducing sugar, phosphorus, iron, total free amino acid content as well as enzymic antioxidants (catalase, peroxidase, superoxide dismutase and glutathione – S- transferase activity and non enzymic antioxidants (ascorbic acid and reduced glutathione) levels in plant. The same treatment also improved the phosphorus content, amylase, cellulase and activity in the soil.

From this study it was concluded that the application of *Azophos* + 50% recommended dose of N and K and vermicompost proved to be beneficial not only in terms of economizing N and P fertilizers but also improved the nutrient content of the leafy vegetables. Thus this technology can be adapted by farmers as cost effective and ecofriently approach to sustain the productivity of the leafy vegetable crops.