ROLE OF OXYGENATED PEPTONE IN IMPROVING THE PRODUCTIVITY OF BRINJAL (*Solanum melongena* L. cv. Ajay)

Thesis Submitted to

University of Pune

Pune - 411 007

For the degree of

Doctor of Philosophy

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CERTIFICATE

This is to certify that the work incorporated in the thesis entitled **"Role of oxygenated peptone in improving the productivity of brinjal (*Solanum melongena* L. cv. Ajay)"** submitted by Mrs. Rupali Dinesh Chitale was carried out by the candidate under my supervision in the P. G. Research Centre, Department of Botany, Tuljaram Chaturchand College, Baramati - 413 102 Dist. Pune, for the degree of Doctor of Philosophy. Such material obtained from other sources has been duly acknowledged in the thesis.

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Date : 27 / 04 / 2010

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DECLARATION

I hereby declare that the work incorporated in this thesis entitled **"Role of oxygenated peptone in improving the productivity of brinjal (*Solanum melongena* L. cv. Ajay)"** has not been submitted in part or full by me for any degree or diploma of any other university or institute.

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Date : 27 / 04 / 2010

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Place : Baramati

Date :27/04/2010

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ABBREVIATIONS

Bicine	N_2N - Bis (2-hydroxymethyl) glycine
cm	Centimeter
chl	Chlorophyll
^0C	degree Celsius
DAS	Days after sowing
2, 4 - D	2, 4 - dichlorophenoxy acetic acid
DCPIP	2, 6 - dicholorophenol indophenol
D.W.	Distilled water
E. C.	Enzyme code
EDTA	Ethylene diamine tetra acetic acid
GA	Gibberellic acid
g	Gram
g^{-1}	per gram
x g	Gravity
ha	Hectare
h	Hour (s)
H_2O_2	Hydrogen peroxide
IAA	Indole - 3 - acetic acid
l	Liter
ml	Milli liter
min	Minute (s)
mM	Milli molar
mm	Milli meter
µ	Micron

µM	Micro molar
M	Molar
MDH	Malic dehydrogenase
mg^{-1}	per milligram
M. Wt.	Molecular weight
µg	Microgram
nm	Nanometer
N	Normality
NA	Nutrient Agar
NAD	Nicotine amide adenine dinucleotide
NADH	Naphthyl ethylene diamine dihydrochloride
Δ O. D.	Change in optical density
pH	Hydrogen ion concentration
ppm	Parts per million
POD	Peroxidase
PPO	Polyphenol oxidase
PVP	Polyvinyl pyrrollidone
PEP Case	Phosphoenol pyruvate carboxylase
%	Percentage
RuBP Case	Ribulose 1, 5 biphosphate carboxylase
rpm	Revolutions per minute
RWC	Relative water content
SOD	Super oxide dismutase
TCA	Trichloro acetic acid
wt	Weight

ABSTRACT

Role of oxygenated peptone in improving the productivity of brinjal (*Solanum melongena* L. cv. Ajay)

Vegetables are the rich and cheap source of vitamins and minerals for human beings and hence they occupy an important place in diet. India is the second largest producer of vegetables in the world, next to China, with an estimated production of about 50.09 million tonnes from an area of 4.5 million hectares at an average yield of 11.3 tonnes per hectare. The per capita consumption of vegetables in India is only about 140 gm, which is far below the minimum dietary requirement of 280 g / day / person. In India, systematic efforts have been made to upgrade vegetable production. The major objective of research on vegetables in India is improving production per unit area through breeding high yielding, disease and pest resistant varieties, developing F_1 hybrids, standardization of agro-techniques for different agro-ecological situations and post-harvest management. Inspite of this, the productivity of vegetables is not much improved. Varieties with longer shelf life and suitable for processing are very few. Multiple disease resistant varieties are yet to be developed. Excessive use of pesticides has created problems of pesticide residues. Hence there is an urgent need for increasing the productivity of vegetables.

In the light of this situation, it has become very essential to develop a new technique, which will fulfill the criteria of organic farming and yet enhance the production sustainably. The present study is a step in this direction by using oxygenated peptone. Oxygenated peptone is an organic soil aerator, having oxygen, peptone and soluble silicate based inert filler compound. It releases oxygen slowly and steadily for 40-50 days after application through soil.

Brinjal (*Solanum melongena* L.) is an easily cultivated, solanaceous fruit vegetable, grown all over the world, round the year. It contributes 9 % of the total vegetable production of India. In Maharashtra, brinjal is grown over an area of 32000 ha with 521600 tonnes of an annual production with 16.3 t / ha productivity. Brinjal is a rich source of carbohydrates, proteins, fibers, vitamins and minerals. It is easily available in market and has been a common vegetable in diet. Different parts of

brinjal plant and its fruits are used as a medicine in various countries for healing kidney stones, liver disorders and diabetes.

Hence, the present investigation was undertaken to study the role of oxygenated peptone in improving the productivity of brinjal with following objectives.

OBJECTIVES:

1. To study the effect of oxygenated peptone on seed germination, seedling growth and seedling physiology.
2. To study the changes in growth parameters of treated plants.
3. To investigate the physiological and biochemical changes in treated plants.
4. To study the changes in soil properties after soil amendments of oxygenated peptone.

SIGNIFICANT FINDONGS:

The significant findings and some broad conclusions emerged from the results of the present investigation are highlighted below in a nutshell.

SEED GERMINATION AND SEEDLING GROWTH:

- The pre-soaking treatment with 1 % oxygenated peptone caused significant increase in germination percentage, root and shoot length, root : shoot ratio, vigour index and biomass.
- The mobilization efficiency, emergence index, speed of germination and coefficient of velocity of germination were improved due to oxygenated peptone.
- The treatment successfully enhanced the biochemical constituents like soluble proteins, total carbohydrates, DNA and RNA in the germinating seeds of brinjal.
- The activity of enzymes like amylase, protease, catalase and super oxide dismutase was stimulated in treated germinating seeds over control (untreated).

VEGETATIVE GROWTH (ROOT, STEM AND LEAF ANALYSIS):

- The soil application of oxygenated peptone caused increase in length, diameter, number of secondary roots and secondary branches of stem, as well as root, stem and leaf biomass. Similarly the number of leaves per plant and leaf area was also enhanced over control.
- There was an increase in aerenchyma in cortex and pith of root and stem of treated plants.
- The treatment was also useful to enhance biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline in root, stem and leaf of treated plants, which might have helped to improve the growth and defense mechanism.
- The stimulated activity of antioxidant enzymes like catalase, peroxidase, polyphenol oxidase and super oxide dismutase in treated plants might be useful for the plants to tolerate stress conditions.
- The treatment caused considerable increase in the activity of nitrate reductase and nitrite reductase enzymes.
- The treatment caused increase in relative water content and osmotic potential and decrease in membrane injury.
- The photosynthetic pigments like chlorophyll a, chlorophyll b, carotenoids and xanthophylls in leaf tissues were enhanced along with chlorophyll a / chlorophyll b ratio and chlorophyll stability index in treated plants.
- The treated plants showed increase in rate of photosynthetic electron transport, activity of photosynthetic and photrespiratory enzymes like RuBP Case, PEP Case and Glycolate oxidase.
- There was increase in the level of mineral nutrients like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese and decrease in phosphorus content in root, stem and leaf of treated plants.

IMPROVEMENT IN YIELD ATTRIBUTES:

- Soil treatment of oxygenated peptone induced early flowering and fruiting, increased the number of flowers and fruits per plant, along with flower to fruit ratio. There was significant increase in length, diameter and weight of fruits.

- The yield as well as shelf life of fruits was enhanced significantly.
- The treatment caused increase in total solids, total soluble solids, fibers, ash content, soluble proteins, total carbohydrates, polyphenols, proline and ascorbic acid (vitamin C) content which improved the quality of brinjal fruits.
- There was increase in various antioxidant enzymes and mineral nutrients like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese in fruits of treated plants as compared to control plants.

CHANGES IN METABOLIC PATHWAYS:

- The treatment was useful to enhance the biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline in root, stem, leaf and fruit of treated plants.
- The treatment was useful to increase the activity of antioxidant enzymes like catalase, peroxidase and polyphenol oxidase in root, stem, leaf and fruit of treated plants.
- The mineral nutrition was mostly shifted to positive direction due to treatment of oxygenated peptone, which caused increase in most of the major and minor elements.

RHIZOSPHERE SOIL ANALYSIS:

- The soil treatment of oxygenated peptone caused significant improvement in pH, EC, moisture, porosity and water holding capacity and decreased its temperature and bulk density along with increase in organic matter and organic carbon of rhizosphere soil which is significant for increasing crop productivity.
- The treatment caused increase in the level of mineral elements like nitrogen, phosphorus, potassium, calcium, copper, iron and manganese but decrease in magnesium and zinc.
- The treatment of oxygenated peptone also favoured the positive increase in the microorganisms like *Bacillus subtilis, Azotobacter chroococcum, Aspergillus fumigatus Penicillium notatum, Trichoderma viridae* and *Paecilomyces lilacinus,* which contributed in phosphate solublization,

nitrogen fixation, synthesis of vitamins and antibiotics and as biocontrol agents. It decreased the population of pathogenic microbes like *Mucor indicus* and *Alternaria alternata*.

Thus, finally it can be concluded that soil application of oxygenated peptone might be increasing oxygen level in soil, which was useful for the growth of plants. It also created a favorable micro-climate for the growth of beneficial aerobic soil microbes. It also depressed the growth of pathogenic anaerobic microbes in the soil. This might have induced the improvement in growth of plants. The increased population of aerobic microbes caused solublization of phosphates, nitrogen fixation, synthesis of vitamins and antibiotics, which was responsible to improve the growth and yield of brinjal. Thus, this eco-friendly, non-hazardous, users' friendly and less expensive technique was highly useful to improve the health of soil and crop along with yield and its quality. But for recommendation to farmers, multilocation trials on different crops are necessary. The studies on market quality and consumer's acceptability of oxygenated peptone treated vegetables are very important before coarse scale applications.

Mrs. R. D. Chitale	Prof. K. N. Dhumal	Dr. Mrs. Neelam Patil
Research student	Research Co-guide	Research Guide

CHAPTER - I

INTRODUCTION AND REVIEW OF LITERATURE

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INTRODUCTION AND REVIEW OF LITERATURE

PART A : INTRODUCTION

1.1 VEGETABLE SCENARIO AT GLOBAL LEVEL:

The significant and continuous growth of world population and improvement in quality of life, combined with an on-going loss of land available for farming, has created an immediate and rapidly increasing need for greater production of vegetables. In 2004, over 28.4 million tonnes of fresh vegetables were traded globally, which is only just over 3% of global vegetable production. The limited export of vegetables indicates a high level of self-sufficiency for most countries. Nevertheless, global vegetable trade is growing steadily and registered annual growth of 4.6% in the period 1994-2004. An increase of 117.54% in the export of vegetables has been observed during the year 2009-10 (Anonymous, 2010). The development and introduction of high yielding varieties of vegetables had contributed a more sustainable food supply and greater stability of grower's income.

1.2 VEGETABLE SCENARIO IN INDIA:

India has taken a bold step towards self sufficiency in food. However, self sufficiency in the true sense can be achieved only when each individual in the country is assured of balanced diet. Varied agro-climatic conditions in India made it possible to grow a wide variety of vegetable crops round the year, in one part of the country or the other. The important vegetable crops grown are; brinjal, tomato, chilli, cabbage, cauliflower, onion, okra, carrot, radish, beans, spinach etc.

India is the second largest producer of vegetables in the world, next to China, with an estimated production of about 50.09 million tonnes from an area of 4.5 million hectares, at an average yield of 11.3 tonnes per hectare. In India, the per capita consumption of vegetables is only about 140g, which is far below the minimum dietary requirement of 280g / day / person. In India, systematic efforts have been made to upgrade vegetable production technology. However, such efforts were quite inadequate due to priority given to food grain production programme. The demand of

vegetables has been increasing fast in the urban areas due to gradual rise in standard of living, coupled with development of communication and transport facilities. It therefore calls for a major research and development to achieve the target (83 million tonnes) for the supply of 200g of vegetables per person per day.

1.3 NUTRITIONAL QUALITY OF VEGETABLES AND THEIR IMPORTANCE IN HUMAN DIET:

Vegetables are the rich and cheap source of vitamins and minerals. They occupy an important place in human diet and play a significant role in human nutrition, especially as sources of vitamin C (ascorbic acid), vitamin A, thiamine (B_1), niacin (B_3), pyridoxine (B_6), folacin (B_9) or folic acid, vitamin E, riboflavin (B_2), minerals and dietary fiber.

Vegetables in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke and other chronic diseases.

1.4 STRATEGIES FOR IMPROVEMENT OF YIELD IN VEGETABLES:

Research on vegetable crops in India, was initiated by Indian Council of Agriculture Research (ICAR) during 1947-48 with ad-hoc schemes in different states including Maharashtra. Systematic research on vegetables began with the creation of Division of Horticulture at the Indian Agricultural Research Institute (IARI) New Delhi, during 1956-57. Establishment of 26 Agricultural Universities in 17 states from 1960 onwards, gave further boost to vegetable research, which is being carried by the Departments of Horticulture and in 9 cases by separate Departments of vegetable crops. Vegetable Improvement Project was also started by ICAR in 1970-71 (Fourth Plan) to provide a national grid for testing of technologies developed by various research institutes and agricultural universities through inter-disciplinary, multi-location research trials. In addition to this, a number of short term, time bound and result oriented ad-hoc schemes on area specific problems of selected vegetable crops were also supported by ICAR at various Central Institutes and State Agricultural Universities.

The major objective of research on vegetables in India was improvement in production per unit area, by solving chronic problems of production, through the breeding of high yielding, disease and pest resistant varieties, developing F_1 hybrids,

standardization of agro-techniques for different agro-ecological situations, disease and pest management and post-harvest studies.

1.5 NEED FOR FURTHER RESEARCH:

Despite a large number of varieties and hybrids developed, the productivity of vegetable crops has not improved. Varieties with longer shelf life and suitable for processing are very few. Multiple disease resistant varieties are yet to be developed. Excessive use of pesticides has created problems of pesticide residues and hence there is a need for integrated pest and disease control. From this point of view, the present research was undertaken for yield improvement in fruit vegetable like brinjal by using oxygenated peptone.

1.6 ABOUT THE SELECTED LOCATION:

The experiment was conducted at P.G. Research Center, Department of Botany, Tuljaram Chaturchand College, Baramati, Dist. Pune (M.S.) India. The details of Baramati Tahsil are briefly given below.

1.6.1 Topography:

Baramati is one of the fourteen Tahsils in Pune District (Plate II A) of Maharashtra State (Plate I). It lies between $18^{o}3'$ N to $18^{o}12'$ N latitude and $74^{o}13'$ E to $74^{o}40'$ E longitude; 548 m above mean sea level. It is situated on the bank of Karha River and is 112 km south east of Pune. The total geographical area of 117 villages of the Tahsil is 1,38,247 hectors. Baramati Tahsil (Plate II B) is surrounded by Purandar to west, Indapur to east, Daund to north and Phaltan to south.

1.6.2 Rainfall:

Baramati Tahsil comes under rain shadow and hence the average annual rainfall is only 530 mm, which is very irregular and uncertain. The rainfall shows marked variation from year to year and locality to locality. The rains are received mainly from the south-west monsoon, during August to October. The variation in rainfall, in this Tahsil for last five years (Table 1.1) indicates great fluctuations.

PLATE I

Location of Maharashtra State in India.

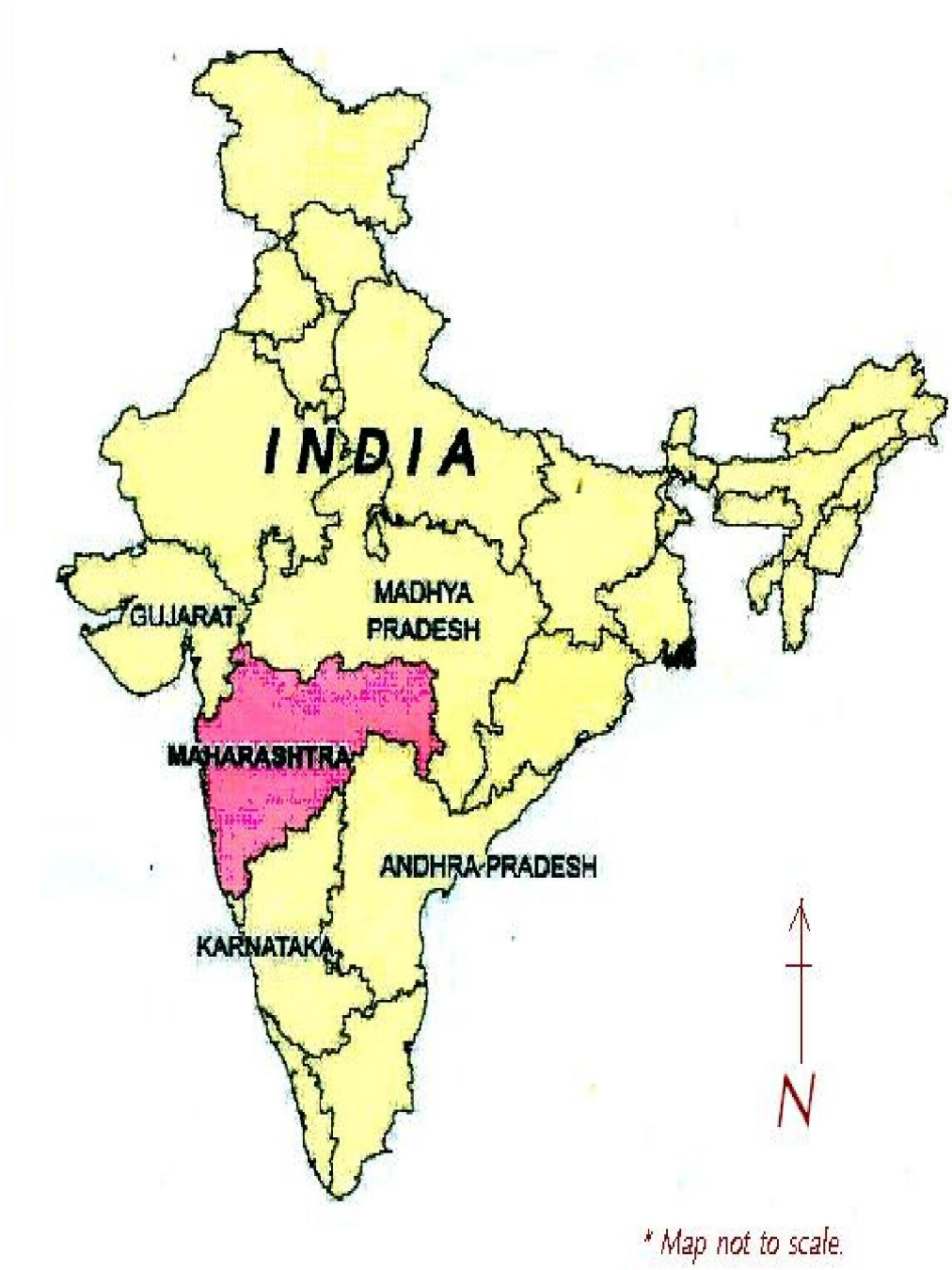
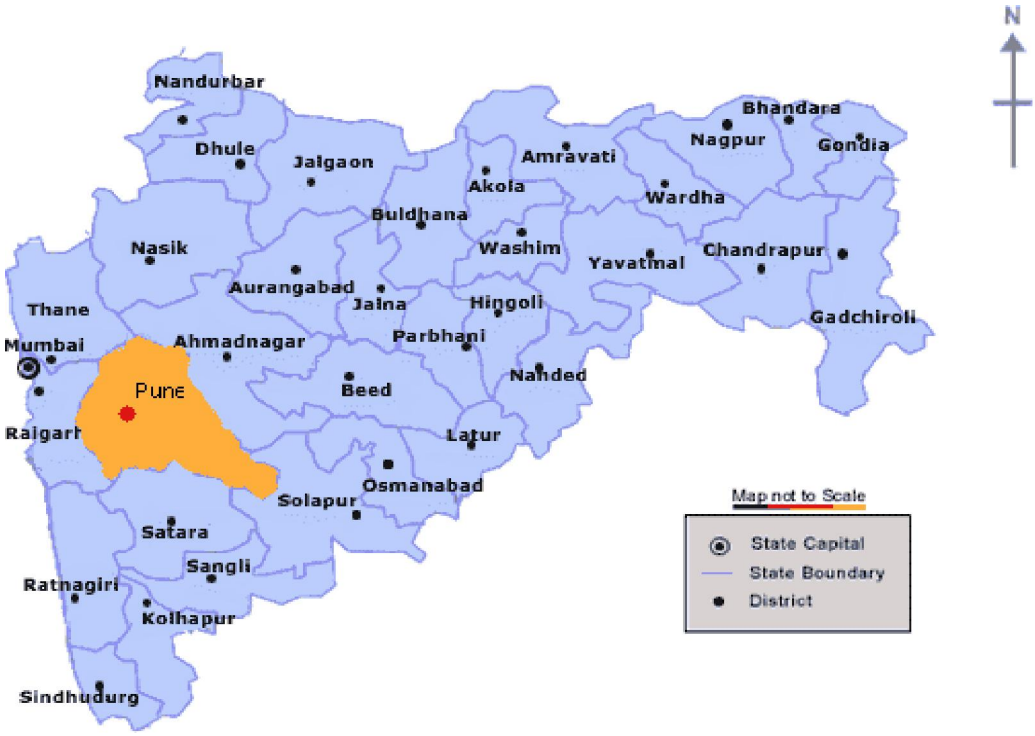


PLATE II

A : Location of Pune District in Maharashtra.



B : Location of Baramati Tahsil in Pune District

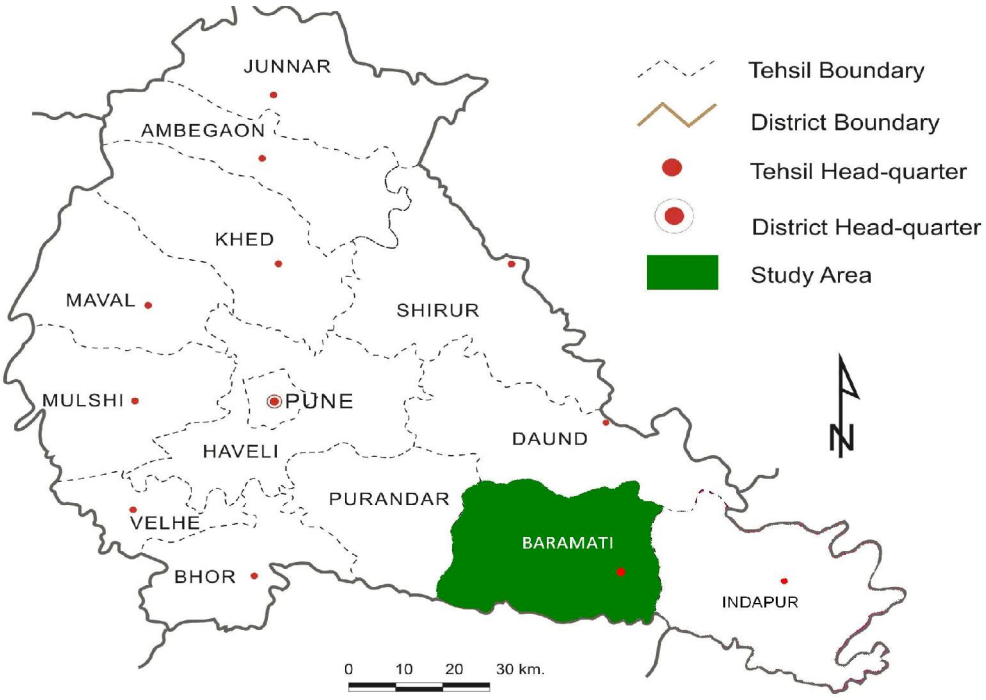


Table 1.1 Rainfall, temperature and relative humidity in Baramati Tahsil for the year 2005-2009.

Year	Rainfall (mm)	Temperature (^{o}C)			Relative Humidity (%)
		Min.	Max.	Average	
2005	640	20.50	32.70	26.60	64.6
2006	714	21.50	33.50	27.50	61.3
2007	593	22.60	34.90	28.75	57.3
2008	502	22.30	35.30	28.80	56.1
2009	695	19.45	31.50	25.47	65.1

Source: Krishi Vidnyan Kendra, Baramati, Dist. Pune.

1.6.3 Temperature:

The hot and dry climate of Baramati is characterized by hot and dry summer (March to mid June), moist and hot monsoon (July to mid September) and almost dry winter (November to mid February). Maximum temperature in summer is 44^{o}C, while minimum temperature in winter is 19^{o}C. The mean daily temperature is above 22^{o}C throughout the year (Table 1.1).

1.6.4 Humidity:

The percent relative humidity ranges from 35-45% in summer, while during monsoon it is more than 50%, indicating dry nature of the climate. For the last five years (2005-2009), the relative humidity remained between 50-64% (Table 1.1).

1.7 ABOUT SELECTED VEGETABLE – BRINJAL:

Brinjal (*Solanum melongena* L.) is an easily cultivated fruit vegetable belonging to family Solanaceae, which can grow round the year. It is mainly cultivated in tropics and subtropics. This perennial fruit vegetable is grown commercially as an annual crop. It prefers warm weather and grown extensively in India, Bangladesh, Pakistan, China, Japan and Philippines. It is also very popular in Egypt, France, Italy and United States.

1.7.1 Botanical information:

Brinjal grows to a height of 60-120 cm. The plant is erect, compact, well branched having fibrous root system. Leaves are simple, large, lobed and alternate. Both the leaves and stem are covered with fine hairs. The flowers sprout singly or in small clusters from the leaf axis. The individual flower is star-shaped, large and has a short stalk. It is light purple, violet or white in colour with five stamens attached to the corolla tube and a single superior ovary. Fruit is pendent, fleshy berry having ovoid, oblong, ob-ovoid to long cylindrical shape. Its colour varies from shiny purple, white, green, yellowish or striped. The seeds are borne on the fleshy placenta which fills the locular cavity completely.

There are three main botanical varieties under the species *Melongena*. The round or egg shaped fruit cultivars are grouped under var. *esculentum*, the common egg plant. The long, slender types are included under var. *serpentinum*, the snake egg

plant. The small fruited straggling plants are put under var. *depressum*, the dwarf egg plant.

1.7.2 Varieties of brinjal:

Popular Indian varieties and the most popular and common varieties of brinjal cultivated in Maharashtra are described in Table 1.2 and Table 1.3 respectively giving all the details like their morphological peculiarities and yield.

1.7.3 About the selected variety:

Brinjal (*Solanum melongena* L. cv. Ajay).

The variety is released by Ankur Seeds Pvt. Ltd., Nagpur (M.S.) India. The variety has a dwarf and spreading type of growth habit. Fruits are oval to oblong and purple coloured with white stripes (Plate III). Average weight of fruit is 80-90 g. Crop is ready for first picking within 60 days after transplanting. Average yield is 40-50 t / ha. This variety is mostly used for cultivation of brinjal in and around the Baramati Tehsil. Hence, it is selected for present investigation.

1.7.4 Yield and production in India and Maharashtra:

Brinjal is an important indigenous vegetable crop of India. It contributes 9% of the total vegetable production of the country. In India, brinjal is grown over an area of 2,99,770 ha. with 31,24,487 tonnes of an annual production with 10.46 t / ha. productivity (Anonymous, 2009). The area, production and productivity of brinjal is given in Table 1.4.

1.8 CULTIVATION PRACTICES:

The field is ploughed to fine tilth by giving 4-5 ploughing. Planking should be done for proper leveling. The field is then divided into beds and channels. Well-decomposed FYM is thoroughly incorporated at the time of land preparation.

1.8.1 Bed Preparation:

Brinjal seeds are sown on nursery beds to raise seedlings for transplanting in the field. Raised beds of size 7.2 x 1.2 m and 10-15 cm in height are prepared. Ten such beds are sufficient to raise seedlings for planting one hectare area. About 70 cm

PLATE III

The selected variety of Brinjal (*Solanum melongena* L. cv. Ajay).

Table 1.2 Popular Indian varieties of brinjal.

Name of variety	Released by	Description	Yield (Tonnes/ha.)
Pusa Purple Long	IARI, New Delhi	Fruits are long, smooth, glossy and light purple in colour. Mature in 100-110 days.	25-37
Pusa Purple Round	IARI, New Delhi	Fruits are round with purple colour. Mature in 110-120 days.	30-40
Pusa Purple Cluster	IARI, New Delhi	Fruits are small, dark purple, borne in clusters. Mature in 75 days.	40-45
Pusa Kranti	IARI, New Delhi	Fruits are oblong and dark purple coloured. Mature in 130-150 days.	14-16
Pusa Ankur	IARI, New Delhi	Fruits are round, dark purple coloured. Mature in 45 days after transplanting.	35-45
Arka Navneet	I I H R, Bangalore	Fruits are large, oval to oblong with deep purple colour, having good cooking quality. Mature in 150-160 days.	65-70
Arka Sheel	I I H R, Bangalore	Fruits medium long with deep shining purple skin. Mature in 150-160 days.	38
Arka Kusumakar	I I H R, Bangalore	Fruits are medium long, finger shaped and pale green in colour. Mature in 140-150 days.	40
Arka Nidhi	I I H R, Bangalore	Fruits are medium long with blue black glossy skin. Fruit have good cooking and keeping quality. Mature in 140 days.	48
Arka Neelkanth	I I H R, Bangalore	Fruits are short with violet blue glossy skin. The variety is resistant to bacterial wilt and has very good cooking and keeping quality. Mature in 150 days.	40

IARI : Indian Agricultural Research Institute.

I I H R : Indian Institute of Horticultural Research.

Table 1.3 The most popular and common varieties of brinjal cultivated in Maharashtra.

Name of variety	Released by	Description	Yield (Tonnes/ha.)
Aruna	PKV, Akola	Fruits are small round with purple colour. Mature in 120-140 days.	25-30
MHB-1	MAHYCO, Jalana	Fruits are long and blackish purple in colour. Mature in 130-140 days.	50-60
MHB-20 (Kalpataru)	MAHYCO, Jalana	Fruits are round with bright reddish purple stripes on a pale whitish green background. Mature in 130-150 days.	40-50
Manjiri Gota	MPKV, Rahuri	Fruits are medium-large, round with purple coloured stripes. Mature in 130-150 days.	15-20
Vaishali	MPKV, Rahuri	Fruits are oval and purple coloured. Mature in 60 days after transplanting.	40-45
Krishna	MPKV, Rahuri	Fruits are egg shaped, spiny with purple coloured stripes on a pale whitish green background. Mature in 120-130 days.	45-48

PKV : Punjabrao Krishi Vidyapeeth.
MAHYCO : Maharashtra Hybrid Seeds Company.
MPKV : Mahatma Phule Krishi Vidyapeeth.

Table 1.4 Area, production and productivity of brinjal in Maharashtra.

Year	Area (ha.)	Production (tonnes)	Productivity (t / ha.)
2000-01	30,450	4,87,200	16.00
2001-02	31,059	4,96,944	16.00
2002-03	31,214	4,99,424	16.00
2003-04	30,910	4,98,269	16.12
2004-05	31,542	4,73,720	16.2
2005-06	32,000	5,21,600	16.3

(Source: National Horticulture Mission. Retrieved on 28 / 02 / 2009).

distance is kept between two beds to carry out operations of watering, weeding etc. The surface of beds should be smooth and well leveled. Well-decomposed FYM may be mixed with the soil at the time of bed preparation.

1.8.2 Raising of Seedlings:

About 250-300 g of seeds is sufficient for raising seedlings for one hectare of land. Prior to sowing, seeds are treated with fungal culture of *Trichoderma viridae* (4g / kg of seed) to avoid damage from damping-off disease. Sowing should be done thinly in lines spaced at 5-7 cm distance. Seeds are sown at a depth of 2-3 cm and covered with a fine layer of soil followed by light watering by water can. The beds should be covered with dry straw or grass or sugarcane leaves to maintain required temperature and moisture. The watering should be done by water can as per the need till germination is completed. The seedlings are ready for transplanting within 4-6 weeks of planting when they attain a height of 15 cm with 2-3 true leaves.

1.8.3 Transplanting:

Seedlings are transplanted in furrows in light soils and on side of the ridges in case of heavy soils. A pre-soaking irrigation is given 3-4 days prior to transplanting. At the time of transplanting, the roots of the seedlings should be dipped in a solution of Bavistin (2g / lit. of water). Transplanting should preferably be done in the evening.

1.8.4 Irrigation:

A light irrigation is given at an interval of 8-10 days during winter and 5-6 days during summer.

1.8.5 Fertilization:

Fertilizer dose depends upon the fertility of soil and amount of organic manure applied to the crop. For a good yield, 15-20 tonnes of well-decomposed FYM is incorporated into the soil. Generally, application of 150 kg N, 100 kg P_2O_5 and 50 kg K_2O is recommended for optimum yield.

1.8.6 Weed Control:

Weeds are controlled either by physical / mechanical methods or chemical control if required.

1.8.7 Harvest:

The time required from flowering to market-fruit size is about 3-4 weeks, but fruit can be harvested and eaten at any earlier stage of the development. Fruit should be harvested while it is still glossy with a desirable colour. Brinjal yields are commonly in the range of 30-40 tonnes / ha of marketable fruit although higher yields can be achieved.

1.8.8 Post harvest:

Brinjal does not have a long storage life and should be marketed immediately after harvest. Fruits are packed to a fiberboard carton or a special crate or other containers. Brinjal can be stored safely for 7-10 days at 7-10^{0}C and 90-95% relative humidity.

1.9 NUTRITIONAL VALUE, ECONOMIC AND MEDICINAL IMPORTANCE:

Brinjal has been a common vegetable in Indian diet since the ancient time. Its nutritional composition per 100g of edible portion is given in Table 1.5.

The unripe fruits of brinjal are primarily used as vegetable and for preparation of various dishes in different regions of world. The cut fruits are soaked in cold salted water before being cooked to avoid discoloration and to remove its mild bitterness. It has much potential as raw material in pickle making and dehydration industries. Different parts of brinjal plant and the fruits are used in medicine in various countries e.g. fruit is used as an antidote in case of mushroom poisoning, the ash of the fruit is used in dry, hot poultice to treat hemorrhoids, white brinjal is specifically useful for healing kidney stone, liver disorders and diabetes.

1.10 DISEASES AND PESTS:

Brinjal is subjected to the attack of many diseases which cause damages in all growth stages (Plate IV).

Table 1.5 Nutritional composition of brinjal per 100g of edible portion.

Energy (kcal)	20.0
Carbohydrates (g)	5.7
Sugars (g)	2.35
Dietary fiber (g)	3.4
Fat (g)	0.19
Protein (g)	1.01
Thiamine (mg)	0.039
Riboflavin (mg)	0.037
Niacin (mg)	0.649
Pantothenic acid (mg)	0.281
Vitamin B_6 (mg)	0.084
Folate (µg)	22.0
Vitamin C (mg)	2.2
Calcium (mg)	9.0
Iron (mg)	0.24
Magnesium (mg)	14.0
Phosphorus (mg)	25.0
Potassium (mg)	2.0
Sodium (mg)	3.0
Copper (mg)	0.17
Zinc (mg)	0.16
Manganese (mg)	0.25

(Source: USDA Nutrient database. Retrieved on 24 / 02 / 2009).

Damping off (*Pythium spp.; Phytophthora spp.; Rhizoctonia spp.*):

The disease is soil-borne. The affected seedlings are pale green and a brownish lesion is found at the basal portion of the stem that girdles the stem. The affected tissue rots and the seedling collapses. The disease may be controlled by soil sterilization and seed treatment with fungicides or hot water.

Leaf spot (*Alternaria spp.*; *Cercospora spp.*):

The *Alternaria* leaf spots produce the characteristic leaf spots with concentric rings. The spots are mostly irregular, 4-8 mm in diameter and may enlarge and cover a large area of the leaf blade (Plate IV). The leaves may drop off due to severe infection. The *Cercospora* leaf spots are characteristically chlorotic lesions, angular to irregular in shape and latter turn grayish brown with profuse sporulation at the center of the spot. Severely infected leaves drop off prematurely resulting in the reduction of yield. The leaf spot disease may be primarily controlled by maintaining proper field sanitation.

Bacterial wilt (*Pseudomonas solanacearum*):

The symptoms of bacterial wilt are yellowing, curling and wilting of leaf, disintegration of stem and root and dying of the plant. Crop rotations, eradication of weeds, good drainage and growing healthy seedlings are important control measures.

Little leaf:

Little leaf disease of brinjal is caused by mycoplasma. It is a serious disease of brinjal throughout India. The infected plant is generally shorter but possesses a large number of branches, leaves and roots than a healthy one. The leaves are malformed into tiny chlorotic structures. Many lateral shoots develop in the axils of leaves and with the shortened internodes give the plant a bushy appearance (Plate IV). The mycoplasma is transmitted by leaf hopper *Hishimonus phycitis*. The suggested control measures are the complete eradication of all solanaceous weeds, the chemical control of leaf hopper, the roguing out of the diseased plants in the early stage of infestation and the use of resistant cultivars.

PLATE IV

Diseases and Pests of Brinjal.

Alternaria **leaf spots**

Little leaf

Shoot borer

Fruit borer

Fruit and Shoot borer (*Leucinodes orbonalis*):

Brinjal fruit and shoot borer is a very destructive pest in Southeast Asia. It has been reported that the insect causes a loss up to 70% in yield. The larva attacks the terminal shoots and bores inside, resulting in withering and drying of the shoots. It also bores into the young fruit and feeds inside which makes the fruit unmarketable (Plate IV). Continuous cropping of brinjal on the same piece of land should be avoided. Fruits showing any boring should be picked and destroyed. Spraying with Carbyl (0.1%) or Cypermethrin (0.5 ml / liter of water) is effective in controlling this pest.

Aphids (*Aphis gossypii*):

The aphid is small, soft, yellowish green or greenish brown found in colonies on the tender shoots and the undersurface of young leaves. They feed on leaves and stems by sucking the plant juice. Black sooty mould develops on the honeydew excreted by the aphid and covers the leaves and adversely affects the photosynthesis. As a result, infested plants appear weak. Spraying with Bifenthrin is suggested to control the aphids.

1.11 ABOUT OXYGENATED PEPTONE:

Chaitanya Biologicals Pvt. Ltd., Malkapur, Dist. Buldhana (M.S.) India has introduced the unique concept of soil aeration in 1996 through the invention of oxygenated peptone (Plate V).

Oxygenated peptone is the first and best technological innovation, which fulfills the oxygen demand of roots and allows them to grow to full extent even in oxygen deficient soil. It includes three basic changes in the vicinity of seed / root, leading to number of physical, chemical and biological interactions of plant with soil and soil microbes. These changes are: improvement in oxygen supply, microbial activity and nutritional availability. Oxygenated peptone is a unique solution to the oxygen-deprived roots in waterlogged soil, which has the conditioning effect on destabilized soil.

PLATE V

Oxygenated peptone supplied in polyethylene bags
Brand name - Chaitanya

1.11.1 Physico-chemical properties:

Chemical name	:	Oxygenated peptone
Trade name	:	Chaitanya
Composition	:	Oxygen (100 mg/g) Peptone (650 mg/g) Soluble silicate based inert filler compound (250 mg/g)
Solubility	:	Water-soluble
Physical form	:	Whitish powder
Odour	:	No specific odour
pH	:	Neutral
Stability	:	Bacteriologically stable
Toxicity	:	Non-poisonous, non hazardous
Storage	:	Can be stored for more than two years.
Compatibility	:	Compatible with fertilizers and biological cultures.
Working	:	Releases oxygen slowly and continuously for 40-50 days under moist conditions.

1.11.2 Doses:

1. 1% aqueous solution for pre-sowing soaking treatment to seeds.
2. 50 g / kg of seeds at the time of sowing for nursery plants.
3. 5 kg / ha for annual and seasonal crops at the time of sowing or transplantation.
4. Booster dose of 5 kg / ha after two months near root zone if required.
5. 2-10 grams per plant for horticultural trees, floricultural plants and ornamental plants depending upon age and crown of the plant.
6. 5 kg / ha at the time of planting and the same booster dose after three months for sugarcane.

1.11.3 Physiological Role(s):

1. Increases germination percentage by preventing the secondary dormancy in the seed.
2. Induces an early germination.
3. Increases the number and the length of secondary and tertiary roots.
4. Increases the root mass resulting in better utilization of nutrients.

5. Induces rapid, early flowering and fruiting with higher yield.
6. Reduces fruit drop that results from oxygen starvation.
7. Induces nodule formation in leguminous crops.
8. Improves overall quality of grains / fruits.
9. Enables the plant to tolerate water stress because of deeper root zone.
10. Enables the plant to withstand waterlogged condition. Even three hour water logging causes root mortality and 24 hours water logging causes 50% decrease in yield in pea (Taiz and Zeiger, 1984).
11. Enables the plant to absorb and utilize the nutrients available from expanded soil strata due to better expanse of roots.
12. Promotes conversion of ammonia nitrogen to nitrate nitrogen which is readily absorbed by roots.
13. Supports beneficial microbial activity in the rhizosphere by providing aerobic atmosphere and food in the form of peptone.
14. Checks the growth of harmful anaerobic pathogens e.g. *Pseudomonas* in the soil by providing oxygen rich atmosphere.
15. Promotes healthy growth of crop resulting into higher yield.
16. Confers disease resistance due to presence of silicates in oxygenated peptone.
17. Indirectly increases synthesis of cytokinin (which takes place at root apex) by increasing number of tertiary roots.
18. Enhances oxygen-mediated transport of PGA (Phosphoglyceric acid) within the plant body.

1.11.4 Role as soil conditioner:

1. Increases soil porosity through proper balance between macro-pores and micro-pores.
2. Increases water holding capacity of soil.
3. Promotes growth of aerobic soil microbe population useful for plant growth.
4. Represses the growth of anaerobic pathogenic microbes in soil e.g. *Pseudomonas*.
5. Reduces toxicity caused by reduced metals in soil by oxygenating them.
6. Corrects the adverse soil properties caused by continuous and excessive use of inorganic fertilizers, pesticides and water.

1.11.5 Role in organic farming:

1. Principle of "Feed the soil and not the crop" is followed.
2. Proper soil management without impairing soil health.
3. Working with natural systems rather than seeking to dominate them.
4. High quality yield in sufficient quantity.
5. Maintenance and increase of long time soil fertility.
6. Encouraging biological cycle in the soil.
7. Pollution free, non-toxic, non-hazardous, safe working environment.
8. Increasing beneficial microbial population in soil.

Thus oxygenated peptone fulfills the criteria for organic farming laid down by International Federation of Organic Agriculture Movement (IFOAM) and at the same time increases crop yield (Patil *et al.,* 2005, 2006 and 2008).

Oxygenated peptone used in the present investigation supplies both oxygen and organic nitrogen for respiration and growth of root cells and soil microbes. Improved oxygen level in the soil micro-climate encourages metabolic activities of aerobic soil microbes and thereby increases the availability of nutrients in the rhizosphere. On the other hand, it discourages growth of anaerobic pathogenic microbes and decreases the toxicity caused by reduced metals under hypoxic conditions. This is supported by observation of Noordwijk *et al.* (1998), who noticed that non-aerated soil condition produced only 33% and 9% of the number of flowers as compared to control in gerbera and carnation respectively.

Improved oxygen level in the rhizosphere favours metabolic activities of the shoot system of the plant (Patil, 2003). There is proper utilization of enhanced uptake of water, minerals and oxygen by roots. There in increase in the synthesis of photosynthetic pigments like chlorophylls and carotenoids, leading to increased photosynthetic ability. This favours vegetative growth resulting into enhanced yield with upgraded quality of product.

So in the present investigation, it was aimed to study the role of oxygenated peptone in improving the productivity of brinjal (*Solanum melongena* L. cv. Ajay).

PART B : REVIEW OF LITERATURE

The research work on various aspects of brinjal is reviewed in brief in the following paragraph.

1.12 SEED GERMINATION AND SEEDLING GROWTH IN BRINJAL:

As seed germination and seedling growth is the fundamental process in the life cycle of any crop, many researches have focused this aspect in great detail. Both the processes are very crucial for establishment of the plants, growth, development and even yield.

Gupta (1971) studied the effect of NAA, IAA and GA on seed germination of brinjal and found that all treatments caused enhanced germination, but 10 ppm concentration was most effective. In 1975, Winden *et al.* studied the seed germination in eggplant under different temperature regimes and 100% germination of fresh seeds was achieved at 29^0C day / 23^0C night temperature. In the same year, Avakyan *et al.* studied the effect of seed irradiation on productivity of brinjal and noted that seed treatment with 1 Krad dose advanced fruit ripening, appreciably increased yield and improved fruit quality. Alekseev (1976 a and b) noted that warming the seeds caused increase in germination. Further he reported that the weight and size of seeds was increased with fruit ripening. Singh and Sidhu (1985) studied the effect of fruit maturity and water soaking of cut fruits on seed germination of brinjal and recorded highest seed germination when the seeds were obtained from fully-ripe and half-ripe fruits. Soaking of seeds up to 48 h had no adverse effect on germination. Quagliotti and Rota (1986) found that the type of cultivar had greater effect on seed germination than the environmental conditions like temperature and light.

Rao and Bhatt (1990) studied differential sensitivity of seed germination and seedling radical growth to water stress in eggplant and noted that radical extension was less sensitive than germination to water stress and it varied among the five cultivars studied. In 1993, Krishnaswamy and Irulappan worked on the germination response to water stress in the seeds of hot pepper and eggplant genotypes. They subjected twenty two genotypes of eggplant to moisture stress during germination and early seedling growth using PEG 600 solution and observed that water uptake, rate of germination, seedling growth and vigour declined with increase in moisture stress. In the same year, Hashem studied the effect of saline water on germination and seedling

growth in four cultivars of eggplant in Egypt and found that hypocotyl and root growth rates decreased with increase in salinity. Lou and Kato (1993) worked on influence of seedling age on endogenous hormones, seedling quality and productivity in eggplant and observed that younger seedlings grow more vigourously after transplanting, contain more nitrogen in the stem, more zeatin, abscisic acid and IAA and less GA in the shoot apices and higher yields than older seedlings. Hussein and Siddiqui (1997) studied the effect of Ethyl Methane Sulphonate (EMS) on germination and seedling growth of brinjal. Trigo and Trigo (1999) worked on the effect of priming on germination and vigour of eggplant seeds. Wang (2001) studied the effects of GA seed-soaking treatments on germination of eggplant seeds and found that this treatment significantly increased germination percentage. Hikawa (2004) studied the effects of priming on the seeds of brinjal using GA, PEG and combination treatment of GA and PEG and found that the combination treatment effectively promoted seed germination. Demir and Okcu (2004) studied the effect of aerated hydration treatment for improved germination and seedling growth in brinjal and noted that the treatment improved germination and establishment of brinjal. Akinci *et al*. (2004) observed that increase in salt stress decreased germination and seedling growth of brinjal seeds.

Siddiqui *et al.* (2005) worked on the effects of chromium and lead on germination and accumulation of phenolic contents of cotton and brinjal and observed that chromium had little effect on seed germination of both plants. However, phenolic contents increased in seedlings of both plants. Dem *et al.* (2006) studied the effect of seaweed suspensions obtained from green, red and brown algae on seed germination of tomato, pepper and brinjal at optimum (25^0C) and low temperatures (15^0C). In the same year, Li *et al.* observed the effects of osmoregulation on germination, enzyme activity and membrane permeability during seed germination and found that the treatments increased seed germination rate. Peroxidase activity increased during sprouting while catalase activity increased at early stages and decreased at later stages and electrical conductivity was reduced by the treatments.

Patil *et al.* (2008) studied role of oxygenated peptone in enhancing germination of tomato, brinjal and chilli and observed that the pre-soaking treatment of oxygenated peptone enhanced germination process and increased biochemical constituents and enzyme activity in seedlings of test crops.

1.13 GROWTH AND PRODUCTIVITY:

Influence on growth and yield attributes of plant result into final productivity. The research work on this aspect is summarized below.

Mal'nikov (1971) worked on the characteristics of abscission of the reproductive organs and the productivity of egg plants in relation to variety and weather and reported that low soil and air moisture and high and fluctuating temperatures retarded growth and caused flower abscission in egg plants. The productivity and fruit composition of eggplant cultivars was studied by Bujdoso and Videki (1976) and found that the Romanian cv. Danubiana produced the highest total and early yields and the largest fruits with highest crude protein content. El-Zawily *et al.* (1985 a) noted that GA increased plant height and leaf number but decreased the number of branches. The other three treatments reduced plant height and increased the number of leaves and branches. GA, Alar and Pix had induced flowering, increased the number of flowers and fruit set and enhanced the early yield. In the consecutive paper (1985 b), they found that highest early and total yields were obtained with the treatment of GA plus nitrogen.

Mohamed and Amer (2001) found that planting date and cultivar significantly affected all the parameters of vegetative growth. Plant height, number of fruits per plant and dry weight of whole plant were significantly increased when planted in spring season in Qatar. Lee *et al.* (2003) found that maintaining the soil temperature at 14-16^{0}C, using grafted seedlings and keeping the soil temperature at 19^{0}C increased productivity of brinjal. In the same year, Ferratto and Rotondo remarked that crop yield increased under pruning treatments and double row was superior to single row for productivity. Illangakoon *et al.* (2004) mentioned that the days to 50% flowering and fruit number were correlated with yield and can be used as indicators to predict the yield. Prabhu *et al.* (2008) worked on correlation and path analysis in brinjal for assessing the association between marketable yield and its component characters. Marketable yield per plant showed positive significant correlation with plant height, branches per plant and mean fruit weight. Path analysis revealed that branches per plant, mean fruit weight, fruit length and number of fruits per plant exhibited positive direct effect on marketable yield.

1.14 EFFECT OF FERTILIZERS ON YIELD:

Different types of fertilizers e.g. organic manures, biofertilizers, vermicompost, compost, FYM as well as green manures and several inorganic fertilizers usually influence growth and yield of crop plants.

Doikova (1976) observed that the treatment of FYM in combination with NPK gave the early yield and produced the highest yield, followed by the treatment using mineral fertilizers. Further in 1977, he found correlation between harvesting date and fertilizer use and observed that the fertilizers increased fruit N content but no correlation was observed between N content and fertilizer rate. Singh *et al.* (1988) studied the effect of nitrogen and phosphorus application on brinjal productivity under rain fed conditions and obtained highest yield with highest N / P rates. Sawan and Rizk (1998) found that as S-rate increased, P and K contents in the leaf tissues were increased, while N content decreased. The total fruit yield increased when sulphur was added to the control treatment.

Khedr *et al.* (2004) studied the effect of some nutrients and growth substances on productivity of eggplant growing under high temperature conditions. The combination of Zn and sugar showed earliness of flowering, increase in fruit set percentage, yield per plant as well as fruit diameter and dry matter percentage. Chaudhuri *et al.* (2005) investigated the effect of integrated nutrient management on growth and productivity of brinjal. Jilani *et al.* (2007) indicated that N-application at the rate of 100 kg / ha produced significantly maximum survival percentage, fruit length, fruit diameter, fruit volume, fruit weight and yield per hectare under agro-climatic conditions of Pakistan. In the same year, Siddiky *et al.* investigated the performance of brinjal as influenced by boron and molybdenum and found that boron and molybdenum produced significantly higher yields over the control. Further, interaction effect of boron and molybdenum was found to be highly responsive to the yield and yield components of brinjal.

1.15 EFFECT OF PGRS:

PGRs play very important role in agriculture as they influence seed germination, seedling growth, development of flowering and fruiting and yield also. All these aspects can be manipulated with PGRs.

Avakyan and Oganesyan (1976) found that GA appreciably increased yield in two cultivars but in hybrid eggplants the treatment stimulated vigorous vegetative growth but depressed yield. Xu *et al.* (1997) found that the growth regulator (unspecified) improved the germination performance, increasing the percentage germination and shortening the average germination time. Sorte *et al.* (2001) noted that Pusa purple round sprayed with 200 ppm GA showed the highest growth in terms of height and number of branches and weight, number and size (length and diameter of fruits per plant), resulting in the highest yield.

1.16 EFFECT OF IRRIGATION:

Water is the highly essential compound in growth and yield of almost all the plants, which influence cellular reactions, metabolic processes, growth and yield. Puglia and Cascio (1979) found that furrow irrigation gave the highest yield while the average weight of fruit was lowest with sprinkling. Goswami *et al*. (2006) worked on crop growth and fruiting characteristics of brinjal as influenced by gravity drip irrigated crop. Drip irrigation with fertigation was superior in fruit yield over surface method of water supply.

1.17 EFFECT OF CLIMATIC FACTORS:

The phenotypic expression and yield of a plant is the result of genotype and environmental interaction. Climatic factors govern the life cycle of every plant. Bakker (1990) studied the effect of day and night humidity on yield and fruit quality of glass house grown eggplant and observed that mean fruit weight was higher at high humidity. Murage and Masuda (1997) studied the response of pepper and eggplant to continuous light in relation to leaf chlorosis and activities of anti-oxidative enzymes. Suzuki *et al.* (2005) studied the effect of minimum air temperature on yield and fruit quality of eggplant cv. Mizunasu grown in heated plastic house. In 1997, Chartzoulakis and Loupassaki found that salinity delayed germination along with significantly reduced plant height, leaf area, fruit number per plant and fruit size.

1.18 BIOCHEMICAL CONSTITUENTS AND ENZYME ACTIVITIES:

Physiological, biochemical and enzymological aspects are the most fundamental and basic once in the life cycle of a plant. They govern growth, development and yield. These parameters are the indicators of yield.

Flick *et al.* (1977) made a comparison of nutrient composition and enzyme activity in purple, green and white eggplants using the parameters like total solids, fibers, ash, nitrogen, fat content, minerals and amino acids along with enzymes like polyphenol oxidase, alcohol dehydrogenase and catalase and concluded that the green variety appeared to have better properties for processing than the more popular purple variety. Aluko and Ogbadu (1986) studied the different eggplant varieties for enzymes related to their organoleptic properties. Lee *et al.* (1997) studied the changes in IAA content and in activities of sucrose-metabolizing enzymes during fruit growth in eggplant and found that IAA content was increased during fruit set along with increased activities of the sucrose-metabolizing enzymes. Zubini *et al.* (2005) studied the enzymatic anti-oxidant system during the post harvest cold storage of brinjal using the real time PCR technique in order to monitor changes in the transcript level of genes encoding for ROS scavenging enzymes. The results suggested that oxidative stress can cause damage during cold storage of brinjal.

1.19 ORGANIC FARMING:

In view of pesticidal pollution of land, water and air as well as environmental degradation, presently emphasis is given on organic farming.

Prasanna and Rajan (2001) studied the effect of organic farming on storage life of brinjal fruits and observed increase in storage life of brinjal fruits with the practice of organic farming. Singh (2004) reported maximum yield of brinjal fruits when FYM, organic manure and biofertilizers were used. The attack of fruit and shoot borer was minimum when chemical fertilizers were used along with biopesticides.

1.20 BIOLOGICAL CONTROL:

This practice is becoming more popular among the brinjal growers for protecting consumers from ill effects of pesticides. Chakraborty and Chatterjee (2007) reported that the antagonistic agents like *Trichoderma viridae, Trichoderma harzianum* and *Glomus fasciculatum* in combination brought about significant

reduction in the incidence of wilt disease along with increased production of brinjal. Based on the overall performance, they pointed out that use of VAM symbiont and *Trichoderma harzianum* appeared beneficial in reducing the incidence of wilts and in improving growth and productivity of brinjal.

Considering the overall review of literature, it was observed that there is scanty work on role of oxygenated peptone for improving the productivity of brinjal. Hence, the present investigation was undertaken with following objectives.

1.21 OBJECTIVES:

1. To study the effect of oxygenated peptone on seed germination, seedling growth and seedling physiology.
2. To study the changes in growth parameters of treated plants.
3. To investigate the physiological and biochemical changes in treated plants.
4. To study the changes in soil properties after soil amendments of oxygenated peptone.

CHAPTER - II

MATERIALS AND METHODS

CHAPTER - II

MATERIALS AND METHODS

MATERIALS:

2.1 Procurement of seeds:

The authentic seeds of brinjal (*Solanum melongena* L. cv. Ajay) were obtained from Ankur Seeds Pvt. Ltd., Nagpur (M.S.) India.

2.2 Procurement of oxygenated peptone:

Oxygenated peptone is obtained from Chaitanya Biologicals Pvt. Ltd., Malkapur, Dist. Buldhana (M.S.) India.

METHODS:

2.3 SEESD GERMINATION BIOASSAY:

The pilot experiment was done to standardize the dose of oxygenated peptone for pre-sowing soaking treatment of seed germination. The seeds were surface sterilized with 0.05% $HgCl_2$ for 1 minute, thoroughly washed with distilled water and were soaked in 0.5%, 1%, 1.5% and 2% solution of oxygenated peptone prepared in distilled water for 8 h. Seeds soaked in D.W. were used as control. Twenty seeds of each treatment were kept in sterilized petridishes over Whatman No.1 filter paper at room temperature for germination. The filter paper was moistened with 10 ml D.W. The germination percentage and seedling growth were recorded upto 6^{th} DAS at an interval of 24 h. On the basis of results of pilot experiment, 1% dose was selected and the germinating seeds were studied for various growth parameters and analyzed for biochemical constituents and enzyme activities. All the experiments were conducted in five replicates.

2.4 GROWTH PARAMETERS OF SEEDLINGS:

The various growth parameters like germination percentage, length of root and shoot, shoot / root ratio and fresh biomass were measured on 6^{th} DAS using routine laboratory methods.

Vigour Index (VI) was calculated according to the method suggested by Baki and Anderson (1973).

Vigour Index = (Root length + shoot length) x Germination percentage

Mobilization Efficiency (ME) of reserve food material present in seed during germination was calculated as per the method described by Srivastava and Sareen (1974).

$$\text{Mobilization Efficiency (ME)} = \frac{\text{Dry wt of embryonal axes}}{\text{Dry wt of residual grains}} \times 100$$

Emergence Index (EI) was calculated by the formula given by Baskin (1969).

$$EI = n1 / dn1 + n2 / dn2 + n3 / dn3 \ldots\ldots + nx / dnx$$

where, n = number of seeds emerged on the day (I^{st}),

dn = number of days from the day of sowing,

dnx = number of days to the final count.

Speed of Germination (SG) was calculated by the formula given by Maguire (1962).

$$SG = n / t$$

where, n = number of seeds emerged on the day,

t = time or days from sowing.

Coefficient of Velocity of Germination (CVG) was calculated by the formula given by Kotowski (1962).

$$CVG = \text{sum of } n / \text{sum of } (n\,t) \times 100$$

where, n = number of seeds emerged on the day,

t = time or days from sowing.

2.5 POT CULTURE EXPERIMENT:

The experiments were conducted at P.G. Research Center, Botany Department, Tuljaram Chaturchand College, Baramati, Dist. Pune (M.S.) during 2007-2009 using pot culture experiment. To standardize the dose of oxygenated peptone for soil treatment, pilot experiment was carried out. Earthen pots (40 x 40 cm) were filled with soil and vermicompost (10:1 kg per pot) and treated with different doses of oxygenated peptone, ranging from 1g to 4g per pot. Pot without the addition of oxygenated peptone was considered as control. In each treatment there were five pots, which were watered daily. The growth parameters like plant height, number of

PLATE VI

Pot culture experiment for the soil application of oxygenated peptone to brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Treated **Control**

secondary branches and leaves per plant were recorded for 20 plants of each treatment and average values were recorded at 60th DAS. On the basis of results of pilot experiment, dose of 2g oxygenated peptone per pot was selected for soil treatment. Seeds of brinjal cv. Ajay were sown on raised seed beds. The watering was done by using water can as per requirement. Seedlings of 21 days old were transplanted in fifty pots (1 seedling / pot) and watered daily. Twenty five pots were kept as treated and twenty five pots were kept as control (Plate VI). All necessary intercultural operations like weeding and pest control were performed as and when required. No chemical fertilizers and pesticides were used. Plants were analyzed at 60th DAS for various growth parameters, biochemical constituents and enzyme activities. The experiments were conducted in five replicates.

2.6 GROWTH PARAMETERS:

The various growth parameters of root, stem and leaf like length and diameter of root and stem, number of secondary roots per plant, number of secondary branches per plant, number of leaves per plant, leaf area, leaf area index and biomass of root, stem and leaf were measured at 60th DAS using standard laboratory methods.

2.7 ANATOMICAL FEATURES:

The anatomical features of root and stem were studied by taking transverse sections of root and stem of treated as well as control brinjal plants of 60 days old. The sections were stained with dilute safranine, mounted in glycerin and observed under microscope. The aerenchyma tissues in cortex and pith region of root and stem were measured by actual counting.

2.8 COLLECTION OF SAMPLES:

The freshly harvested third leaf from top (which is physiologically active) of ten different plants from treatment and control was collected, cleaned properly, blotted dry, cut into small pieces and the composite leaf sample was prepared. For collection of root and stem sample, ten different plants of treatment and control was uprooted and the roots as well as stem were cut into small pieces, cleaned properly, blotted dry and the composite sample was prepared. Similarly, the healthy and ripened fruits from ten different plants of treatment and control were collected, cleaned

properly, blotted dry, cut into small pieces and the composite sample was prepared. The composite sample of root, stem, leaf and fruit (fresh or dry) were used for different physiological analysis.

2.9 BIOCHEMICAL CONSTITUENTS:

Biochemical constituents like total soluble proteins, total carbohydrates, DNA and RNA were estimated at 12th DAS in germinating seeds of brinjal. The soluble proteins, total carbohydrates, polyphenols and proline were measured in root, stem, leaf and fruit of brinjal plants at 60th DAS.

2.9.1 Total soluble proteins:

The total soluble proteins were estimated by employing Lowry *et al.* (1951) method. One gram fresh composite sample was homogenized in 10 ml of phosphate buffer, centrifuged and the supernatant was used to prepare the reaction mixture containing reagent C and D. The absorbance of blue colour developed was recorded at 660 nm using spectrophotometer. Bovine serum albumin was used at the concentration of 1 mg / ml as a standard protein, to prepare the standard curve.

2.9.2 Total carbohydrates:

Total carbohydrates were estimated according to the method of Hedge and Hofreiter (1962). One gram fresh composite sample was hydrolyzed in 2.5 N hydrochloric acid for three hours in boiling water bath. It was cooled to room temperature and neutralized with sodium carbonate. The final volume was made up to 100 ml with distilled water. The reaction mixture consisting of Anthrone reagent and plant extract was prepared. The absorbance of the colour developed was recorded at 630 nm by using spectrophotometer. Glucose (1 mg/ml) was used to prepare the standard curve.

2.9.3 Deoxyribose Nucleic Acid (DNA):

DNA was estimated according to the method of Ashwell (1957). One gram fresh composite sample was homogenized in 10 ml of saline sodium citrate solution, centrifuged and the supernatant was used to prepare the reaction mixture containing diphenyl amine reagent. The absorbance of blue colour developed was recorded at

600 nm using spectrophotometer. Standard DNA at the concentration of 1 mg / ml was used to prepare the standard curve.

2.9.4 Ribose Nucleic Acid (RNA):

RNA was estimated according to the method of Ashwell (1957). One gram fresh composite sample was homogenized in 10 ml of citrate buffer, centrifuged and the supernatant was used to prepare the reaction mixture containing orcinol reagent. The absorbance of colour developed was recorded at 660 nm by using spectrophotometer. Standard RNA at the concentration of 1 mg / ml was used to prepare the standard curve.

2.9.5 Polyphenols:

Polyphenols were estimated by following the method of Malick and Singh (1980). One gram of fresh composite sample was homogenized in 80% ethanol, centrifuged and the supernatant was condensed on hot water bath. The final volume was made up to 50 ml with distilled water. The reaction mixture was prepared with Folin-Ciocalteau reagent and 20% Na_2CO_3. The absorbance of blue colour was recorded at 650 nm by using spectrophotometer. Tannic acid at the concentration of 1 mg ml^{-1} was used to prepare the standard curve.

2.9.6 Proline:

Proline content was determined by following the method of Bates *et al.* (1973). One gram composite dried sample was homogenized in 10 ml of 3% sulphosalicylic acid. Two ml aliquot of supernatant was mixed with an equal volume of glacial acetic acid and acid-ninhydrine. The reaction mixture was kept in boiling water bath for one hour, after that the reaction was terminated by placing the tubes in ice bath. To this, 4 ml of toluene was added and it was vigorously shaken for 20-30 seconds. After some time the upper toluene layer was separated and kept at room temperature. The red colour developed was measured at 520 nm on spectrophotometer. Standard proline at the concentration of 1 mg ml^{-1} was used to prepare the standard curve.

2.10 ENZYME ACTIVITIES:

2.10.1 Amylase (E.C. 3.2.1.2):

The activity of enzyme amylase was assayed by using the method of Peter Bernfield (1955). One gram of fresh composite sample was homogenized in 10 ml of calcium chloride solution, centrifuged and the supernatant was used as enzyme source. The enzyme assay was prepared by using 1 ml of 1% starch solution and 1 ml of enzyme. The reaction was terminated by adding 2 ml of dinitrosalicylic acid reagent and 1 ml of 40% potassium sodium tartarate solution. The absorbance was recorded at 560 nm using spectrophotometer. Maltose at the concentration of 1 mg ml^{-1} was used to prepare the standard curve.

2.10.2 Protease (E.C. 3.4.2.2):

The enzyme protease was assayed according to the method of Penner and Ashton (1967). One gram of fresh composite sample was homogenized in 10 ml of 0.1 M phosphate buffer (pH 7). The homogenate was filtered through 4 layered muslin cloth and it was centrifuged in refrigerated centrifuge at 10,000 g for 10 min. The supernatant was used as enzyme source. The enzyme assay was prepared by using 1 ml 0.5% casein (pH 7), 3 ml (0.2 M) phosphate buffer (pH 7) and 1 ml enzyme. The reaction was incubated for 1 hr at 37^0C after which it was terminated by adding 2 ml 5% trichloroacetic acid. After 20 minutes, reaction mixture was centrifuged and 1 ml aliquot from supernatant was taken for estimation of free tyrosine. To this, 4 ml 0.5 N NaOH and 1.2 ml Folin-phenol reagent was added and mixed thoroughly. The absorbance of developed blue colour was read at 660 nm on spectrophotometer. For blank, distilled water was used instead of enzyme source and the same procedure was followed.

2.10.3 Catalase (E.C. 1.11.1.6):

The enzyme catalase was assayed according to the method described by Luck (1974). One gram of fresh composite sample was homogenized in 10 ml 0.067 M phosphate buffer (pH 7) and centrifuged at 10,000 x g for 10 minutes at 0 to 4^0C using refrigerated centrifuge. The supernatant was used as enzyme source. The enzyme assay was prepared by using 3 ml phosphate buffer and 0.5 ml enzyme. The reaction was initiated by the addition of 0.05 ml H_2O_2 and immediately change in optical

density was recorded per minute at 240 nm on spectrophotometer. Activity of an enzyme catalase was expressed as Δ OD min^{-1} g^{-1} fresh wt.

2.10.4 Peroxidase (E.C. 1.11.1.7):

The activity of peroxidase enzyme was determined according to the method of Malik and Singh (1980). One gram of fresh composite sample was homogenized in 10 ml of 0.1 M phosphate buffer (pH 7) and centrifuged at 10,000 x g for 10 min. at 0 to 4^0C using refrigerated centrifuge. The supernatant was used as enzyme source. The enzyme assay was prepared using 2 ml of 0.1 M phosphate buffer (pH 7), 1 ml guaiacol (20 mM) and 1 ml enzyme extract. The reaction was initiated by the addition of 0.05 ml H_2O_2 and immediately change in optical density was recorded at an interval of one minute at 436 nm on spectrophotometer. Activity of an enzyme peroxidase was expressed as Δ OD min^{-1} g^{-1} fresh wt.

2.10.5 Polyphenol oxidase (E.C. 1.14.18.1):

The activity of enzyme polyphenol oxidase was determined following the method of Mahadevan and Sridhar (1982). One gram of fresh composite sample was homogenized in 10 ml of 0.1 M phosphate buffer ((pH 6.1) using pre-chilled mortar and pestle. It was filtered through 4 layered muslin cloth and the filtrate was centrifuged at 10,000 x g for 10 min. at 0 to 4^0C using refrigerated centrifuge. The supernatant was used as enzyme source. The enzyme assay was prepared using 2 ml 0.1 M phosphate buffer (pH 6.1), 0.5 ml enzyme extract and 1 ml 0.01 M catechol and the change in optical density per minute was recorded at 412 nm on spectrophotometer. Activity of an enzyme polyphenol oxidase was expressed as Δ OD min^{-1} g^{-1} fresh wt.

2.10.6 Super oxide dismutase (E.C. 1.15.1.1):

The activity of super oxide dismutase was determined according to the method of Giannopolitis and Ries (1977). One gram of fresh composite sample was homogenized in 10 ml cold K-phosphate buffer (pH 7.8) containing 1% polyvinyl pyrrollidone (PVP) to protect the enzyme from the action of polyphenols. Then it was filtered through 4 layered muslin cloth and the filtrate was centrifuged at 10,000 x g for 20 min at 0 to 4^0C using refrigerated centrifuge. The supernatant was used as enzyme source. The enzyme assay was prepared using 2 ml K-phosphate buffer

(pH 7.8), 0.2 ml methionine (13 mM), 0.1 ml nitroblue tetrazolium (77 µM), EDTA 0.5 ml (0.1 mM), enzyme 0.1 ml and riboflavin 0.1 ml (2 µM). The total volume of reaction mixture was made 3 ml and immediately the absorbance of the assay was measured at 560 nm. Then the reaction mixture was exposed to full sunlight for 30 min and change in (increased) absorbance at 560 nm was measured. The enzyme activity was expressed as units g^{-1} min^{-1}.

2.10.7 IAA oxidase (E.C. 1.13.16):

The activity of enzyme IAA oxidase was determined by using the method of Tang and Bonner (1947). One gram of fresh composite sample was homogenized in cold phosphate buffer (0.1 M, pH 7) in pre-chilled mortar and pestle. The extract was filtered through 4 layered muslin cloth and centrifuged at 10,000 x g for 10 min. at 0 to 4^0C using refrigerated centrifuge. The supernatant was used as enzyme source. The enzyme assay was prepared using 4 ml of IAA (0.01 M), 2 ml of 2-4 dichlorophenol (0.01 M), 0.5 ml of $MnCl_2$ (0.02 M) and 3 ml of 0.1 M phosphate buffer (pH 7) and 2 ml of enzyme extract. During the enzymatic reaction, 2 ml of reaction mixture was pipetted out at different time intervals such as 0, 30 and 60 minutes and 8 ml of Tang and Bonner's reagent was added to it and mixed well and kept for 30 minutes. The optical density of each reaction mixture was then recorded on spectrophotometer at 520 nm.

2.10.8 Nitrate reductase (E.C. 1.6.6.1):

The activity of enzyme nitrate reductase was determined by following the method of Guerrero (1982). One gram of fresh composite sample was homogenized in 10 ml of isolation medium, containing 2 mM potassium phosphate, 1 mM EDTA and 1 mM cystein adjusted to a final pH 8.8 with KOH. Then it was filtered through 4 layered muslin cloth and the filtrate was centrifuged at 30,000 x g for 15 minutes. The supernatant was used as enzyme source. The enzyme assay was prepared using 0.5 ml of phosphate buffer (pH 7.5), 0.2 ml 0.1 M potassium nitrate solution, 0.4 ml 2 mM NADH solution, 0.7 ml D.W. and 0.2 ml enzyme extract. The reaction was terminated by the rapid addition of 1 ml 1% sulphanilamide followed by 1 ml 0.02% naphthyl ethylene diamine reagent. After 30 minutes, the absorbance was measured at 540 nm on spectrophotometer. The amount of nitrite produced was calculated by using a standard graph. Potassium nitrite at the concentration of 1 mg/ml was used to

prepare the standard curve. The activity of an enzyme was expressed as µg NO_2 produced min^{-1} g^{-1} fresh wt.

2.10.9 Nitrite reductase (E.C. 1.6.6.4):

The activity of enzyme nitrite reductase was determined by using the method of Guerrero (1982). One gram of fresh composite sample was homogenized in Tris - HCl buffer (pH 7.5) and centrifuged at 30,000 x g for 15 min. The supernatant was used as enzyme source. The enzyme assay was prepared using 6.25 ml 0.5 M Tris - HCl buffer, 2 ml sodium nitrite solution, 2 ml methyl viologen solution, 14.75 ml D.W. and 0.3 ml enzyme extract. The reaction was started by adding 0.2 ml of recently prepared dithionite-sodium bicarbonate solution and was incubated at 30^0C for 15 minutes. The reaction was terminated by the rapid addition of 1 ml 1% sulphanilamide followed by 1 ml 0.02% naphthyl ethylene diamine reagent. After 30 minutes, the absorbance was measured at 540 nm on spectrophotometer. The amount of nitrite reduced was calculated using a standard graph. Potassium nitrite at the concentration of 1 mg/ml was used to prepare the standard curve. The activity of an enzyme was expressed as µg NO_2 reduced min^{-1} g^{-1} fresh wt.

2.11 WATER RELATIONS:

2.11.1 Relative Water Content (RWC):

Relative water content of leaves was determined by using the method of Hsiao (1973). The composite leaf samples were cut into small discs of uniform size using leaf punch. Twenty-five such discs were weighed to obtain fresh weight. These discs were suspended in distilled water for four hours. The water was poured out carefully, saving the discs, which were surface blotted rapidly and the turgid weight was recorded. These discs were placed in an oven at 60 ± 5 ^{0}C for about 72 hours to get dry weight. The percent relative water content was calculated using the formula given below:

$$\text{RWC (\%)} = \frac{\text{Fresh wt.} - \text{Dry wt.}}{\text{Wt. at full turgid level} - \text{Dry wt.}} \times 100$$

2.11.2 Osmotic Potential of cell sap (O.P.):

Osmotic potential of cell sap was determined following the method of Janardhan *et al*. (1976). 1 g fresh composite leaf sample was homogenized in 10 ml D.W. using mortar and pestle. It was squeezed through 4 layered muslin cloth and the volume of filtrate was adjusted to 25 ml with D.W. The electrical conductance was measured on conductivity meter. Osmotic Potential of cell sap was calculated using the following formula:

$$\text{O P (bars)} = \frac{0.36 \times \text{E.C.} \times \text{d.f.}}{0.987}$$

where, 0.36 = a constant

E.C. = Electrical conductivity of a plant extract (in m mhos cm^{-1} at 25^0C)

d.f. = dilution factor (final volume of extract)

0.987 = Factor for converting atmospheric pressure into bars

2.11.3 Membrane stability:

Membrane stability in terms of percent membrane injury was determined by the method of Premchandra *et al.* (1990). The freshly punched 1 g leaf discs (0.5 cm diameter) were kept in flask containing 25 ml D.W. and were incubated at 30^0C for 4 h. The electrical conductance of this was measured on conductivity meter (C_1). Then the leaf discs were boiled in the same solution for 15 min and cooled to room temperature. The electrical conductance was measured (C_2). The percent membrane injury was calculated using the formula given below:

Membrane stability (% membrane injury) = $[1 - C_1 / C_2] \times 100$

2.12 PHOTOSYNTHETIC PIGMENTS:

2.12.1 Chlorophylls:

Chlorophylls were estimated by using the method of Arnon (1949). 1 g fresh composite leaf material was homogenized in 20 ml 80% acetone, centrifuged at 5000 rpm for 10 min and the supernatant was transferred to a 100 ml volumetric flask. The

residue was again homogenized in 20 ml 80% acetone, centrifuged and the supernatant was transferred to the same volumetric flask. The procedure was repeated until the residue becomes colourless. The final volume was made up to 100 ml using 80% acetone. The volumetric flask was covered with black paper to avoid photo-oxidation of chlorophyll. The absorbance of solution was recorded at 645 and 663 nm on spectrophotometer using 80% acetone as blank.

2.12.2 Carotenoids:

The carotenoids were estimated according to the method suggested by Jensen (1978). The fresh extract of leaf prepared for the estimation of chlorophylls was used for the determination of carotenoids and the absorbance was recorded at 480 nm on spectrophotometer using 80% acetone as blank. The carotenoid content was calculated by using following formula:

$$\text{Carotenoids} = \frac{A_{480} \times V \times 10 \times 100}{2500 \times W}$$

where, A = absorbance at specific wavelength,
V = final volume of extract,
W = fresh wt. of sample extracted

2.12.3 Xanthophylls:

The xanthophyll content was estimated by using the method of Neogy *et al.* (2001). The fresh extract of leaf prepared for the estimation of chlorophylls was used for the determination of xanthophylls. The final volume of extract was made up to 100 ml using 80% acetone and was taken in a separating funnel. Equal volume of hexane was added in a separating funnel. After shaking, the hexane fractions were separated and equal volume of distilled water was added. To separate xanthophylls from carotenoids, equal volume of 90% methanol was added in the hexane fraction containing carotenoids in a standard flask. The absorbance of the solution was recorded at 450 nm using 80% acetone as blank. The xanthophyll content was calculated as per the formula given below:

$$\text{Xanthophylls} = \frac{A_{450} \times V \times 10 \times 100}{2500 \times W}$$

where, A = absorbance at specific wavelength,
V = final volume of extract,
W = fresh wt. of sample extracted

2.12.4 Chlorophyll Stability Index (CSI):

Chlorophyll stability index was determined by the method suggested by Henkel (1975). The total chlorophyll content from known quantity (1 g) of fresh leaf material was analyzed and the same quantity of leaf material was kept in an oven at 60^0C for 1 h. The total chlorophyll content of it was analyzed. CSI was calculated by dividing the total chlorophylls of oven dried tissue by total chlorophylls of fresh tissue.

2.13 PHOTOSYNTHESIS AND PHOTORESPIRATION:

2.13.1 Hill reaction : DCPIP reduction:

The Hill reaction was studied as the light dependent evolution of oxygen by isolated chloroplasts using DCPIP reduction technique (Mannan, 1988).

A. Isolation of chloroplasts:

Isolation medium was prepared using 8.5 ml of 0.15 M phosphate buffer (pH 7.3), 0.5 ml of 0.3 M sucrose, 0.5 ml of 0.2 M EDTA and 0.5 ml of 0.18 M $MgSO_4$. The fresh leaves were first chilled to 0^0C and cut into the pieces of about 1 cm^2 and immersed in isolation medium. Then it was homogenized in ice cold isolation medium using chilled mortar and pestle, filtered through two layers of cheese cloth and centrifuged at 600 x g for 2 min. in cooling centrifuge at 4^0C. The sediment containing mostly whole cells and cell debris was discarded. The green supernatant was centrifuged for 12 min. at 1000 x g. The pellet containing chloroplasts were resuspended in ice-cold 5 ml of 0.3 M sucrose phosphate buffer and centrifuged at 1000 x g for 7 min. The supernatant was discarded and the sediment containing chloroplasts was used for photochemical activities such as DCPIP reduction.

B. DCPIP reduction:

The reaction mixture was prepared using 1 ml 0.05 M phosphate buffer (pH 7.5), 0.5 ml 2 mM DCPIP, 0.5 ml 1 mM $MgCl_2$, 0.5 ml 2 mM NaCl and 0.5 ml chloroplasts. The reduction of DCPIP was measured by following the decrease in absorbance at 620 nm after illuminating the cuvette with projection lamp for 1 min. and expressed as µ mole DCPIP reduced mg^{-1} chl. min^{-1}.

2.13.2 Photosynthetic enzymes:

A. RuBP Carboxylase (E.C. 4.1.1.39):

The activity of an enzyme Ribulose Biphosphate Carboxylase (RuBP Case) was measured as per the method of Kluge and Osmond (1972). The extraction medium was prepared by dissolving 78.5 mg Tris - HCl (pH 7.8, 5 mM), 101.5 mg $MgCl_2$ (5 mM), 39.0 mg 2-mercaptoethanol (5 mM) and 29.2 mg EDTA (1 mM) in 100 ml distilled water. 1 g of fresh composite leaf sample was homogenized in 20 ml ice cold extraction medium using pre-chilled mortar and pestle and centrifuged at 20,000 x g for 10 min at 5^0C. The supernatant was used as enzyme source. The enzyme assay was prepared using 0.8 ml 1 M Tris - HCl (pH 7.8), 0.5 ml $MgCl_2$ (1 mM), 0.5 ml RuBP (1 mM), 0.5 ml 2-mercaptoethanol (5 mM) and 0.2 ml enzyme extract. The reaction was initiated by adding 0.5 ml $NaHCO_3$ (1 mM) and the change in optical density per minute was recorded at 340 nm. The activity of an enzyme was expressed as µ mole CO_2 mg^{-1} chl. min^{-1}.

B. PEP Carboxylase (E.C. 4.1.1.31):

The activity of an enzyme Phosphoenol Pyruvate Carboxylase (PEP Case) was measured using the method of Kluge and Osmond (1972). The enzyme extracted for scoring the activity of RuBP Carboxylase was used for studying the activity of PEP Carboxylase. The enzyme assay was prepared using 0.8 ml 0.1 M Tris - HCl (pH 7.8), 0.5 ml $MgCl_2$ (1 mM), 0.5 ml $NaHCO_3$ (10 mM), 0.5 ml PEP (5 mM) and 0.2 ml enzyme extract. The reaction was initiated by adding 0.5 ml NADH (0.4 µM) and the change in optical density per minute was recorded at 340 nm. The activity of an enzyme was expressed as µ mole CO_2 mg^{-1} chl. min^{-1}.

2.13.3 Photorespiratory enzyme:

A. Glycolate oxidase (E.C. 1.1.3.1):

The activity of enzyme glycolate oxidase was scored spectrophotometrically in which the absorbance increased due to formation of glycolate phenylhydrazone was measured at 340 nm using the method of Hess and Tolbert (1967). The enzyme extracted for scoring the activity of RuBP Carboxylase was used for assaying glycolate oxidase activity. The enzyme assay was prepared using 1 ml 0.1 M phosphate buffer (pH 8.3), 0.5 ml phenyl hydrazine hydrochloride (0.1 M), 0.5 ml cystein (0.1 M) and 0.5 ml enzyme extract. The reaction was initiated by adding 0.5 ml Glycolate (0.1 M). The change in optical density per minute was recorded at 340 nm. The activity of an enzyme was expressed as μ mole CO_2 mg^{-1} chl. min^{-1}.

2.14 MINERAL NUTRIENTS:

Mineral contents in root, stem, leaf, fruit and rhizosphere soil of brinjal were analyzed at 60th DAS as per the method of Toth *et al*. (1948). 1 g dried composite sample was firstly digested with 20 ml concentrated nitric acid on hot plate till the solid particles get dissolved and then with 15 ml perchloric acid till the solution became colourless. After cooling, the volume was made up to 100 ml with D.W. and was kept overnight. Then it was filtered and the filtrate was used for analyzing different mineral elements like total nitrogen, total phosphorus, total potassium, calcium, magnesium, zinc, copper, iron and manganese using Atomic Absorption Spectrophotometer (Perkin Elmer - 3030).

2.15 YIELD ATTRIBUTES:

The various yield attributes like days required for flower initiation, days to 50% flowering, length of flowering period, number of flowers per plant, flower to fruit ratio, length of fruiting period, number of fruits per plant, length, diameter and weight of fruits, number of seeds per fruit, weight of 100 seeds, total wt. of seeds per fruit to fruit weight ratio, yield per plant and shelf life of fruits were measured at 60th DAS by using standard laboratory methods.

2.16 BIOCHEMICAL CONSTITUENTS IN FRUITS:

pH, total acid, total solids, total soluble solids, moisture percent, fiber and ash content were measured by using the methods described by Rangana (1977).

2.16.1 pH:

1 g of fresh composite sample was grinded in 100 ml D.W. using blender and pH was measured using pH meter (Elico LI - 120).

2.16.2 Total acid:

2 g of fresh composite sample was grinded in 200 ml D.W. using blender. The mixture was collected in a beaker. The sample solution was titrated against 0.1 N NaOH using phenolphthalein as an indicator. Appearance of light pink colour denoted the end point. The reading was noted and total acid was calculated by using the formula given below:

$$\text{Total acid (\%)} = \frac{1 \times \text{Eq. wt. of acid} \times \text{Normality of NaOH} \times \text{Titration reading} \times 100}{10 \times \text{wt. of sample}}$$

2.16.3 Total solids:

25 g of fresh composite sample was taken in a large dish and weighed (A). Then it was kept in oven for overnight at 60^0C temperature. After cooling, the oven dried sample was weighed (B). Total solids were calculated by subtracting dry weight of sample from fresh weight of sample and were expressed in grams per 100 g.

2.16.4 Total soluble solids (TSS):

1 g of fresh composite sample was grinded in 100 ml D.W. using blender. The mixture was collected in a beaker. One drop of mixture was put on a glass surface of hand refractometer equipped with a percent scale. The refractometer was cleaned after each observation. TSS was expressed in percentage.

2.16.5 Moisture percent:

1 g of fresh composite sample was grinded in 100 ml D.W. using blender. The mixture was collected in a beaker and boiled for 20 min. After cooling, it was filtered

through Whatman No. 1 filter paper and the residue was collected in a preweighed covered weighing dish (W_1) and it was weighed (W_2). The weighing dish was kept covered in oven at 60^0C for 3 hour, cooled and reweighed (W_3). Moisture content was calculated as per the formula given below:

$$\text{Moisture (\%)} = \frac{(W_2 - W_1) - (W_3 - W_1) \text{ x } 100}{\text{Wt. of the sample}}$$

2.16.6 Fiber percent:

1 g dried composite sample was homogenized in 10 ml petroleum ether and filtered through Whatman No. 1 filter paper. The residue was collected and kept in oven at 60^0C for 1 h. Dried material was boiled in 100 ml 1.25% H_2SO_4 for 30 min. After cooling, it was filtered through muslin cloth and the residue was washed using boiling water and again the residue was boiled in 100 ml 1.25% sodium hydroxide solution for 30 min. After cooling, the residue was filtered through muslin cloth and washed with boiling water. The residue was then taken in preweighed ashing dish (W_1) and dried for 2 h at 130^0C. After cooling, the dish was weighed (W_2) and ignited for 30 min. at 500^0C. It was cooled and reweighed (W_3). Fiber content was calculated as per the formula given below:

$$\text{Fiber (\%)} = \frac{(W_2 - W_1) - (W_3 - W_1) \text{ x } 100}{\text{Wt. of the sample}}$$

2.16.7 Ash content:

20 g of fresh composite sample was taken in a porcelain dish and was heated at 90^0C for 1 h or till all the water was lost. It was then kept in muffle furnace at about 525^0C until it was converted to white ash. No black speck should appear in the ash. Ash content was calculated by subtracting dry weight of sample from fresh weight of sample and expressed it in grams per 100 g.

2.16.8 Ascorbic acid (vitamin C):

Ascorbic acid content was estimated using method of Omaye *et al.* (1979). 0.5 g of fresh composite sample was homogenized in 25 ml of 4% aqueous oxalic acid solution and centrifuged at 5000 x g for 10 minutes. 10 ml of supernatant was taken in

a conical flask and bromine water was added drop wise with constant mixing till the extract turns orange yellow. The enolic hydrogen atoms in ascorbic acid were removed by bromine. The final volume of extract was made up to 25 ml by the addition of 4% oxalic acid solution. Similarly, 10 ml of working standard solution (Ascorbic acid at the concentration of 1 mg / ml) was converted into dehydro form by bromination. 1 ml of standard dehydro-ascorbic acid solution was taken into a series of test tubes along with brominated sample extract in a separate test tube. 3 ml distilled water and 1 ml 2% DNPH reagent were added in each test tube. Then 1-2 drops of thiourea was added in each tube and the contents of the tubes were mixed thoroughly and the tubes were incubated at 37^0C for 3 h. After incubation, the orange-red osazone crystals formed were dissolved by adding 7 ml of 80% sulphuric acid. The absorbance was recorded at 540 nm on spectrophotometer and the ascorbic acid content in the sample was calculated using the standard curve.

2.17 RHIZOSPHERE SOIL ANALYSIS:

Rhizosphere soil samples were collected from vicinity of roots of ten different treated and control plants on 60^{th} DAS and mixed thoroughly. Samples were collected in sterile polythene bags and were brought to laboratory for analysis.

2.18 PHYSICAL PROPERTIES:

The fine components of rhizosphere soil were used for analysis. 1:5 soil-water extract was prepared and pH was recorded on pH meter (Elico LI - 120) and Electric conductivity was recorded on E.C. meter (EQ 660 A). Soil temperature was measured using soil thermometer.

Soil moisture, bulk density, soil porosity and water holding capacity of soil were measured according to the methods described by Gupta (2005).

2.18.1 Soil moisture:

1 g of soil sample was taken on a preweighed watch glass and was kept in oven at 105^0C till constant weight was attained. Moisture content was calculated by subtracting the dry weight of soil from fresh weight of soil and was expressed in percentage.

2.18.2 Bulk density and Soil porosity:

Soil sample was dried in oven at 105^0C till constant weight was attained and a part of this soil was transferred to the measuring cylinder and the volume was determined (A). Also the wt. of soil was determined by first weighing measuring cylinder and the soil (B) and then the measuring cylinder alone (C). Bulk density and soil porosity was calculated as per the formulae given below:

$$\text{Bulk density (g / cm3)} = \frac{B - C}{A}$$

$$\text{Soil porosity (\%)} = \frac{2.6 - \text{Bulk density}}{2.6} \times 100$$

where, 2.6 = the approximate specific gravity of soil

2.18.3 Water holding capacity:

Soil sample was allowed to dry in air and then it was crushed. A tin box with perforated bottom was taken and weighed (1). Then a filter paper was taken and weighed (2). Now a filter paper was placed at the bottom of the box and the box was filled gradually with soil by tapping to ensure uniform filling and it was placed in a petridish containing water. It was allowed to remain overnight and weighed (3). This container was placed in oven at 105^0C for about 24 h, till constant wt. was attained and it was weighed (4). The same filter paper (similar to one used in container) was taken and dipped in water and the average amount of water absorbed by the filter paper was found out. The results were calculated in the following way:

1. Wt. of the box
2. Wt. of dry filter paper
3. Wt. of wet soil + box + wet filter paper
4. Wt. of dry soil + box + dry filter paper
5. Wt. of wet filter paper
6. Wt. of wet soil = (3) – (1 + 5)
7. Wt. of oven dry soil = (4) – (1 + 2)
8. Water in soil = (6) – (7)

9. Water holding capacity $= \frac{(8)}{(7)} \times 100$

2.19 ORGANIC CARBON AND ORGANIC MATTER:

Organic carbon and organic matter were estimated titrometrically using Walkley and Black's method as described by Gupta (2005).

1 g of soil sample was taken, crushed and placed in a dry 500 ml conical flask. 10 ml potassium dichromate and 20 ml conc. H_2SO_4 were added in it and the contents of the flask were shaked and kept aside on an asbestos sheet for 30 min. Then 200 ml water, 10 ml phosphoric acid and 1 ml diphenyl amine indicator were added. The contents of the flask attained a bluish purple colour. This solution was titrated against 0.5 N ferrous ammonium sulphate (FAS) till the colour changed and the reading was noted as 'X' ml. 10 ml of 1 N $K_2Cr_2O_7$ was taken in another conical flask. Then 20 ml conc. H_2SO_4, 10 ml phosphoric acid and 1 ml diphenyl amine indicator were added and titrated it with 0.5 N ferrous ammonium sulphate solution till green colour was obtained. The reading was noted as 'Y' ml. The percentage of organic carbon and organic matter was calculated as per the formulae given below:

$$\text{Organic carbon (\%)} = \frac{(Y - X) \times N \times 0.003 \times 100}{\text{Wt. of soil}} \times \frac{4}{3}$$

where, N = Normality of standard FAS solution (0.5494)

$\frac{4}{3}$ = Factor is used because in this method, only about 75% of organic matter is oxidized (100 / 75 = 4 / 3).

Organic matter (%) = organic carbon x 1.724

2.20 BIOLOGICAL PROPERTIES:

Heterotrophic bacteria, non-symbiotic nitrogen fixing bacteria and soil fungi were isolated from rhizosphere soil of brinjal by using serial soil dilution method on nutrient agar medium, Ashby's Mannitol agar medium and Czapek-Dox agar medium respectively and observed daily for appearance of colony. Colony Forming Unit (CFU) was calculated as per the formula given below:

$$\text{CFU / g soil} = \frac{\text{No. of colonies x Dilution factor}}{\text{Dry wt. of soil}}$$

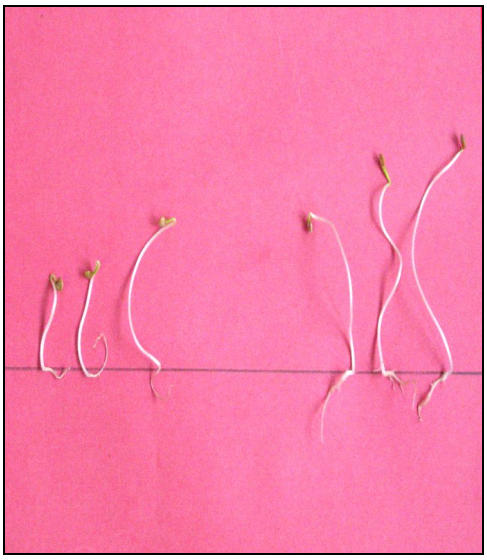
Bacterial colonies were identified on the basis of colony characters, Gram staining and catalase test with the help of authentic literature such as Alexander (1961) and fungal colonies were identified on the basis of mycelium and reproductive organs produced with the help of authentic literature such as Mehrotra and Aneja (1990).

2.21 STATISTICAL ANALYSIS:

All the measurements were done in five replicates and were expressed as mean ± S.D. Statistical comparisons were made by means of student's t - test and $p < 0.05$ is considered as significant.

CHAPTER – III

RESULTS AND DISCUSSION



CHAPTER - III

RESULTS AND DISCUSSION

3.1 PILOT EXPERIMENT:

Results:

The results recorded in Table 3.1 and shown in Plate VII illustrated that 1% dose of oxygenated peptone was most superior to induce increased seed germination percentage, seedling height, biomass and vigour index than other doses of oxygenated peptone (0.5%, 1.5% and 2%) and control. All the results are statistically significant at 1% dose of oxygenated peptone. But other results are non significant. Hence, in future experiments, only 1% oxygenated peptone dose was selected for the present study.

3.2 SEED GERMINATION AND SEEDLING GROWTH:

Results:

The results recorded in Table 3.2 and shown in Plate VIII on seed germination indicated significant increase in seed germination of treated seeds as compared to control. The percent increase in seed germination was 13.3%, in root length 9.0%, and in shoot length 47.7%. The biomass in terms of fresh weight increased by 20.0% while the dry weight increased by 25.0%. Vigour index, mobilization efficiency and emergence index in treated seeds was increased by 26.4%, 36.0% and 20.0% respectively. Speed of germination enhanced by 12.0%, while the coefficient of velocity of germination was increased by 12.8%.

Discussion:

Pre-sowing seed treatment or seed priming is an easy technique to improve germination performance. Pre-sowing soaking treatment by hydro-priming is actually osmo-conditioning, a physiological method which improves seed performance and provides faster and synchronized germination (Siveritepe and Dourado, 1995). Caseiro *et al.* (2004) found that hydro-priming was the most effective method for improving seed germination of onion. Harris *et al.* (1999) showed that under normal conditions, hydro-priming is effective for germination and later growth of maize, rice

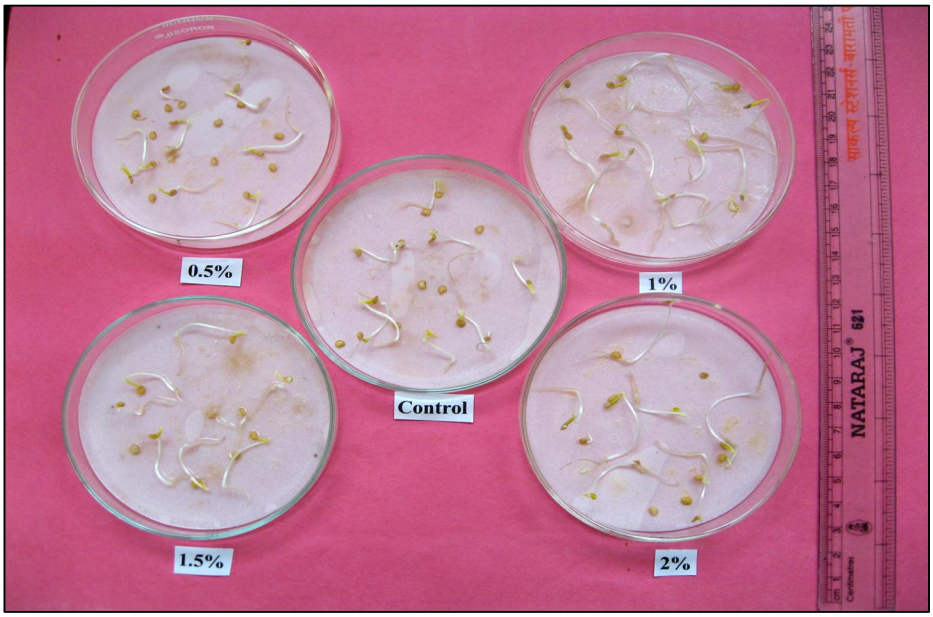
Table 3.1 Effect of pre-sowing soaking treatment of different doses of oxygenated peptone on seed germination and seedling growth of brinjal (*Solanum melongena* L. cv. Ajay) at 6th DAS.

Parameters	Control	Treatments			
		0.5%	**1.0%**	**1.5%**	**2.0%**
Germination %	75.0 ± 0.4	65.0^{ns} ± 0.2	85.0* ± 0.4	55.0^{ns} ± 0.2	50.0^{ns} ± 0.1
Root length (cm)	2.42 ± 0.1	1.2^{ns} ± 0.05	2.64* ± 0.8	1.5^{ns} ± .06	1.4^{ns} ± 0.05
Shoot length (cm)	3.5 ± 0.1	3.0^{ns} ± 0.12	5.17* ± 0.2	4.5* ± 0.12	3.5 ± 0.1
Fresh wt. (g / 10 seedling)	0.40 ± 0.1	0.38^{ns} ± 0.1	0.48* ± 0.1	0.45* ± 0.1	0.38^{ns} ± 0.1
Dry wt. (g / 10 seedling)	0.04 ± 0.01	0.02^{ns} ± 0.01	0.05* ± 0.01	0.04 ± 0.01	0.02^{ns} ± 0.01
Vigour index	517.0 ± 1.0	273.0^{ns} ± 0.5	654.0* ± 1.2	330.0* ± 0.6	245.0^{ns} ± 0.5

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and 'ns' represent significance at $p < 0.05$ and non significance respectively.

PLATE VII

Effect of pre-sowing soaking treatment of different doses of oxygenated peptone on seed germination and seedling growth of brinjal (*Solanum melongena* L. cv. Ajay) at 6th DAS.



A: Seed germination

B: Seedling growth

Table 3.2 Effect of pre-sowing soaking treatment of 1% oxygenated peptone on seed germination and seedling growth of brinjal (*Solanum melongena* L. cv. Ajay) at 6th DAS.

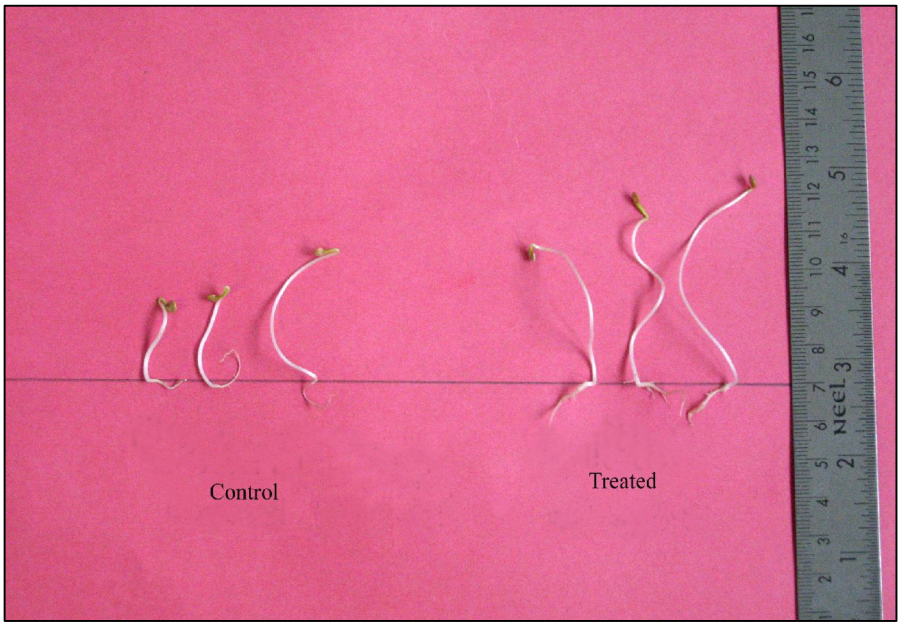
Parameters	Control	Treated	Increase (%)
Germination %	75.0 ± 0.4	85.0* ± 0.4	13.3
Root length (cm)	2.42 ± 0.1	2.64* ± 0.8	9.0
Shoot length (cm)	3.5 ± 0.1	5.17* ± 0.2	47.7
Shoot / Root	1.44	1.95*	35.4
Fresh wt. (g / 10 seedling)	0.40 ± 0.1	0.48* ± 0.1	20.0
Dry wt. (g / 10 seedling)	0.04 ± 0.01	0.05* ± 0.01	25.0
Vigour index	517.0 ± 1	654.0* ± 1.2	26.4
Mobilization efficiency	200.0 ± 0.8	272.0* ± 0.9	36.0
Emergence index	0.5 ± 0.04	0.6* ± 0.04	20.0
Speed of germination	2.5 ± 0.05	2.8* ± 0.05	12.0
Coefficient of velocity of germination	12.5 ± 0.12	14.1* ± 0.12	12.8

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' represents significance at $p < 0.05$.

PLATE VIII

Effect of pre-sowing soaking treatment of 1% oxygenated peptone on seed germination and seedling growth of brinjal (*Solanum melongena* L. cv. Ajay) at 6th DAS.

A: Seed germination



B: Seedling growth

and chickpea. Seed priming has been successfully demonstrated to improve seed germination and emergence in seeds of vegetables (Heydecker and Coolbaer, 1997). In the present investigation, hydro-priming was achieved in control seeds, while in treated seeds, in addition to it, super oxygenation was achieved, which benefited the germinating seeds to improve percent seed germination, seedling growth, biomass, vigour index, mobilization efficiency and the other parameters.

The seeds of brinjal showed positive response to pre-sowing soaking treatment of oxygenated peptone as evident from Plate VIII. Adequate supply of oxygen through oxygenated peptone, might be stimulating the citric acid pathway, liberating more energy per hexose molecule and suppressing the anaerobic pathway, which liberate less energy. Wijte and Gallagher (1996 a) observed reduced seed germination percentage, under decreased oxygen level in *Spartina alterniflora*. They further reported that, under anoxia in the early stages of development, there was no plumule or root growth (Wijte and Gallagher, 1996 b). The results of the present investigation are in agreement with Cherif *et al.* (1997). They proposed that high oxygen treatment resulted in an increase in plant growth in terms of shoot and root biomass in tomato. Williumsen and Roeber (1997) also noted that less aeration in propagation substrates restricted the germination and initial growth of seedlings of cabbage.

Besides oxygen, the oxygenated peptone used in the present investigation for pre-soaking treatment of seeds contains peptone, a soluble form of nitrogen, which is supplied to the germinating seeds, resulting into better seedling growth. Bose and Pandey (2003) found that soaking of seeds of okra with various nitrate salts prior to sowing caused positive impact on germination as well as seedling growth. Trigo and Trigo (1999) studied the effect of seed priming with water and potassium nitrate on brinjal seeds and recorded improvement in germination, radical length, biomass accumulation and emergence of radical and plumule.

Seed priming has been used to increase germination rate and seedling uniformity, mainly under unfavorable environmental conditions. Nascimento (2005) reported that primed seeds of brinjal cv. Cica had higher germination performance compared to unprimed seeds especially at low temperatures. The results of present investigation, in which priming of the brinjal seeds was done with oxygenated peptone, support the work of Demir and Okcu (2004). They gave aerated hydration treatment to seeds of brinjal cv. Pala, which caused significant increase in percent

germination. It also induced the increase in seedling dry weight. It was suggested that aerated hydration treatment can improve establishment of brinjal seedlings.

Vigour Index (VI) is the important criterion to assess the effect of any external factor on seed germination and seedling growth, because it is calculated on the basis of germination percentage, root length and shoot length. The results of present investigation indicated the higher vigour index by pre-soaking treatment with oxygenated peptone. Same is true for mobilization efficiency, emergence index, speed of germination and coefficient of velocity of germination. These observations are supported by Parera and Cantliffe (1994). They had reported that faster emergence gives the seedlings a longer time to develop. An increase in biomass and enhanced seedling vigour observed in the present investigation of brinjal will obviously lead to establishment of good and healthy crop stand leading to increase in crop productivity.

Gupta (1971) reported that pre-sowing treatments with GA, IAA or NAA enhanced seed germination in brinjal. There are many reports which indicate increase in germination percentage and seedling vigour using plant growth regulators like gibberellic acid, kinetin, naphthaleic acid and indole butyric acid in green gram and black gram (Patel and Saxena, 1994). Xu *et al.* (1997) reported that the growth regulators caused improvement in germination performance, percent germination and shortening of the germination time in brinjal. Wang (2001) found that GA treatment significantly advanced seed germination and increased germination percentage in brinjal. According to Taiz and Zeiger (2002) seed germination is a highly orchestrated process, which is regulated by the interaction of plant growth regulators especially GA, IAA and ABA. Ruiz *et al.* (2006) claimed that, enhancement in germination parameters of *Bromus auleticus* by soaking in 0.05% gibberellic acid induced the activity of endogenous hormones involved in seed germination and thereby caused increase in seed germination.

The exogenous supply of plant growth regulators is avoided in organic farming as they enter the metabolic pathways of plant and alter it. The beauty of present investigation is that the enhancement in germination parameters is achieved by oxygenated peptone treatment in most natural way, by supplying oxygen which supported germination.

3.3 BIOCHEMICAL CONSTITUENTS IN GERMINATING SEEDS:

Results:

The results recorded in Fig. 3.1 showed significant increase in soluble proteins (25.0%) and total carbohydrates (50.0%) in treated seeds over untreated once. The contents of DNA and RNA were also increased to the tune of 47.0% and 50.0% respectively.

Discussion:

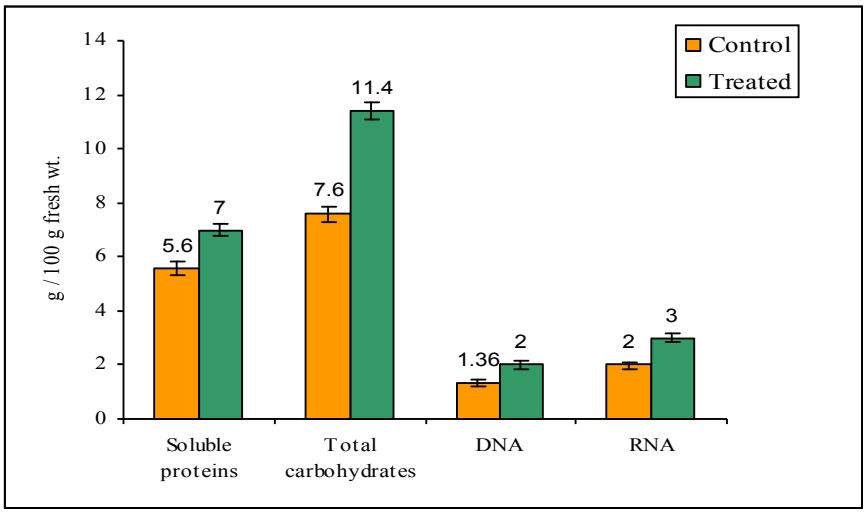
Seed germination is associated with degradation and mobilization of reserve food materials accumulated during seed maturation. The efficiency of reserve food mobilization during germination and seedling establishment mainly depends on these factors. It is also coupled with activation of enzymes. The seed germination and mobilization of storage reserves are independently regulated (Fait *et al.,* 2006). The results of present investigation, where soluble proteins and total carbohydrates showed increase along with increase in the enzyme activity of protease and amylase support this. Interestingly, Qiu *et al.* (2005) studied the effects of cerium on aubergine seed germination and seedling growth under cold stress. They found that cerium alleviated the adverse effects of cold stress enhancing seed vigour and seedling growth. They remarked that these effects may be closely associated with increase in soluble proteins and sugar content. The increased proteins and carbohydrates by the treatment of oxygenated peptone may also be helpful to brinjal seedlings to establish under environmental stress conditions in better ways.

3.4 ENZYME ACTIVITIES IN GERMINATING SEEDS:

Results:

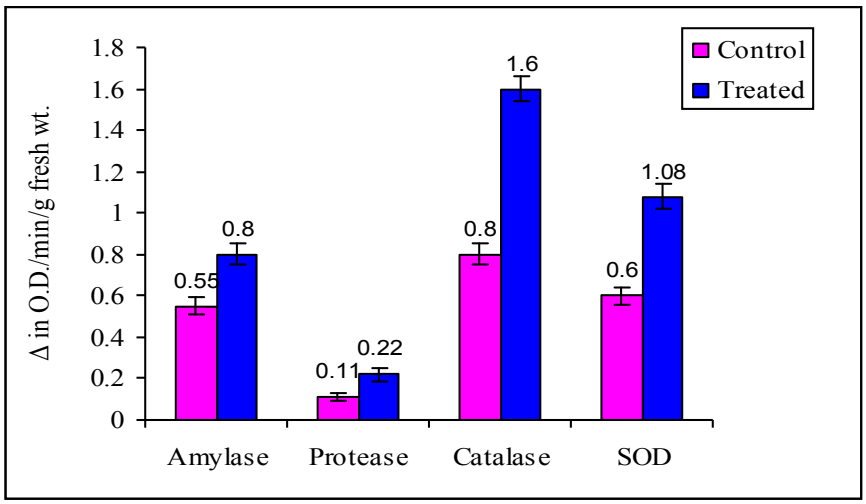
The results shown in Fig. 3.2 revealed that, there was 100.0% increase in the activity of protease and catalase, while the activity of super oxide dismutase and amylase was stimulated by 80.0% and 45.4% respectively, under experimental conditions using oxygenated peptone for priming as compare to control.

Fig. 3.1 Effect of pre-sowing soaking treatment of 1% oxygenated peptone on biochemical constituents in germinating seeds of brinjal (*Solanum melongena* L. cv. Ajay) at 12th DAS.



Values are mean of five determinations and the error bars represent standard deviation.

Fig. 3.2 Effect of pre-sowing soaking treatment of 1% oxygenated peptone on enzyme activities in germinating seeds of brinjal (*Solanum melongena* L. cv. Ajay) at 12th DAS.



Values are mean of five determinations and the error bars represent standard deviation.

Discussion:

The peptone content of oxygenated peptone supplies organic nitrogen. The super-oxygenation during early stages of germination may be helpful for enhanced seed germination in brinjal. Sousa *et al.* (2002) reported that along with respiration, nitrogen metabolism is affected under hypoxic condition. Under present experimental condition, there was super-oxygenation, along with supply of nitrogen in soluble organic form (peptone), which might have accelerated the enzyme activities of amylase, protease, catalase and SOD.

The oxygenated peptone might be acting as the dormancy breaking agent (Patil *et al.,* 2006). Muhyaddin and Wiebe (1989) suggested that the enzymes are activated with accompanying mobilization of reserve food materials, ending in transport of reserve materials in the embryo by osmotic conditioning. The activity of protease in germinating seeds of brinjal was promoted by gibberellic acid (Agarwal and Tayal, 1987) and inhibited by 2, 4, 5-trichlorophenoxy acetic acid (Gangadhar and Kunhi, 2000) and 3-chloro and 4-chlorobenzoate (Ajithkumar *et al.,* 1998). Li *et al.* (2006) studied the effect of polyvinyl alcohol on germination of brinjal seeds. They found that after osmo-regulation, peroxidase and catalase activity was increased. The oxygenated peptone might be acting as growth regulators, enhancing the soluble proteins, carbohydrates and stimulating the activity of above mentioned enzymes.

Reactive oxygen species (ROS) cause damage to proteins, lipids and nucleic acids. To prevent this, anti-oxidant system is very useful (Zubini *et al.,* 2005). The enzyme super oxide dismutase catalyses the dismutation of super oxide radicals (ROS) to hydrogen peroxide and oxygen. In higher plants, SOD plays a major role in combating oxygen radical mediated toxicity (Raychaudhari, 2000; Plazek and Zur, 2003). In the present investigation, the increased activity of SOD and catalase might be playing a similar role.

3.5 VEGETATIVE GROWTH:

3.5.1 Pilot experiment:

Results:

The results recorded in Table 3.3 and shown in Plate IX clearly illustrated that 2g dose of oxygenated peptone was most superior to enhance vegetative growth

Table 3.3 Effect of different doses of soil application of oxygenated peptone on vegetative growth of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treatments			
		1g	2g	3g	4g
Plant height (cm)	17.4 ± 0.5	20.0* ± 0.15	32.4** ± 0.5	25.0* ± 0.2	22.0* ± 0.17
Number of leaves per plant	8.0 ± 0.5	6.0* ± 0.2	18.5** ± 0.52	7.8^{ns} ± 0.2	6.5* ± 0.1
Leaf area (cm^2)	149.7 ± 1.21	125.4* ± 1.5	247.3** ± 1.34	150.0^{ns} ± 1.4	134.8* ± 1.2

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*', '**' and 'ns' represent significance at $p < 0.05$, $p < 0.01$ and non significance respectively.

PLATE IX

Effect of different doses of soil application of oxygenated peptone on vegetative growth of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

parameters in brinjal plants like plant height, number of leaves per plant and leaf area than other doses of oxygenated peptone (1g, 3g and 4g) and control. All the growth parameters showed significant increase in 2g dose of oxygenated peptone as compared to other doses of oxygenated peptone. Hence, in future experiments only 2g dose of oxygenated peptone was selected for present study.

3.6 ROOT, STEM AND LEAF ANALYSIS:

3.6.1 Growth parameters:

Results:

The results shown in Table 3.4 and Plate X revealed that the root and stem length of treated plants was increased by 42.8% and 86.2% respectively as compared to control plants. The diameter of root enhanced by 25.0%, while that of stem increased by 40.0%. The number of secondary roots and secondary branches showed increase by 166.6% and 86.3% respectively. The fresh weight of root and stem was increased by 47.9% and 31.4% respectively, while the dry weight showed enhancement by 76.0% and 11.5%. The improvement in the root system is well depicted in Plate XI. Results exhibited in Table 3.5 showed significant increase in number of leaves per plant, leaf area and leaf area index by 131.2%, 65.1% and 38.4% respectively in treated plants over control. At the same time, the fresh weight showed 66.6% increase while the dry weight showed 77.7% increase.

Discussion:

Jackson *et al.* (1991) observed that hypoxic condition leads to decrease in leaf size of *Ficus*. Our observations are indirectly supported by Atwell and Steer (1990), who reported that lack of aeration in the medium led to 25% decrease in fresh weight of shoot and impaired leaf elongation but not dry weight, suggesting that lack of oxygen in the roots impaired cell expansion in shoots. In the present investigation, it seems that the aeration by oxygenated peptone caused enhancement in growth parameters of root and shoot which led to increase in the growth parameters of leaf.

Table 3.4 Effect of soil application of oxygenated peptone on growth parameters of root and stem of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Root			Stem		
	Control	Treated	Increase (%)	Control	Treated	Increase (%)
Length (cm)	7.0 ± 0.11	10.0* ± 0.10	42.8	17.4 ± 0.5	32.4** ± 0.5	86.2
Diameter (cm)	0.8 ± 0.05	1.0* ± 0.02	25.0	1.0 ± 0.05	1.4* ± 0.05	40.0
Number of secondary roots per plant	90.0 ± 0.41	240.0** ± 0.42	166.6	-	-	-
Number of branches per plant	-	-	-	2.2 ± 1	4.1** ± 1.2	86.3
Fresh weight (g)	6.42 ± 0.02	9.50* ± 0.01	47.9	10.8 ± 0.5	14.2* ± 0.5	31.4
Dry weight (g)	1.42 ± 0.1	2.28** ± 0.12	76.0	2.78 ± 0.05	3.1* ± 0.05	11.5

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

Table 3.5 Effect of soil application of oxygenated peptone on growth parameters of leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
Number of leaves / plant	8.0 ± 0.5	18.5** ± 0.52	131.2
Leaf area (cm^2)	149.7 ± 1.21	247.3** ± 1.34	65.1
Leaf area index	0.26 ± 0.1	0.36* ± 0.11	38.4
Fresh wt. (g)	2.1 ± 0.02	3.5** ± 0.01	66.6
Dry wt. (g)	0.9 ± 0.01	1.6** ± 0.06	77.7

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

PLATE X

Effect of soil application of oxygenated peptone on vegetative growth of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

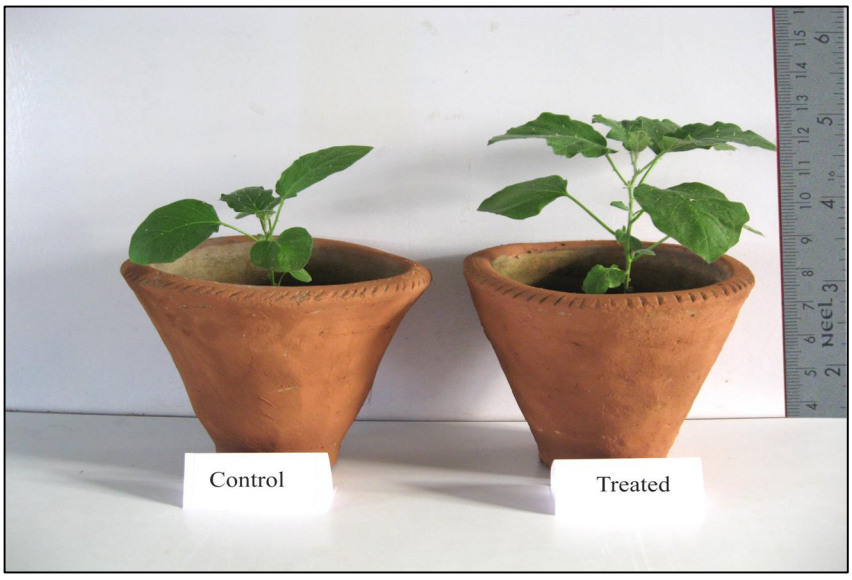


PLATE XI

Effect of soil application of oxygenated peptone on root system of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

3.6.2 Anatomical features:

Results:

T. S. of root showed increase in aerenchyma in cortex and pith region by 70.0% in the treated plants over control, while the T. S. of stem showed increase by 81.0% in the treated plants (Plate XII).

Discussion:

Internal transport of gases from shoot to root and vice-versa is crucial for vascular plants. According to Colmer (2003), aerenchyma provides a low resistance internal pathway for this gas transport. This pathway is useful to transport oxygen from shoot to root and to rhizosphere, while the same pathway is useful for the transport of carbon dioxide, ethylene and methane from soil to shoot and to the atmosphere. According to Belonogova and Chirkova (1995), the ability of oats to produce supplementary roots and to transport oxygen from leaves to roots enabled them to survive for a longer time under flooded conditions. Although plants transport large amount of oxygen between shoot to root, most of it is consumed for respiration within the shoot before it reaches to root system. Secondly, oxygen from shoot enters the rhizosphere through root apex and it is used for respiration by the microbes present in the rhizosphere which are supported by carbon compounds derived from the plant in the form of root exudates (Bedford *et al.,* 1991). The oxygen released from oxygenated peptone might be helpful for the development of aerobic conditions around the rhizosphere of treated plants, which might be enhancing the absorption of water and minerals by roots. At the same time, the peptone must be helping to maintain the energy status of existing roots and for the formation of new roots. Root growth plays decisive role in the spatial availability of most of the nutrients, because of the restricted movement of nutrients by diffusion through soil (Marschner, 1998). As stated by Helal and Mengal (1981) and Meiri and Plaut (1985), improved photosynthesis causes the increase in root growth and nutrient acquisition.

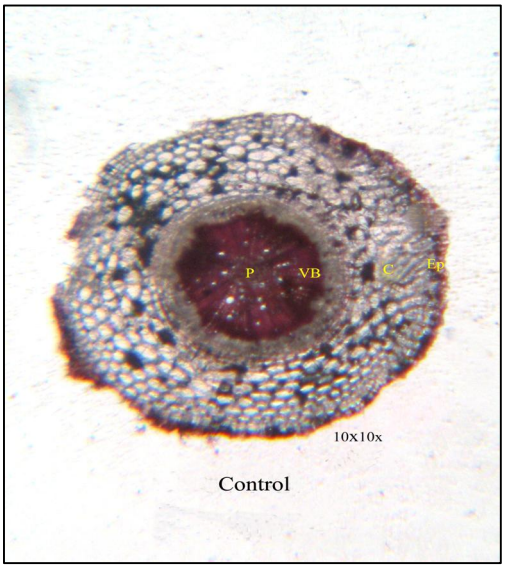
High rate of respiration during night time consumes most of the oxygen present within the shoot system. So oxygen concentration gradient develops between the shoot and rhizosphere. As stomata are closed during night and there is no

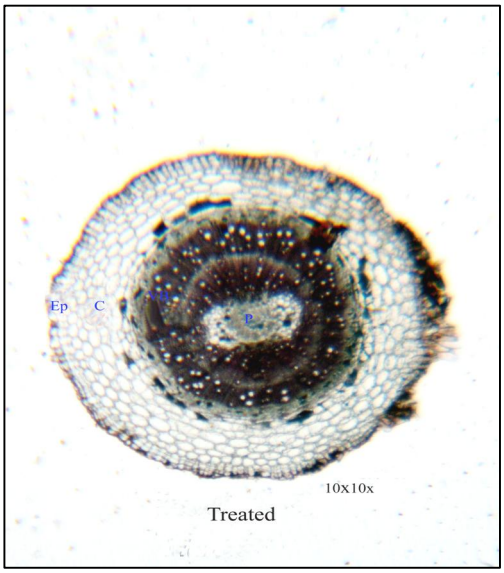
communication of internal parts of shoot with the atmosphere, the only pathway to get oxygen is from soil through roots. So oxygen from soil enters the root system and

PLATE XII

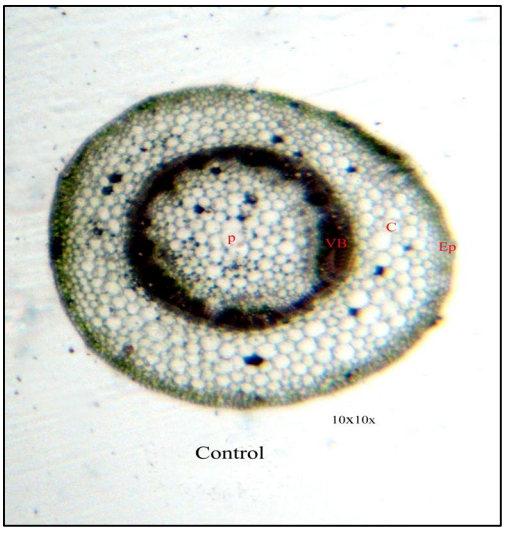
T. S. of root and stem of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS showing increase in aerenchyma in cortex and pith region in oxygenated peptone treated plants over control plants.

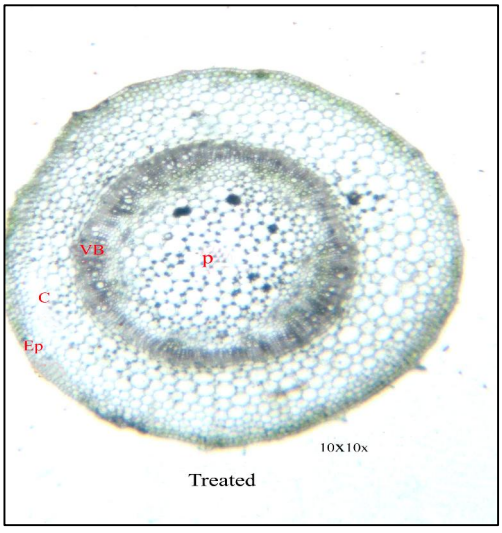
A: Root T.S.





B: Stem T.S.





Ep : Epidermis, C : Cortex, VB : Vascular Bundle, P : Pith

diffuses into shoot system. The rate of oxygen diffusion from root to shoot during night increases because the internal temperature of shoot is higher than the temperature of ambient air. Thus it seems that the demand for oxygen by plant tissue is fulfilled during day by atmospheric oxygen and during night by soil oxygen.

The increase in length and diameter of root in the present investigation is correspondingly reflected in length and diameter of stem. The vigorous growth of root with increase in the number of secondary roots and biomass is useful to the plant to absorb more nutrients from different soil pockets, which leads to enhanced stem growth. This observation can be attributed to improved soil micro-climate as a result of supply of oxygen and peptone by oxygenated peptone. According to Stockdale *et al.* (2002), soil fertility is defined as the ability of soil to provide the favourable conditions required for plant growth and it is a result of physical, chemical and biological processes that act together to provide nutrients, water, aeration and stability to the plant. The improved soil micro-climate in the present investigation leads to enhancement in root and shoot growth. This is supported by the observation of Soffer *et al*. (1991), who recorded production of leaves at a faster rate in *Ficus* plant growing in oxygen saturated water in aero-hydroponics. High oxygen demand in soil resulting from intense oxygen consumption for respiration of root cells and soil microbes influences oxygen transport from soil to plant, affecting root elongation and shoot growth. Oxygenated peptone avoids such type of soil reduction and improves the soil micro-climate so that it becomes favorable for plant growth. Stockdale *et al*. (2002) stated that nutrient management in organically managed soils is fundamentally different from soils managed conventionally. In present investigation, the nutrient cycling process is promoted by the availability of abundant oxygen released in soil by oxygenated peptone. Possibly, nutrient reserves from less available pools are quenched due to activation of nutrient cycles. This is due to aerobic micro-climate created within soil as a result of oxygen released by oxygenated peptone for 40-50 days, slowly and steadily. By this, aerobic soil microbes from different soil pockets are attracted towards rhizosphere of plant to carry out various processes useful for plant growth.

This aerobic soil condition also suppresses the growth of anaerobic pathogenic soil microbes in vicinity of rhizosphere. Thus plant's potential is not diverted for

combating diseases but it is fully used for plant growth. All this leads to better plant growth. Our observations are in agreement with findings of Cherif *et al*. (1997), who reported that high oxygen treatment resulted in an increase in plant growth as measured by shoot and root weights in tomato. They further added that highly oxygenated plants remained healthy throughout the experiment and showed a significant decrease in root colonization by the pathogen *Pythium*. Zakrazhevski *et al*. (1995) studied the growth processes in roots and leaves of maize and pea at different soil oxygen contents. On lowering the rate of oxygen diffusion in soil, similar changes were observed in systems preventing oxidative destruction in root and leaf cells, even though the heterotrophic root cells were directly affected by hypoxia and the autotrophic leaf cells remained under natural aeration condition. These changes were coupled to a varying degree with main metabolic processes reflected by growth rate, production of biomass and some of its constituents like chlorophylls and carotenoids.

Oxygenated peptone is used for both soil aeration and soil conditioning and it can be used safely in organic farming as it fulfils the conditions of organic farming (Patil *et al.,* 2006). It increases soil oxygen level and soil porosity making the soil micro-climate inducive for the growth of both plant and aerobic nonpathogenic soil microbes. It discourages the growth of anaerobic pathogens and reduces the toxicity of reduced metal ions in the soil by oxidizing them. In addition, it avoids soil reduction which is very significant because Pezeshki and De Laune (2002) pointed out that intense soil reduction adversely affected growth and biomass accumulation in plants. Peptone is the readily available nitrogen source for microbes. The presence of oxygen and peptone in rhizosphere attracts the aerobic microbes from different soil pockets and their population increases in rhizosphere area to carry out various processes as per needs of the plant. So genetic potential of the plant is better exploited which results in better growth and yield of plant as seen in present investigation. In deed, healthy soil and healthy crop are the essential factors for higher yield with better quality. Morra *et al*. (2003) reported that soil amendment using organic compounds leads to better yield than using mineral treatment in vegetable crops including brinjal. This is supported by Lathiff and Moraikar (2003) in brinjal.

Cell expansion is a central process in plant morphogenesis. The elongation of roots and root hairs is essential for uptake of minerals and water from soil (Foreman *et al.,* 2003). In the present investigation, there is considerable increase in root length and number of secondary roots as a result of oxygenated peptone treatment. This is

supported by the observations of Tisserat *et al.* (2002), who observed increase in growth (fresh weight) and morphogenesis (production of leaves, roots and shoots) of mint (*Mentha* sp.) and thyme (*Thymus vulgaris*) shoots which showed enhancement depending upon the level of oxygen administered. Tanaka *et al.* (2001) also remarked that the concentration of dissolved oxygen in the culture solution is one of the most important environmental factors affecting the shoot and root growth of plants under hydroponic culture. They found that super saturation of dissolved oxygen in culture solution, though low in nitrogen and phosphate, led to an increase in plant height and fresh weight of root, stem and leaves compared with no supplementation of dissolved oxygen in tomato.

3.6.3 Biochemical constituents:

Results:

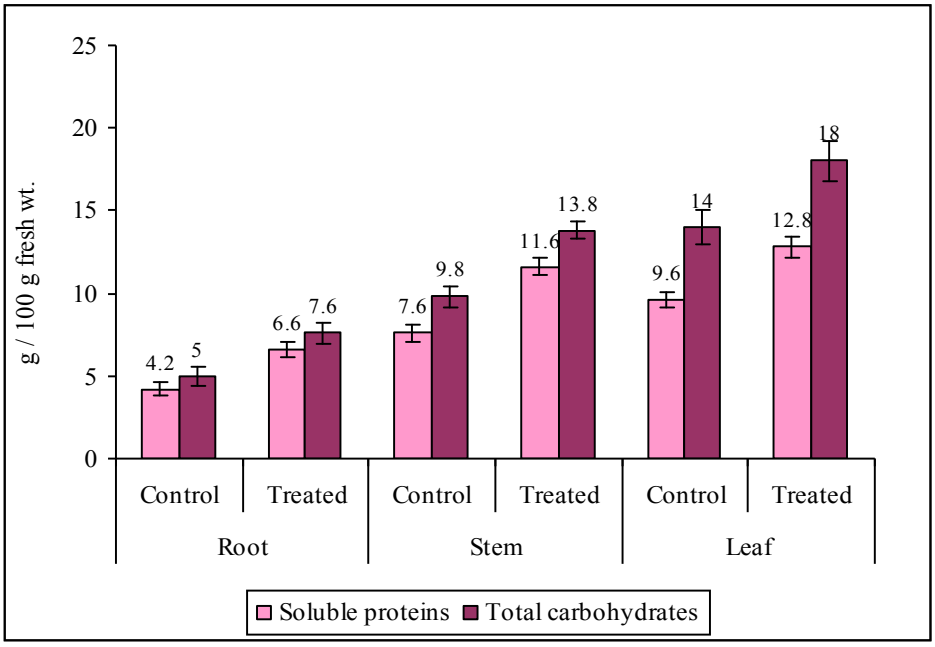
The results presented in Fig. 3.3 depicted that the soluble proteins and total carbohydrates in root, stem and leaf showed increase in treated plants over control by 57.1%, 52.6% and 33.3% and by 52.0%, 40.8% and 28.5% respectively. The polyphenols and proline contents were also increased in root, stem and leaf of treated plants by 32.3%, 50.0% and 42.8% and by 48.8%, 46.1% and 31.1% respectively as compared to control.

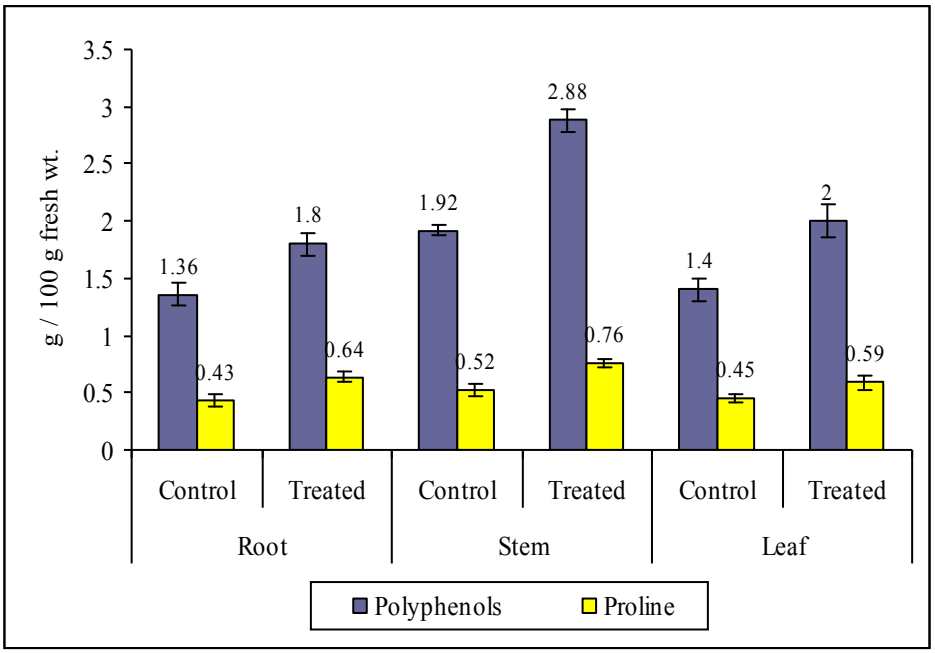
Discussion:

Proteins:

Proteins are structural constituents of plant body and hence are important in organization of several cellular compounds. All the basic functions of life depend upon proteins. These are present in each cell in one form or the other. Proteins account on an average, about one fourth to one third of the total dry weight of any living organism (Srivastava, 2001). The increase in the soluble protein content in the present investigation in root, stem and leaf is well related to increase in the dry weight observed in root, stem and leaf. According to Ferrari *et al.* (1994), protein is the antioxidant group which protects the plant from stress induced free radical formation. The enhanced protein in treated plants in present investigation might be contributing to enhanced growth and yield.

Fig. 3.3 Effect of soil application of oxygenated peptone on biochemical constituents in root, stem and leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.





Values are mean of five determinations and the error bars represent

standard deviation.

antioxidant group which protects the plant from stress induced free radical formation. The enhanced protein in treated plants in present investigation might be contributing to enhanced growth and yield.

Carbohydrates:

Carbohydrates are involved in structural organization of many tissues in plants. These are the chief sources of energy in the living cells and are involved in ATP synthesis through oxidation process. The oxidation also produces several important intermediate compounds, which serve as carbon sources for the synthesis of amino acids, lipids and other important bio molecules. The present investigation exhibits increase in total carbohydrates in the root, stem and leaf of treated plants as compared to control plants. The increase might be helpful to the oxygenated peptone treated brinjal plants to improve the growth and yield.

Polyphenols:

Polyphenols are secondary metabolites that play a significant role in disease resistance (Salem and Michail, 1981). They also inhibit the activity of IAA oxidase (Shekhawat *et al.,* 1980). Kathiresan and Veera Ravi (1990) remarked that polyphenols have good correlation with stress condition. In present investigation, there was significant increase in polyphenol contents of root, stem and leaf, when brinjal plants were treated with oxygenated peptone. It seems that the stimulation of polyphenol synthesis with oxygenated peptone might be useful to improve the defense system of plants to tolerate biotic and abiotic stress conditions.

Proline:

Proline (Pyrrolidine-2-carboxylic acid) is a five carbon cyclic amino acid belonging to glutamate family, which accumulates in leaves in large quantities under stress conditions. It has been suggested that free proline synthesized from glutamate serves as an energy donor during environmental stress (Dashek and Erickson, 1981). According to Matysik *et al.* (2002), less than five percent of total amino acids in plants under stress-free condition are provided by proline. It acts as an osmolyte and a reservoir of carbon and nitrogen. In present investigation, proline contents in root,

stem and leaf increased under experimental condition, which has significant role in plant metabolism. It also acts as an antioxidant and compatible solute, providing stress tolerances to treated plants.

3.6.4 Enzyme activities:

Results:

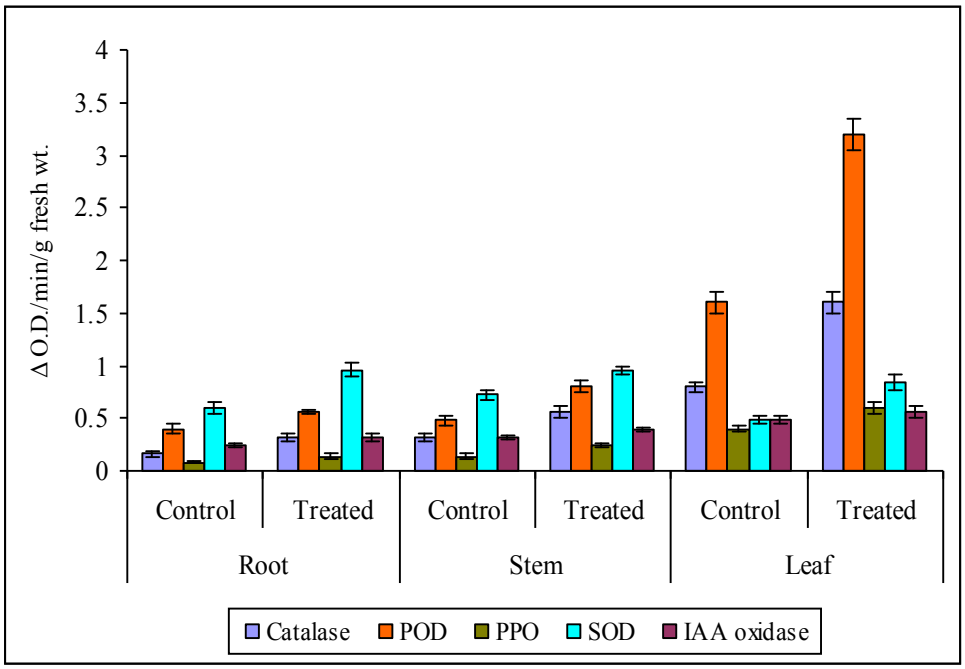
The activity of enzymes like catalase, peroxidase, polyphenol oxidase, super oxide dismutase and IAA oxidase in root, stem and leaf of oxygenated peptone treated plants showed stimulation over control plants and the enzymes of nitrogen metabolism like nitrate reductase (NR) and nitrite reductase (NiR) in leaf of treated plants were increased by 45.0% and 36.0% respectively (Fig. 3.4).

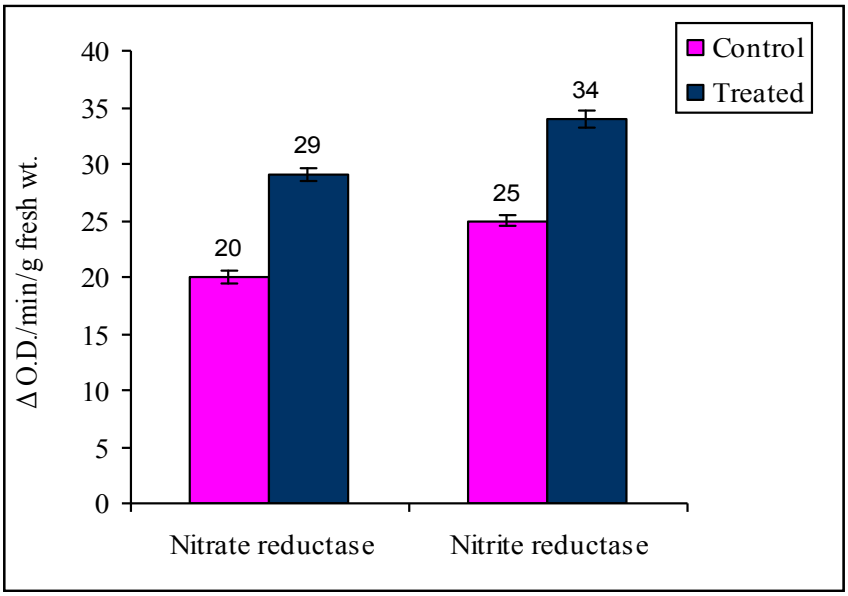
Discussion:

Catalases belong to group of enzymes involved in regulating the cellular level of reactive oxygen species. These are present in all aerobic organisms and convert H_2O_2 to H_2O and O_2, thus protecting the cells from damaging effects of H_2O_2. Although highly elevated levels of H_2O_2 are toxic at lower concentrations, they appear to play important roles in signal transduction in both plants and animals (Prasad *et al.,* 1994). Since H_2O_2 production is an ongoing process in plants, inhibition of catalase activity, one of the main routs of H_2O_2 degradation, should result in H_2O_2 accumulation. Catalase also plays an important role in protective mechanism against oxidative stress and is a sink for H_2O_2 and is indispensable for stress defense (Willekens *et al.,* 1997). In the present investigation, the increased activity of catalase enzyme in root, stem and leaf of oxygenated peptone treated plants might be useful for the plants to tolerate stress conditions.

Peroxidases are involved in the formation of the phenolic components of suberin and suberin decomposition is correlated with wound reactions and disease resistance in some plant species (Kollatukudy *et al.,* 1989). Besides providing structural resistance against invading parasites, peroxidases may also be involved in 'chemical' defense against pathogens. Peroxidase itself can be toxic to micro-organisms. Isolated peroxidases have been reported to exhibit antimicrobial activity towards pathogens grown in axenic culture (Lewis and Yamamoto, 1990).

Fig. 3.4 Effect of soil application of oxygenated peptone on enzyme activities in root, stem and leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.





Values are mean of five determinations and the error bars represent standard deviation.

Peroxidases are involved in several physiological processes such as modulation of cell wall plasticity, phenolic cross-links, lignification, pathogen infection, wounding, and regulation of IAA level in apoplast. Narsimhan and Chawla (1984) observed that fungal infection results in changes of multiple forms and activity of enzymes in the host-parasite complex.

The enzyme peroxidase is found to be present in various sub cellular components, cell membrane, nucleus etc. and it is reported to be an important anti oxidative enzyme system. It plays pivotal role in lignin synthesis and auxin catabolism (Breda *et al.,* 1993), which clearly indicates role of peroxidase in plant growth and development.

Peroxidase, a hydrogen dependent haeme protein, exhibits high oxidative and hydroxylative activities, besides the conventional peroxidase activity. The main feature of peroxidase catalysis is production of free radicals, which participate in different post enzymatic reactions (Murugan and Sumitha, 2006). Peroxidase is also involved in pathogen resistance, oxidation of fatty acid and phenols, phytohormone catabolism etc. (Gonzalez *et al.,* 2000).

Similarly, Kawano (2003) described the role of reactive oxygen species generating peroxidase reactions in plant defense and growth induction. He reported that peroxidase catalyses the generation of reactive oxygen species coupled to oxidation of plant hormone indole - 3 acetic acid and defense related compounds. Actually, peroxidase transduces the extra cellular signals into the redox signals that eventually stimulate the intracellular Ca^{++} required for induction of defense responses. Edreva *et al.* (1998) reported that heat shock induced oxidative damage was regulated by enhanced activities of peroxidase and super oxide dismutase (SOD) as well as accumulation of polyphenols.

In many cases, a close correlation has been found between the enhanced activity of polyphenol oxidase (PPO) and peroxidase (POD) and the concentration of phenolic substances (Dickinson and Lucas, 1982). The increase in polyphenol oxidase activity in a number of diseases has been linked with resistance and with increase in respiration, which usually accompanies resistance. Jite and Tressa (1999) found an increase in PPO activity in *Jasminum* plants infected with *Uromyces hobsoni*. Gawande *et al.* (2002) commented that enzymes PPO and POX are responsible for resistance or susceptibility of host plant against pathogen.

In present investigation, significant increase in polyphenol oxidase (PPO) activity was reported in root, stem and leaf of treated plants, which may help in creating disease resistance in brinjal. Polyphenol oxidase catalyzes the hydroxylation of monophenol to diphenol which in turn is converted into quinine by molecular oxygen. Kong *et al.* (2001) studied the changes in PPO activities of susceptible and resistant brinjal varieties infected with *Verticillium dahliae*. They noted that greater activity of PPO, POD and SOD resulted in more resistance. In present study, the oxidative enzymes like polyphenol oxidase, peroxidase and super oxide dismutase showed increase in their activities in root, stem and leaf. This gives the indication that oxygenated peptone treatment to soil induces disease resistance in brinjal. In addition, the increase in the activity of catalase, peroxidase and polyphenol oxidase under experimental condition denotes higher level of H_2O_2 breakdown so as to protect the tissues against oxidative damage.

The imbalance in endogenous auxin level may occur as a consequence of either excess synthesis of indole acetic acid or change in the activity of IAA oxidase that degrades auxin (Daly, 1972). The endogenous IAA level is controlled by an enzyme IAA oxidase which is involved in plant growth (Waldrum and Davies, 1981) and IAA concentration in the plant tissue is inversely correlated with IAA oxidase activity. According to Kawano (2003), IAA can react with oxygen and plant peroxidase in absence of H_2O_2 by forming an enzyme complex, which readily dissociates into enzyme, IAA radical and oxygen. In the present investigation, the increase in IAA oxidase activity in root, stem and leaf of treated plants mediates the IAA induced cell elongation. That is why there is increase in the diameter and length of root and stem, leaf area and biomass of root, stem and leaf of treated plants.

Nitrate is the most preferred source of nitrogen available to the plants. It is taken up by active transport through roots, distributed through xylem and assimilated by sequential action of the enzymes like nitrate reductase (NR) and nitrite reductase (NiR). Optimum uptake of nitrate is the first step to enhance nitrogen use in any plant. Plants acquire their nitrate from the soil through the combined activities of a set of high and low affinity transport systems (Chopin *et al.*, 2007) with the influx of NO_3, being driven by the H^+ gradient across the plasma membrane. Some of these transporters are constitutively expressed, while others are nitrate-inducible and subject to negative feedback regulation by the products of nitrate assimilation.

Nitrate reductase is a cytosolic enzyme. Nitrate absorbed by plants is either reduced to nitrite by nitrate reductase in cytosol or transported unaltered to the shoot, where it is reduced to nitrite. The resultant nitrite moves into chloroplast, where it is reduced to ammonium, which is then used in amino acid biosynthesis.

A portion of nitrate taken up is utilized or stored in the root cells while the rest is transported to the other parts of plants. Due to abundant availability of photosynthetic reductants, leaf mesophyll cells are the main sites of nitrate reduction. This is initiated by NAD or NADP dependent NR. Being the first irreversible and often rate determining step of nitrogen assimilatory pathway, nitrate reduction has been a favorite step for physiological and biochemical approaches to optimize fertilizer N use (Pathak *et al.,* 2008).

The present investigation shows that the level of protein is higher where NR activity is higher. Dey and Srivastava (2006) have rightly claimed that in vivo NR activity can be taken as an index of protein level in leaves. Moreover, Engelaar *et al.* (1994) stated that nitrate reductase activity in the plant leaves can be used as an indicator of availability of nitrate to the plants. According to Bose and Mishra (1999), NR activity is a major contributor in productivity of plant and it is an indicator enzyme of nitrogen assimilatory pathway. Further, Saxena *et al.* (2006) remarked that the enzyme nitrate reductase can be proposed as an index of nitrogen incorporation. They further stated that NR is a very sensitive plant enzyme and it is substrate inducible i.e. the supply of nitrate invariably increases the level of NR.

The present investigation shows an increase in the activity of NR when the plants are treated with oxygenated peptone which may lead to increase in productivity. This is well supported by the remarks of Johnson *et al.* (1976), who suggested that NR is a parameter which ultimately determines leaf biomass and yield. Therefore, it is expected that the treatment that increases NR activity, also enhances the crop yield. Srivastava and Shankar (1996) stated that oxygen concentration is one of the factors influencing the enzyme activity of NR. According to Mishra and Srivastava (1993), NR is a rate limiting and substrate inducible enzyme and its activity is positively correlated with total proteins, organic nitrogen content and overall productivity of the plant.

Premabatidevi (1998) studied the effect of IAA, GA_3 and kinetin on nitrate reductase and nitrite reductase in the leaves of *Parkia javanica* and found that there is increase in the activity of NR and NiR sprayed with these plant growth regulators. In

the present investigation, the same effect is obtained without using plant hormones as the use of plant hormones is costlier and does not go hand in hand with organic farming. So, this is a significant achievement of the present investigation.

3.6.5 Water relations:

Results:

Table 3.6 shows the effect of soil application of oxygenated peptone on water relations in leaf of brinjal at 60th DAS. The relative water content was 50.0% in the leaves of control plants while the value in leaves of treated plant was 55.0%, showing an increase of 10.0%. The osmotic potential of cell sap was –3.82 in control plants as against –3.37 in treated plants showing an increase of 11.7%. The membrane injury was found to be decreased by 27.2% as the membrane injury decreased from 11.0% (control) to 8.0% (treated).

Discussion:

Water is the important participant of basic process of plant life, the photosynthesis. About 95% of water is lost by the leaf through the process of transpiration and about only 5% of the water is available to the plant for different metabolic processes taking place within the plant body. So 10.0% increase in RWC under present experimental condition is very significant for plant metabolism. Increase in osmotic potential of cell sap is useful for osmotic adjustment which requires regulation of intracellular levels of several compounds, collectively known as osmolytes (Janardhan and Bhojaraj, 1999). In the present investigation, electrical conductivity of cell (which depends on various solutes with different electrical charges oozing out of the tissue as a result of membrane injury) is used as the basis for studying membrane stability in terms of percent membrane injury. The present experimental condition is useful to decrease membrane injury. According to Sairam (1994), decrease in percent membrane injury is correlated to higher RWC. In the present investigation, increase in RWC and OP has significant role in decreasing membrane injury.

Table 3.6 Effect of soil application of oxygenated peptone on water relations in leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
Relative Water content (RWC) (%)	50.0 ± 0.50	55.0* ± 0.54	10.0
Osmotic potential of cell sap (OP) (- bar)	-3.82 ± 0.04	-3.37* ± 0.02	11.7
Membrane injury (%)	11.0 ± 0.10	8.0* ± 0.05	- 27.2

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' represents significance at $p < 0.05$.

Table 3.7 Effect of soil application of oxygenated peptone on photosynthetic pigments in leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
Chlorophyll a (mg / 100^{-1}g fresh wt.)	120.0 ± 0.50	230.0** ± 0.52	91.6
Chlorophyll b (mg / 100^{-1}g fresh wt.)	100.0 ± 0.12	160.0** ± 0.67	60.0
chl. a / chl. b	1.20	1.43*	19.1
Total chlorophylls (mg / 100^{-1}g fresh wt.)	220.0 ± 1.4	390.0** ± 1.8	77.2
Chlorophyll Stability Index (CSI)	0.45 ± 0.01	0.64* ± 0.05	42.2
Carotenoids (mg / 100^{-1}g fresh wt.)	72.0 ± 0.18	104.0* ± 0.20	44.4
Xanthophylls (mg / 100^{-1}g fresh wt.)	64.0 ± 0.12	96.0* ± 0.15	50.0

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

3.6.6 Photosynthetic pigments:

Results:

Table 3.7 exhibits the effect of soil application of oxygenated peptone on photosynthetic pigments in leaf of brinjal at 60 DAS. The treatment of oxygenated peptone caused 91.6% and 60.0% increase in chl. a and chl. b along with 77.2% increase in total chlorophylls. The contents of Carotenoids and xanthophylls were also increased by 44.4% and 50.0% respectively. The CSI was also improved by 42.2%.

Discussion:

Chlorophyll is a good index to meet an overall evaluation of any crop for its photosynthetic ability. Moreover, the productivity of any crop is linked with chlorophyll content, which decides the solar energy harnessing ability of plant.

Chlorophyll stability index (CSI) is the indicator of plant's resistance to abiotic stress or it may be considered as the capacity to withstand adverse environmental conditions. It gives the indication that the treated plants are better adopted to environmental conditions along with increase in total chlorophylls which leads to better growth.

In all higher plants, carotenoids are synthesized and accumulated in plastids like chloroplasts, together with the chlorophylls in functional pigment protein complexes in the thylakoid membranes (Siefermann-Harms, 1985). The reaction centre core complexes of PS I and PS II are rich in β-carotene, whereas the more peripheral light harvesting chlorophyll protein associated with photosystems contains xanthophylls like lutuin, violaxanthin and neoxanthin (Britton, 1988). Light is the main regulatory requirement for carotenoid biosynthesis. Carotenoids have two major functions in photosynthesis. They act as photo-protective agents preventing photo-oxidation damage and as accessory light harvesting pigments (Cogdell, 1988). The first function is essential because without carotenoids, there would be no photosynthesis in presence of oxygen. The second function allows the plant to utilize light over a wider spectral range.

When chlorophylls are excited by light, some molecules get converted into triplet excited form (which lasts for one tenth of microsecond or longer), and therefore, are able to interact with molecular oxygen. Oxygen, in its ground state, is a triplet. When it reacts with triplet chlorophyll, it forms singlet oxygen which is a very

powerful oxidizing agent. It can oxidize chlorophylls, lipids, proteins and nucleic acids leading to cell death. Carotenoids prevent this photo-oxidative killing in two ways. They react directly with singlet oxygen to detoxify it or they can quench the chlorophyll sensitizer and so prevent singlet oxygen production (Foote, 1976). They react with singlet oxygen to produce carotenoid triplet which then decays harmlessly producing heat, rather than any toxic product. Secondly, carotenoids react with chlorophyll triplets to produce carotenoid triplets and this effectively prevents the generation of singlet oxygen and also reduces life time of chlorophyll triplet which is the major photo-protective mechanism. This requires the carotenoid and chlorophyll molecules to be arranged precisely in very close proximity to each other. Both pigments are attached to the same protein forming a complex called 'photosynthin' (Datta, 2003). According to Siefermann-Harms (1987), the main role of xanthophylls is as an accessory light harvesting pigment to absorb light and pass the excitation energy onto the antenna chlorophylls by singlet - singlet energy transport.

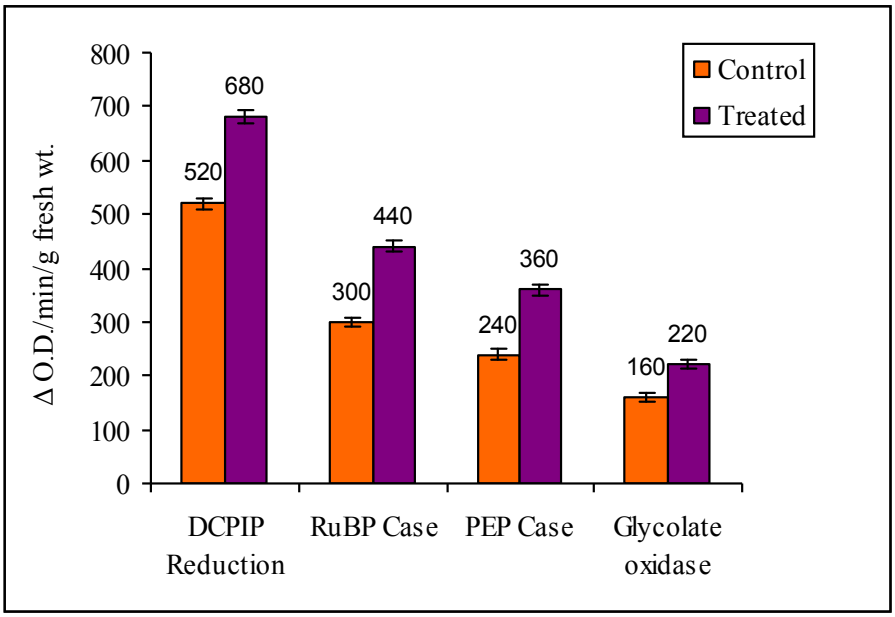
With this view in mind, carotenoids and xanthophylls were analyzed in the present investigation under control and oxygenated peptone treated condition. The carotenoids showed 44.4% increase while the xanthophylls showed 50.0% increase. This indicates that the chlorophylls are well protected under experimental conditions so that there is less degradation of chlorophylls by photo oxidation. This is the reason why there is increase in chlorophyll stability index under experimental conditions.

3.6.7 Photosynthesis and Photorespiration:

Results:

The results recorded in Fig. 3.5 showed that the rate of photosynthetic electron transport (Hill reaction), as evidenced by DCPIP reduction, is found to be stimulated by 30.7% as a result of soil treatment of oxygenated peptone. RuBP Case level was 300.0 and 440.0 and PEP Case level was 240.0 and 360.0 in control and treated plants respectively. However, the percent increase in the activity of both the enzymes is more or less similar (46.6% and 50.0%) under experimental condition. The activity of photorespiratary enzyme - Glycolate oxidase was much lower as compared to that of RuBP Case and PEP Case (160, 300 and 240 respectively) in control plants while the treated plants showed the activity to the tune of 220, 440 and 360 respectively.

Fig. 3.5 Effect of soil application of oxygenated peptone on enzymes of photosynthesis and photorespiration in leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.



Values are mean of five determinations and the error bars represent standard deviation.

Discussion:

Productivity of crop plants is intimately associated with the process of photosynthesis. It is essentially an oxido-reduction process in which photolysis of water (Hill reaction) takes place with the help of chlorophyll and light and the electrons generated are used in the formation of reducing power $NADPH_2$, which is finally utilized in the reduction of CO_2 to carbohydrate level. Thus photosynthesis is the most important process which begins with Hill reaction, followed by CO_2 fixation and photophosphorylation using the enzymes such as RuBP Carboxylase and PEP Carboxylase, whereby the plant not only produces carbohydrates but also liberates oxygen which sustains life. Up till now, there is no published work on the effect of soil oxygen supply on the photochemical activities of intact plant.

DCPIP is generally considered as PS II electron acceptor and the electron transport dependent on this Hill oxidant is considered to be the PS II electron transporter. It should be mentioned here that this Hill oxidant also accepts electrons from the reducing site of PS I. Therefore, strictly speaking, this Hill oxidant dependant reaction is not pure PS II reaction, unless PS I electron transport is blocked (Mannan, 1988). However, looking at the data, it can be safely said that oxygenated peptone can help in promoting rate of photosynthetic electron transport. Nichiporovich *et al.* (1972) stated that during photosynthesis in chloroplasts, not only carbohydrates but also amino acids, proteins and other substances are being synthesized. Consequently, not only water and CO_2 but also simple compounds of other elements, especially nitrogen must be included among the substrates needed for photosynthesis. The enhanced level of photosynthetic process due to oxygenated peptone may be because of availability of soluble nitrogen due to soil application of oxygenated peptone. As such, nitrogen is important in photosynthesis as indicated by higher nitrogen content in the chloroplasts (Natr, 1975).

Brinjal, being a C_3 plant, shows higher level of RuBP Case than that of PEP Case, which is apparent in the present investigation. Our observations are supported by Osmond *et al.* (1969), who found that C_3 species had a higher activity of RuBP Case than that of PEP Case. The activity of RuBP Case is regulated by cellular water level. In the present investigation, relative water content increases under experimental condition which may be one of the factor enhancing the activity of RuBP Case. RuBISCO initiates photosynthetic carbon metabolism by determining the rate at

which CO_2 is incorporated into sugar phosphate through carboxylation of RuBP. A co-ordinate regulation of RuBP utilization in carboxylation / oxygenation, light absorption and use of captured energy for RuBP regeneration are essential for effective photosynthesis in dynamic natural environments (Woodrow and Berry, 1989). Gimenez *et al.* (1992) found that large RuBP pool size with faster rate of RuBP synthesis or the ability to maintain large concentration of RuBP are major factors which support greater CO_2 assimilation. This view is further supported by Karadge and Thombare (1992), who studied photosynthesis in *Aptenia cordifolia* and indicated that high rate of $^{14}CO_2$ assimilation, could be contributed to high level of carboxylating enzymes in C_3 plants where RuBP is dominant.

Photorespiration is a group of processes by which C_3 plants release CO_2 in presence of light at the cost of photosynthesis (Zelitch, 1979). The activity of glycolate oxidase serves as an index of rate of photorespiration. According to Garrete (1978), low photorespiration is the key to better crop as it tends to have more availability of RuBP for carboxylation rather than for oxygenation. However, Lorimer *et al.* (1977) argued that the photorespiration is not an essential process but it functions as safety valve against photo-oxidative destruction of chloroplasts by photorespiratary consumption of toxic oxidants. An alternative mechanism is available to plant cells that enable toxic oxidants to be degraded without the wasteful photorespiration process in the form of carotenoids that protect chlorophylls from photo-oxidation. The increase in chlorophylls, CSI and carotenoids found in the present experimental condition is noteworthy in this respect.

3.6.8 Mineral nutrients:

The economic value of any crop is determined by its yield and quality which are the resultant of the grower's ability to exploit the plant's genetic make-up and of the environment, in which the plant is growing. If the growing conditions provide all that the plant needs for full expression of genetic potential, yield and quality will be maximized. Within the constraints posed by site and climate, the genetic potential of a crop can be exploited to a greater extent by maintaining adequate air, water and mineral supply. So, in the present investigation mineral status of root, stem and leaf was analyzed.

Results:

The results recorded in Fig. 3.6 showed increase in nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese contents and decrease in phosphorus content in root, stem and leaf of treated brinjal plants over control plants.

Discussion:

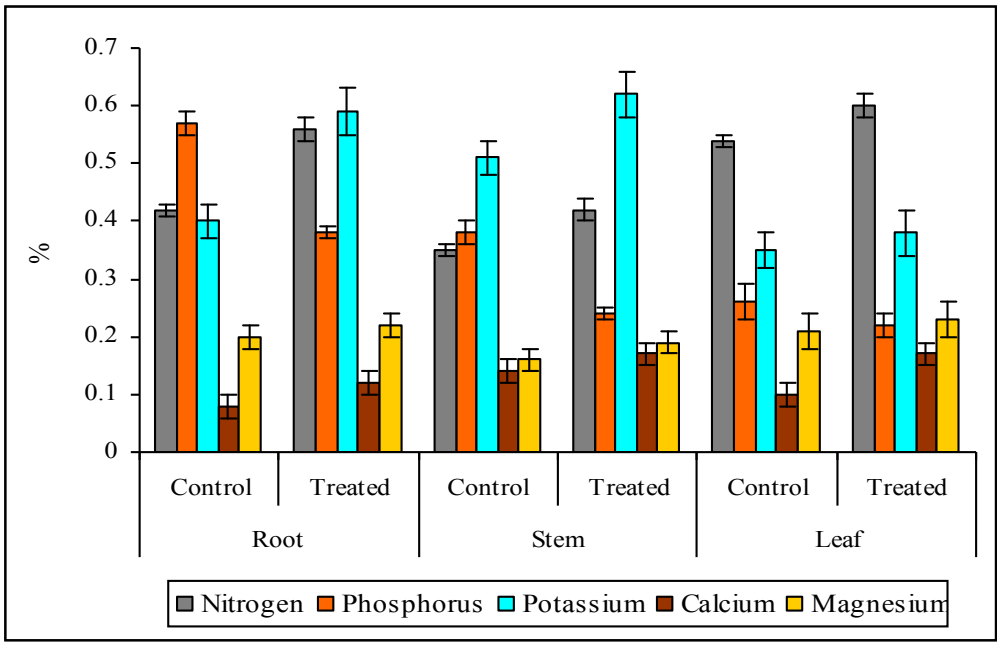
Nitrogen:

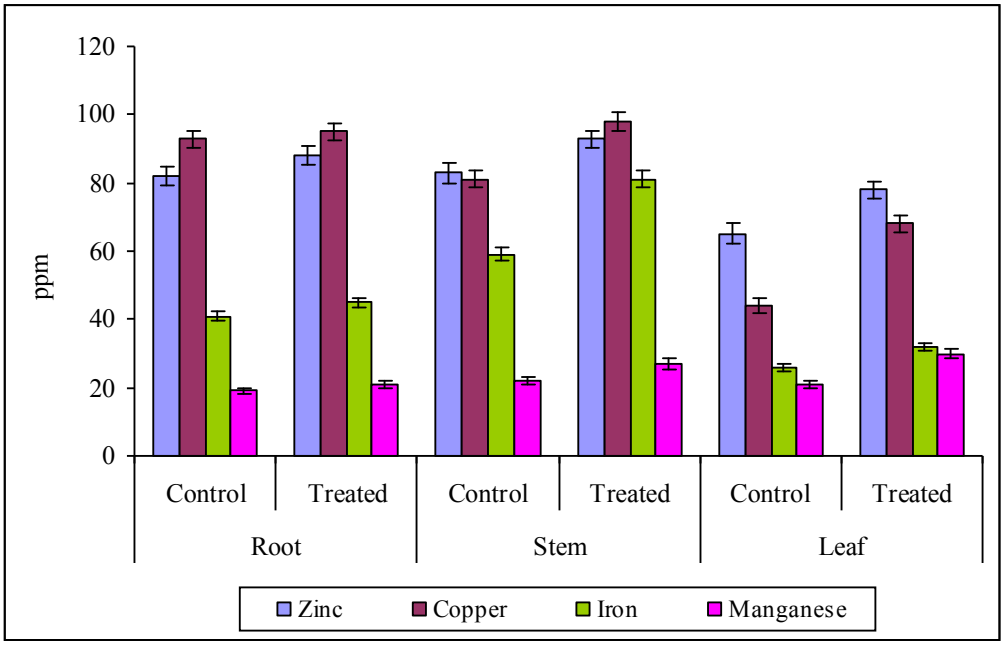
Nitrogen is a constituent of proteins, chlorophylls, amino acids, nucleic acids, nucleotides, IAA, cytokinin and several secondary metabolites. It is an important constituent of protoplasm and cell constituents, involved in storage and transport of genetic information. It plays active role in the enzyme reactions and energy metabolism. It is required for nutrient absorption, vegetative growth, photosynthesis, production of assimilates for sink development and reproductive growth. In the present investigation, total nitrogen content was increased in root, stem and leaf of oxygenated peptone treated plants. This is useful for elongation of stem and roots as evident in Table 3.4. According to Tisdale and Nelson (1984), an adequate supply of nitrogen to crop plants during their early growth period is very important for the initiation of leaves and floret primordia. Super oxygenation of the nutrient medium accompanied by supply of organic nitrogenous compound like peptone is found to be useful to increase total nitrogen in root and stem. Incidentally Ha *et al.* (1992) observed rapid decrease in N, P and Mg content at low oxygen supply in cucumber plants grown hydroponically. This observation indirectly supports to results of present investigation.

Phosphorus:

Phosphorus is present largely in inorganic form as a component of phosphate ester (sugar phosphates, nucleotides and phospholipids), certain enzymes, proteins and ATP. It is involved in energy transport reactions and genetic information. The sugar phosphates have an important role in photosynthesis. The nucleotides are related to genetic information. The phospholipids are present in the membrane. Phosphorus governs the synthesis and breakdown of energy storage and release processes. In the present investigation, there is decrease in total phosphorus in root, stem and leaf of treated plants as compared to control plants. This is because

Fig. 3.6 Effect of soil application of oxygenated peptone on mineral contents in root, stem and leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.





Values are mean of five determinations and the error bars represent standard deviation.

phosphorus has high mobility and it is transported to the growing parts of the plant from root and stem.

Potassium:

Potassium is neither structurally bound in plants nor it is a constituent of any compound. Potassium ion activates a number of enzymes involved in photosynthesis and respiration. It is required for translocation of assimilates, osmo-regulation and opening and closing of stomata. It increases the solar energy harvesting efficiency and the availability of metabolic energy for the synthesis of starch and proteins (Mengel and Kirkby, 1987). According to Morard *et al.* (2000), K^+ is the nutrient most sensitive to oxygen concentration. The K^+ ion is highly mobile in both xylem and phloem which enables the plant to regulate its K-budget easily. As per Hogh and Pedersen (2003), the crops modify their root hair length in response to soil K concentration and thereby maintain K-uptake from sparingly soluble K-source. The potassium level in the plant tissue is proportional to protein content (Malick and Srivastava, 1982). Increased total potassium contents in root, stem and leaf of treated plants may be useful for the increased vegetative growth of treated plants.

Calcium:

Calcium is required for physical maintenance of cell integrity and membrane permeability. It activates a number of enzymes for cell division. It takes part in protein synthesis and carbohydrate transfer. It is most important to dividing cells as it plays a role in the mitotic spindle during cell division and forms calcium pectate in the middle lamella of the cell plate. It is considered as a second messenger in certain hormonal and environmental responses. According to Singh (2000), calcium deficiency causes poor root growth. Since little or no calcium is re-distributed in the plant, calcium content of plant can not be regarded as calcium reserve. The plant must continuously take up calcium and transport it wherever needed to maintain metabolism and growth. In the present investigation, increased calcium contents in root of treated plants leads to enhanced root growth as observed in Table 3.4.

Magnesium:

Magnesium is a component of chlorophylls and porphyrin in plants. It is also required for stabilizing ribosome structure and cell membranes. It serves as a co-factor in most of the enzymes that activate phosphorylation process and acts as a bridge between pyrophosphate structures of ATP or ADP and the enzyme molecules (Singh, 1999). According to Gunther (1981), about three hundred enzyme reactions are influenced by magnesium. In the present investigation, increased magnesium contents in leaf of treated plants leads to higher concentration of chlorophylls in the leaf (Table 3.7).

Zinc:

The major role of zinc in plants is maintenance of cell membranes. Zinc provides protection to the membrane lipids and proteins against oxidation by toxic oxygen radicals (Cakmak, 2000). Being the metal component of super oxide dismutase, it inhibits the generation of free radicals (Pandey *et al.,* 2000). Zinc is an essential catalytic compound of over three hundred enzymes, most of them occurring as zinc metalo-enzymes (Coleman, 1992). Carbonic anhydrase is a ubiquitous enzyme that catalyzes reversible reaction of CO_2 hydration. This enzyme can be a diamer, tetramer, hexamer or octamer having one Zn atom in every cell unit (Sandman and Boger, 1983). Carbonic anhydrase is important for photosynthesis. It is located in cytosol and in chloroplast. Zinc is also bound to the enzyme alcohol dehydrogenase which catalyses the reduction of ethanol to acetaldehyde. This reaction prevents the accumulation of pyridine in the root cells and lockage of glycolytic pathway. In the present investigation, zinc content was increased in root, stem and leaf of treated plants. At the same time, root, stem and leaf showed increased activity of super oxide dismutase indicating the capacity of the plant to resist oxidative damage. Since zinc is required for synthesis of tryptophan (a precursor of IAA), the higher level of zinc in root, stem and leaf indicates high IAA level. This is supported by high IAA oxidase activity in root, stem and leaf of oxygenated peptone treated plants (Fig. 3.4).

Copper:

The biochemical functions of copper are dependent to a large extent on the activity of copper to participate in redox reaction and to undergo change in valency.

Copper is also required for the synthesis of plastocyanin and plastoquinone. Copper has a catalytic role in chloroplast and it is required for enzyme action of SOD (Vaughan *et al.,* 1982). SOD protects the plant cell from super oxide radicals which are formed by single electron transfer during photosynthesis and respiration. Copper has variable mobility in the phloem. It can be translocated from vegetative to reproductive parts (Caballero *et al.*, 1996). In the present investigation, increased copper contents in treated plants may be helpful for the enhanced reproductive growth of treated brinjal plants (Table 3.8).

Iron:

The physiological role of iron is due to its affinity for forming chelate complexes and its tendency to undergo change in valency. Iron forms important constituent of the electron transport system of chloroplasts and mitochondria. The cytochromes contain a haeme-iron porphyrin structure. Iron is involved in the activity of oxidative enzymes like catalase, peroxidase and super oxide dismutase. Iron also plays a major role in oxidation-reduction reaction e.g. Ferrodoxin (Fd) is involved in photosynthesis, nitrite reduction, sulphate reduction and nitrogen assimilation. Iron is a constituent of enzyme aconitase (Broquisse *et al.*, 1986) which catalyses the isomerization of citrate to iso-citrate in the TCA cycle. The enzyme nitrogenase also contains iron. The optimum absorption of iron by the plant induces various responses like increase in root branching and number of root hairs. Under present experimental condition, root, stem and leaf of treated plants showed increased iron contents, which may be helpful to increased vegetative growth of treated plants.

Manganese:

Manganese can compete and also substitute various reactions involving magnesium, calcium, zinc and iron. It can replace magnesium for bridging ATP with enzyme complexes. It also acts as a co-factor of various enzymes catalyzing oxido-reduction, decarboxylation and hydrolytic reactions of TCA cycle such as malate dehydrogenase, malic enzyme and isocitrate dehydrogenase (Burnell, 1988). However, in CAM plants PEP carboxykinase in bundle sheath chloroplasts has an absolute requirement for Mn^{2+} which can not be replaced by Mg^{2+} (Burnell, 1986). Mn^{2+} is involved in PS II. Mn^{2+} is a constituent of SOD. Enzymes of shikimic acid pathway leading to synthesis of amino acids (like tyrosine, tryptophan and

phenylalanine) and secondary metabolites (flavonoids and IAA) are activated by Mn^{2+} (Hughes and Williams, 1988). It also stimulates the activity of peroxidase enzyme. Under present investigation, increased manganese contents in root, stem and leaf of treated plants might be helpful for the vegetative growth of plant.

3.7 YEILD ATTRIBUTES:

Results:

Results exhibited in Table 3.8 showed improvement in yield attributes of oxygenated peptone treated brinjal plants. The treated plants required 65 days for flower initiation while control plants required 80 days. The days required to 50% flowering are 90 days in treated and 110 days in control plants. The length of flowering period was 126 days in control plants and 138 days in treated plants, while the length of fruiting period was 112 days in control plants and 124 days in treated plants. The number of flowers per plant increased by 68.1% while the number of fruits per plant increased by 65.0% in treated plants over control. The flower to fruit ratio increased by 1.76% in treated plants over control plants. The length, diameter and weight of fruit increased by 58.7%, 54.3% and 174.8% respectively in treated plants over control plants. The number of seeds per fruit increased by 40.0% while the weight of 100 seeds increased by 148.0%. The ratio of total weight of seeds per fruit to fruit weight showed a decrease of 9.37%. The yield showed an increase of 108.3% in treated plants along with increase in shelf life from 05 days (control) to 08 days (treated) indicating an increase of 60.0%. The overall picture shows that soil application of oxygenated peptone improved quality and quantity of the fruits along with improvement in marketability. The effect of soil application of oxygenated peptone on flowering and fruit size of brinjal is well depicted in Plate XIII.

Discussion:

The concept of food quality has changed dramatically in recent years. It refers not only to the final product but also to the way in which it is produced, processed and transported. Organically grown food is nutritious, tastier and leads to better health. Consumers are ready to pay 1.5 to 5 times more price to natural food products (green food) as compared to chemical food. 130 countries all over the world produced

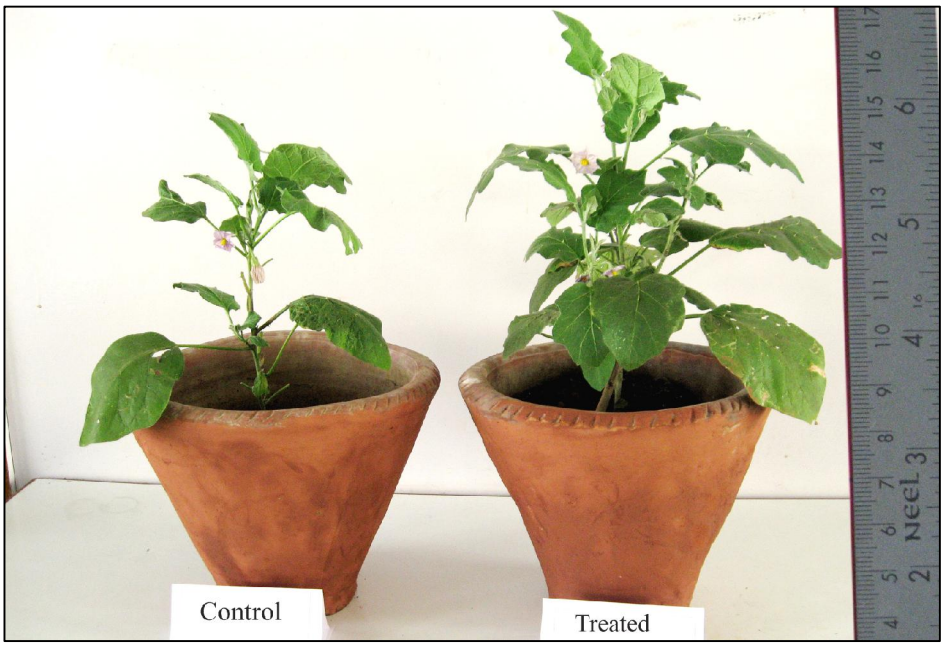
Table 3.8 Effect of soil application of oxygenated peptone on yield attributes of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
Days required for flower initiation	80.0	65.0*	-18.7
Days to 50% flowering	110.0	90.0*	-18.1
Length of flowering period (days)	126.0	138.0*	9.52
Length of fruiting period (days)	112.0	124.0*	10.7
Number of flowers / plant	11.3 ± 1.0	19.0** ± 1.2	68.1
Number of fruits / plant	10.0 ± 1.0	16.5** ± 1.4	65.0
Flower / fruit ratio	1.13	1.15*	1.76
Length of fruit (cm)	6.3 ± 0.1	10.0** ± 0.2	58.7
Diameter of fruit (cm)	12.7 ± 1.0	19.6** ± 1.2	54.3
Fresh weight of fruit (g)	47.3 ± 1.5	130.0** ± 1.8	174.8
Number of seeds / fruit	750.0 ± 10	1050.0* ± 12	40.0
Weight of 100 seeds (g)	15.4 ± 1.2	38.2** ± 1.5	148.0
Total weight of seeds / fruit to fruit wt. ratio	0.32	0.29*	-9.37
Fruit yield / plant (kg)	2.4 ± 0.01	5.0** ± 0.05	108.3
Shelf life (days)	05.0	08.0**	60.0

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

PLATE XIII

Effect of soil application of oxygenated peptone on flowering and fruit size of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.



organic food using 26.5 million ha. area in 2004. Commercial organic farming in India is still in nascent stage producing only 14000 tones of organic food in 2002. Total land under organic management has been showing an increasing trend rising from 1700 ha. in 2001 to 76326 ha. in 2004. According to Hazra (2003), the productivity of agricultural crops in organic farming in India is low and continued research and development efforts are required to improve productivity.

In sustainable agriculture, the theme is, "Feed the soil and not the crop." If the soil health is taken care of, it will ultimately lead to crop health and human health. This can be achieved by soil amendment using oxygenated peptone. Soil oxygen is the fundamental requirement for the growth and productivity of a plant because oxygen is the framework element which constitutes about 44% of dry matter of plant material (Sharma, 2006). According to Patil *et al.* (2006) during night time, respiratory rate is higher, more oxygen is needed, but stomata are closed. So plants have the only option to absorb oxygen from soil. So oxygen rich soil is essential for proper plant growth. Unfortunately soil oxygen is the most neglected factor in plant growth due to lack of suitable technique to improve soil oxygen status. Oxygenated peptone, an organic soil aerator releases oxygen slowly and steadily for 40-50 days when applied in the soil at the depth of 10 cm, buried and watered. In the light of this situation, the present investigation was undertaken with a view to amend the soil organically, using oxygenated peptone and to study its quantitative and qualitative effect on organically grown brinjal, as brinjal is a solanaceous fruit vegetable grown all over the world, round the year. Besides, brinjal is a rich source of carbohydrates, proteins, ash, fibers and vitamin C. Moreover, organically grown vegetables show high content of both vitamin C and protein with better shelf life (Singh *et al.,* 2001).

The present investigation indicated that the decrease in number of days required for flower initiation and days required for 50% flowering and increase in length of flowering period, number of flowers per plant and length of fruiting period led to better yield. This is supported by the observations of Illangakoon *et al.* (2004), who evaluated six cultivars of brinjal to determine the relationship of physico-agronomic and chemical characteristics with yield. They found that days to 50% flowering and fruit number were correlated with yield and can be used as indicators to predict the yield. Our observation is supported by Gayathiri and Anburani (2008), who worked on influence of organic and inorganic nutrients on yield in Kacholam (*Kaempferia galanga* L.). They found that organic nutrition

improved soil physical texture, decreased bulk density and increased water holding capacity. All these consequences paved the way for greater fresh weight of rhizome acting as a sink. In present investigation, the increase in quality and quantity of the fruit under treated condition is the result of improved soil micro-climate leading to better vegetative and reproductive growth with fruit as the sink. The present investigation is in concurrence with the findings of Gill *et al.* (2001) in turmeric. According to Morra *et al.* (2003), organic amendment is useful to increase the yield. Prasanna and Rajan (2001) reported that organic fertilizers increase the shelf life of brinjal. Prabhu *et al.* (2008) reported that marketable yield per plant showed positive significant correlation with plant height, branches per plant, mean fruit weight, fruit length and number of fruits per plant. Soil amendment with oxygenated peptone is found to increase flowering, fruit set, early yield and yield per plant. The same effect is obtained by spraying the leaves of brinjal plants with GA (El-Zawily *et al.* 1985 a; El-Zawily and Zayed 1985 b; Sorte *et al.,* 2001 and Khedr *et al.,* 2004).

The present investigation could bring about 108.3% increase in yield with better marketable fruits using very simple, easy, less costly, rapid, eco-friendly and user friendly technique. It is interesting to know here that Acciarri *et al.* (2002) experimented with brinjal to get genetically modified parthenocarpic fruits with 33% increase in yield and marketable seedless fruits. However, such technique is highly sophisticated, costly and not within the reach of common farmer. In the present investigation, it should be noted that the heavier seeds obtained under experimental condition denote healthy condition of seeds and also better germination capacity leading to healthy future crop. At the same time, the ratio of total weight of seeds per fruit to fruit weight exhibited 9.37% decrease. This is the indication of more fleshy fruits with less seeds, which is a commercially desirable character.

3.8 BIOCHEMICAL CONSTITUENTS IN FRUITS:

Results:

Effect of soil application of oxygenated peptone on biochemical constituents in fruits of brinjal at 60 DAS is depicted in Table 3.9. The pH of fruits of treated plants was 6.2 as compared to pH 6 in fruits of control plants. Total acid content decreased from 6.1% to 4.4% in fruits of treated plants. The increase in pH tends

Table 3.9 Effect of soil application of oxygenated peptone on biochemical constituents in fruits of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
pH	6.0	6.2* ± 0.1	3.33
Total acid (%)	6.1 ± 0.1	4.4* ± 0.11	-27.8
Total solids (g)	7.35 ± 0.5	8.40* ± 0.6	14.2
Total soluble solids (%)	0.65 ± 0.1	0.78* ± 0.1	20.0
Moisture (%)	35.7 ± 1.0	29.4* ± 1.32	-17.6
Fiber (%)	4.0 ± 0.2	7.5** ± 0.22	87.5
Ash content (g)	0.12 ± 0.01	0.13* ± 0.01	8.33
Soluble proteins ($g\ 100^{-1}g$ fresh wt.)	5.2 ± 0.50	9.2** ± 0.57	76.9
Total carbohydrates ($g\ 100^{-1}g$ fresh wt.)	9.6 ± 0.60	14.6** ± 0.68	52.0
Polyphenols ($g\ 100^{-1}g$ fresh wt.)	0.80 ± 0.01	1.56** ± 0.1	95.0
Proline ($g\ 100^{-1}g$ dry wt.)	0.26 ± 0.01	0.36* ± 0.01	38.4
Ascorbic acid (vitamin C) ($mg\ 100^{-1}g$ fresh wt.)	285.0 ± 0.1	410.0* ± 0.5	43.8

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

towards neutrality under experimental condition, this is related to decrease in acid content along with decrease in moisture content. The total solids increased by 14.2% while the total soluble solids increased by 20.0%. The moisture content decreased by 17.6% while the fiber content increased by 87.5%. The ash content is increased by 8.33%. The soluble proteins, total carbohydrates, polyphenols and proline showed a significant increase in fruits of treated plants by 76.9%, 52.0%, 95.0% and 38.4% respectively. Ascorbic acid (vitamin C) content increased from 285 mg (control) to 410 mg (treated) showing a significant increase of 43.8%.

Discussion:

Singh *et al.* (2001) made a remark that the glorious food grain production could not save our majority of population from malnutrition problem due to inadequate consumption of costly animal food products. This alarming situation may be tackled by increasing our vegetable production in order to enhance per capita vegetable consumption. Doubtlessly, vegetables being cheap and rich source of nutrients, vitamins and carbohydrates, may lead to solve this problem up to a greater extent but on the other hand the present production system has endangered our health and environmental security due to unjudicial use of chemical fertilizers and pesticides. In view of the above situation, the organic farming has been used to develop an alternative eco-friendly technology for sustainable vegetable production. Present investigation is based on these facts.

Chen and Li (2008) reported that on an average, the oblong-fruited eggplant cultivars are rich in total soluble sugars, whereas the long-fruited cultivars contain a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (such as solasodine), dry matter and amide proteins. High anthocyanin content and low glycoalkaloid content are considered essential, regardless of how the fruit is to be used. For processing purposes, the fruit should have high dry matter content and a low level of phenolics. Bitterness in eggplant is due to the presence of glycoalkaloids which are of wide occurrence in plants of Solanaceae family. The glycoalkaloid contents in the Indian commercial cultivars vary from 0.37 mg to 4.83 mg / 100g fresh weight. Generally, the high contents of glycoalkaloid produce a bitter taste and off flavor. The discoloration in eggplant fruit is attributed to high polyphenol oxidase activity. The cultivars which are least susceptible to discoloration are considered suitable for processing purposes. In the present investigation, increase in total solids,

total soluble solids, fiber and ash content and decrease in moisture content make the fruits fleshy and not pulpy. The increase in soluble proteins, total carbohydrates, polyphenols and proline make the fruit tasty. Along with this, the increase in vitamin C content suggests enhancement in the nutritional value.

3.9 ENZYME ACTIVITIES IN FRUITS:

Results:

The results recorded in Fig. 3.7 illustrated that catalase, peroxidase and polyphenol oxidase showed a higher level of activity (50.0%, 66.6% and 33.3% respectively) under experimental condition. Moreover, the activity of catalase and peroxidase was higher (0.24 and 0.40 respectively) as compared to that of polyphenol oxidase (0.16).

Discussion:

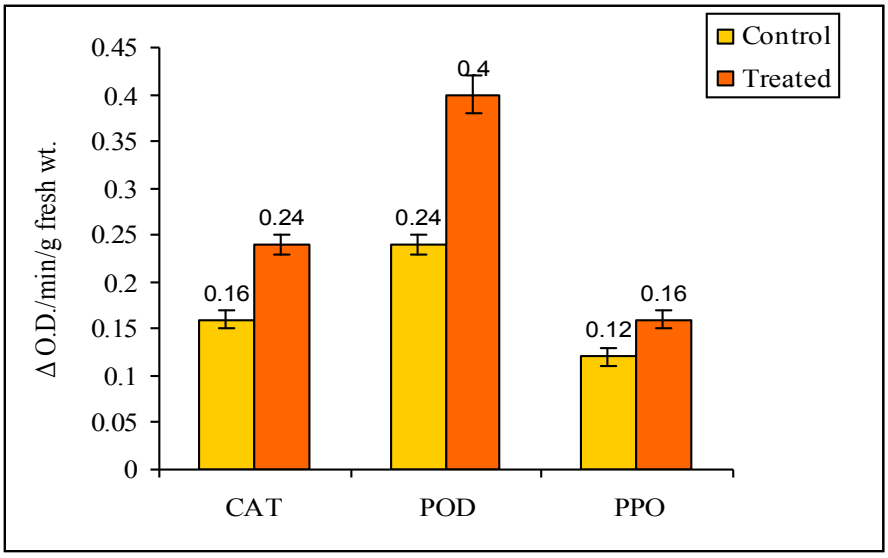
Aluko and Ogbadu (1986) stated that the situation with high activity of catalase and peroxidase with low activity of polyphenol oxidase is the best situation for storage and resistance to injury and diseases in brinjal. Present investigation indicates that level of catalase goes on increasing from root to stem and to leaf which drops in the fruit. It seems that during transition of plant from vegetative to reproductive stage, catalase activity increases. This is well supported by the observations of Lokhande *et al.* (2003), who reported that during the transition from vegetative to reproductive phase, the level of active oxygen species and antioxidant enzymes increases, suggesting that the plants undergo stressful conditions during the flowering process. The same is the case for peroxidase and polyphenol oxidase.

3.10 MINERAL NUTRIENTS OF FRUITS:

Results:

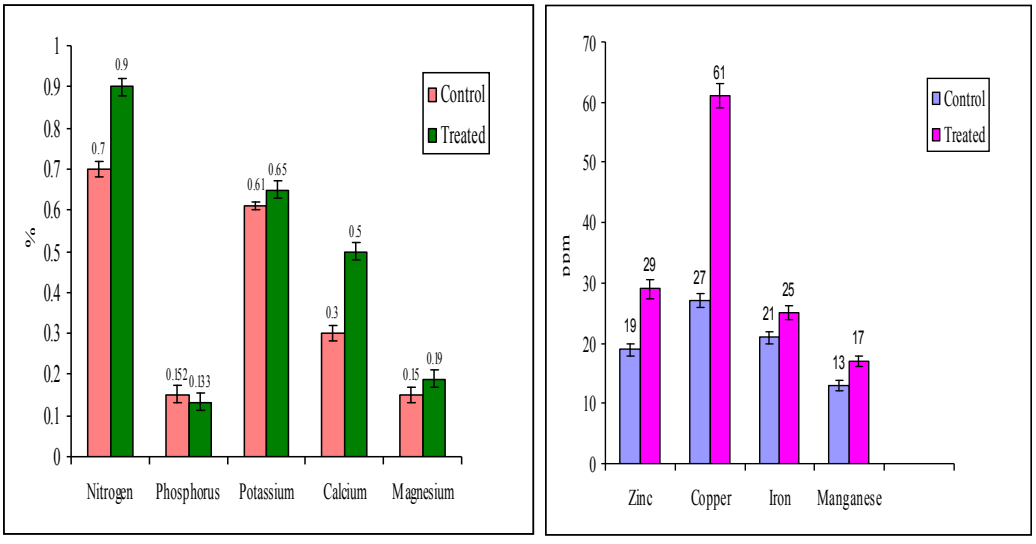
The results recorded in Fig. 3.8 showed increase in nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese contents and decrease in phosphorus contents in fruits of treated brinjal plants over control plants.

Fig. 3.7 Effect of soil application of oxygenated peptone on enzyme activities in fruits of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.



Values are mean of five determinations and the error bars represent standard deviation.

Fig. 3.8 Effect of soil application of oxygenated peptone on mineral contents in fruits of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.



Values are mean of five determinations and the error bars represent standard deviation.

Discussion:

The increase in the mineral contents is significant from human nutrition point of view. Jilani *et al.* (2007) remarked that heavy dosage of nitrogen increases vegetative growth and makes the plant luxuriant. This in turn reduces reproductive growth and delays flowering in brinjal. Such situation is avoided under present experimental condition leading to early flowering and early fruiting with high yield. Sherin and Anuja (2008) studied the effect of organic and inorganic fertilizers on yield and yield attributes of cluster bean. They found that the combination treatment of N, P, and K with vermicompost recorded highest number of seeds. They made a comment that this may be due to the accelerated mobility of photosynthates from the source to the sink as influenced by the growth hormones, released or synthesized due to organic sources. Susan (1995) stated that K-uptake held the mobility of photo assimilates to the sink. Increase in number of seeds per fruit found in our investigation is significant from this point of view.

Flick *et al.* (1977) remarked that there appeared to be a correlation between Cu content and polyphenol oxidase activity and also between Fe and catalase activity. According to Agrawal *et al.* (2008), among the micro-nutrients zinc, boron, iron and copper, zinc were effective for more number of fruits per plant in tomato while fruit diameter, weight and volume were markedly higher under Fe spray. Indeed, zinc increases metabolic activities, biosynthesis of auxins and nutrient uptake. As a result, there is higher yield. Similar results are reported by Singh and Verma (1991). Khedr *et al.* (2004) reported that a combination treatment of calcium and gibberellic acid resulted in the highest significant increase in all vegetable characteristics (plant height, number of leaves and number of branches) in brinjal while the combination of zinc and sugar showed the maximum value for earliness in flowering along with increase in fruit set percentage, yield per plant, fruit diameter and dry matter percentage. Gibberellic acid can not be used for organic farming. The enhancement in the yield found under present experimental condition is noteworthy because such treatment can replace gibberellic acid or direct use of micronutrients in the form of plant spray which again goes against the principles of organic farming i.e. feed the soil and not the crop.

3.11 CHANGES IN METABOLIC PATHWAYS:

Metabolic path analysis of biochemical constituents, enzyme activities and mineral contents in root, stem, leaf and fruit of brinjal is shown in Fig. 3.9, 3.10 and 3.11.

Protein and total carbohydrate contents were lowest in root and increased in stem. The highest level was seen in leaf and then it decreased in fruit in both treated and control plants yet showing higher level in treated plants. Polyphenols and proline showed increase in stem as compared to root but then the level went on decreasing in leaf and fruit in both treated and control plants. However, the treated plant showed upper hand (Fig. 3.9).

The levels of oxidative enzymes like catalase, peroxidase and polyphenol oxidase exhibited more or less the same pattern showing lowest activity in root which slightly increased in stem. Suddenly it showed very high level of activity in leaf which dropped in fruit. Treated plants showed higher level of activity as compared to control plants (Fig. 3.10).

The minerals like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese showed increase in root, stem, leaf and fruit of oxygenated peptone treated brinjal plants as compared to control plants while phosphorus content showed decrease in root, stem, leaf and fruit of treated plants over control plants.

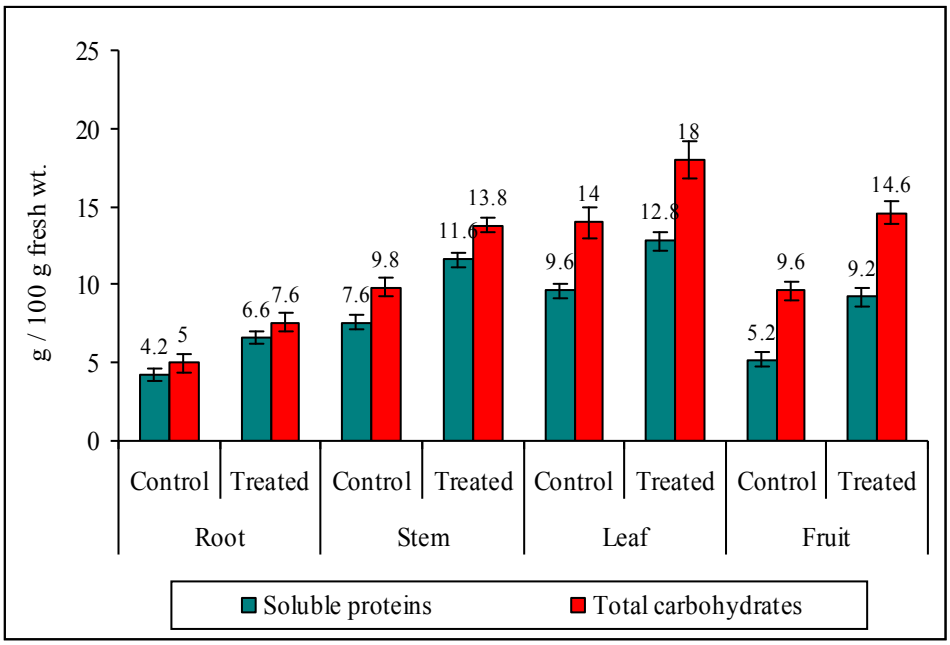
3.12 RHIZOSPHERE SOIL ANALYSIS:

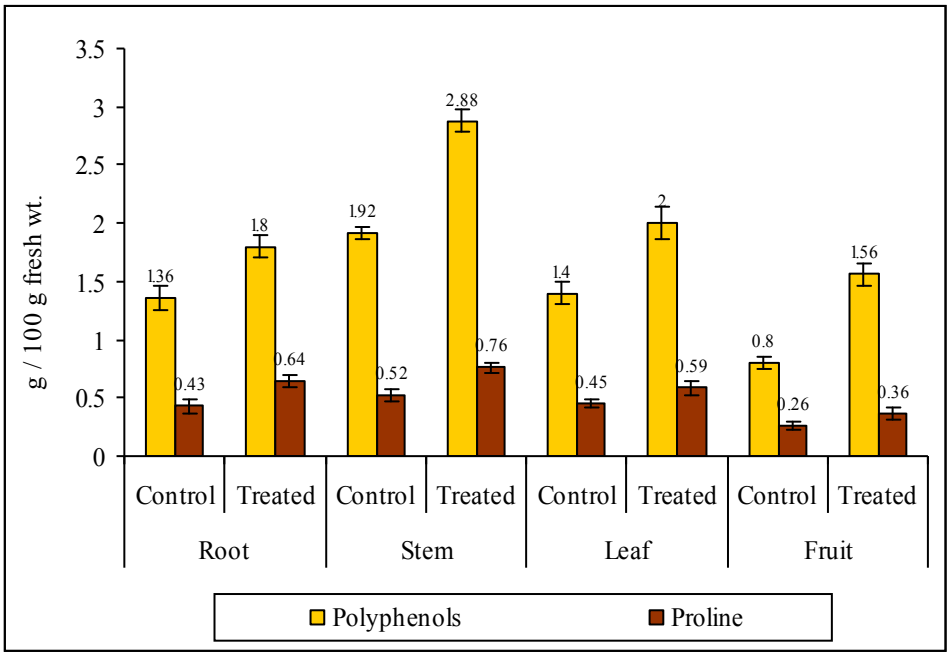
3.12.1 Physical properties:

Results:

The results recorded in Table 3.10 showed that the pH of treated rhizosphere soil was 7.24 as against control rhizosphere soil having pH 7.97. It indicated that due to soil treatment with oxygenated peptone, soil pH improved in the neutral direction. The electrical conductivity increased from 0.37 to 0.49 showing an increase of 32.4%. There was increase in soil moisture (31.0%), soil porosity (9.52%) and water holding capacity (34.6%), while there was decrease in both soil temperature (2^0C) and bulk density (6.66%) in oxygenated peptone treated rhizosphere soil over control.

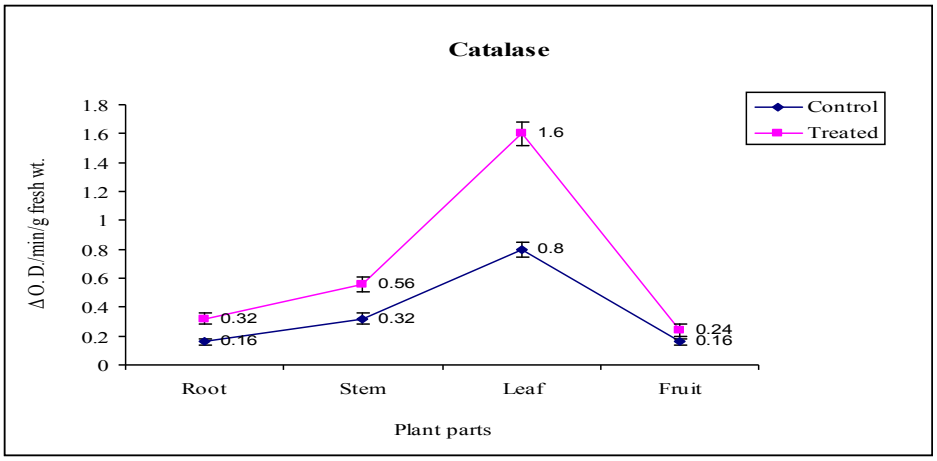
Fig. 3.9 Effect of soil application of oxygenated peptone on biochemical constituents in root, stem, leaf and fruit of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

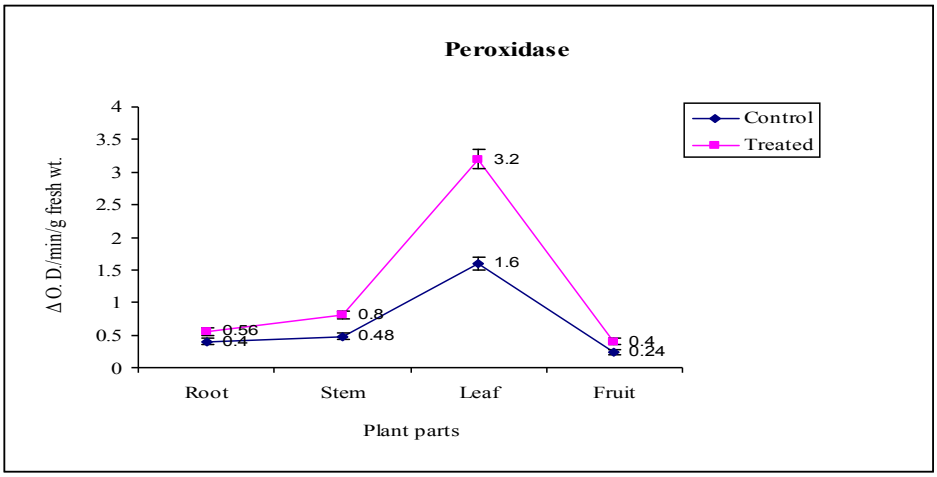


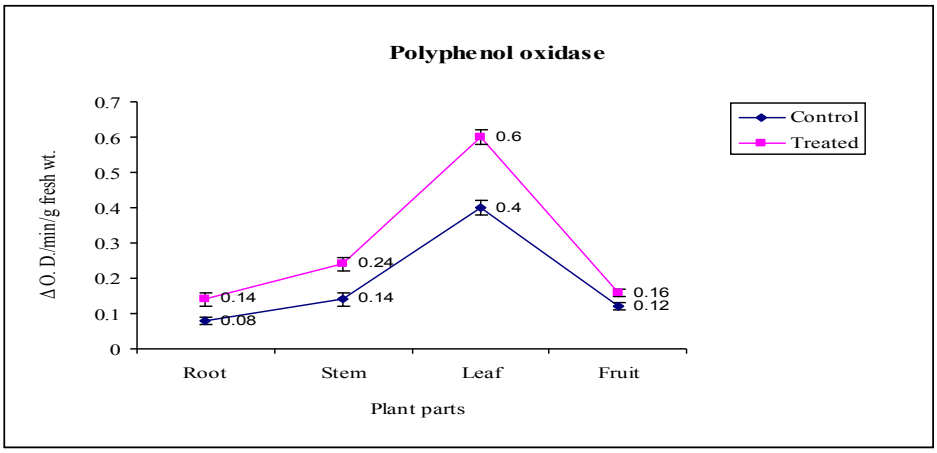


Values are mean of five determinations and the error bars represent standard deviation.

Fig. 3.10 Effect of soil application of oxygenated peptone on enzyme activities in root, stem, leaf and fruit of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

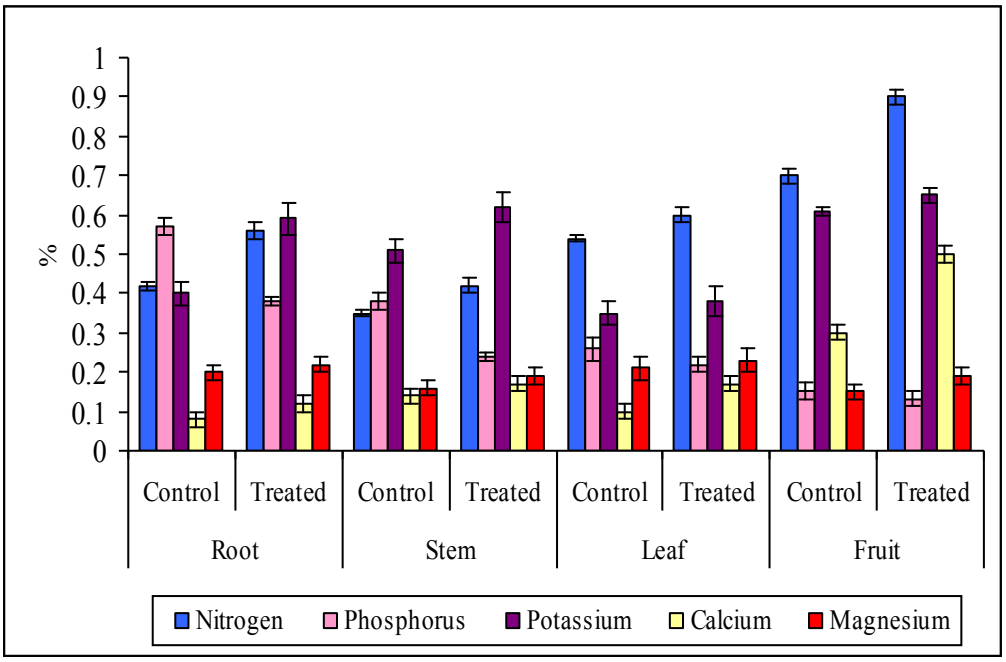


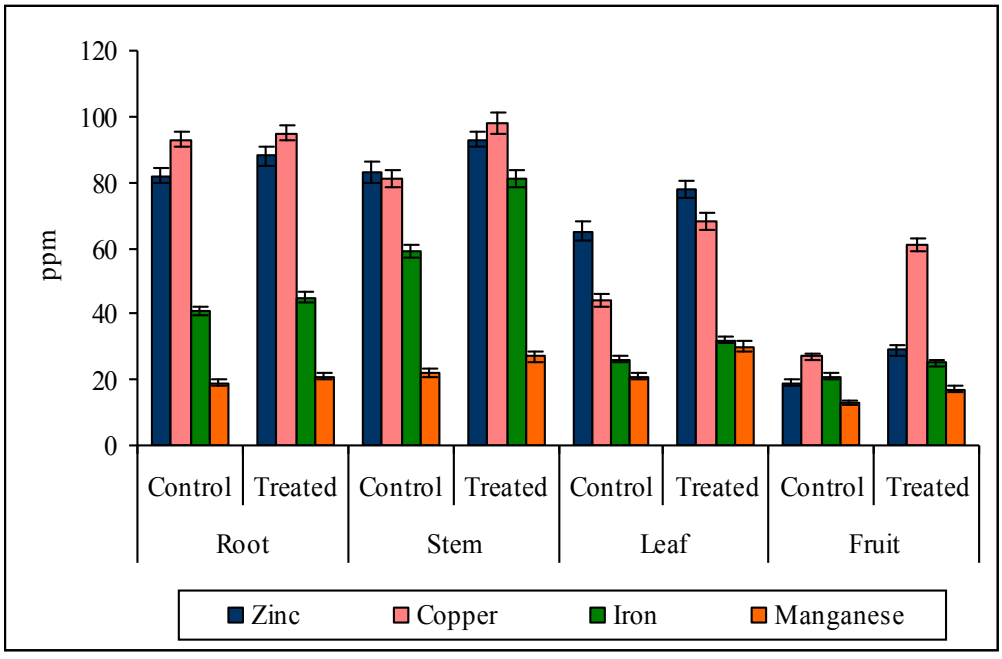




Values are mean of five determinations and the error bars represent standard deviation.

Fig. 3.11 Effect of soil application of oxygenated peptone on mineral contents in root, stem, leaf and fruit of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.





Values are mean of five determinations and the error bars represent standard deviation.

Table 3.10 Effect of soil application of oxygenated peptone on physical properties of rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameters	Control	Treated	Increase (%)
Soil pH	7.97 ± 0.01	7.24* ± 0.01	- 9.15
E.C. (d sm^{-1})	0.37 ± 0.01	0.49* ± 0.05	32.4
Soil temperature (^{0}C)	22.0 ± 0.1	20.0* ± 0.1	- 2.0
Soil moisture (%)	29.0 ± 1.2	38.0* ± 1.5	31.0
Bulk density (g / cm^3)	1.5 ± 0.05	1.4* ± 0.05	- 6.66
Soil porosity (%)	42.0 ± 2.0	46.0* ± 2.0	9.52
Water holding capacity (%)	34.3 ± 1.5	46.2* ± 2.0	34.6

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' represents significance at $p < 0.05$.

Discussion:

If the rhizosphere is inadequate in oxygen, it would not support the absorption of minerals in proper way. So soil must have optimum quantity of water, oxygen and minerals. Mikkelsen (2000) made a case study of a farmer in the Coastal Plain of North Carolina, who cultivated vegetables for 12 years using organic farming technique. He found that within this period, the concentration of several plant nutrients increased as much as five fold in the soil. Hence in the present investigation, soil conditioning is done using oxygenated peptone so as to improve soil characters. Vaquero (2005) studied soil physical properties and banana root growth. He observed that physical properties of soil regulate the conditions in which the roots grow. Therefore, these properties should be evaluated to determine the soil's potential for production. He further remarked that the physical characteristics that affect the water-air balance and soil consistence (the resistance of a soil to mechanical stress at various water contents), are manifested in the growth of the plant root system and consequently in crop productivity. Under adequate nutritional conditions and with good water supply, the roots require aeration and low mechanical resistance for normal growth.

Soil pH:

Soil reaction is the indication of acidity or basicity of the soil. It is measured in pH units ranging from 0 - 12 with pH 7 as a neutral point. The soil pH greatly affects the solubility of minerals. It influences plant growth by its effect on activity of beneficial micro-organisms. Most nitrogen fixing legume bacteria are not very active in strongly acidic soil. Bacteria that decompose soil organic matter and thus release nitrogen and other nutrients for plant use are also hindered by strongly acidic soil. Soil basicity is undesirable for plants. The ability to resist changes in pH is the buffering capacity of soil. The buffering action is effective in controlling concentrations of H^+, Al^{3+}, Ca^{2+}, Mg^{2+}, K^+ and Na^+. Soils high in humus and clay have high buffering capacity. For effective absorption of manure, the soil should be neutral. In the present investigation, the soil pH tends towards neutralization in the soil treated with oxygenated peptone which was useful for plant growth. This is well supported by Dwivedi *et al.* (1982, 1983). They reported that there is significant decline in the pH of rhizosphere soil of alkali halophytes and rice. The reduction in pH is due to

synthesis of organic acids in the leaves which are translocated to the roots and exuded in soil and thereby reduction in rhizosphere pH. This finally provides favorable conditions to plants for growth and higher yield. In the present investigation, the pH of soil treated with oxygenated peptone tends towards neutrality which is favourable for plant growth.

Electrical Conductivity:

Soil possesses at least small amount of various soluble salts. These salts may be acidic, neutral or basic. If excess salts are present in soil, the plant growth is adversely affected, because excessive salts in soil solution cause osmotic pressure which prevents absorption of moisture and nutrients by plants in adequate amounts. Soluble salts present in the soil dissociate into their respective cations and anions in the soil solution. These cations and anions carry current and impart conductivity. Higher the concentration of ions in solution, more is its electrical conductivity (less the resistance to electric current). Thus, the measurement of electrical conductivity is directly related to the concentration of soluble salts. The electrical conductivity provides a rapid and reasonably accurate estimate of solute concentration. Hence in the present investigation, electrical conductivity is measured. Under experimental conditions, the electrical conductivity of the treated rhizosphere soil showed increase which indicates the increase in the concentration of salts in the treated rhizosphere. This leads to increase in the absorbance of water and minerals by the root system.

Soil temperature:

Soil temperature is one of the most important soil properties that affect crop growth. Germination entirely depends on soil temperature as the seed is inside the soil. Too high or too low temperature injures or even kills the seed. Optimum soil temperature for germination and emergence differs from plant to plant. Organic matter decomposition (mineralization), nitrogen fixation in legumes and other microbial activities are all temperature dependent. Nutrient availability is higher at optimum temperature. Soil structure is greatly influenced by soil temperature. The temperature affects the aggregation of soil particles and binding material present in it. Hence in the present investigation, soil temperature was noted which showed a decrease under experimental condition. It seems that, increase in both soil moisture

and water holding capacity caused decrease in the soil temperature of treated rhizosphere soil as compared to control.

Soil water:

Plants absorb water through the roots from soil. Water acts as a lubricant allowing the roots to penetrate through the soil for absorption of water and minerals. Water allows mobility of nutrients within the soil microclimate. It is also necessary for the mobility and activity of soil microbes. If soil is dry, water uptake by plant stops, nutritional absorption ceases and the root growth practically stops. The increased soil moisture as a result of soil application of oxygenated peptone is significant in this case.

Bulk density:

Density is the weight per unit volume of a substance. Soil density is measured in terms of particle density and bulk density. The weight per unit volume of the solid portion of soil is called particle density. It is also termed as true density. It depends upon the accumulative densities of the individual inorganic and organic constituents of the soil. Bulk density is defined as the mass (weight) per unit volume of a dry soil including pore spaces. The bulk density of a soil is always lower than its particle density. Bulk density normally decreases as mineral soils become finer in texture. Bulk density is important in understanding the physical behavior of soil. In the present investigation, bulk density was decreased under experimental condition, which is an indication of favorable physical conditions of soil. This is supported by the observation of Qazi *et al.* (2006), who observed decrease in bulk density with supply of organic manure. Further, Paikaray *et al.* (2007) pointed out that the effect of bulk density was influenced largely by soil texture, initial soil moisture content and source of sulfur after infiltration and re-distribution under varying soil texture.

Soil porosity:

Volume percentage of total pore space in a soil is known as soil porosity. Pore spaces in a soil consist of that portion of the soil volume not occupied by solids, either mineral or organic. The pores in soil are the result of irregular shapes of primary particles and their aggregation, the forces of penetrating roots and of expanding gases entrapped by water. Under field conditions, pore spaces are occupied at all the times

by air and water. Clay soils have 50-60% pore spaces while sandy soils have above 30% pore spaces. There are two types of pores in soil, macro-pores and micro-pores (capillary pores). Macro-pores are large sized pores which allow the movement of air and water readily. Sands and sandy soils have a large number of macro-pores. Micro pores are smaller in size, in which movement of air and water is restricted to some extent. Clay and clayey soils have a greater number of micro-pores. If the soil has macro-pores mostly, the attraction forces in the soil retain the water within the fine pores. This results in waterlogged soil and poor aeration. Thus, to the growing plant, pore size is more important than total pore space. The best balance of water retention (smaller pores) plus adequate air and water movement (larger pores) is found in medium textured soil such as loam. Aggregation, or the lack of it, can modify this balance of large and small pores which results from the soil texture. The relative amount of air and water drives air from the pores, but as soon as soil water disappears by deep percolation, evaporation and transpiration, air gradually replaces the water. Soil porosity is essential for the exchange of gases for respiration by plant roots and micro-organisms within the soil useful for the decomposition of organic matter. The most desired condition is well aerated soil in which oxygen exchange between soil-air and atmospheric air is rapid. In the present investigation, soil porosity was increased under experimental condition, which may be due to the evolution of oxygen in the soil from oxygenated peptone under moist condition.

Water Holding Capacity:

Water holding capacity is defined as the amount of moisture in a soil when its total pore spaces (both macro and micro spaces) are completely filled with water. This happens when a thin layer of soil is allowed to absorb water. Moisture content of such saturated soil column determined on oven-dry soil basis is called as Water Holding Capacity (WHC). In general, WHC increases with increase in proportion of micro-pores in the soil. In the present investigation, WHC was increased under experimental condition, which is well correlated with increased soil porosity. The improved soil porosity along with increased WHC indicates a well balanced condition of air and water in the soil micro-climate. This is conducive to the growth of roots as well as growth of micro-organisms.

3.12.2 Chemical properties:

Results:

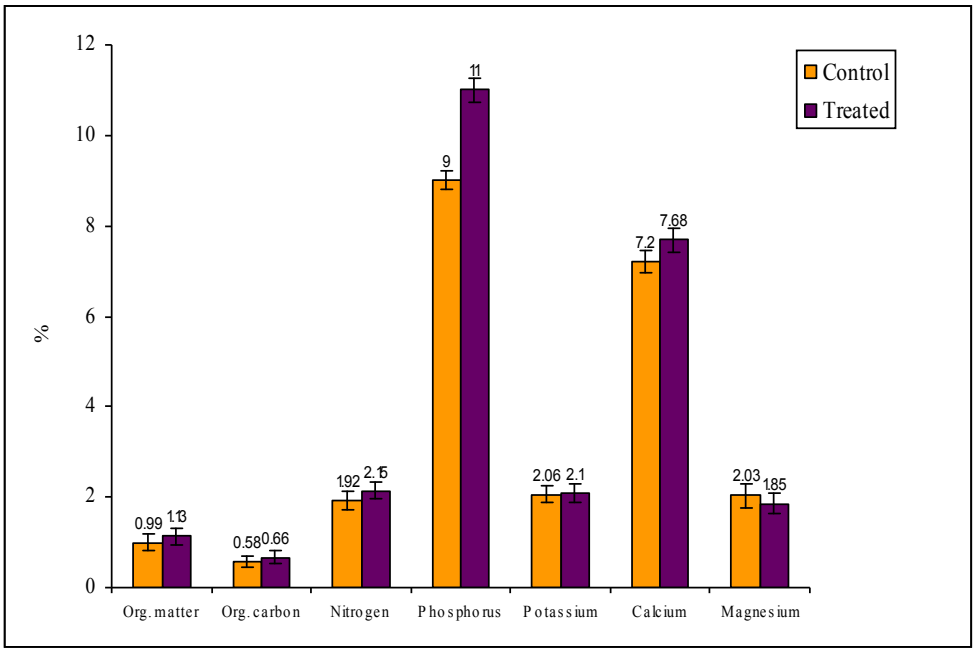
Results recorded in Fig. 3.12 showed increase in organic matter and organic carbon content of treated rhizosphere soil as compared to control rhizosphere soil. There was increase in the contents of constitutive elements like nitrogen (11.9%), phosphorus (22.2%) and calcium (6.66%) and the non-constitutive elements like potassium, copper, iron and manganese by 1.94%, 56.0%, 24.8% and 18.4% respectively in treated rhizosphere soil, while magnesium and zinc contents was decreased by 8.86% and 15.6% respectively in treated rhizosphere soil.

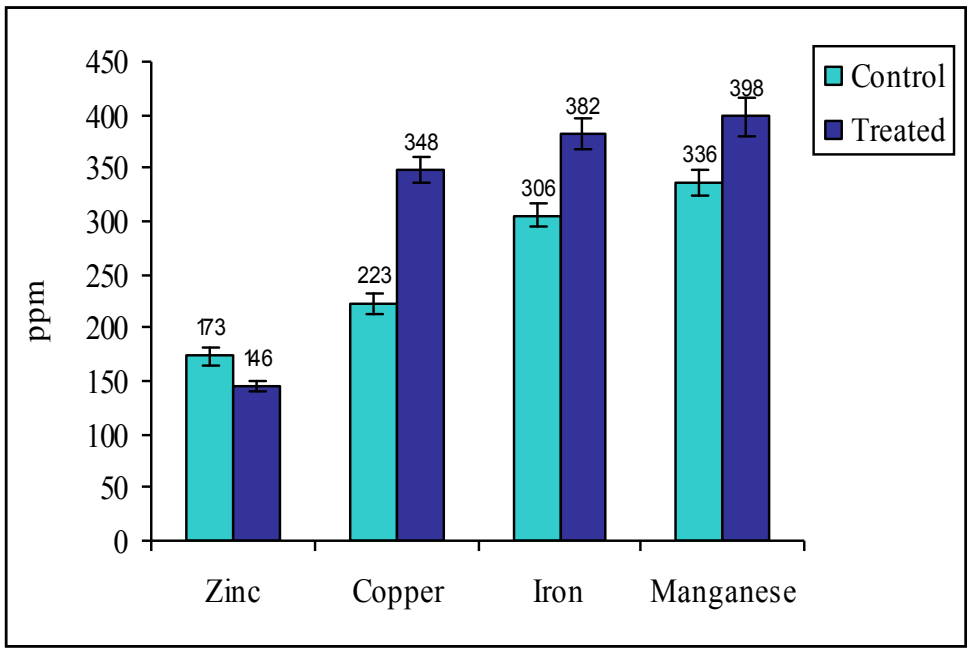
Discussion:

Organic matter:

Soil organic matter consists of plant, animal and microbial residues in various stages of decay. Organic matter contains about 5% total nitrogen so it serves as a store house for reserve nitrogen. But nitrogen in organic matter is in organic form and not immediately available for plant use, since decomposition usually occurs slowly. Organic matter decomposition tends to release nutrients, but nitrogen and sulfur can be temporarily tied up during the process. Micro-organisms involved in the decomposition of organic matter require nitrogen to build protein in their bodies. The physical and chemical properties of soil depend on soil organic matter. Activities of soil micro-organisms, aggregate stability of soil and water holding capacity depend upon soil organic matter. Soil organic matter consists of a whole series of products which range from undecayed plant and animal tissues to fairly amorphous brown to black material bearing no traces of anatomical structures of the material. In addition, it contains living and dead microbial cells, compounds synthesized by microbes and derivatives of these materials, produced as a result of microbial decay. This is called as humus, which contains about 50% carbon, 35% oxygen, 5% nitrogen and 5% hydrogen. Thus, organic matter is a source of plant nutrients which are liberated in forms readily available to plants. Humus can be considered as a storehouse of various nutrients essential for plant growth. It improves structure, drainage and aeration of the soil. In addition, it improves water holding capacity, buffer and exchange capacities, influences the solubility of minerals and serves as a source of energy for the

Fig. 3.12 Effect of soil application of oxygenated peptone on chemical properties of rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.





Values are mean of five determinations and the error bars represent standard deviation.

development of micro-organisms. In the present investigation, treated rhizosphere soil showed increased percentage of organic matter, which is correlated with the observations of Lynch *et al.* (2005). They observed that there is increase in the soil organic matter using compost treatment. Tsadilas *et al.* (2005) remarked that organic matter content was positively correlated with water holding capacity, available water infiltration rate and finally yield and was negatively correlated with bulk density, which supports our observation in the present investigation. Gupta *et al.* (2006) indicated that agro-forestry improves physical properties of the soil by adding high amounts of organic matter in the form of leaf biomass. In addition, there is increase in porosity and WHC of the soil.

Organic carbon:

Organic carbon is necessary for soil microbes to get their nutrition because they require many micro nutrients which are available only in the organic carbon. An efficient organic farming system requires maintenance of optimum organic carbon in the soil. This parameter decides how easily and at what cost one can switch over to organic farming system without compromising the yield level. Due to tropical climate (low rain and high temperature) prevalent in large part of Maharashtra and cultivation practices like ploughing (which promote higher rate of decomposition and oxidation) result in low organic carbon content of soil. The countries like Sweden and Switzerland show the organic carbon content in the soil at a higher rate of 2.5 and 3.5. As against these, 0.50% organic carbon is considered as low, 0.50 - 0.75% as medium and higher than 0.75% as high soil organic carbon in India (Hegde *et al.,* 2006).

Soil organic carbon plays a vital role in soil productivity. So it is essential to analyze this parameter. According to Nguyen and Goh (1992), soil sulfur was significantly correlated with organic carbon and total nitrogen. Further, long term super phosphate application increased organic carbon and total nitrogen. However, Badole and More (2000) stated that the organic carbon content was relatively higher with organic nutrient treatment than those having inorganic nutrient treatment. The combination of different organic sources is superior for higher carbon status and slow degradation. The organic carbon declined gradually with the length of incubation period. This decline was greater in chemical fertilizer treatments rather than organic sources. Hati *et al.* (2007) observed that balanced application of inorganic fertilizer and organic amendments greatly influenced the accumulation of soil organic carbon,

improved soil physical environment and sustained higher crop productivity. In the present investigation, increase in soil organic carbon was correlated with increase in total nitrogen.

Mineral nutrients:

According to Sharma (2006), plants feed themselves from atmosphere and from soil. The nutrients available from atmosphere are carbon (44%), hydrogen (6%), oxygen (44%) and nitrogen (2-3%) with the total approximately 95%. The soil provides about 5% of plant's diet. This consists of small quantities of various minerals. Thus plants feed quantitatively from atmosphere and qualitatively from soil.

The elements taken from soil are constitutive and non-constitutive of plant matter. The constitutive elements are absorbed by the plant in oxidized or chelated form. These transformations are brought about by the micro-organisms in the soil. The non-constitutive elements simply provide the plants with electric charges needed for their various growth processes. These elements are returned to the soil at maturity state in the form of litter. Only green parts and other living parts like seeds contain minute quantities of these elements. Thus, it appears that all constitutive elements pass through the biological cycle and enter the plant in organic way. The non-constitutive elements enter the plants in an atomic way. Thus the plants have organic diet (Sharma, 2006). It seems that conventional (chemical) farming system promotes odd practices (use of chemical fertilizers) that go against the nature of plants. That is why during course of time, there is decrease in the soil fertility and crop productivity under conventional farming system. Under this situation, soil conditioning by organic amendment using oxygenated peptone is promoting soil fertility as well as crop productivity in natural way.

The results of present investigation are well supported by Gupta *et al.* (1991). They showed that soil organic carbon has significant positive correlation with total nitrogen, total phosphorus and total potash. Dhanya *et al.* (2006) studied variation in soil organic carbon and micro nutrient status in teak plantations under different rotations in Kerala (India). They found that soil organic carbon content was the highest in the first rotation which went on decreasing in successive rotations along with decrease in zinc, manganese and iron. However in present investigation, interestingly, it is found that there was increase in the soil organic carbon, iron and manganese after first rotation, due to oxygenated peptone treatment under organic

farming condition. This was indeed a great achievement when we consider the observation of Parfitt *et al.* (2005), who could find no convincing evidence that net nitrogen mineralization, pasture growth and soil biological diversity increased under organic farming.

3.12.3 Biological properties:

Results:

Results recorded in Table 3.11 showed that the total number of colonies of heterotrophic bacteria was 52 colonies with 86.6 x 10^4 CFU / g soil in control rhizosphere soil while oxygenated peptone treated rhizosphere soil showed 84 colonies with 140 x 10^4 CFU / g soil showing an increase of 61.5%. Non-symbiotic nitrogen fixing bacterium showed 18 colonies with 30 x 10^4 CFU / g soil in control rhizosphere soil while the treated rhizosphere soil showed 34 colonies with 56.6 x 10^4 CFU / g with an increase of 88.8%. Soil fungi showed 11 colonies with 18.3 x 10^4 CFU / g soil in control rhizosphere soil while the treated rhizosphere soil showed 12 colonies with 20 x 10^4 CFU / g soil exhibiting an increase of 9.0. The colonies of *Bacillus subtilis* isolated on NA medium, colonies of *Azatobacter chroococcum* isolated on Ashby's mannitol agar medium and the colonies of soil fungi isolated on Czapek-Dox agar medium are well observed in Plate XIV, XV and XVI. Results recorded in Table 3.12 and observed in Plate XVII showed the effect of soil application of oxygenated peptone on the population of soil fungi isolated from rhizosphere soil of brinjal. The fungi like *Aspergillus fumigatus, Penicillium notatum*, Trichoderma *viridae* and *Paecilomyces lilacinus* showed positive increase in their population in rhizosphere soil of brinjal treated with oxygenated peptone while the population of *Mucor indicus* and *Alternaria alternata* showed decrease in treated rhizosphere soil over control.

Discussion:

The region where the soil and root make contact is called as rhizosphere. The microbial population on and around the roots is considerably higher than that of root-free soil. The differences are both qualitative and quantitative. Bacteria in

Table 3.11 Effect of soil application of oxygenated peptone on biological properties of rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Types of Organism	Total no. of colonies			Colony forming units (CFU) / g soil		
	Control	Treated	Increase (%)	Control	Treated	Increase (%)
Heterotrophic bacteria	52.0 ± 1.5	84.0** ± 1.5	61.5	86.6 x 10^4	140 x 10^4	61.5
Non symbiotic nitrogen fixing bacteria	18.0 ± 1	34.0** ± 1	88.8	30 x 10^4	56.6 x 10^4	88.8
Fungi	11.0 ± 0.5	12.0* ± 0.5	9.0	18.3 x 10^4	20 x 10^4	9.0

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

PLATE XIV

Bacterial colonies of *Bacillus subtilis* isolated from oxygenated peptone treated rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS on NA medium.

PLATE XV

Colonies of *Azotobacter chroococcum* isolated from oxygenated peptone treated rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS on Ashby's mannitol agar medium.

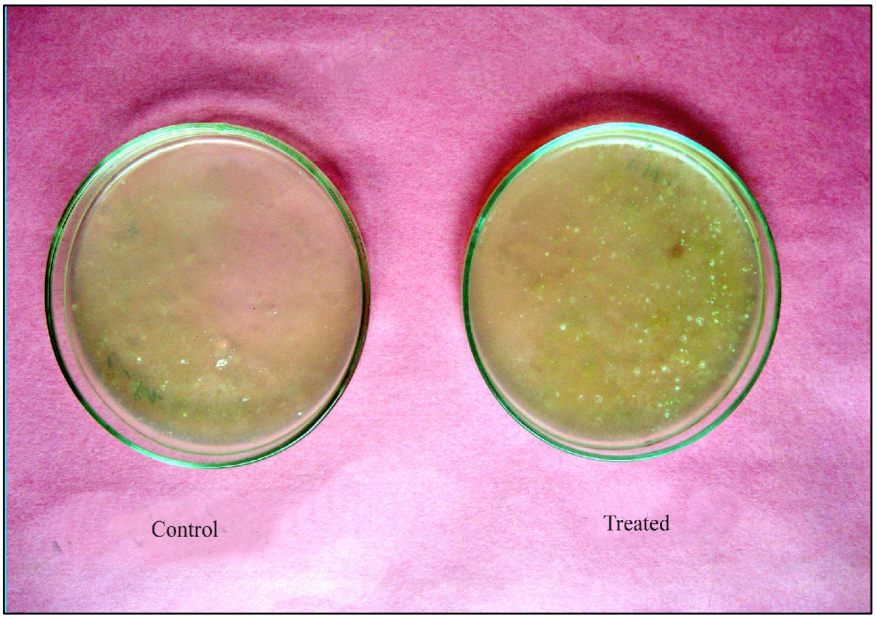


PLATE XVI

Colonies of soil fungi isolated from oxygenated peptone treated rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS on Czapek-Dox agar medium.

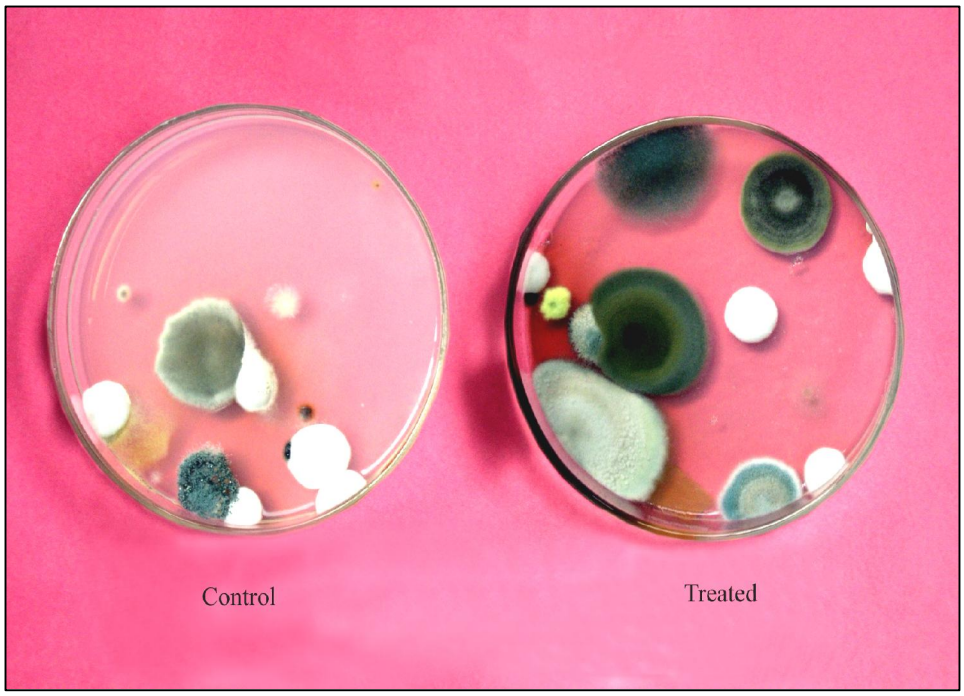


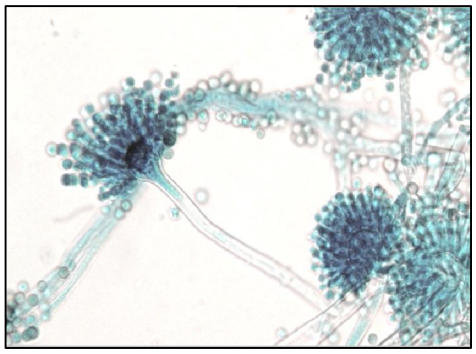
Table 3.12 Effect of soil application of oxygenated peptone on soil fungi isolated from rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.

Name of fungi	Number of colony			Diameter of colony (cm)		
	Control	Treated	Increase (%)	Control	Treated	Increase (%)
Aspergillus fumigatus	2.0 ± 0.01	2.0 ± 0.01	-	1.0 ± 0.1	1.6** ± 0.1	60.0
Penicillium notatum	0	2.0** ± 0.01	200.0	-	1.8 ± 0.1	-
Rhizopus stolonifer	3.0 ± 0.05	3.0 ± 0.05	-	0.8 ± 0.01	0.8 ± 0.01	-
Mucor indicus	3.0 ± 0.05	1.0* ± 0.01	- 66.6	0.6 ± 0.01	0.4* ± 0.01	- 33.3
Trichoderma viridae	2.0 ± 0.01	3.0* ± 0.05	50.0	1.5 ± 0.1	2.2* ± 0.1	46.6
Paecilomyces lilacinus	0	1.0** ± 0.01	100.0	-	0.4 ± 0.01	-
Alternaria alternate	1.0 ± 0.01	0	- 100.0	0.2 ± 0.01	-	-

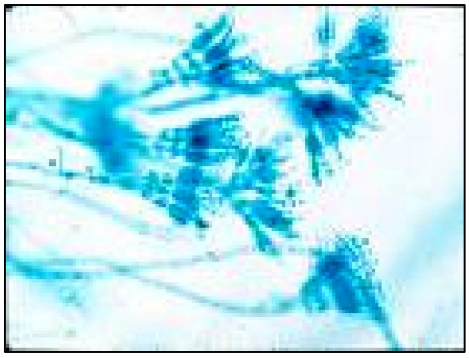
Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$ respectively.

PLATE XVII

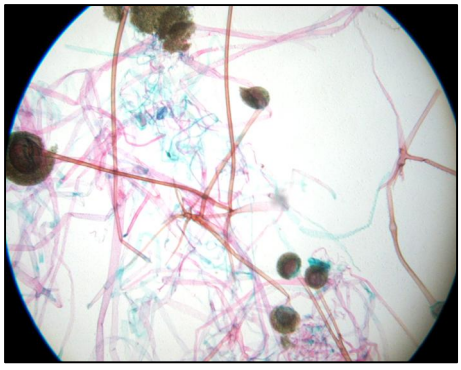
Soil fungi isolated from oxygenated peptone treated rhizosphere soil of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS on Czapek-Dox agar medium.



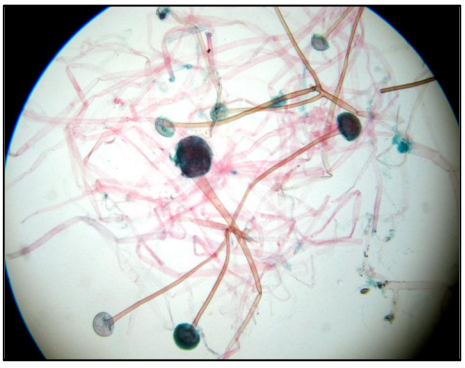
Aspergillus fumigatus



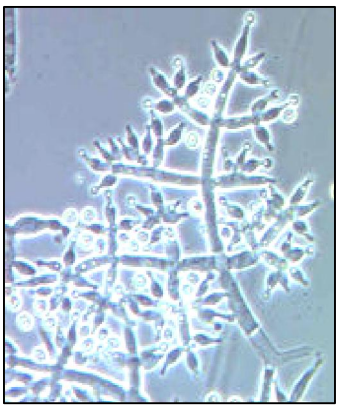
Penicillium notatum



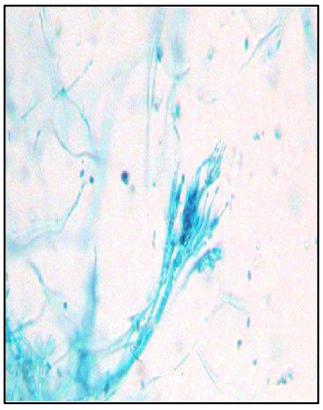
Rhizopus stolonifer



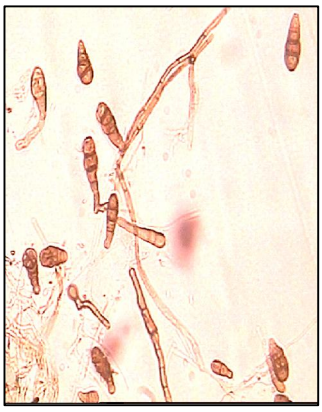
Mucor indicus



Trichoderma viridae



Paecilomyces lilacinus



Alternaria alternata

(Magnification : 10 X 40x)

rhizosphere are predominating and their growth is enhanced by nutritional substances released from plant tissue e.g. amino acids, vitamins and other nutrients. The growth of plants is influenced by the products of microbial metabolism that are released into soil. The rhizosphere represents a tremendously complex biological system and there is a great deal yet to be learnt about the interactions which occur between the plant and the micro-organisms, intimately associated with its root system.

Microbial ecosystem of soil includes the total microbial flora together with physical composition and physical characteristics of soil. It is the sum of the biotic and abiotic components of soil. The soil is an excellent medium for the development of microbes, since it contains all the elements essential for their activities. The plant and animal residues with suitable sources of energy keep the various microbes in a state of constant activity and reproduction. The relationships between soil, plants and microbes are mutual. The soil and plant supply the medium for the growth of microbes. They also supply the energy and other nutrients for microbial activities and reproduction. The microbes carry out the processes which keep the elements in constant circulation, thus enabling the plants to develop with a limited supply of nutrients. They transform these elements in soluble form so that these elements become available to plant.

***Bacillus subtilis*:**

Bacillus subtilis is also known as hay bacillus or grass bacillus. It is a Gram positive, saprophytic bacterium commonly found in soil. It is rod shaped, aerobic, catalase positive bacterium and is used to produce amylase enzyme. It has a natural fungicidal activity and so it is employed as a biological control agent. It secretes various organic and inorganic acids which act on insoluble phosphates and convert them into soluble phosphates in the rhizosphere. The bacteria are found to be more efficient in the secretion of organic acids. Addition of organic manures helps in increasing the solublizing power of the bacteria (Panda, 2006). In the present investigation, the number of colonies of *Bacillus subtilis* is found to be increased using soil application of oxygenated peptone. The supply of oxygen by oxygenated peptone might be helpful for the growth and multiplication of this aerobic bacterium exhibiting increase in the population. This led to increase in the total phosphorus in the rhizosphere soil (Fig. 3.12).

***Azotobacter chroococcum*:**

It is Gram negative, aerobic, non-symbiotic nitrogen fixing bacterium. It fixes atmospheric nitrogen in the rhizosphere. It also produces Thymine, Riboflavin, Nicotine, Indole Acetic Acid and Gibberellin and some substances which check the growth of the plant pathogens such as *Alternaria, Fusarium* and *Helminthosporium.* Hence, *Azotobacter* also acts as a biological control agent (Anonymous, 2009). In the present investigation, the number of colonies of *A. chroococcum* is found to be increased. Soil application of oxygenated peptone supplies organic nitrogen to *Azotobacter chroococcum,* which enhances its nitrogen fixing ability. Gibberellin produced by *Azotobacter chroococcum* leads to increase in plant productivity. At the same time, it acts as a biological control agent for fungal plant pathogens and thus increases plant's disease resistance. All this leads to overall better plant growth.

Soil fungi:

Soil fungi are useful to decompose cellulose, lignin and pectin present in the soil in the form of plant and animal residues which form the humus. Humus formation is a slow decomposition process, which improves physical structure of soil. The soil fungi convert the proteins, humic acid, fulvic acid and complex amino acids into simpler forms like carbon, hydrogen, oxygen, nitrogen, sulfur and other nutrients. The fungal mycelium helps the soil particles to bind together and thus the soil structure is improved. The net result is stability of soil structure, better drainage and aeration of soil. In the present investigation, there is higher density of microbial biomass as a result of soil application of oxygenated peptone. This is supported by the work of Agele *et al.* (2005), who hypothesized that low input system involving reduced tillage methods and mineral fertilizer and / or live stock manure use would support a higher density of microbial biomass, soil aggregation, organic carbon and total nitrogen and hence improve the soil quality. Microbial biomass is positively correlated with both soil organic carbon and water holding capacity. These activities mediate many biological and physical processes of soil carbon, nitrogen mineralization, soil aggregation, water holding capacity and microbial biomass which lead to improvement in soil quality. According to Antwerpen *et al.* (2005), the soil micro-organisms have the potential to be important indicators of soil health. These are responsible for the decomposition and transformation of organic matter in soils and

are also responsible for a significant number of mineral transformations. These processes affect nutrient availability, and hence, soil quality and crop yield. The increase in the number of colonies and population of soil micro-organisms in the present study indicates improvement in soil health, soil quality and crop yield. The impact of bio fertilizers / bio inoculants on the crop yield is studied by various workers. Sharma *et al.* (2005), studied efficacy of native bio inoculants like AM fungi and *Azotobacter* separately as well as in combination for enhancing biomass productivity in agro-forestry systems. The combined inoculation of AM fungi and *Azotobacter* gave the best results. Chaudhuri *et al.* (2005) studied the effect of integrated nutrient management on growth and productivity of brinjal. They found that nutrients available in soil such as N, P and K, increased significantly with the application of various organic and microbial sources of nutrients. The inoculated and nitrogen fertilizer added soil maintained the increase in microbial population. Lu *et al.* (2006) investigated effects of organic fertilizers on continuous cropping of watermelon, its growth and soil microflora. The results of their investigations showed that applying organic fertilizers ameliorated soil ecological environment, increased the root activity and watermelon growth and improved soil microflora. The number of soil bacteria and actinomycetes significantly increased after applying organic fertilizers. Surulirajan and Kandhari (2006) observed that fungal and bacterial population of soil was increased significantly over the control by addition of soil amendment material.

***Aspergillus fumigatus*:**

Aspergillus is a filamentous, cosmopolitan and ubiquitous fungus. It includes about 200 species. *Aspergillus* is highly aerobic and is found in almost all oxygen-rich environments. It acts on insoluble phosphates and converts them into soluble phosphates in the rhizosphere. In the present investigation, the number of colonies remained the same in treated and control rhizosphere soil yet the diameter of colony increased in treated rhizosphere soil.

***Penicillium notatum*:**

Penicillium is a filamentous fungus. It is saprophytic in nature and cosmopolitan in occurrence. The species of *Penicillium* are useful to the plants as they carry out phosphate solublization. In the present investigation, control rhizosphere soil

showed no colony of *Penicillium* while the treated rhizosphere soil showed two colonies and this is useful for better plant growth.

***Rhizopus stolonifer* :**

Rhizopus is a saprophytic fungus with about 35 species. *R. stolonifer* is a common species producing white mycelium. It causes soft rot of sweet potatoes in storage. It also causes lactic acid fermentation. In the present investigation, there is no change in the number and diameter of colonies under treated and control condition.

***Mucor indicus*:**

Mucor is a saprophytic fungus with about 60 species. It occurs very commonly in the humus of the soil. It is pathogenic to plants and human beings. It also brings about alcoholic fermentation. In the present investigation, the number and diameter of colonies showed decrease in treated rhizosphere soil over control. This decrease was significant because it indicates that oxygenated peptone does not allow the growth of the pathogenic fungus in vicinity of the plant root system and thus induces disease resistance in the plant.

***Trichoderma viridae*:**

Trichoderma viridae is a saprophytic fungus present in all types of soil. It is useful as biocontrol agent against fungal diseases of plants. The disease resistance is through various mechanisms such as antibiosis, parasitism, inducing host-plant resistance and competition. Generally, it grows on the root surface and so affects root disease in particular but it can also be effective against foliar diseases. In addition, it carries out phosphate solublization (Panda, 2006). Thus, this fungus is useful for both inducing disease resistance and increasing availability of phosphate to the plant, which leads to better crop growth. In the present investigation, the number and diameter of colonies was increased in treated rhizosphere soil, which leads to more phosphorus in rhizosphere soil (Fig. 3.12) and better growth of plant.

***Paecilomyces lilacinus*:**

Paecilomyces lilacinus is a common saprophytic, filamentous fungus present in all types of soil. It is useful as a biocontrol agent mostly used to control the growth

of destructive root-knot nematodes. Under present experimental condition, the number and diameter of colonies showed increase in treated rhizosphere soil.

***Alternaria alternata*:**

Alternaria is an ascomycetes fungus with 50 sp. *Alternaria alternata* is a common plant pathogen. It also brings about decay and decomposition of humus. The presence of *A. alternata* was diminished under present experimental condition. This indicates that oxygenated peptone brought about killing of this fungus and thus induced disease resistance by improving soil micro-climate.

Soil is the home of thousands of different types of organisms including micro-organisms. These micro-organisms play a very vital role in the mobilization of different nutrients from organic and inorganic sources. To sustain the fertility status of soil, the maintenance of appropriate status of microflora is very essential as they act on complex organic matter and release a wide range of micro nutrients useful for plant growth.

Biofertilizers are ready to use live formulations of beneficial micro-organisms. When applied to seed, root or soil, they mobilize the availability of nutrients by their biological activity in particular and help to build up the microflora and in turn the soil health. Microbial inoculants differ in their effectiveness under varying environmental conditions. This is the major constraint for their successful use in the field. Microbial inoculants successful at one specific geographic location may not do well in other location, because their establishment depends on temperature, soil type, pH, available nutrients, crop type, aeration and moisture content of soil. It is difficult to manipulate the soil environment and make it conducive for establishment of the introduced organism. Rhizosphere competence is another major constraint.

Soil application of oxygenated peptone is significant under this condition. It supplies oxygen slowly and steadily for 40-50 days. It also supplies organic nitrogen in the form of peptone by which nitrogen becomes easily available to the soil micro-organisms. The plant releases about 30% of the photosynthate in the soil by the way of root exudates to attract soil micro-organisms towards the rhizosphere so that they will carry out the specific functions as required by the plant. Here it should be noted that the roots are fixed in the soil and so there is a limitation for attracting the soil micro-organisms from the soil pockets away from the rhizosphere. The role of oxygenated peptone is crucial here. Oxygenated peptone attracts the micro-organisms

from different soil pockets by providing peptone as nitrogen source and oxygen for respiration. The function of root and that of oxygenated peptone are complimentary to each other by which the microbes from far away soil pockets are attracted towards the rhizosphere. Here they get their requirements completely fulfilled, so there is increase in microbial population**.** They carry out their biological activities by which the plants are benefited. Thus soil application of oxygenated peptone is a natural process of microbial inoculation. There is increase in microbial population in natural way. This indeed leads to sustainable agriculture because the plants and the micro-organism in the soil live in harmony with each other. All this leads to better vegetative growth of plant leading to better yield yet maintaining the soil health. Hence, there is no need to use bioinoculants if oxygenated peptone is used.

Thus it can be concluded that pre-sowing soaking treatment as well as soil conditioning with oxygenated peptone was useful to enhance quantity and quality of brinjal under organic farming condition. It supplies both oxygen and peptone which is useful to create favorable micro-climate in the soil useful for the growth of aerobic soil biota as well as plant root system. Such a condition leads to the improvement in soil fertility and crop productivity. As a result, there is enhancement in quantity and quality of fruit. This is also useful for commercial organic farming.

CHAPTER – III

RESULTS AND DISCUSSION

CHAPTER - IV

SUMMARY AND CONCLUSIONS

Vegetables are the rich and cheap source of vitamins and minerals for human beings and hence they occupy an important place in diet. India is the second largest producer of vegetables in the world, next to China, with an estimated production of about 50.09 million tonnes from an area of 4.5 million hectares at an average yield of 11.3 tonnes per hectare. The per capita consumption of vegetables in India is only about 140 gm which is far below the minimum dietary requirement of 280 g / day / person. In India, systematic efforts have been made to upgrade vegetable. The major objective of research on vegetable in India is improving production per unit area by solving chronic problems of production, through breeding high yielding, disease and pest resistant varieties, developing F_1 hybrids, standardization of agro-techniques for different agro-ecological situations and post-harvest studies with a view to reduce post-harvest losses. Despite a large number of varieties and hybrids developed, the productivity of vegetable crops is not improved. Varieties with longer shelf life and suitable for processing are very few. Multiple disease resistant varieties are yet to be developed. Excessive use of pesticides has created problems of pesticide residues and hence there is a need for increasing productivity of vegetables and minimizing the use of chemical fertilizers and pesticides.

After 1990s, the production is decreasing as Indian agriculture is facing serious problem of soil degradation and water pollution due to residues of chemical fertilizers and pesticides. So the need for sustainable agriculture is increasingly felt. Organic farming is a sound and viable option for this problem.

The productivity of agricultural crops in organic farming in India is low and continued research and development efforts are required to improve productivity. In sustainable agriculture, the theme is, “Feed the soil and not the crop.” If the soil health is taken care of, it will ultimately lead to crop health and human health. This can be achieved by soil aeration. Soil oxygen is the fundamental requirement for the growth and productivity of a plant because oxygen is one of the framework elements of plant. Plant requires oxygen for respiration and the energy released during respiration is utilized for growth. Oxygen also takes part in various oxygenation reactions of cell

metabolism and transport of plant growth regulators. So, oxygen availability is a critical factor in plant growth.

In the light of this situation, it has become very essential to develop a technique which will fulfill the criteria of organic farming and yet enhance the vegetative growth of plant leading to increase in yield. The present study is a step in this direction as oxygenated peptone can be used in organic farming. Oxygenated peptone is an organic soil aerator having oxygen (100 mg / g), peptone (650 mg / g) and soluble silicate based inert filler compound (250 mg / g). It releases oxygen slowly and steadily for 40-50 days when applied to the soil at the depth of 10 cm, buried and watered.

Brinjal (*Solanum melongena* L.) is an easily cultivated solanaceous fruit vegetable grown all over the world, round the year. It contributes 9 % of the total vegetable production of India. In Maharashtra, brinjal is grown over an area of 32000 ha with 521600 tonnes of an annual production showing 16.3 t / ha productivity. Brinjal is a rich source of carbohydrates, proteins, fibers, vitamins and minerals. It is easily available in market and has been a common vegetable in diet. The unripe fruit of brinjal is primarily used as a cooking vegetable. Different parts of brinjal plant in addition to fruit are used as a medicine in various countries for healing kidney stone, liver disorders and diabetes.

The present investigation is an attempt to study the role of oxygenated peptone in improving the productivity of brinjal. The experiments were carried out by using pot culture method in Baramati Tehsil and the cultivar of brinjal ‘Ajay’ was used. The influence of oxygenated peptone on germination of seeds and seedling growth of brinjal was studied and biochemical constituents and enzyme activities in seedlings of brinjal were analyzed. The effect of oxygenated peptone on vegetative and reproductive growth of brinjal plant was studied. Biochemical constituents, enzyme activity and mineral contents of root, stem, leaf and fruit were analyzed. The influence of oxygenated peptone on rhizosphere soil of brinjal was also studied. Metabolic path analysis was done.

The significant findings and some broad conclusions emerged from the results of the present investigation are highlighted in a nutshell.

SEED GERMINATION AND SEEDLING GROWTH:

- The pre-soaking treatment with 1 % oxygenated peptone caused significant increase in germination percentage, root and shoot length, root : shoot ratio, vigour index and biomass.
- The mobilization efficiency, emergence index, speed of germination and coefficient of velocity of germination were improved due to oxygenated peptone.
- The treatment was useful to increase the level of biochemical constituents like soluble proteins, total carbohydrates, DNA and RNA in germinating seeds.
- The treatment increased the activity of enzymes like amylase, protease, catalase and super oxide dismutase in germinating seeds.
- The stimulation of catalase activity by this treatment may increase the resistance of seeds to oxidative stress and may cause growth stimulation in the seedlings, which ultimately may help in induction of defense mechanism at later stage of plant growth.

VEGETATIVE GROWTH:

Growth parameters:

- The soil application of oxygenated peptone caused increase in length, diameter, number of secondary roots and secondary branches of stems, as well as root, stem and leaf biomass. Similarly the number of leaves per plant and leaf area were also enhanced over control.

Anatomical features:

- There was an increase in aerenchyma in cortex and pith of root and stem of treated plants.

Biochemical constituents:

- The treatment was useful to enhance the level of biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline in root, stem and leaf of treated plants, which might have helped to improve the growth and defense mechanism.

Enzyme activities:

- The treatment was useful to increase the activity of antioxidant enzymes like catalase, peroxidase, polyphenol oxidase and super oxide dismutase in root, stem and leaf of treated plants which might be useful for the plants to tolerate stress conditions.
- The treatment caused considerable increase in the activity of nitrate reductase and nitrite reductase enzymes in leaf of treated brinjal plants.

Water relations:

- The treatment led to increase in relative water content and osmotic potential of cell sap while it decreased membrane injury in leaf of treated plants.

Photosynthetic pigments:

- The treatment was useful to increase the level of photosynthetic pigments like chlorophyll a, chlorophyll b, carotenoids and xanthophylls in leaf. It also increased chlorophyll a / chlorophyll b ratio and chlorophyll stability index in leaf of treated plants.

Photosynthesis and Photorespiration:

- The treatment increased rate of photosynthetic electron transport (Hill Reaction) in leaf. It also brought about increase in the activity of photosynthetic enzymes like RuBP Carboxylase and PEP Carboxylase and that of photorespiratory enzyme glycolate oxidase in leaf of treated plants.

Mineral nutrients:

- The treatment led to increase in the level of minerals like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese and decrease in phosphorus content in root, stem and leaf of treated plants.

YIELD ATTRIBUTES:

- Soil treatment induced early flowering and fruiting. It also increased length of flowering and fruiting period in treated plants as compared to control plants.
- The treatment increased number of flowers and fruits per plant, along with flower to fruit ratio. This is significant for yield.
- The treatment was useful to increase length, diameter and weight of fruits. It also increased number of seeds per fruit and weight of 100 seeds and decreased ratio of total weight of seeds per fruit to fruit weight. Thus quantity as well as quality of fruits increased.
- The treatment also increased yield as well as shelf life of fruits.

BIOCHEMICAL CONSTITUENTS IN FRUITS:

- The treatment was responsible for increasing total solids, total soluble solids, fibers and ash content and for decreasing moisture and total acid content in treated brinjal fruits. This leads to qualitative enhancement in yield.
- The treatment led to a significant increase in soluble proteins, total carbohydrates, polyphenols, proline and ascorbic acid (vitamin C) contents in fruits. This increases nutritional value of fruits of brinjal.

ENZYME ACTIVITIES IN FRUITS:

- The treatment led to higher level of activity of oxidative enzymes like catalase, peroxidase and polyphenol oxidase in fruits of treated plants, which enhances antioxidant properties of brinjal.

MINERAL NUTRIENTS OF FRUITS:

- Minerals like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese showed increased level in fruits of treated plants as compared to control plants. This is a sign of higher nutritional value of fruits.

CHANGES IN METABOLIC PATHWAYS:

- Protein content and total carbohydrate content were lowest in root and increased in stem. The highest level was seen in leaf and then it decreased in fruit in both treated and control plants yet showing higher level in treated plants. Polyphenols and proline showed increase in stem as compared to root but then the level went on decreasing in leaf and fruit in both treated and control plants. However, the treated plants showed upper hand.
- The levels of oxidative enzymes like catalase, peroxidase and polyphenol oxidase exhibited more or less the same pattern showing lowest activity in root which slightly increased in stem. Suddenly it showed very high level of activity in leaf which dropped in fruit. Treated plants showed higher level of activity as compared to control plants.
- The minerals like nitrogen, potassium, calcium, magnesium, zinc, copper, iron and manganese showed increase in root, stem, leaf and fruit of oxygenated peptone treated brinjal plants as compared to control plants while phosphorus content showed decrease in root, stem, leaf and fruit of treated plants over control plants.

RHIZOSPHERE SOIL ANALYSIS:

Physical properties:

- The soil treatment of oxygenated peptone improved the soil pH in the neutral direction.
- The soil treatment increased electrical conductivity, soil moisture, soil porosity and water holding capacity and decreased soil temperature and bulk density of rhizosphere soil of treated plants.

Chemical properties:

- Soil treatment increased organic matter and organic carbon of rhizosphere soil which is significant for crop productivity.
- The treatment led to increase in the level of minerals like nitrogen, phosphorus, potassium, calcium, copper, iron and manganese and decrease in magnesium and zinc in rhizosphere soil of treated brinjal plants.

Biological properties:

- The treatment of oxygenated peptone also favoured the positive growth in the microorganisms like *Bacillus subtilis, Azotobacter chroococcum, Aspergillus fumigatus Penicillium notatum, Trichoderma viridae* and *Paecilomyces lilacinus,* which contributed in phosphate solublization, nitrogen fixation, synthesis of vitamins and antibiotics and also as biocontrol agents. It decreased the population of pathogenic microbes like *Mucor indicus and Alternaria alternata*.

Thus, it can be concluded that soil application of oxygenated peptone might be increasing oxygen level of soil. This oxygen is useful for the growth of plant. Soil oxygen creates a favorable micro-climate for the growth of beneficial aerobic soil microbes. It also depressed the growth of pathogenic anaerobic microbes in the soil. Such a condition is inducive for the growth of plant and soil microbes. So plant-soil-microbe ecosystem is well balanced. Aerobic microbe population increases while pathogenic anaerobic microbe population decreases. Aerobic microbes bring about solublization of phosphates, nitrogen fixation, synthesis of vitamins and antibiotics, which are absorbed by the plant. As a result, the plant becomes healthy and shows increase in vegetative growth parameters, photosynthetic pigments and photosynthetic rate which finally leads to increase in quantitative and qualitative yield under organic farming conditions. This is significant achievement, beneficial to farmers. Thus, this eco-friendly, non-hazardous, user's friendly, less expensive technique is useful to improve the health of soil and crop along with yield and its quality. But for recommendation to farmers, multilocation trials on different crops are necessary. The studies on market quality and consumer's acceptability of oxygenated peptone treated vegetables are very important before coarse scale applications.

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