

**INFLUENCE OF DIFFERENT GROWING CONDITIONS  
ON GROWTH, YIELD AND QUALITY OF  
LEAFY VEGETABLES**

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PARBHANI - 431 402 (M.S.), INDIA**

**2018**

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**B.Sc. (Agri.)**

**DISSERTATION**

*Submitted to the*  
*Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani*  
*In partial fulfillment of the requirements for the*  
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**MASTER OF SCIENCE  
(HORTICULTURE)**

**IN  
VEGETABLE SCIENCE**

**DEPARTMENT OF HORTICULTURE  
COLLEGE OF AGRICULTURE, PARBHANI  
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH,  
PARBHANI - 431 402 (M.S.), INDIA**

**2018**

## CANDIDATE'S DECLARATION

I hereby declare that the dissertation

or part thereof, has not been

previously submitted by

me for a degree of

any University

or

Institution

Place : Parbhani

Date :     /     / 2018

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## **CERTIFICATE – I**

This is to certify that the thesis entitled “**INFLUENCE OF DIFFERENT GROWING CONDITIONS ON GROWTH, YIELD AND QUALITY OF LEAFY VEGETABLES**” submitted by **MR. GARDE ANGAD PRAKASH** to the Vasandrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in the subject of **VEGETABLE SCIENCE** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

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Date:     /     /2018

**(A. S. Kadam)**  
Research Guide

## **CERTIFICATE – II**

This is to certify that the thesis entitled “**INFLUENCE OF DIFFERENT GROWING CONDITIONS ON GROWTH, YIELD AND QUALITY OF LEAFY VEGETABLES**” submitted by **MR. GARDE ANGAD PRAKASH** to the Vasantnao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in the subject of **VEGETABLE SCIENCE** has been approved by the student’s advisory committee after viva-voce examination in collaboration with the external examiner.

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*Place : V.N.M.K.V., Parbhani*

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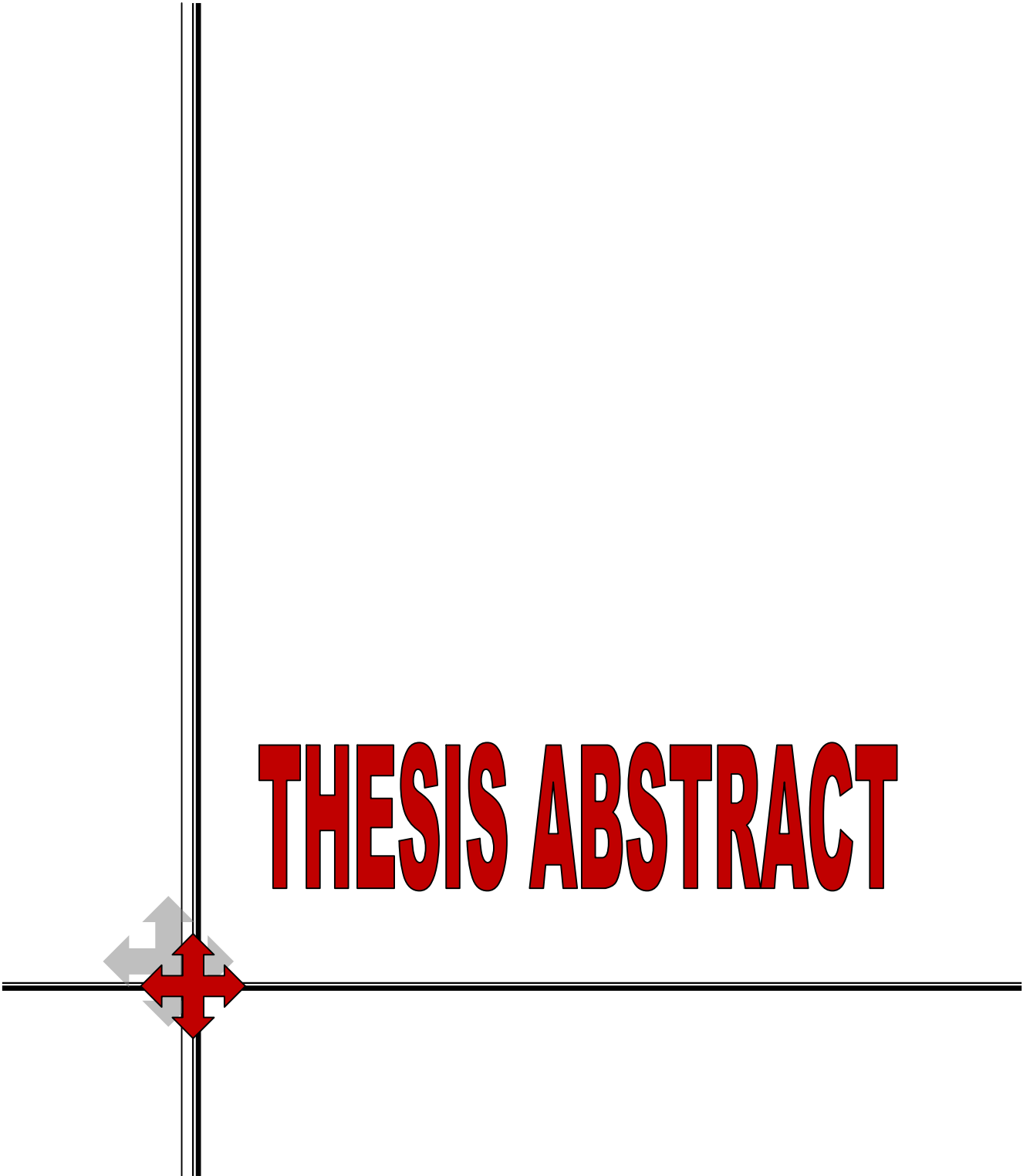
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## ABBREVIATIONS USED

%	:	Percent
@	:	At the rate of
C.D.	:	Critical difference
cm	:	Centimeter (s)
DAP	:	Diammonium phosphate
DF	:	Degree of freedom
etc.	:	Etcetera
MT	:	Metric ton
mm	:	Millimeter
Lit.	:	Liter
g	:	Gram
Cv.	:	Cultivar
ha	:	Hectare
<i>et al.</i>	:	et alia (and others)
Fig.	:	Figure
DAS	:	Days after sowing
DAS	:	Days after storage
i.e.	:	Id est (That is)
Kg	:	Kilogram
m	:	Meter(s)
/	:	Per
Mg	:	Milligram
MOP	:	Muriate of potash
No.	:	Number(s)
°C	:	Degree centigrade
qt/ha	:	Quintals per hectare
t/ha	:	Tonnes per hectare
Var.	:	Variety
Spp.	:	Species
NPV	:	Naturally ventilated polyhouse
S.E. <sub>±</sub>	:	Standard error
pH	:	Pouvoir Hydrogene
<i>viz.,</i>	:	Videlicet (namely)
Sr. No.	:	Serial number
°C	:	Degree Celsius
RDF	:	Recommended dose of fertilizer

m <sup>2</sup>	:	Square meter
cm <sup>2</sup>	:	Square centimetre
R - R	:	Row to Row
EC	:	Electrical conductivity
FRBD	:	Factorial Randomized Block Design
GMR	:	Gross monetary returns
NMR	:	Net monetary returns
B: C ratio	:	Benefit: cost ratio
VPD	:	Vapour pressure deficit
IU	:	International unit
Kcal.	:	Kilo calories
Kmph.	:	Kilo meter per hours
Hrs.	:	Hours
BSS	:	Bright sunshine
G	:	Growing conditions
G <sub>1</sub>	:	Open field
G <sub>2</sub>	:	Polyhouse
V	:	Leafy vegetables
V <sub>1</sub>	:	Amaranthus
V <sub>2</sub>	:	Beet leaf
V <sub>3</sub>	:	Coriander
V <sub>4</sub>	:	Fenugreek
N	:	Nitrogen
P	:	Phosphorus
K	:	Potash
Rs.	:	Rupees
UV	:	Ultra violet
Temp.	:	Temperature
RH	:	Relative humidity
LI	:	Light intensity
CV	:	Coefficient of variation
e.g.	:	Exempli Gratia (for Example)
PLW	:	Physiological loss in weight
Vitamin A	:	Retinol
Vitamin C	:	Ascorbic acid
NS	:	Non-significant
MgCO <sub>3</sub>	:	Magnesium Carbonate

# THESIS ABSTRACT



## THESIS ABSTRACT

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### INFLUENCE OF DIFFERENT GROWING CONDITIONS ON GROWTH, YIELD AND QUALITY OF LEAFY VEGETABLES

By

**MR. GARDE ANGAD PRAKASH**

Reg. No.: 2015HT/14M

A Candidate for the Degree

of

**MASTER OF SCIENCE (HORTICULTURE)**

In

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An investigation entitled “Influence of different growing conditions on growth, yield and quality of leafy vegetables” was undertaken at the experimental farm, Department of Horticulture, VNMKV, Parbhani, during *Kharif* season, 2016. The experiment was laid out in Factorial Randomized Block Design (FRBD) with two growing conditions, open field ( $G_1$ ) and polyhouse ( $G_2$ ) with four leafy vegetables *viz.*, Amaranthus ( $V_1$ ), Beet leaf ( $V_2$ ), Coriander ( $V_3$ ) and Fenugreek ( $V_4$ ) comprising eight treatments replicated thrice. The leafy vegetables were shown on 20 August 2016 by line sowing methods with 15 cm row to row spacing. The observations on metrological parameters as well as growth, yield and quality parameters of leafy vegetables were recorded and economics was worked out and subjected for statistical analysis.

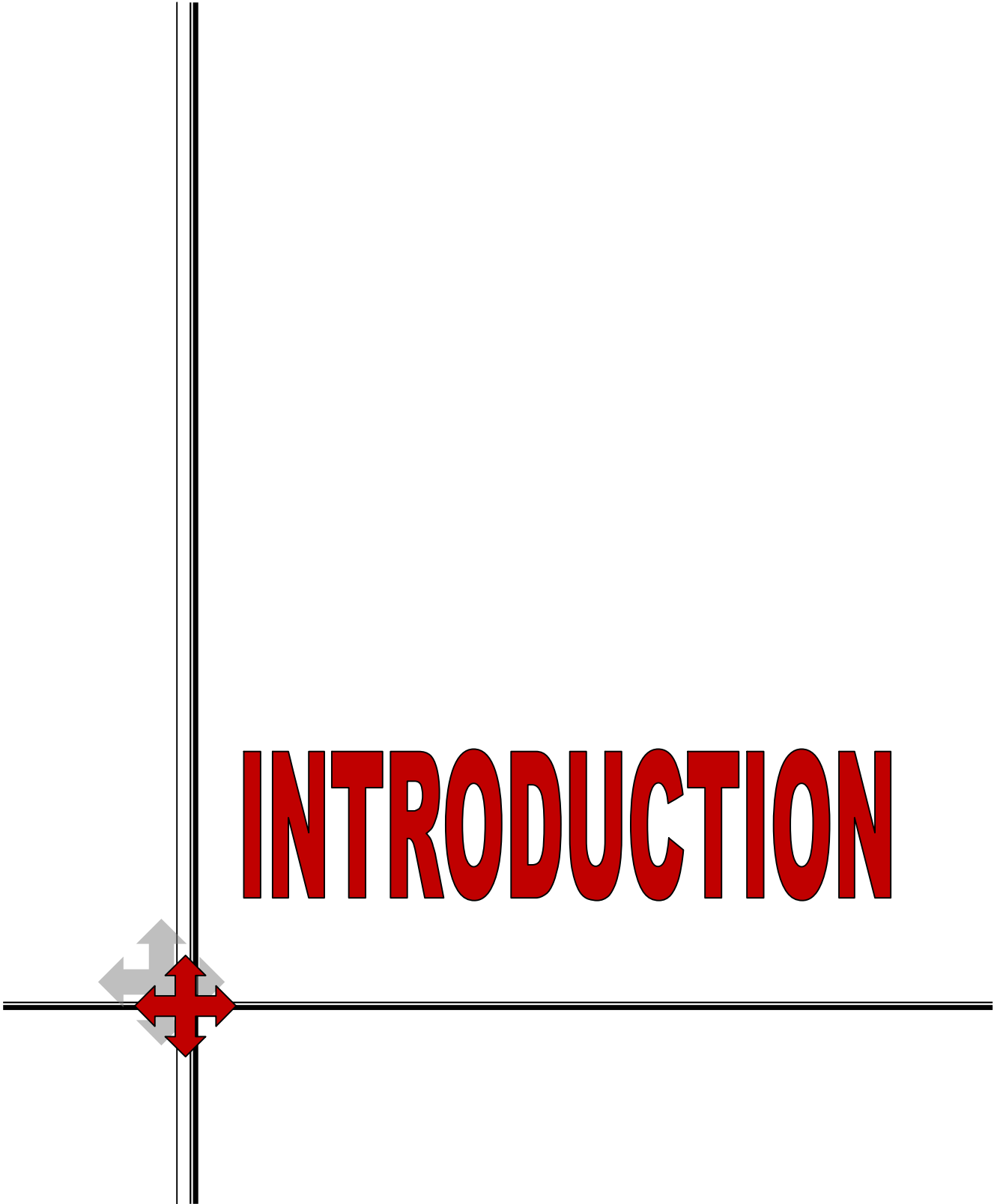
The results of the present investigation indicated that, the mean highest temperature ( $33.27\text{ }^{\circ}\text{C}$ ) and relative humidity (91.28 %) was recorded under polyhouse growing condition, while, it was lower in open field condition. The highest mean light intensity (43,781 Lux) was observed under open field growing condition during the experimental period. Regarding the growth attributes of different vegetables it is observed that, the different growth parameters were significantly influenced due to growing conditions. The high germination percentage, and the

higher values of growth attributes *viz.*, plant height, No. of branches per plant, No. of leaves per plant, leaf length, leaf width, leaf area, No. of stomata, length of whole plant, length of shoot, length of root, dry weight of whole plant, dry weight of shoot, dry weight of root and minimum days to potential germination (7.75) and days required for horticultural maturity (30.00) were recorded under polyhouse condition as compared to open field conditions. Among, the leafy vegetables, amaranthus recorded higher germination percentage, and showed better performance with respect to most of the growth attributes of the plant. It has also taken less number of days (4.73) for potential germination and days required to horticultural maturity (33.00).

The higher values of yield attributes *viz.*, fresh weight of whole plant, fresh weight of shoot, fresh weight of root, yield per plot (2.60 Kg) and yield (7.14 t/ha) was recorded under polyhouse condition as compared to open field conditions. Among, the leafy vegetables amaranthus recorded higher values of yield attributes and yield. The vegetables produced under polyhouse condition have recorded the higher values of the quality parameters, *viz.*, vitamin A (7880 IU/100 g), vitamin C (84.15 mg/100 g), calcium content (324.15 mg/100 g), iron content (5.73 mg/100 g), total chlorophyll content (38.90 SPAD value), shelf life (4.67 and 11.25 days at ambient and refrigerator storage) and less PLW (45.85 and 14.76 % at ambient and refrigerator storage) as compared to vegetables produced under open field conditions. Among, the leafy vegetables beet leaf recorded higher vitamin A (9343 IU/100g) and iron content (15.00 mg/100 g). The higher vitamin C (133.31 mg/100 g) and shelf life (5.01 and 10.49 days at ambient and refrigerator storage respectively) and less PLW (48.14 and 13.59 % at ambient and refrigerator storage respectively) was observed in coriander. The fenugreek produced under polyhouse recorded high calcium content (382.66 mg/100 g) and total chlorophyll content (48.48 SPAD value).

The polyhouse condition has provided better growing situation for germination, growth and high production of quality produce resulting in high monetary returns and higher B: C ratio. However, the high cost of production was required for production of vegetables under polyhouse growing condition. Among, the leafy vegetables highest B: C ratio was recorded by fenugreek, which was closely followed by coriander. Hence, for judging the suitability and profitability of leafy vegetables during rainy season under polyhouse condition, the order of preference should be fenugreek followed by coriander, beet leaf and amaranthus.

# INTRODUCTION



## CHAPTER - I

### INTRODUCTION

World population is expected to increase by about 40% till 2020 to a total population of 8 billion. More than 80% of this population will live in what is today called the developing world, which is already most food insecure. An estimated 2 billion people suffers from lack of vitamins and essential minerals. The women and children living in developing countries are the worst affected ones. Hence, the leafy vegetables are best available option for the global nutritional security in future (Singh and Kalloo, 2000). Leafy vegetables represent an excellent component of the habitual diet in the world. They are appreciated because they not only supply the protective nutrients and add variety to a monotonous diet but also have an alternative taste, pleasing appearance and aroma. The severity of micronutrient malnutrition widely prevalent in India can be easily reduced, if the consumption of green leafy vegetables is actively promoted in daily diet, especially among the low income groups of the populations (Mini and Krishnakumary, 2007).

Consumption of herbs is as old as human race itself. Majority of the Indian population is vegetarian and a daily intake of at least 125 g of fresh green leafy vegetables is recommended per day per person (Gupta, 2015) and that can provides vitamins, minerals, carbohydrates, fat, fiber, amino acid, oxalic acid, fatty acid, folic acid, antioxidants, carotenoids, calories and appreciable quality of proteins (Pandita and Lal, 1998; Saxena, 1999; Raju *et al.*, 2007; Gupta and Prakash, 2011). The ethno-botanical report offers information on medicinal properties of green leafy vegetables like anti-diabetic, anti-histaminic and anti-carcinogenic activity (Kubo *et al.*, 2004) and also known for their therapeutic value (Shyamalas *et al.*, 2005).

Leafy vegetables are important items of commerce and thus can play a major role in the economic development. During the recent years, the interest in leafy vegetable production has increased rapidly as a result of greater appreciation towards their food value. Leafy vegetables are high yielding and provide nutritional security, more employment, more cash and foreign exchange (Chadda, 2004). During the year 2016-2017 the India is second largest producer of vegetable in the world next after china with an estimated production about 163.86 million tonnes from an area of 9.39 million hectare and productivity is 17.3 metric tonnes per hectare. India contributing

15 per cent of the world production of vegetable crops (Anon., 2016a). The medical council of India informs the production is much less than the requirement if balanced diet is provided to every individual. The present production of vegetables is to be raised to 250 million tons by 2024-2025. There are different ways and means to achieve this target; e.g., bringing additional area under vegetable crops, using hybrid seeds, use of improved agro-techniques. Another potential approach is perfection and production of protected cultivation of vegetables (Singh and Brahma, 1998).

Ancient times, agriculture is an outdoor or open field production of crops. Hence, open field production is climate and weather dependent. In fact, growth and development of crops under a particular set of climate parameters define geographical location, productivity and production period of different crops. The magnitude of impact of climate and weather on agricultural productivity and quality of produce is appreciated by farmers and the scientific community, including horticulturists. Abiotic and biotic environments govern crop production potential and quality of products. Among the major constraints in production of horticultural crops are temperature (hot to cold), sunlight duration, quality and intensity, water deficiencies or excesses, atmospheric moisture (relative humidity), weeds, deficiency of nutrients, heavy winds, carbon dioxide and host of diseases and insect pests. There are ecological optima for obtaining production potential of each of the crops. Deviation from these conditions results in yield losses partially and sometimes totally. However, near optimal climatic conditions could be created by controlling the climate with the help of greenhouse using different protected structures/ methods/ devices and such cultivation under controlled environment conditions is termed as protected cultivation.” Protected cultivation means some level of control over plant microclimate to alleviate one or more abiotic stresses for optimum plant growth which can be achieved in greenhouses, poly house, net house, poly- tunnels, cold frames, etc. Usually under open field conditions, plants experience short cropping season but under protected conditions, the environmental factors are controlled or altered to a desirable extent to provide large growing period of the crop. In protected conditions, the production and availability of crop can be taken successfully all the year round for many crops, because protected production technology is a specialized form of cultivation of vegetables where environmental and edaphic conditions are adjusted as per the crops requirements. The protected structures are designed as per the climatic

require of the crops so that optimum growth and yield could be realized. In the changing scenario of increase population, rapid urbanization and industrialization, the natural resources particularly land and water are shrinking. Consequently, there is increasing pressure on available land for crop production and that too with effect of climate change (Paroda, 2013).

The huge gap between present production and future requirements necessitates for high production and productivity of horticultural crops for ensuring availability. The production of quality vegetables and other horticultural crops can be enhanced either by increasing productivity, use of improved cultivar/hybrids and effective production systems, bringing additional land under horticulture crops or by promotion of protected cultivation which can support in adverse climatic conditions. Among horticultural crops, production of vegetables under protected condition has proved the best alternative to use the land and other resources more efficiently. The protected cultivation particularly in vegetable crops has made it possible for year round production and availability of quality produce both for domestic use and export purposes. Yield level of horticultural produce under these structures can be several times than those of open field conditions. The quality of produce is also produce superior and input use efficiencies are usually higher under such structures. More than 90 % of Indian farmers have land holding with an average farm size of about 1.57 hectare comprising nearly 55 % of the arable land. These farmers are resources-poor but are capable to sustain an intense and efficient agro- production system if provided with critical inputs like, technology, marketing and credit. The most important aspects are to insure greater participation of small and marginal farmers and convert their inherent weaknesses into opportunities. In order to realize the full benefit of the protected cultivation technology, appropriate package of practices for suitable varieties at various locations need to be promoted (Paroda, 2013).

Cultivation of leafy vegetables is a profitable business for farmers; however, these vegetables are highly perishable and need to be sold in the market within a few hours of harvest. Therefore these vegetables are usually grown in peri-urban production areas. Daily sales of these vegetables provide valuable cash income to farmers, most of who have small landholdings. In some cases, all members of the family are involved in the cultivation and marketing of the vegetables. In the past, all leafy vegetables were grown in open fields and production in our country significantly

influenced by the insect-pest, diseases, seasonality and weather conditions. The extents of abundance and deficiency in production cause considerable fluctuation in the prices and quality of leafy vegetables. Leafy vegetable production, at present, is also characterized by a strong dependence on chemical plant protection with its all inherent environmental and health hazards, both for the growers and consumers. Striking a balance between all season availability of high quality leafy vegetables with minimum environmental impact, and still to remain economically competitive in this time of globalization, is major challenges for the modern technology of vegetable production so protected cultivation offers several advantages to produce high yield and superior quality of leafy vegetables, thus efficiently using the land and other resources. This becomes relevant to leafy vegetable growers in India who have small holding say less than one hectare. They would be interested in a technology, which helps them to produce more crops each year from their land, particularly during off-season when prices are higher. However, growing leafy vegetables under protected conditions requires comparatively high input cost and good management practices, which have direct bearing on the economic viability of the production system (Mini and Krishnakumary, 2007).

The need to improve leafy vegetable production has led to the popularization and adoption of the new technology of protected cultivation which is reported to be ideal for year round cultivation and better yields, in terms of quantity and quality. Leafy vegetables grown under open field conditions are exposed to abiotic and biotic stresses which affect productivity and quality. The production of leafy vegetables is affected due to rainfall and unfavorable climatic conditions. Protected cultivation has the potential to reduce the stresses, offset the vagaries of weather and permitting year round cultivation to ensure regular supplies in the market (Singh *et al.*, 2005). However, the profitability of protected cultivation depends upon the choice of structure, selection of crop, varieties, production technology and market price (Rajasekar *et al.*, 2013).

Among different leafy vegetables; Amaranthus, Beet leaf, Coriander and Fenugreek are most commonly grown in the different parts of country for their tender and succulent leaves (Bose *et al.*, 2003). Leafy vegetables are very popular around the world and easily available at cheaper rate in the market as compared to other

vegetables because of its low production costs and high productivity per unit area (Mini and Krishnakumary, 2007).

High quality is major importance in all horticultural products particularly in leafy vegetables and somewhat more difficult to maintain because of the tender tissues and high surface to volume ratio. The quality traits of leafy vegetables include, colour, texture, size, shape, flavor and defects in addition to their nutritional value. The lack of knowledge especially on the nutritive value of leafy vegetables among the public in general is the main drawback in their production and consumption (Mini and Krishnakumary, 2007). The, nutritive value of these leafy vegetables is given in Table 1.

Table 1. Nutritive value of leafy vegetables (per 100 g of edible portion on fresh weight basis)

Content	Leafy Vegetables			
	Amaranthus	Beet Leaf	Coriander	Fenugreek
Moisture (%)	85.70	86.40	86.30	86.10
Vitamin A (I.U.)	9,200	9,770	6,750	6,450
Vitamin B <sub>1</sub> (mg)	00.01	00.26	00.05	00.05
Vitamin B <sub>2</sub> (mg)	00.24	00.56	00.06	00.31
Vitamin C (mg)	99.00	70.00	135.00	52.00
Minerals (g)	02.70	02.20	02.30	01.50
Calcium (mg)	397.00	380.00	184.00	395.00
Iron (mg)	03.49	16.20	01.42	01.93
Phosphorus (mg)	60.00	30.00	71.00	51.00
Carbohydrates (g)	08.60	06.50	06.30	06.00
Fat (g)	01.00	00.80	00.60	00.90
Protein (g)	05.90	03.40	03.30	04.40
Fiber (g)	02.10	00.70	01.20	01.10
Calories (Kcal)	45.00	46.00	44.00	49.00

(Bose *et al.*, 2003; Mini and Krishnakumary, 2007).

*Amaranthus* (*Amaranthus spp.*) is belonging to the family Amaranthaceae and it is a native of India and southern china region. Amranthus constitute a single major group which has attained commercial significance in India and its cultivation is more

widespread in southern India. Amaranthus varied in colour depending on the species from green and dark red with smooth body surface (stem) (Makus, 1990). Many parts of the plant including the leaves, stem and seeds are edible and are frequent used as food all over the world. In Ghana, it is used medicinally both internally and as a lotion. In South Africa, the leaf is used as an abortifacient. The leaf has also been used as tea for relieving pulmonary condition (Anon., 1992). Amaranthus are recommended as a good food with medicinal properties for young children, lactating mothers and pettiness with constipation, fever, haemorrhage, anemia and xerophthalmia etc (Neth *et al.*, 2002). It enhances mental development and stimulates the release of growth, hormones, hence advisable for children's consumption; it helps lower cholesterol levels significantly in the blood and it also reported to contain twice the amount of calcium that fresh milk contains per unit of serving. Hence, amaranthus is considered to be the cheifest leafy vegetable in the market and there for it is often described as 'poor-mans vegetable' or 'poor-mans spinach' (Sekar, 2010).

Beet leaf (*Beta vulgaris var. bengalensis*) is most probably native of Indo-Chines region and it was belonging to Chenopodiaceae family. It is also known as palak, spinach beet and Indian spinach. It is commonly grown during winter season. It is an herbaceous annual and it produces rosette, succulent tender edible leaves on small thick stem and harvested and cooked as vegetable. The herbaceous parts are mildly laxative besides other medicinal values. Its leaves are used in inflammation, paralysis, headache, earache and are remedy for diseases of spleen and liver. The fresh leaves are applied to burn and it neutralizes the acidity produced during digestion of fatty substances and help to prevent constipation. It is a rich and cheap source of vitamin A as compared to spinach and carrot. It also contains high quality of ascorbic acid and iron, 100g of leaves supply as much essential amino acids as 100g of any non-vegetarian food like meat and fish (Bose *et al.*, 2003).

Coriander (*Coriandrum sativum L.*) is a native of Mediterranean region and belonging to the Umbelliferae (Apiaceae) family occupies the next important place to curry leaf in our daily food stuff as a spicy leaf vegetable. Coriander is a smooth, erect annual herb, grown for its green fresh leaves, seed, essential oil and oleoresin. A long tap root, branching leafy stem, bipinnate leaves, the pinnae with broad wedge shaped toothed segments, the upper leaves becoming gradually more compressed with very narrow linear segments and these of the uppermost almost setaceous. It is also known

as cilantro and chine parsley. Its name is derived from the 'greek' word 'koris' meaning bedbug, because of the unpleasant fetid bug-like odour of the green herb and unripe fruits. It is commonly known as 'Dhania' or 'Dhana'. It is an important ingredient in soups, curries, sauces, chutney and salad. Fruits are said to have carminative, diuretic, tonic, stomachic and aphrodisiac properties. The oil of coriander is a valuable ingredient in perfumes. Good quality oleoresin is used for flavoring beverages, pickles and sweets. The residue from distillation can be used as a fodder (Dhokle *et al.*, 2009).

Fenugreek (*Trigonella foenum-graecum* L.) belongs to Leguminosae (Fabaceae) family. Commonly called as Methi is one of the oldest leafy vegetable crops and a native of South Eastern Europe and West Asia, is cultivated as a leafy vegetable, Condiment and as medicinal plant and fodder purpose besides being consumed directly as vegetable. Fenugreek is cultivated throughout India and other part of the world. Fenugreek is a cool season crop; it has been adapted to hot climate. The fresh tender leaves and Stem are consumed as curried vegetable alone or in combination with potato and other vegetable. It has a high medicinal value as it prevents constipation, removes indigestion, stimulates spleen and liver and is appetizing and diuretic. It contains diosgenin which is used to prepare contraceptive pills and to promote lactations (Bose *et al.*, 2003).

Studies on the cultivation of vegetables in poly houses have been limited to high valued vegetables like capsicum, tomato, cucumber etc. and although leafy vegetables are also often affected by the vagaries of weather elements in the open. But the information regarding the performance of different leafy vegetables under protected conditions is very scanty. In recent days farmers are also asking the economics of leafy vegetables under protected conditions. Hence the present investigation entitled "Influence of different growing conditions on growth, yield and quality of leafy vegetables" is planned with following objective.

1. To study the effect of growing conditions on growth, yield and quality of leafy vegetables.
2. To findout more profitable leafy vegetable suitable for growing under polyhouse condition.

# REVIEW OF LITERATURE



## **CHAPTER-II**

### **REVIEW OF LITERATURE**

Now a day, the practical use of polyhouse in horticulture has assumed variable significance due to revealed capacity of many compounds to exploit many significant mechanisms in plant, which had led to situation nearly approaching the horticultural revolution. The work done on the effect of open field and poly house on leafy vegetable is very meager. Hence, the literature available on other crops has also been included under different heads in this chapter.

#### **2.1 Effect of meteorological parameters**

#### **2.2 Effect on growth parameters**

#### **2.3 Effect on yield parameters**

#### **2.4 Effect on quality parameters**

#### **2.5 Economics**

#### **2.1. Effect of metrological parameters**

Baudoin and Nisen (1990) reported that a plastic cover can increase the air temperature by 2-10<sup>0</sup>C during day time when ambient temperatures are comparatively high and growth was increased due to high temperature.

Wolff and Coltman (1990) conducted an experiment to study the productivity of eight leafy vegetable crops grown under shade in Hawaii. They studied the, Lettuce, Green Mignonette, Salinas, Parris Island Cos, Amaral 400, WR-55 Days Chinese Cabbage, Waianae strain green mustard cabbage, Tastie hybrid head cabbage and unnamed local selection of green bunching onions, were field-grown fall 1987 and spring 1988 in full-sun and with four artificially produced levels of shade (30%, 47%, 63% and 73%) and reported that, the shading reduced maximum temp. by ~1C per 15% increase in shade level. Minimum temperature was not affected by shade.

Asha and Nair (1992) found that, some plants grown in full sun were stunted, while in shade these plants put forth abundant foliage.

Cockshull *et al.* (1992) reported that, the greenhouse microclimate may have significant effects on the growth, development and productivity of crops. Net photosynthetic rates are reduced at light levels and the loss of tomato yield was propor

-tional to the loss of light.

El-Gizawy *et al.* (1992) observed that, increasing shade intensity in a tomato crop by up to 51% resulted in total production increase. They further reported that, the highest tomato production was obtained under 35% shading.

Peet and Willits (1992) observed that, the light was low and often spectrally unbalanced, given for only 8 hrs daily in growth chambers or varied throughout the year in greenhouses. In a series of experiments in North Carolina, maintaining night temperatures below 21°C during fruit set increased fruit weight by 28, 53 and 11 % in the autumn of 1989, autumn 1990 and spring 1991, respectively. Thus, it was clear that high night temperature during fruit set can limit tomato production in greenhouses in climates as warm as North Carolina. Presumably, fruit set would have been limited outside as well since night temperatures in the un-cooled greenhouses were within 0.5<sup>0</sup>C of outdoor temperatures and the studies were conducted in double-polyethylene covered houses, where long wave transmissivity was high enough approximately 63 % to permit significant radiant cooling. Seasonal variations in night temperatures were not sufficient to determine if cooling at night to 20 °C was too low or not low enough.

Romano and Leonardi (1994) studied the effect of three minimum air temperatures (9, 11 and 13°C) on the vegetative growth and fruiting of tomato and eggplant (normal and parthenocarpic cultivars). The temperature conditions did not affect the vegetative growth of tomato, but the lower minimum temperatures reduced or delayed the fruiting process. By contrast, in eggplant both vegetative and fruit growth were negatively affected by the lower minimum temperatures.

Uzun (1996) found there was a positive relationship between light intensity and plant stem diameter in both tomato and eggplant. Stem diameter in tomato and eggplant increased curvilinear with increasing temperatures and there was as an interactive effect of temperature and light intensity on stem diameter. It was also found that an increase in temperature from 10 to 32°C led to an increase in plant height of tomato and eggplant.

Kinet and Peet (1997) reported that, the explanations suggested for poor fruit set in tomatoes at high temperatures include: direct effects on pollen and other reproductive tissues, low levels of carbohydrates, and hormonal imbalances.

Aloni *et al.* (1999) concluded that, the many crops are sensitive to high temperatures, which may induce bud and flower abscission related to assimilate levels and partitioning within the plant. Abscission of sweet pepper flowers is known to be enhanced by low light and high temperature.

Sato *et al.* (2000) reported that, air temperature and VPD are very important microclimate parameters affecting tomato crop production and quality. Temperature and irradiation conditions during fruit development greatly influenced fruit development and quality.

Dorais *et al.* (2001) found that, the temperature may influence the distribution of photo-assimilates between fruits and vegetative parts. From fresh weight growth measurements high temperatures have been shown to interfere with the reproductive development in numerous species, including tulip, iris, chrysanthemum and tomato, and in general, the higher temperature the higher percentage of abortion.

Katsoulas *et al.* (2001) studied the effect of fog cooling on greenhouse air temperature and VPD, on eggplant leaf temperature, crop transpiration rate and crop water stress index. They found that, fog cooling reduced VPD by about 50% significantly reduced crop temperature, reduced crop transpiration rate by about 30% and enhanced crop physiological status as indicated by the crop water stress index.

Kumar and Kumar (2001) studied the effect of modified environments *viz.*, 50 per cent summer shading, winter plastic covering, 50 per cent shading followed by winter covering and natural sunlight on five gerbera cultivars. Among the different environments, plants grown in 50 *per cent* shading followed by winter covering produced the highest flower diameter (9.20 cm).

Ganesan (2002a) studied the performance of low cost naturally ventilated greenhouse in comparison to open field conditions and its effect on the yield and quality of fruits of two varieties of tomato (Vaishali and PKM1) in two seasons (Kharif and Rabi) during 1999 to 2000 and result indicated that all the greenhouse treatments showed a higher temperature in both the seasons compared to the open field. The increase in temperature may have been helpful to the plants by preventing root damage. The enhanced fruit yield in the particular greenhouse plots may also be attributed to the increase in temperature during these critical periods.

Ganesan (2002b) studied the effect of changes in microclimate produced by

poly-greenhouse conditions on plant growth characteristics and fruit yield of tomato and observed that UV stabilized plastic film covered greenhouse recorded higher day temperature than the open environment but relative humidity at 8 am was lower inside the greenhouse except from May to August. The light intensity inside the greenhouse was lower than in the open and result also showed that increase growth, yield and better quality due to climatic condition.

Ganesan (2002c) studied on effect of poly-greenhouse models on plant growth and yield of tomato (*Lycopersicon esculentum* L.). Four different poly-greenhouse models were compared with open field condition at the M. S. Swaminathan Research Foundation, Tamil Nadu in 1999 and different sized poly-greenhouse ventilation gaps with 25 % shade net and UV stabilized plastic film sheet materials were used. Also the effects of temperature on plant growth and yield of tomato in poly-greenhouses and open field condition were investigated and reported that air temperature in the open field condition was lower than in the poly-greenhouse treatments throughout the growth period. Poly-greenhouse with ventilation gaps in the triangular roof and four side walls was found more suitable for better plant growth and yield of tomato than those with the other ventilation gaps in poly-greenhouses and open field condition.

Saud *et al.* (2005) conducted an experiment to evaluate the effect of reduced light intensities (0, 30, 50 and 75 percent shading) on vegetative, floral, corm and cormel attributes and physiological aspects in gladiolus cultivars (fop Bras, American Beauty and Subhangini) in two seasons. Varied response of gladiolus cultivars to different shade levels in winter 2003 and summer 2004 seasons were observed and concluded that amongst the cultivar, Subhangini was less affected by reduced light intensity with highest flower quality and the cultivar American Beauty was most sensitive to reduced light conditions.

Dixit (2007) conducted an experiment to study the performance of leafy vegetables under protected environment and open field condition at Raipur. They have studied the, spinach, amaranthus, fenugreek and coriander vegetables with metrological parameters temperature and relative humidity in and outside a greenhouse from January to December 2007 and reported that, the temperature in green house was found to be higher (4-7<sup>0</sup>C) than the ambient condition. Temperature and humidity also play a vital role in the design of protection structures for growing vegetable crops and direct effect on plant growth and development.

Katsoulas and Kittas (2008) conducted an experiment to study the impact of greenhouse microclimate on plant growth and development with special reference to the solanaceae vegetables (tomato, pepper and eggplant) and results showed that the effect of greenhouse microclimate on the solanaceae the carried out measurements during (a) a winter and (b) a summer crop season in a tomato crop developed under a greenhouse with a polyethylene cover and a total solar radiation transmission of about 60% and under a control greenhouse with a total solar radiation transmission of about 78%. The leaf area index of the tomato crop was similar in the two greenhouses during the winter period but was higher under the low radiation transmission greenhouse during the summer period. Depression of crop yield is frequently observed under Mediterranean conditions when strong radiation and low air humidity prevails. Such conditions reduce water transfer in to the tomato fruit and enhance fruit transpiration. Temperature plays a major role in the growth of sweet pepper. The highest night temperature caused considerable blossom drop, but the highest day temperature tested did not cause increased blossom drop.

Shylaja *et al.* (2008) investigation on the influence of micro meteorological factors on flowering and quality of cured beans in vanilla were under taken at collage Vellanikkara and in selected farmer's fields during 2004-2007. The micro meteorological parameters were found to vary in the experimental fields of three districts selected for the study. Flower initiation, flower opening and quality of cured beans in vanilla were influenced by micro meteorological parameters. The ideal micro meteorological parameters identified in the present study could be extended to other areas to improve production and productivity of vanilla. The information gathered on micro meteorological situations of vanilla gardens of different districts could be utilized for manipulation of micro climate.

Parvej *et al.* (2010) an experiment was conducted in a covered polyhouse along with an open field (control) aside the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from December 2007 to April 2008 to compare the phenological development and production potentials of two tomato varieties *viz.* BARI Tomato-3 and Ratan under polyhouse and open field conditions and reported that the Photo-synthetically active radiation inside the polyhouse was reduced by about 40% compared to the outside (i.e. open field) while air temperatures were always remained higher. From December

to February the mid day air temperature under polyhouse and open field varied from 31.8 to 39.1°C and 23.3 to 31.1°C, respectively indicating about 8°C higher air temperature inside polyhouse and during that time the average air temperature inside polyhouse was about 28°C which was optimum for the growth and development of tomato plants. Relative humidity had opposite trends with that of air temperature i.e. it was lower inside the polyhouse as compared to open field. The above microclimatic variabilities inside polyhouse favoured the growth and development of tomato plant.

Vinh *et al.* (2010) studied the vegetable production in polyethylene house under hot climate condition and results revealed that in the polyhouse, mean temperature ranged from 31.4 to 32.9 ° C (2°C higher than those outside), mean humidity was 54.6-56.6% (6.7-7.8% higher than outside's), mean sunshine was from 41.8 to 44.2 Klux (17.8-18.8 Klux lower than outside's). In 24 hours, temperature in polyhouse was the lowest from 8:00 pm to 4:00 am, varied 24-26°C, after that temperature increased gradually, and reached to 29°C at 8:00 am and 34.7°C at 12:00 noon. In the afternoon, temperature reduced at 29.7°C at 4:00 pm. Observations on both inside and outside of polyhouse, it is indicated that from 4:00 pm to 4:00 am, there was not different in between. From 8:00 am, temperature was still cooler than outside but up to 12:00 noon, inside temperature was higher than outside one, with mean difference of 1.3°C (34.7°C as compared to 33.4°C). This gap was not much and plant might tolerate in this range. Another, there were differences in heat value, humidity, sunshine in area of 40 cm (effect on plants) and 150 cm (people can feel hot when stand in polyhouse) from the ground. Data showed that at 150 cm height, the temperature is 1.5°C higher and the humidity is 2% lower those in 40 cm height. This explained that normally we feel hot when standing in the house but plants can.

Kumar *et al.* (2011) studied on influence of growth conditions on yield, quality of strawberry (*Fragaria ananassa* Duch.) var. Ofra and Chadler under mild hills of Sikkim Himalaya and both the varieties were grown under polyhouse, plastic tunnel and open field. The meteorological data was recorded from open, polyhouse and plastic tunnel. Meteorological variation during fruit production season i.e., January to May revealed that temperature varied from 8.5 to 33.3 °C while the relative humidity ranged from 60.9 to 73.1 %. Average rainfall varied from 7.2 to 339.0 mm/month with variation in sunshine hours from 77.9 to 127.0 h/month and also reported that the yield and quality was better performance under polyhouse than plasti

-c tunnel and open field because favorable condition.

Umesha *et al.* (2011) conducted an experiment to study the effect of changes in microclimate produced by poly house conditions on plant growth characteristics and fruit yield of tomato during 2009-2010 at TNAU. Daily climatic parameter fluctuations of temperature, relative humidity and light intensity were measured at various stages of crop growth. Temperature (39.88 °C) was high in poly house during afternoon time. The relative humidity (91.06 %) was higher during morning time, and in afternoon (38.48 %) it was lower under polyhouse. The light intensity inside the poly house was higher at afternoon (58865 Lux.) and it was also observed that during morning and evening hours there was low light intensity. The changes in microclimates are positively influenced on growth and yield parameters of tomato under polyhouse condition.

Gonzaga *et al.* (2012) conducted research on low-cost protected cultivation: enhancing year-round production of high-value vegetables in the Philippines, in the net tunnel, plastic tunnel and open field and reported that the above mentioned crops, the plastic covering was no better than the open field, which may have been due to high temperatures inside the tunnel. Temperatures were higher under the tunnel covered with plastic than in net-covered tunnels and the open field and this appeared detrimental to the growth of lettuce, which is a cool-season crop. Air temperatures under plastic tunnels were about 2°C higher than under net, and 5°C higher than in the open field. That tunnels covered with plastic increased the air temperature by 2–10°C during daytime, much greater increases than those under house-type structure. It is clear that the use of net covering has potential for growing vegetables, since such tunnels are better ventilated than those with plastic roofing, hence the lower temperatures inside. In times of heavy rain, the net also moderates the impact of the rainwater reaching the plant, but allows adequate penetration of light rain. Also result showed that the rainfall pattern in the Eastern Visayas could explain the seasonal effect on crop yields. While there is less rain during February and March, and a period of high rainfall of between 400 and 1000 mm per month for the rest of the year, there is still sufficient rainfall during the so-called dry season to cause significant problems for growing vegetable crops such as tomato, lettuce, sweet pepper and bitter melon that are susceptible to water logging. Another factor could be that the environment inside greenhouses is generally more favorable to plant growth and development,

especially for warm-season crops. Environmental stress is the primary cause of crop losses worldwide, reducing the average yields for most major crops by more than 50% (Bray *et al.* 2000). The lower yields in the wet season, particularly for plants grown in the open field, were likely due to high rainfall.

Richardson (2012) conducted a research on evaluation of five leafy green vegetables during Nov. 2011 to Feb. 2012 and reported that, the mean daily maximum and minimum temperatures for the trial period were 27.1°C (80.8°F) and 19.6°C (67.3°F), respectively. The total rainfall for the period was 93.8 mm (3.69 in). Mean monthly sunshine duration for the period was 7.8 h was recorded and concluded that the leafy vegetables are better performance due to favorable climatic condition.

Karistsapol *et al.* (2013) studied the effect of shading and variety on the growth and yield of broccoli during the dry season in southern Thailand and result showed that the environmental variables: Light intensity, minimum and maximum temperatures of shaded broccoli plants were lower than those of broccoli plants grown under the full sunlight whereas the relative humidity of the air of shaded plant was higher than of plants grown under the full sunlight. Under the shading created the decreasing light intensity (36.50%) and the increasing relative humidity (8.15%) compared to the full sunlight. Plants under the shading had higher plant height and width than the full sunlight because of low light intensity that cells expand more to receive light for photosynthesis. Plants obtain the low light intensity that stimulated the synthesis of Gibberellins (GA). Growing under the shading had high total yield and quality because the environment under the shading had the decreasing average maximum temperature (2.84-3.63°C) and the increasing relative humidity (8.15%).

Rajasekar *et al.* (2013) conducted an experiment to study the influence of growing environment on seven different vegetables *viz.* tomato, eggplant, Chili, cucumber, radish, amaranthus and coriander with metrological parameters (temperature, relative humidity) in summer and winter in shade net and open field condition at Tamil Nadu and reported that, the relative humidity in shade net house was (59.50 % in summer and 67.10 % in winter) and in open field condition (52.60% in summer, 59.42% in winter). They further reported that, temperature in open field was (34.20°C in summer and 32.85°C in winter). Mean weekly temperature during summer and winter season were higher under open field than in the shade net house. High temperature increased growth and yield in shade net house than open field condi

-tion.

Singh (2013) observed the differential behavior of varieties of different crops under protected environment controlled greenhouse. There are several instances reported for high productivity under protected conditions for chilli, tomato, cucumber, gherkins, summer squash, winter squash, watermelon, lettuce, cauliflower, broccoli, chrysanthemum, gerbera, carnation, liliun, rose, strawberry, etc. due to favorable air temperature, optimum relative humidity and light intensity in the structure, which had helped in getting good vegetative and reproductive growth.

Kishore *et al.* (2014) conducted an experiment in polyhouse and open field condition and concluded that the yield advantage under polyhouse condition may be attributed to the prevalence of congenial microclimate in terms of temperature and relative humidity which might have improved soil moisture status and duration of fruiting and variations of microclimate in polyhouse due to the variation of temperature and humidity.

Kumar *et al.* (2014) conducted an research on evaluation of gerbera genotypes for cut flower production under different growing conditions of Kashmir and reported that growth, yield and quality gerbera genotype was good than the open field because the more favorable environment under polyhouse as compared to open field conditions.

Rana *et al.* (2014) conducted research on tomato fruit quality under protected environment and open field conditions and results reveal that, the light intensity and other climatic factors in the protected environment were around 10% higher than those in the field. High relative air humidity can reduce plant transpiration and promote xylematic flux of water, which is favorable to the fruits, since the fruits act as drains for high concentrations of organic molecules and, consequently, low water potential. Thus, absorption of water by the fruits may have been favored in the protected environment and, consequently, may have led to a “dilution effect”, causing the fruits grown in the protected environment to be less flavorful and have lower contents of soluble solids, reducing sugar and ascorbic acid contents than the fruits grown in the field.

Yadav *et al.* (2014) conducted an experiment at the research farm, Division of Vegetable Science, IARI, New Delhi, during third week of November, 2012-13 by

utilizing two types of low cost polyhouse (polyhouse for raising nursery and crops and low height polyhouse for crops) for higher income and nutritional security and result showed that the temperature inside low cost polyhouse was 6-10<sup>0</sup>C higher than outside. The cold waves during December-January did not enter and the growths of the plants were normal. Vegetable crops like, French bean, amaranth and summer squash were grown during winter season successfully under low cost low height temporary poly structure during off season from November to February when it was difficult to raise under open field.

Isaac (2015) conducted an experiment to study the performance evaluation of leafy vegetables in naturally ventilated polyhouse. They studied, five leafy vegetables viz. palak, coriander, lettuce, green amaranthus, red amaranthus in poly house and open field condition at Kerala and reported that, the low temperature and low humidity in poly house than open field condition and that helps to increasing production of leafy vegetables.

Lekshmi and Celine (2015) research conducted on evaluation of tomato hybrids for fruit yield and quality traits under polyhouse conditions and concluded that the optimum temperature accompanied by low relative humidity inside polyhouse hasten crop development and early maturity.

Bhargava (2016) conducted a research on performance of snapdragon (*Antirrhinum majus* L.) under protected and open field conditions in Himachal Pradesh. The growing factors especially temperature and light were taken into consideration to interpret their effect on growth and flowering of the plants. Results showed that, the growing factors especially temperature, light and humidity provide optimum conditions to the plants under protected condition.

Dhaliwal *et al.* (2016) studied on growth and yield of tomato influenced by condition of culture, mulch, and planting date. In culture condition they used polyhouse and open field and concluded that, below optimal temperatures can restrict growth of autumn planted tomato resulting in delayed fruiting and decreased fruit yield under field conditions. Highest early, marketable, and total yields were obtained from planting in the polyhouse in the third week of October using black polyethylene mulch, and this is attributed to increased root zone temperature, air temperature, and net radiation.

Kumar *et al.* (2016) conducted an experiment with two brinjal varieties Pusa Purple Long and Pusa Purple Cluster to evaluate their performance and suitability under open and naturally ventilated polyhouse conditions in cold desert region of Himachal Pradesh, India and concluded that, the optimum temperature accompanied by CO<sub>2</sub> enrichment inside polyhouse hasten crop development and early maturity, so growers can be benefited by being able to produce brinjal which fetch premium prices in the market.

Sam and Regeena (2016) conducted an experiment on production potentials of tomato and capsicum under polyhouse condition in Kerala and result showed that, the micro climatic parameters were varied between polyhouse and outside. Solar radiation (PAR) inside the polyhouse was reduced by about 50% compared to the open field while air temperatures were always remained higher. The relative humidity was less in polyhouse structure compared to outside the structure (5-8 % increase in outside) and also reported that production is increased due to favorable environmental condition.

## **2.2. Effect on growth parameters**

Baudoin and Nisen (1990) reported that the growing in a greenhouse enables the plants to mature at up to 30% faster than field-grown crops.

Wolff and Coltman (1990) conducted an experiment to study the productivity of eight leafy vegetable crops grown under shade in Hawaii. They reported that, the specific leaf area of ‘Green Mignonette’ and ‘Amaral 400’ lettuce, Chinese cabbage, green mustard cabbage, head cabbage, and green bunching onions was increased as *per cent* shade increased.

Armitage (1991) reported that, plants of anthuriums grown under shade (55% and 67%) had longer flower stems than those grown at ambient conditions and also had increased scape length and spathe width with increase in shade intensity.

Dhulakhandi *et al.* (1995) conducted an experiment to study the growth and yield of fenugreek, spinach, coriander and lettuce under continuous day light condition in Antarctica and reported that, the average of six spinach genotypes *viz.* DARL selection and reported that, the average increase in plant height in per day 0.6 cm in banaraci and 1.2 cm in other cultivars. The plant started flowering after 18<sup>th</sup> to

20<sup>th</sup> days after emergence and crop was ready to harvest after 30<sup>th</sup> days after sowing the seeds.

Ganesan (2002b) studied the effect of Poly-Greenhouse on plant micro climate and Fruit yield of tomato and observed that height of the plant, number of nodes, internodal length, total dry matter production and average fruit weight was increased under greenhouse conditions as compared to open field condition.

Kandpal *et al.* (2003) observed that, average number of leaves at the end of one year was maximums (48.47) in cv. DB-113, followed by Orange Glem (44.10), while minimum (5.94) in cv. Sangria under shadenet of gerbera.

Dixit (2007) conducted an experiment to study the performance of leafy vegetables under protected environment and open field condition at Raipur. They have studied the, spinach, amaranthus fenugreek and coriander vegetables and reported that, the germination percentage was found 10-20% more under greenhouse condition as compared to open field. The vegetative growth parameters like plant height (25.21, 26.81, 15.28 and 15.24 cm - spinach, amaranthus, fenugreek and coriander respectively), were recorded higher under greenhouse condition and the some characters was recorded lower in open field condition (19.14, 22.22, 12.31 and 12.62 – spinach, amaranthus, fenugreek and coriander respectively). Similarly the number of leaves, number of branches, length of leaves and width of leaves were also recorded higher under protected environment and the same traits were recorded lowest in outdoor cultivation.

Kotadia *et al.* (2012) conducted an experiment to study the influence of different growing conditions on yield of leafy vegetables during summer season. They have studied four leafy vegetables *viz.* fenugreek, coriander, spinach and amaranthus and reported that, the growing of leafy vegetables in shade net situation fevered plant growth attributes as compared to open field condition during summer season. Amaranthus and spinach grown in 30 *per cent* shade net produce vigorous growth in terms of plant height, number of leaves and leaf area. In case of fenugreek and coriander grown in 75 *per cent* shade net got maximum growth attributes.

Cheema *et al.* (2013) studied twenty six hybrids of tomato along with Check Naveen were obtained from public and private sectors and grown under net house and

open field conditions and concluded that under net house genotypes performed better for growth parameters than open field condition.

Rajasekar *et al.* (2013) reported that, the mean plant height of amaranthus under shade net condition in cm during summer 67.36, in winter 88.09 and in open field condition in summer 32.2 and winter 39.11. Mean number of leaves of amaranthus in shade net condition in summer 74 and in winter 30.36 and in open field condition in summer 32.2 and in winter 39.11. Mean leaf area (mm<sup>2</sup>) of amaranthus in shade net condition in summer 7061.7 and in winter 6933.19 and in open field condition in summer 3199.26 and in winter 1069.33. That the also reported, mean plant height of coriander in cm in shade net condition in summer 26.95 and in winter 33.97 and in open field condition in summer not available and in winter 24.11 cm. Mean number of leaves coriander in shade net condition in summer 53.9 and in winter 172.96 and in open field condition in winter 74 and in summer not available. Mean leaf area (mm<sup>2</sup>) of coriander in shade net condition 999.13 in summer and 979.36 in winter and in open field condition 532.30 in winter. Leaf area per plant was highest under shade net house compared to open field condition in all vegetables during summer and winter. The exception was for coriander which has the most leaf area under open condition during the winter while the most area observed under shade net house during summer season. Ultimately, the study revealed that the prospect of cultivation of tomato, Brinjal, chilli, cucumber, radish and amaranthus under shade net house are bright than open field condition.

Rao *et al.* (2013) studied the performance of capsicum crop in open field and under covered cultivation and results showed that, the plant growth characteristics such as plant height, number of branches, root zone length, were measured for capsicum crop under open field and in shade net house. it can be seen that the plant height, number of branches per plant, number of leaves per plant were higher for the capsicum crop cultivated in shade net over open field. Root zone length of 8 cm more was also observed for the crop under shade net.

Karetha *et al.* (2014) studied the effect of different dates of sowing and growing conditions on coriander (*Coriandrum sativum* L.) cv. Gujarat coriander-2 and concluded that influence of different growing conditions on growth parameters, germination percentage found maximum (76.30 %) in condition C<sub>2</sub> (natural ventilated polyhouse), while mortality percentage was found minimum (3.73 %) in condition C<sub>2</sub>

(natural ventilated polyhouse). It is clear from the data there was significant difference in the number of leaves per plant in respect of various growing conditions. The condition C<sub>3</sub> (net house low-cost) produced maximum number of leaves per branch (3.98). The lowest numbers of leaves per branch (3.62) were produced under condition C<sub>1</sub> (fan pad polyhouse). Length of leaf observed in respect of various growing conditions. The condition C<sub>2</sub> (natural ventilated poly house) growing conditions produced maximum length of leaf (2.26 cm). The lowest length of leaf (1.88 cm) was produced under condition C<sub>4</sub> (open field condition). The width of leaves observed significant in respect of various growing conditions. The condition C<sub>1</sub> (fan pad polyhouse) produced maximum width of leaf (2.00 cm). The lowest width of leaf (1.70 cm) was produced under condition C<sub>4</sub> (open field condition) growing conditions. The fresh weight of plant was observed significant in respect of various growing conditions. The growing conditions had an effect on fresh weight of plant. The maximum fresh weight of plant (6.61 g) was recorded from C<sub>1</sub> (fan pad polyhouse) growing conditions, while it was minimum (4.88 g) from C<sub>4</sub> (open field condition) growing conditions. The greater plant height might have helped in the production of more number of branches per plant and number of leaves per plant, which ultimately resulted in the production of fresh weight of plant. The growing conditions had an effect on dry weight of plant, the maximum dry weight of plant (2.11 g) was recorded from C<sub>2</sub> (natural ventilated polyhouse) growing conditions, while it was minimum (1.60 g) from condition C<sub>3</sub> (net house (low-cost) growing conditions. The greater plant height might have helped in the production of more number of branches per plant and number of leaves per plant, which ultimately resulted in the production of dry weight of plant. The increased leaf area might be due to better vegetative growth of aerial parts.

Kaddi (2014) reported that, the number of fruits developed to maturity was significantly more in *kharif* (2.15) than summer (1.90). The vine length, number of leaves, fruit weight, and fruit length and fruit width of cucumber were significantly higher under naturally ventilated polyhouse and insect proof net house compared to open field in both of the seasons.

Rana *et al.* (2014) conducted an experiment on tomato crop under protected environment and open field conditions. The results reveal that, the increased plant

height (1.4m) and number of branches per plant was higher in polyhouse than open field condition.

Isaac (2015) conducted an experiment to study the performance of leafy vegetables in naturally ventilated polyhouse. They studied five leafy vegetables viz. palak, coriander, lettuce, green amaranthus, red amaranthus in poly house and open field condition at Kerala and reported that, the days to 50 % germination was rapid in Green Amaranthus 2.7 days and Red Amaranthus 2.5 days varieties while it was slowest in coriander 15 days and Palak 13 days recorded slow germination. Initial growth was slow in coriander and lettuce while amaranthus varieties and palak performed satisfactorily during the first month putting fourths a good canopy. In the open field, crop establishment was very poor and could not be raised successfully due the heavy rains and growth character of leafy vegetables. In poly house crop, significant variation in plant height was observed with taller plant observed in Amaranthus, and plant height of Palak (31.13 cm), Coriander (20.76 cm), Lettuce (21.63 cm), Green Amaranthus (50.90 cm) and Red Amaranthus (47.38 cm). Number of leaves per plant in palak (30.5), coriander (99), Lettuce (15.9), green Amaranthus (35) and red amaranthus (32.2) were reported.

Nangare *et al.* (2015) reported that, the plant height of tomato was highest in 75 % green shade net house as compared to open field.

Bhargava *et al.* (2016) studied on performance of Snapdragon (*Antirrhinum majus* L.) under protected and open field conditions in Himachal Pradesh. The aim of the present study was to evaluate and compare the effect of protected and open field cultivation on growth of *Antirrhinum majus* L. plants (selection UHFSA-13). The results revealed that, protected cultivation enhanced plant height (81.42 cm), plant spread (42.84 cm) and number of spikes (12.29) as compared to open field cultivation (65.67 cm, 40.15 cm and 9.79, respectively).

Kumar *et al.* (2016) conducted an experiment with two brinjal varieties Pusa Purple Long and Pusa Purple Cluster to evaluate their performance and suitability under open and naturally ventilated polyhouse conditions in cold desert region of Himachal Pradesh, India and reported that, the growing conditions had significant influence on parameters like days to marketable maturity, harvest duration, plant height, number of fruits per plant (16.02) higher under naturally protected condition in

comparison to open field. Pusa Purple Long was significantly early to reach marketable maturity and also recorded the highest value for harvest duration.

Malshe *et al.* (2016) studied on evaluation of bell pepper hybrid Indra under different growing structures and concluded that the maximum plant height was (164.13 cm) in NVP and minimum plant height (99.85cm) was recorded under open field conditions. Under open field conditions, variation in plant height (crop vigor) was anticipated as standard deviation (6) was 9.84. Early flowering and highest fruit set was in naturally ventilated polyhouse.

Sam and Regeena (2016) studied the performance of trailing tomato and capsicum with respect to vegetative and yield parameters under protected structures along with an open field (control) and reported that the tallest plants, maximum number of branches/plant and higher leaf area expansion were found in the crops grown under polyhouse as compared to natural condition (i.e. open field).

### **2.3. Effect on yield parameters**

Baudoin and Nisen (1990) reported that, the total fruit yield of tomato plants were significantly enhanced by plastic covering.

Wolff and Coltman (1990) reported that, the yield of Cos lettuce, green mustard cabbage, green bunching onions were irresponsive to shade or negatively affected by shade in both seasons. Yield responses of the other crops to shade varied seasonally. Optimum shading of 30% to 47% increased green mignonette Salinas, and head cabbage respectively, compared to full-sun plots in one or both seasons.

Weerakkody and Ando (1994) studied the effect of maturity and sampling time on the quality of spinach cv. King of Denmark leaves were investigated in greenhouse and reported that, the significant variations in dry matter (DM) with maturity. The highest leaf DM was recorded in the 5<sup>th</sup> week after planting (WAP).

Dhulakhandi *et al.* (1995) reported that, the yield of fenugreek 0.775 kg/m<sup>2</sup>, spinach 1.007 kg/m<sup>2</sup>; coriander 1.371 kg/m<sup>2</sup> and lettuce 0.888 kg/m<sup>2</sup> under greenhouse.

Wittwer and Castilla (1995) reported that, the greenhouse crops can be protected out-of-season on year-round their yields are higher than those grown in open fields.

Ganesan (2002a) carried out studies to evaluate the performance of low cost naturally ventilated greenhouse in comparison to open field conditions and its effect on the yield and quality of fruits of two varieties of tomato (Vaishali and PKM1) in two seasons (*Kharif* and *Rabi*) during 1999 to 2000. Results of the study indicated that greenhouse plots gave higher yields with Vaishali variety than the open field condition. PKM1 variety did not perform very well in the greenhouses.

Ganesan (2002b) studied the effect of Poly-Greenhouse on plant micro climate and fruit yield of tomato and observed that the yield performance inside the greenhouse was highest 2145 g/plant and 2156 g/plant in the first and second season, respectively) than the open field crop. The fruit yield inside the greenhouse was nearly two times more than in the open field condition.

Ganesan (2002c) concluded that, the yield of tomato could be increased with the use of ultraviolet-stabilized plastic film covered in the parallelogram roof and 25% shade net used in the four side walls and triangular portions of roof in the poly-greenhouse.

Singh *et al.* (2002) concluded that, the protected cultivation of vegetables provides the best way to increase the productivity of vegetables especially cucurbits. The yield of some cucurbits like cucumber can be increased manifold compared to open field cultivation.

Sonwal *et al.* (2004) studied performance of ten varieties of tomato under poly house and open field conditions in NEH region at Meghalaya and observed that the high yield in polyhouse than open field condition.

Singh and Asrey (2005) studied the performance of tomato and sweet pepper under unheated greenhouse and reported that, the production of tomato and sweet pepper under medium cost greenhouse was found to the tune of 93.2 and 75.4 t/ ha respectively.

Dixit (2007) reported that, 2.3 times more yield of leafy vegetables than that of outdoor cultivation. The yield was found more under protected environment 6.94, 6.62, 8.63 and 2.34 kg/m<sup>2</sup> in spinach, amaranthus, fenugreek and coriander respectively as compared to open field condition 3.15, 3.00, 4.95, and 1.68 kg/m<sup>2</sup> in spinach, amaranthus, fenugreek and coriander respectively. They revealed that the

greenhouse cultivation produced superior yield and yield attributing characters as compared to open field condition.

Kumar *et al.* (2009) conducted research on off-season vegetable based cropping sequence under protected cultivation in mild-hills of north-western Himalayan region and a field experiment was conducted during 2004-2006 to evaluate year round off-season vegetable cultivation, using naturally ventilated greenhouse. Five cropping sequence considering the off –seasonality of 2 months were selected for evaluation. The cropping sequence of squash – French bean – tomato- spinach gave highest economic yield (1585 kg/100m<sup>2</sup>/year) with production efficiency (4.34 kg/100m<sup>2</sup>/day), followed by capsicum – tomato- spinach cropping sequence that gave yield of 963 kg/100m<sup>2</sup>/year and production efficiency of 2.64 kg/100m<sup>2</sup>/day. Selected cropping sequence resulted in 1.45-2.80 times higher crop yield inside the greenhouse as compared to open field condition.

Tehlan and Malik (2010) studied the influence of different shading intensity (25%, 50% and 75% shade) on green leaf production of different varieties of coriander during summer season. Among the shade nets of different intensity evaluated, maximum green leaves yield was recorded under 50% shade net (8297 kg/ha) which is significantly superior to all other treatments.

Singh *et al.* (2011a) studied the performance of sweet pepper (*Capsicum annum*) varieties and economics under protected and open field conditions in Uttarakhand and summaries that the protected technology enhanced crop duration, (270 days) in polyhouse, (180 days) in poly tunnel, (150 days) in poly mulching as compared to (117 days) in open field condition. highest number of fruit weight (2.91 kg/plant) and yield (17.48 kg/m<sup>2</sup>) were achieved in polyhouse, followed by poly-tunnel (1.89 kg/plant, 11.34 kg m<sup>2</sup>), poly-mulching (1.57 kg/plant, 9.43 kg/m<sup>2</sup>) and open field condition (0.98 kg/plant, 5.90 kg/m<sup>2</sup>), respectively. It is concluded that protected features considerably enhanced production of sweet pepper as compared to open fields, particularly during rainy and off-season in Uttarakhand.

Singh *et al.* (2011b) concluded that, under greenhouse conditions the yield is 3-5 times more than the open field conditions.

Kotadia *et al.* (2012) reported that, the growing of leafy vegetables in shade net situation favored for higher production as compared to open field situation during

summer season. Particularly fenugreek and coriander grown in 75 % shade net situation, spinach and amaranthus grown in 30% shade net gave maximum yield.

Richardson (2012) evaluated five leafy green vegetables for their marketable yield at the Gladstone Road Agricultural Centre from November 2011 to February 2012. Single leaves of each of the five types of leafy vegetables were harvested on six occasions over a period of five weeks. Results indicate that under local conditions, during the cooler months of the year, these leafy green vegetables show good potential increased productivity.

Karistsapol *et al.* (2013) studied the effect of shading and variety on the growth and yield of broccoli during the dry season in southern Thailand and result showed that the yield response of Broccoli growing under the shading had higher harvested plant than under the full sunlight. The Yok Kheo had the highest harvested plant (100%), followed by the Top Green and Green Queen (81.98-83.36 %). The interactions between treatments and varieties were significantly influenced on each particular head diameter and weight. Under the shading, the three varieties had higher head diameter and weight than the full sunlight. The highest head diameter and weight were obtained in the Yok Kheo (12.11 cm and 371.48 g/plant) when growing under the shading. These results are consistent with total yield of the three varieties. Growing under the shading had high total yield as compared to full sunlight.

Rajasekar *et al.* (2013) reported that, the yield of amaranthus (kg per plot) in shade net condition was 16.76 in summer and 25.58 in winter and in open field it was 7.80 in summer and 11.67 in winter. Yield of coriander in shade net condition 15.63 in summer and 19.61 in winter kg per plot and open field 8.70 kg per plot in winter. They also reported, yield per plant of tomato, eggplant, chilli, raddish, cucumber, coriander, amaranthus and that yield is higher under shade net house than open field.

Rao *et al.* (2013) studied the performance of capsicum crop in open field and under covered cultivation and result showed that under shade net the crop yield was increased by 80 per cent over open field cultivation.

Karetha *et al.* (2014) studied the effect of different dates of sowing and growing conditions on coriander (*Coriandrum sativum* L.) cv. Gujarat coriander-2. Result showed that Influence of different growing conditions on green yield, it was observed that, C<sub>2</sub> (natural ventilated polyhouse) growing condition produced the

highest green yield (21.82 tones/ha), which was superior over late and early dates, indicating the progressive increase in green yield, with successive increase in sowing dates. C<sub>1</sub> (fan pad poly house) growing condition resulted the lowest green yield.

Rana *et al.* (2014) reported that, the fruit yield of tomato from the polyhouse was higher (2.6 kg plant<sup>-1</sup>) than the open field (1.5 kg plant<sup>-1</sup>). The parameters of economic importance like fruit weight and yield are better under protected conditions.

Yadav *et al.* (2014) conducted research on Low-Cost Polyhouse Technologies for Higher Income and Nutritional Security. An experiment was conducted at the research farm, Division of Vegetable Science, IARI, New Delhi, during third week of November, 2012-13 by utilizing two types of low cost polyhouses (polyhouse for raising nursery and crops and low height polyhouse for crops) and result showed that the off season vegetable production under low cost polyhouse per 1000 m<sup>2</sup> is 2300, 2000, 2000, 2500 Kg in gherkin, cherry tomato, bitter gourd, cucumber, respectively and off season vegetable production under temporary protected low height polyhouse per 1000 m<sup>2</sup> was 950, 4500, 1500 Kg in French bean, summer squash and amaranth respectively.

Isaac (2015) reported that, the yield per plant in g in palak was 80.9, coriander 47.81, lettuce 3.39, green amaranthus 69.33, and red amaranthus 74.98. Yield per plot (3.75m<sup>2</sup>) in kg in, palak 3.94, coriander 1.66, lettuce 0.70, green amaranthus 5.37 & red amaranthus 3.98 reported in naturally ventilated polyhouse.

Kumar *et al.* (2015) studied the comparative economics of cucumber cultivation under polyhouse and open field conditions in Haryana and the results revealed that, the average yield of cucumber 456.25 and 210.78 quintal per acre was obtained under polyhouse and open field cultivation respectively. Thus in open field cultivation of cucumber the yield was estimated 245.47 quintal/acre less than the production under polyhouse cultivation.

Nangare *et al.* (2015) reported that, the yield of tomato was highest 3.43 kg/plant in 35% shading net followed by open field 2.27. Lowest yield observed 1.07 kg/plant in 75% shading net.

Spehia (2015) studied the impact of protected cultivation in polyhouse on productivity of important crops as compared to open cultivation. Revealed that, crops wise productivity under open and protected cultivation is based on the field level

information collected from the beneficiaries. Data was collected for important cash crops suitable for protected cultivation, *viz.* capsicum, tomato, cucumber, beans, peas, coriander and spinach. Observations of the data reveal an increase in crop productivity by a minimum of 59% (coriander) to a maximum of 414% (cucumber) inside polyhouse as compared to open cultivation. Capsicum was the most dominant crop under polyhouse cultivation. Almost all beneficiaries had at one point or the other cultivated capsicum irrespective of the size of the polyhouse. It was reported that under open cultivation, the productivity ranged between 25 and 30 mt/ha as compared to 90– 150 mt/ha under polyhouse cultivation. On an average, the productivity obtained under protected cultivation was 3.36 times (range 2.6 to 4.0 times) more when compared to open cultivation. As the greenhouse effect works best under polyhouse, increase production was attained which is not possible in open field cultivation.

Kumar *et al.* (2016a) studied the economic analysis of capsicum cultivation under polyhouse and open field conditions in Haryana on per acre basis and results showed that, the average yield of 356.48 and 136.55 quintal per acre was obtained under polyhouse and open field cultivation of capsicum respectively. Thus, in open field the yield was estimated 219.93 quintal/acre less than the production under polyhouse.

Kumar *et al.* (2016b) the carried out an experiment with two brinjal varieties Pusa Purple Long and Pusa Purple Cluster to evaluate their performance and suitability under open and naturally ventilated polyhouse conditions in cold desert region of Himachal Pradesh, India. Growing conditions had significant influence on parameters like days to fruit yield per plant and fruit yield per ha. Fruit yield per ha were 31.87%, higher under naturally protected condition in comparison to open field.

Malshe *et al.* (2016) concluded that, the average fruit weight and fruit volume of bell pepper was also higher (172.52 g and 324.13 cm<sup>2</sup> respectively) under naturally ventilation polyhouse. The maximum fruit yield (3.40 kg per plant and 75.45 t per ha) was recorded under naturally polyhouse (E1). The lowest yield (1.39 kg plant<sup>-1</sup> and 30.38 t ha<sup>-1</sup>) was recorded under open field.

Sam and Regeena (2016) reported that, the highest yield was recorded in poly house structures than in open field for trailing tomato and capsicum. The increase in

yield was to the tune of 82.84% and 90.85% for trailing tomato and capsicum respectively.

Singh *et al.* (2016) concluded that, the yield of capsicum can be increased under polyhouse condition as compared to open field conditions.

#### **2.4. Effect on quality parameters**

Asha and Nair (1992) found that, under shade net high chlorophyll content of gerbera than full sun.

Ganesan (2002a) carried out studies to evaluate the performance of low cost naturally ventilated greenhouse in comparison to open field conditions and its effect on the yield and quality of fruits of two varieties of tomato (Vaishali and PKM1) in two seasons (Kharif and Rabi) during 1999 to 2000. Results of the study indicated that, the leaf chlorophyll content was not affected by the treatment in both the varieties.

Kurubetta and Patil (2009) reported that, the capsicum quality parameter like shelf life (8.62 days) were also significantly more under naturally ventilated polyhouse than under naturally ventilated shadow hall.

Moniruzzaman *et al.* (2009) conducted an experiment on effects of shade on quality bngladhonia production and studied the four shade levels (0, 25, 50, and 75% shades) and concluded that the chlorophyll increased progressively with the increase of shade levels. The maximum amount of chlorophyll was recorded at 75% shade followed by 50% shade. It has been postulated that shading increased the quantity of chlorophyll. They also reported that vitamin C content of the leaf was significantly influenced by different shade levels. Vitamin C decreased gradually with the increase of shading density. The highest amounts of vitamin C (71.76 mg/100 g) were recorded from 0% shade (unshaded condition). The second highest vitamin C was recorded from 25% shade, which was statistically similar to 50% shade.

Rana *et al.* (2014) reported that, the fruits harvested from the field had higher ascorbic acid (14.7 mg 100g<sup>-1</sup>) than the fruits grown under protected conditions.

Lekshmi and Celine (2015) observed that, different tomato hybrids showed variation in quality characters like ascorbic acid and vitamin A. The results indicated that under the net house conditions tomato hybrid Naveen recorded maximum

ascorbic acid content (25.46 mg) whereas, minimum ascorbic acid content (20.64 mg) was recorded in INDAM Ruchi. Increased ascorbic acid content of tomato under shading was also reported by Smitha (2002). They also reported that vitamin A content recorded maximum under net house conditions.

Malshe *et al.* (2016) studied on evaluation of bell pepper hybrid Indra under different growing structures and concluded that, the fruits grown under shade net house recorded significantly highest self life (9.75 days) followed by 8.25 days in NVP and 6.75 days in open field conditions.

Sam and Regeena (2016) observed that, the shelf life of tomato and capsicum was better in poly house produced crops than open field crops and they also reported minimum PLW was observed under polyhouse produced crops than open field crops.

## **2.5. Economics**

Sharma *et al.* (1992) studied the profitability of vegetable crops under polyhouse conditions and reported that, the vegetable crops provided higher net returns under polyhouse conditions.

Sonwal *et al.* (2004) recorded that, the cost of production (for 1 year) for 100 m<sup>2</sup> polyhouse cum rain shelter was total cost (with hired labour was 10900 Rs, with 50 percent hired plus 50 percent family labour was 7700 Rs. with family labour only is 4500 Rs). Gross income from cropping sequence tomato plus palak plus tomato plus cucumber was 9500 Rs and tomato plus palak plus capsicum plus cucumber was 5750 Rs. Further they reported that annual net profit from 100 m<sup>2</sup> polyhouse cum rain shelter and gross income (with hired labour 19500 Rs, with 50 percent hired plus 50 percent own 19500 Rs and with family labour only 19500 Rs). Net income (with hired labour 8600 Rs, with 50 percent hired plus 50 percent own 11800 Rs and with family labour only 15000 Rs). Benefit cost ratio (with hired labour is 1.79:1, with 50 percent hired labour plus 50 percent own is 2.53:1 and with family labour only 4.33:1).

Singh and Asrey (2005) reported that, the cultivation of tomato and sweet pepper under greenhouse would not only help in getting higher productivity but also fetch better returns Rs.7-8 per m<sup>2</sup> per season.

Singh *et al.* (2007) reported that, cost of polyhouse was US\$11/M<sup>2</sup> (Rs. 500/M<sup>2</sup>) and cost-benefit ratio of cucumber cultivation under greenhouses worked out as 1:2.29 under Delhi conditions of India.

Singh and Sirohi (2008) reported that, protected cultivation of vegetables provided more market rate Rs./Kg with higher income as compared to traditional cultivation.

Kumar *et al.* (2009) studied on off-season vegetable based cropping sequence under protected cultivation in mild-hills of north-western Himalayan region and a field experiment was conducted during 2004-2006 to evaluate year round off-season vegetable cultivation, using naturally ventilated greenhouse. Concluded that pooled analysis of two years data showed higher gross returns (Rs. 11636/100m<sup>2</sup>/year) in cropping sequence of squash- French bean tomato – squash, whereas net returns (Rs. 8252/100m<sup>2</sup>/year). However highest B: C ratio (3.34) was obtained for cropping sequence of capsicum -tomato-spinach. Lowest net returns (Rs. 1265/100m<sup>2</sup>/year) and B: C ratios (1.34) were recorded in cropping sequence tomato-cucumber-French bean coriander under greenhouse condition.

Murthy *et al.* (2009) studied on the economic viability of production of capsicum and tomato in a NVP and reported that naturally ventilated polyhouse had provided more net income, more market prices with higher cost.

Vinh *et al.* (2010) revealed that, the investment for growing vegetables in polyhouses requires high cost than outside's. They also concluded that in polyhouse, vegetables and flowers expressed 5-10 folds of economic value higher than those in open fields.

Singh *et al.* (2011a) reported that, in sweet paper the different protected technologies exhibited greater net return (253.84 /m<sup>2</sup> in polyhouse, 132.08 /m<sup>2</sup> in poly-tunnel, 88.56 /m<sup>2</sup> in poly-mulching, 37.37/m<sup>2</sup> in open) and B:C ratio (1.0:4.72) in polyhouse, (1.0:3.68) in poly-tunnel, (1.0:3.03) in poly-mulching was achieved while it was lowest in open field condition (1.0:2.12).

Sreedhara *et al.* (2013) reported that, the cost of establishment of capsicum production under protected condition was Rs. 2,51,109 per unit (0.25acre). The total cost of cultivation of capsicum production under protected conditions was Rs. 55,080 per units. The total variable cost was Rs. 20,374 per unit. Among the variable costs, the labour cost was highest (Rs. 10,291), followed by expenditure on material cost (Rs. 8,487) and among the total cost of cultivation, the proportion of total fixed cost was highest (Rs. 34,707) compared to total variable cost (Rs. 20,373). The total

returns and net returns from capsicum production under protected conditions were Rs. L,54,734 per unit and Rs. L,15,279 per unit, respectively. The B: C ratio of capsicum production under protected conditions was 3.92.

Kaddi (2014) studied on effect of growing conditions on seed yield and quality of cucumber (*Cucumis stivus*) hybrid and concluded that the benefit-cost ratio (BCR) is higher in insect proof net house (1:2.25) followed by open condition (1:1.12) naturally ventilated polyhouse (1:0.37).

Kishore *et al.* (2014) conducted research on sequential vegetable production under protected (polyhouse and open field) condition in temperate humid region and concluded that, under protected condition, tomato - pea- carrot - cucumber gave the higher, net return (Rs. 13,336.1/100m<sup>2</sup>), BCR (4.05) and profitability (Rs. 36.53/100m<sup>2</sup>/day). Whereas, pea - coriander - French bean - bitter gourd was least profitable. The production cost under polyhouse was about 1.5 times higher than that of open field; however return was about two times higher.

Yadav *et al.* (2014) conducted an experiment on Low-Cost Poly house Technologies for Higher Income and Nutritional Security and concluded that, the produce from protected structures was off-season and hence fetched higher prices in the market. Under low cost protected structure of 50 m<sup>2</sup> a total of Rs. 9500/- was earned in first year and around Rs. 24,000/- from second year onwards by raising offseason nursery. Similarly a net profit of Rs.15, 000/- and 59,500/- can be earned by growing French bean and gherkins in first year and Rs. 43,500/- and Rs. 59,000/- second year onward from 1000 m<sup>2</sup> area respectively. Therefore to enhance income of the small and marginal farmers, off-season nursery as well as vegetables cultivation under low cost poly houses is found to be economical and profitable enterprise.

Kumar *et al.* (2015) studied on comparative economics of cucumber cultivation under naturally ventilated polyhouse and open field conditions in Haryana on per acre basis and concluded that, income of farm can be increased by adoption of polyhouse technology.

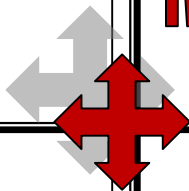
Spehia (2015) studied the effect of polyhouse on productivity of important crops as compared to open cultivation. Revealed that, the protected cultivation helped in increasing the income generation of farmers by producing higher yields with 2–3 crops grown in a year. Of all the crops under study, capsicum was the best option for

getting maximum income from polyhouse as it showed net income of Rs. 213,830 (including self-labour) in a 500 sq. m area. This was followed by tomato (Rs. 77,127) and cucumber (Rs. 34,756). The net income trend indicates that income (excluding the self labour) for different crops varied from Rs 568 to Rs. 1,893 in polyhouse of size 40 sq. m, except for capsicum where the income generated was Rs. 12,830.

Bhargava *et al.* (2016) studied the performance of Snapdragon (*Antirrhinum majus* L.) under protected and open field conditions in Himachal Pradesh. The aim of the present study was to evaluate and compare the effect of protected and open field cultivation on economics of *Antirrhinum majus* L. plants (selection UHFSA-13) and results showed that, protected cultivation exhibited greater net return (Rs. 115.16/m<sup>2</sup>) and B:C ratio (1.0:4.45) as compared to open field cultivation (Rs. 55.63/m<sup>2</sup> and 1.0:2.99 respectively).

Kumar *et al.* (2016) studied the economics of capsicum cultivation under polyhouse and open field conditions in Haryana on per acre basis and result showed that the cost of cultivation of capsicum under polyhouse was worked out to be RS. 1,01,667.91, and concluded that, income of farm can be increased by adoption of polyhouse technology.

# MATERIAL AND METHODS



## **CHAPTER-III**

### **MATERIAL AND METHODS**

The quality of any research is judged on the basis of its methodological approach. It is a way to systematically solve the research problem. It explains not only the steps adopted by a researcher in studying the research problem but also the logic behind them. The details of material used and methods adopted during the course of present investigation are summaries in this chapter. The present investigation entitled “Influence of different growing conditions on growth, yield and quality of leafy vegetables” was carried out at Department of Horticulture, Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India.

#### **3.1 Experimental site**

An experiment was conducted during *Kharif* 2016 at Experimental Farm, Department of Horticulture, Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S.) India.

#### **3.2 Experimental soil**

In open field soil type of experiment was fairly uniform, medium black with uniform texture and well drained as well as in polyhouse uniform texture and well drained. The beds were prepared of 30 cm height with the mixture of red soil, FYM and fine sand.

The chemical properties of soil were determined by taking soil samples from 0 to 30 cm depth, with the help of screw auger at random all over the experimental area before layout of experiment. The estimation of soil pH, organic carbon, N, P and K etc. was done by following the standard procedure recommended for analysis of soil samples. The chemical properties of experimental site have been presented in Table 2.

#### **3.3 Geographical location of experimental site and climate**

Parbhani comes under sub-tropical region and is situated at 408.50 m above the sea level. Geographically, it is situated between 19°16' N latitude and 76°47' longitude. The annual precipitation of Parbhani, which comes under assured rainfall zone. The rainfall is mostly received during June to September. The maximum and minimum temperatures are 32.0 to 20.9°C in August and 32.9 to 15.1°C in November.

Summer is hot and dry, while winter is cool. The mean relative humidity ranges from 20 to 88 per cent and thus, the climate is sub-tropical. The data on rainfall, temperature and relative humidity and light intensity during entire crop season was obtained from the Meteorological Observatory of Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani and poly house data was recorded all experimental site.

**Table 2. Chemical properties of surface soil (0-30 cm) of the experimental plot.**

Sr. No.	Particulars	Units	Values in %		Analytical method used
			Open field	Polyhouse	
1	Organic carbon	g/kg	3.47	2.96	Walkey & Blocks wet oxidation (Jackson,1967)
2	Available Nitrogen	Kg/ha	159.93	151.64	Alkaline permanganate method (Jackson,1967)
3	Available phosphorus	Kg/ha	28.31	21.55	Olsen's methods (Olsen's <i>et al.</i> , 1954)
4	Available potassium	Kg/ha	605.01	465.10	Flame photometer (Jackson,1967)
5	Available Sulphur	Kg/ha	15.59	15.17	Spectro-photometer (William and Steinberg, 1969)
6	Soil pH	-	7.85	5.59	Blackmans pH meter (Jackson,1967)
7	Electrical conductivity (EC)	dSm <sup>-1</sup>	0.31	0.28	Conductivity bride (Jackson,1967)

### 3.4 Climatic condition during experimental period

The weather data recorded at Agriculture Meteorological Observatory, VNMKV, Parbhani during the period of experimentation are given in appendix-I.

### 3.5 Planting material

Genetically pure seeds of leafy vegetable of required variety were obtained from private agro service center, Parbhani.

### 3.6 Experimental details

1. The information of leafy vegetables is given in Table 3 and experimental details are given as below.

**Table 3. Detail information regarding leafy vegetables used for experimentation.**

Sr. No.	Leafy Vegetables	Variety	Seed Rate Kg/ha	RDF Kg/ha	Spacing (R - R) cm
1	Amaranthus	Green leaves	2	80:40:40	15
2	Beet leaf	All green	10	80:40:40	
3	Coriander	S-909	40	100:50:50	
4	Fenugreek	Local	40	80:40:40	

2. Location : Department of Horticulture, VNMKV, Parbhani
3. Design : Factorial Randomized Block Design (FRBD)
4. Season/Year : *Kharif* 2016
5. Treatments : Eight (8)
6. Replications : Three (3)
7. Total numbers of plots : 24
8. Distance between two treatments : 0.5 m
9. Distance between two replications : 1m
10. Plot size : 3 x 1.2 m
11. Total number of rows per plot : Eight (8)
12. Total experimental area : 164.25 m<sup>2</sup>
13. Date of sowing : 20 August 2016

### 3.7 Treatment

#### A) Factor A: Growing conditions (G)

The crop is tried in two growing conditions which are as follows.

G<sub>1</sub> – Open field

G<sub>2</sub> – Poly house

## B) Factor B: Leafy vegetables (V)

Four leafy vegetables were taken for the study.

V<sub>1</sub> – Amaranthus

V<sub>2</sub> – Beet Leaf

V<sub>3</sub> – Coriander

V<sub>4</sub> – Fenugreek

### 3.8 Treatment details

In all total eight treatment combinations were tried. The details are presented in Table 4.

**Table 4. Treatment combinations [growing conditions (G) x leafy vegetables (V)]**

Sr. No.	Treatment	Interaction details
1	G <sub>1</sub> V <sub>1</sub>	Amaranthus in open field
2	G <sub>1</sub> V <sub>2</sub>	Beet Leaf in open field
3	G <sub>1</sub> V <sub>3</sub>	Coriander in open field
4	G <sub>1</sub> V <sub>4</sub>	Fenugreek in open field
5	G <sub>2</sub> V <sub>1</sub>	Amaranthus in polyhouse
6	G <sub>2</sub> V <sub>2</sub>	Beet Leaf in polyhouse
7	G <sub>2</sub> V <sub>3</sub>	Coriander in polyhouse
8	G <sub>2</sub> V <sub>4</sub>	Fenugreek in polyhouse

### 3.9 Field layout

Gross plot size for each plot was 3.0 m x 1.2 m. The distance between two replications was 1m and distance between two treatments was 0.5 m. The total number of treatments was eight and replicated thrice and total number of plots were twenty four. There were eight total numbers of rows per plots. The total area of experiment was 164.25 m<sup>2</sup>. The detail plan of layout is depicted in Fig. 1.

### 3.10 Details of cultural operations

The detail information regarding different cultural operations carried out during the course of investigation is given in appendix-II.

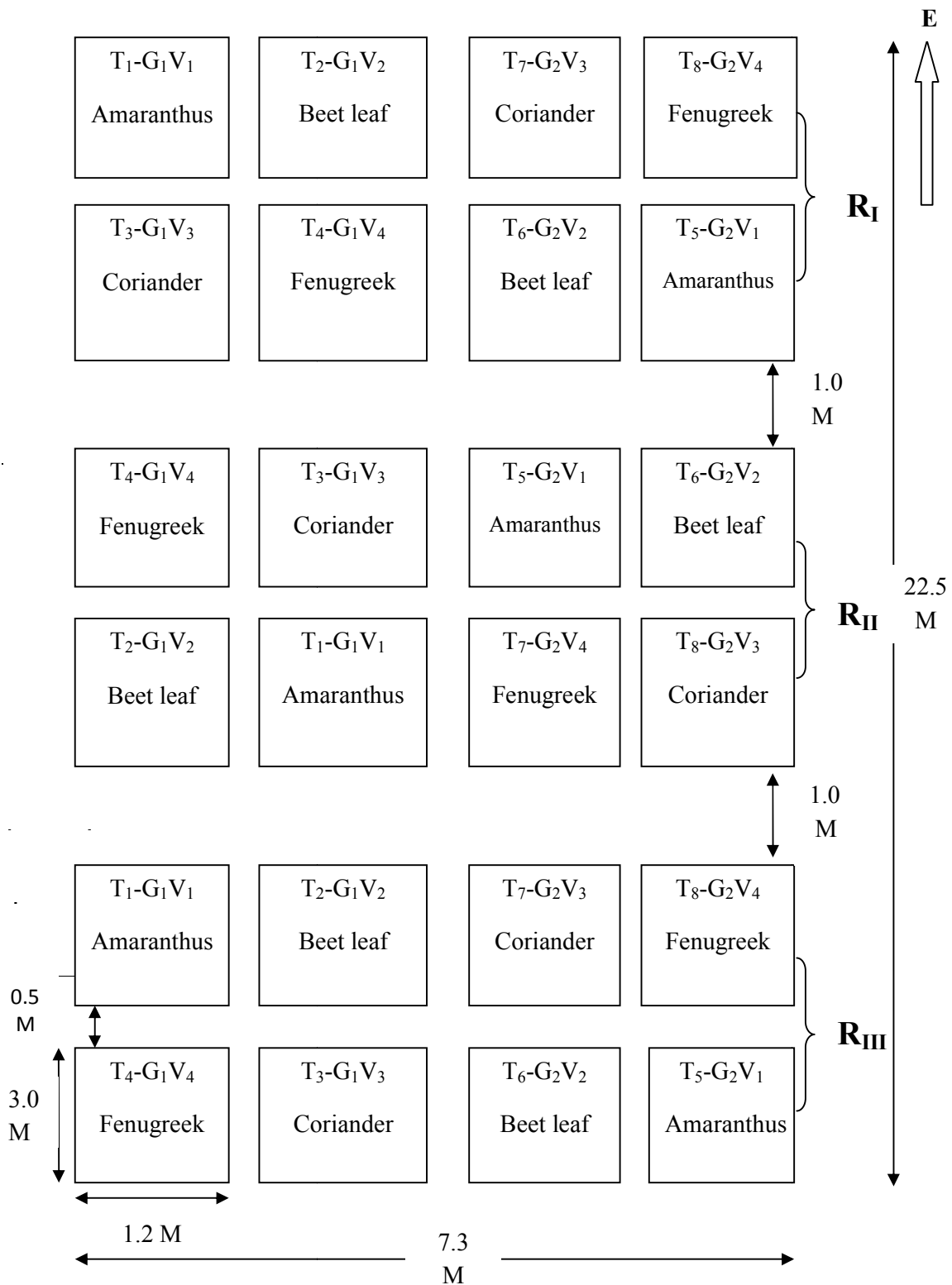
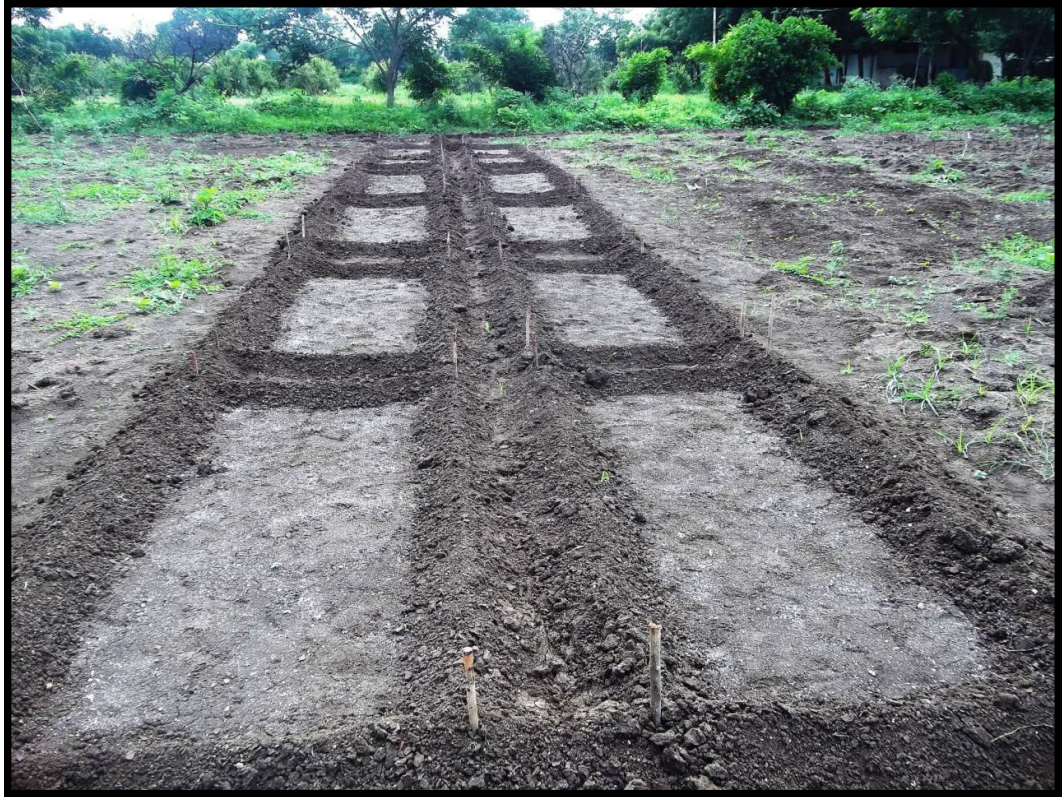


Fig.1. Plan of layout



**PLATE 1. VIEW OF LAYOUT IN OPEN FIELD**



**PLATE 2. VIEW OF EXPERIMENTAL POLYHOUSE**

### **3.11 Experimental procedure**

#### **3.11.1 Details of polyhouse (Naturally Ventilated Polyhouse)**

The polyhouse used for experiment was oriented in North-South direction with a size of 28 m length, 20 m width ( $28\text{ m} \times 20\text{ m} = 560\text{ m}^2$ ) with central height of 6 m. The frame was constructed with galvanized iron pipe. The area for side ventilation and top was one meter. A rollable low density polyethylene (LDPE) flap was provided on both sides of the polyhouse to control the ventilation area and to cover the side vents during rainy season to avoid the entry of rainwater. Glazing was provided with  $200\mu$  (800 gauges) thick ultra violet stabilized low density polyethylene film. Shade net of 50 per cent (white colour) was fitted inside naturally ventilated polyhouse, which is used to spread and roll according to the requirement of shade and cooling effects inside the polyhouse. The temperature and relative humidity inside the polyhouse were maintained by opening both side rollable low density polyethylene (LDPE) flaps at morning.

#### **3.11.2 Fumigation of soil**

The soil fumigation was with 2% formaldehyde to control soil borne pathogens. After application of formaldehyde, the soil was covered with black polythene for one week and then removed. Later, the plots were thoroughly irrigated to drain the chemical residues.

#### **3.11.3 Preparatory tillage**

In open field experimental land was ploughed and weeds, stubbles of previous crop were picked up. Two cris-crosses harrowing were given to bring the soil to fine tilth. Before the last harrowing farm yard manure @ 10 t/ha per hectare was applied in the field. Field was divided into different plots as per required dimensions by using the measuring tape, rope and pegs. The plots were prepared by keeping 1m distance between two replications and 0.5 m distance between two treatments with manual labour and 3 x 1.2 m size plots were prepared.

Land area inside the polyhouse was thoroughly dug to a depth of 30 cm. All the weeds, stubbles *etc.* were completely removed. The land was incorporated with well decomposed farm yard manure @ 10 t/ha was also applied to the soil and land was prepared to a fine tilth. The beds of required dimensions were prepared by using the measuring tape, rope and pegs. The plots were prepared by keeping 1m distance

between two replications and 0.5 m distance between two treatments with manual labour and 3 x 1.2 m size plots were prepared.

#### **3.11.4 Manures and fertilizers application**

Farm yard manure was applied at the rate of 10 t/ha at the time of land preparation. The recommended dose of inorganic fertilizers for Amaranthus, Beet leaf and fenugreek (80:40:40 kg NPK/ha) and for coriander (100:50:50 kg NPK/ha) was applied through urea, single super phosphate and muriate of potash was applied as per the recommendations of university of Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (Anon., 2016b). At the time of sowing, half the dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose and mixed thoroughly in the soil. The remaining half dose of nitrogen was applied 15 days after sowing for amaranthus, beet leaf, and fenugreek and for coriander 21 days after sowing.

#### **3.11.5 Seed source, Seed rate, Seed treatment and Sowing**

The seeds of amaranthus, beet leaf, coriander and fenugreek variety were obtained from Private Agro service center, Parbhani. The seeds were mechanically treated before sowing. Coriander seeds are crushed into halves by rubbing with hands before sowing. Seeds were chemically treated with Bavistin @ 3 g per kg before sowing in order to control the soil diseases. The seed rate 2, 10, 40 and 40 kg/ha was used for amaranthus, Beet leaf, coriander and fenugreek respectively. The seed sowing was done on 20 August, 2016 by manually opening the small chari or furrows as per treatments at a depth of 3-5 cm, keeping an inter row spacing of 15 cm for amaranthus, beet leaf, coriander and fenugreek with the help of khurpi and seeds were sown by hand drilling and covered with fine soil.

#### **3.11.6 Irrigation/ Water management**

The experimental plots of open field were irrigated as per the need during dry spell and in polyhouse irrigation was given by drip irrigation methods. Light irrigation immediately after sowing was given to both condition and further irrigations in open field depending on weather conditions and in polyhouse irrigations were given at an interval of 7 days.



**PLATE 3. SOWING OF VEGETABLES IN OPEN FIELD**



**PLATE 4. SOWING OF VEGETABLES IN POLYHOUSE**

### 3.11.7 Thinning

In open field as well as in polyhouse thinning was done immediately after complete germination of seeds.

### 3.11.8 Weeding

In open field two hand weeding were done at 7<sup>th</sup> and 21<sup>st</sup> days after sowing and in polyhouse one hand weeding was carried out in 21<sup>st</sup> days after sowing to keep the plots free of weeds.

### 3.11.9 Plant protection

The crop was sprayed with Bavistin 1g + Malathion 1.5 ml per liter of water at 14<sup>th</sup> and 21<sup>st</sup> days after sowing in open field and in polyhouse 21<sup>st</sup> days after sowing.

### 3.11.10 Harvesting and marketing

The crop was harvested separately as per treatment at the stage of horticultural maturity stage. The experimental produce was sold in local market. The selling cost as per vegetable under different growing conditions is given in Table 5.

**Table 5. Selling cost and quantity of leafy vegetable produce**

Treatment	Rate (Rs./ Kg)
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	20
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	25
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	50
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	60
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	35
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	40
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	90
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	80

### 3.12 Sampling and collection of experimental data (observations recorded)

#### 3.12.1 Sampling procedure/observations recorded

The observations of meteorological parameters as well as growth, yield, quality and economical parameters of different vegetables were recorded. Five plants were selected randomly from each plot and stakes were fixed near each of the selected plants, and labeled. The data obtained from all plots per repetition under each

treatment were averaged and reported. The procedures for recording the data are mentioned in Table 6 with the appropriate headings.

**Table 6. Schedule of observations**

Sr. No.	Observations	Units	Time of recorded
<b>I Meteorological parameters</b>			
1	Temperature	<sup>0</sup> C	Daily
2	Relative Humidity	%	
3	Light Intensity	Lux	
<b>II Growth parameters</b>			
1	Germination	%	At germination
2	Days to potential germination	-	
3	Height of plant	cm	At harvesting
4	Number of branches per plant	-	
5	Number of leaves per plant	-	
6	Leaf length	cm	
7	Leaf width	cm	
8	Leaf area	cm <sup>2</sup>	
9	Number of stomata	/mm <sup>2</sup>	
10	Days required for horticultural maturity	-	At sowing to hort. Maturity
11	Whole plant length	cm	At harvesting
12	Shoot length	cm	
13	Root length	cm	
14	Root: shoot ratio (Length basis)	-	
<b>III Yield parameters</b>			
1	Fresh weight of whole plant	g	At harvesting
2	Fresh weight of shoot	g	
3	Fresh weight of root	g	
4	Root: shoot ratio (Fresh weight basis)	-	
5	Yield per plot	Kg	
6	Yield	t/ha	
7	Dry weight of whole plant	g	After drying
8	Dry weight of shoot	g	
9	Dry weight of root	g	
10	Root: shoot ratio (Dry weight basis)	-	
<b>IV Quality parameters</b>			
1	Vitamin 'A' content	IU/100g	

2	Vitamin 'C' content	mg/100g	At harvesting
3	Calcium (Ca) content	mg/100g	
4	Iron (Fe) content	mg/100g	
5	Total chlorophyll content	SPAD Value	
6	Physiological loss in weight	%	After harvesting
7	Shelf life	Days	
<b>V Economics</b>			
1	Cost of cultivation	Rs./ha	Ploughing to marketing
2	Gross monetary returns	Rs./ha	After marketing
3	Net monetary returns	Rs./ha	
4	B: C ratio	-	

### 3.12.2 Details of observations recorded

#### 3.12.2.1 Metrological parameters

##### 3.12.2.1.1 Temperature ( $^{\circ}\text{C}$ )

The all over crop period temperature was recorded daily as per the LMT at morning 7.27 am and afternoon 2.27 pm with the help of *Temperature and Humidity meter (M288CTH)* and data was converted in to mean weekly basis by calculating average mean of morning and afternoon of a week separately.

##### 3.12.2.1.2 Relative Humidity (%)

The relative humidity was recorded daily as per the LMT at morning 7.27 am and afternoon 2.27 pm with the help of *Temperature and Humidity meter (M288CTH)* and data was converted in to mean weekly basis by calculating average mean of morning and afternoon of a week separately.

##### 3.12.2.1.3 Light Intensity (Lux)

The light intensity was recorded in daily as per the LMT at morning 7.27 am and afternoon 2.27 pm with the help of *Digital light meter (HI97500)* and data was converted in to mean weekly basis by calculating average mean of morning and afternoon of a week in separately.

### **3.12.2.2 Growth parameters**

#### **3.12.2.2.1 Days to potential germination**

The days required for potential germination were recorded by counting the number of days required to complete germination from seed sowing for each treatment and number was recorded.

#### **3.12.2.2.2 Germination (%)**

The germination % was calculated by using following formula,

$$\text{Germination (\%)} = \frac{\text{Number of normal seedling}}{\text{Total number of seeds sown}} \times 100$$

#### **3.12.2.2.3 Height of plant (cm)**

The height of the five randomly selected observational plants was measured from ground level to the top of the largest leaf with the help of meter scale and mean was computed and recorded as plant height in cm.

#### **3.12.2.2.4 Number of branches per plant**

The count of branches produced on observational plants was taken by counting the number of branches on the observational plants and mean was computed and recorded.

#### **3.12.2.2.5 Number of leaves per plant**

Numbers of leaves produced per plant were recorded from the tagged observational plants by counting the number of leaves and average number of leaf produced per plant was worked out.

#### **3.12.2.2.6 Leaf length (cm)**

The length of leaf randomly selected observational plants was measured with the help of meter scale and mean was computed and recorded as length of leaf in cm.

#### **3.12.2.2.7 Leaf width (cm)**

The width of leaf randomly selected observational plants was measured with the help of meter scale and mean was computed and recorded as width of leaves in cm.

### **3.12.2.2.8 Leaf area (cm<sup>2</sup>)**

Leaf area was recorded with the help of *Leaf area meter (LICOR 10)* by selecting leaves randomly of the observational plant. The readings were taken from the tagged plants and leaf area was expressed in centimeters square (cm<sup>2</sup>).

### **3.12.2.2.9 Numbers of stomata/mm<sup>2</sup>**

Leaf stomata count of the observational plants was taken under light microscope with counting the stomata and expressed as average number per mm<sup>2</sup>.

### **3.12.2.2.10 Days required for horticultural maturity**

The days required for horticultural maturity was calculated from the date of sowing to the days required for crop to attain the stage to fit for consumption.

### **3.12.2.2.11 Length of whole plant (cm)**

The length of whole plant was recorded at harvest after uprooting five observational plants from each treatment with the help of meter scale and average was worked out and recorded as length of whole plant in cm.

### **3.12.2.2.12 Shoot length (cm)**

The length of shoot was recorded by separating root and shoot portion of observational plants from each treatment with the help of meter scale and average was worked out and recorded as length of shoot in cm.

### **3.12.2.2.13 Root Length (cm)**

The length of root was recorded by roots separating of five observational plants from each treatment at harvest with the help of meter scale and average was worked out and recorded as length of root in cm.

### **3.12.2.2.14 Root: shoot ratio (Length basis)**

The ratio of root: shoot (length basis) was derived using formula as follows.

$$\text{Root: shoot ratio (Length basis)} = \frac{\text{Root length (cm)}}{\text{Shoot length (cm)}}$$

### **3.12.2.3 Yield parameters**

#### **3.12.2.3.1 Fresh weight of whole plant (g)**

The fresh weight of whole plant was calculated by weighing five observational plants from each treatment at harvest and average was worked out and recorded as fresh weight of whole plant in grams.

#### **3.12.2.3.2 Fresh weight of shoot (g)**

The fresh weight of shoot was calculated by weighing shoots of five observational plants from each treatment at harvest and average was worked out and recorded as fresh weight of shoot in grams.

#### **3.12.2.3.3 Fresh weight of root (g)**

The fresh weight of root was calculated by weighing roots of observational plants from each treatment at harvest and average was worked out and recorded as fresh weight of root in grams.

#### **3.12.2.3.4 Root: shoot ratio (Fresh weight basis)**

The ratio of root: shoot (Fresh weight basis) was derived using formula as follows.

$$\text{Root: shoot ratio (Fresh weight basis)} = \frac{\text{Fresh weight of root (g)}}{\text{Fresh weight of shoot (g)}}$$

#### **3.12.2.3.5 Yield per plot (kg)**

The green leaf yield per plot was measured at the time of harvesting from each treatment and replication and it was recorded as leaf yield per plot and expressed in kg.

#### **3.12.2.3.6 Yield (t/ha)**

At harvest the total biomass yield obtained per treatment and per replication and after computing the averages it was recorded and was multiplied with hector factor and recorded as yield t/ha.

### 3.12.2.3.7 Dry weight of whole plant (g)

The dry weight of whole plant was calculated after oven drying of five observational plants till constant weight at 48<sup>0</sup>C temperature and average was worked out and recorded as dry weight of whole plant in grams.

### 3.12.2.3.8 Dry weight of shoot (g)

The dry weight of shoot was calculated after oven drying of five shoots from each treatment at 48<sup>0</sup>C temperature till constant weight and average was worked out and recorded as dry weight of shoot in grams.

### 3.12.2.3.9 Dry weight of root (g)

The dry weight of root was calculated by weighing roots of five observational plants from each treatment after oven drying at 48<sup>0</sup>C temperature till constant weight and average was worked out and recorded as dry weight of root in grams.

### 3.12.2.3.10 Root: shoot ratio (Dry weight basis)

The ratio of root: shoot (dry weight basis) was derived using formula as follows.

$$\text{Root: shoot ratio (Dry weight basis)} = \frac{\text{Dry weight of root (g)}}{\text{Dry weight of shoot (g)}}$$

### 3.12.2.4 Quality parameters

#### 3.12.2.4.1 Vitamin 'A' content (IU/100g)

Vitamin A was estimated by using chloroform, Diethyl ether, Antimony dichloride solution from selected observational plants and the amount of vitamin- A was estimated and expressed in (IU/100g) by using formula,

$$\text{U.S.P. unit/ ml} = \frac{A}{B - A} \times \text{concentration of vita - A standard (U.S.P. unit/ml)}$$

#### 3.12.2.4.2 Vitamin 'C' content (mg/100g)

The ascorbic acid was determined by using standard procedure given by Rangana (1995).

**Reagents:**

1. 3% Metaphosphoric acid (HPO<sub>3</sub>).
2. Ascorbic acid standard
3. Dye solution.

**Procedure:****Standardization of dye**

Take 5 ml of standard ascorbic acid solution and add 5 ml of HPO<sub>3</sub>. Fill a micro burette with dye. Titrate with the dye solution to a pink colour which should persist for 15 sec. determine the dye factor, i.e. mg of ascorbic acid per ml of the dye, using the formula.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value with Std. Ascorbic acid solution}}$$

**Preparation of sample**

Solid and semi-solid food: Take 10 g of sample, blend with 3% HPO<sub>3</sub> and make up to 100 ml with HPO<sub>3</sub>. Filter or centrifuge.

**Assay of extract**

Take an aliquot (20-10 ml) of the HPO<sub>3</sub> extract of the sample and titrate with the standard dye to a pink end-point which should persist for at least 15 sec. Titrate rapidly and make a preliminary determination of the titre. In the next determination, add most of the dye required and then titrated accurately. The aliquot of sample taken should be such that the titre should not exceed 3 to 5 ml.

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Volume of filtrate taken} \times \text{Wt. of sample taken}}$$

**3.12.2.4.3 Calcium (Ca) content (mg/100g)****Reagents**

1. NH<sub>4</sub>CL – NH<sub>4</sub>OH buffer: is used to maintain pH at which the colour is developed.

For its preparation, dissolve 67.5 g NH<sub>4</sub>Cl in 570 ml of NH<sub>4</sub>OH and dilute to 1000 ml with water.

2. NaOH - 4N: dissolve 180g NaOH in 1000 ml water.

3. N/100 standard calcium chloride solution: Prepare this dissolving 0.5g CaCl<sub>2</sub> in 10 ml of 3 NH<sub>4</sub>Cl and make the volume 1000 ml.

4. Eriochrome black-T indicator: dissolve 0.5 of EBT and 4.5 ml hydroxyl amine hydrochloride solutions in 100 ml of 95% ethanol.

5. Ammonium perpurate: mix 0.5 g ammonium perpurate in 100 g of K<sub>2</sub>SO<sub>4</sub>.

6. EDTA: Dissolve 2 g disodium dihydrogen ethylene diamine tetraacetate and 0.5g Mg Cl<sub>2</sub> in water and make the volume 1000 ml. It should be N/100. It can be standardized with CaCl<sub>2</sub> solution where normality is 0.01 using both the indicators viz. EBT and ammonium perpurate. For 5 ml of CaCl<sub>2</sub>, EDTA used after adding EBT/ammonium perpurate is calculated as under:

$$N_1V_1=N_2V_2$$

$$N_1 \times 0.5 = 0.01 \times 5 = N_2 = \frac{0.01 \times 5}{0.5}$$

N<sub>1</sub> = Normality of EDTA N<sub>2</sub> = Normality of CaCl<sub>2</sub>

V<sub>1</sub> = Volume of EDTA = V<sub>2</sub> = Volume of CaCl<sub>2</sub>

### Procedure

Take 5-10 g of the sample/aliquote in a china dish. Dilute it to 20 ml with water. Add 5 drops of 4 N NaOH and nearly 50 mg ammonium perpurate or a pinch of ammonium perpurate indicator. Then 4 N NaOH is added to have desired pH (colour of the indicator appears at pH 11.0). Titrate it with EDTA using 10 ml microburette. Change of colour from orange red to purple marks the end point. Simultaneously, run a blank to have a clear idea of the end point.

### Procedure for Calcium + Magnesium

Take 5 - 10 ml aliquote. Dilute it with water and add 5 ml of NH<sub>4</sub>Cl - NH<sub>4</sub>OH buffer and 3 - 4 drops of EBT indicator. Now titrate it with EDTA using 10 ml microburette. Change of colour from red to blue or green marks the end point.

### Calculation:-

Volume of EDTA used = X (say)

$$\text{Miliequivalent of Ca/Ca +Mg} = \frac{\text{EDTA used} \times \text{N of EDTA} \times 1000}{\text{Volume of aliquote}}$$

$$(Ca + Mg) - Ca = Mg$$

ppm Ca/Mg = milliequivalent x Eq. wt. Actual ppm = ppm x Eq. wt.

$$\% \text{ Ca or Mg} = \frac{\text{ppm} \times \text{diL}}{10^4}$$

#### 3.12.2.4.4 Iron (Fe) content (mg/100g)

The Iron was determined by using standard procedure given by Rangana (1995).

##### Reagent:

1. Conc H<sub>2</sub>SO<sub>4</sub> (iron-free)
2. Saturated potassium persulphate (K<sub>2</sub>S<sub>2</sub>O<sub>8</sub>) Solution shake 7 to 8 g of reagent grade iron free potassium persulphate with 100 ml of water in glass stoppered bottle. The undissolved excess settles to the bottom and compensates for loss by decomposition. Shake briefly before using. Keep the reagent in the refrigerator.
3. 3 N potassium thiocyanate (KSCN) solutions: Dissolve 146 g of reagent grade potassium thiocyanate in water and dilute to 500 ml. Filter of turbid. Add 20 ml of pure acetone to improve the keeping quality.
4. Standard iron solution: Dissolve 0.702 g of reagent grade crystalline ferrous ammonium sulphate (FeSO<sub>4</sub> · (NH<sub>4</sub>)<sub>2</sub> SO<sub>4</sub> · 6H<sub>2</sub>O) in 100 ml of water. Add 5 ml of conc. H<sub>2</sub>SO<sub>4</sub>, warm slightly, and add conc. potassium permanganate solution drop by drop until one drop produces a permanent colour. Transfer to a one-litre volumetric flask, rinse with water and make up to volume. This solution contains 0.1 mg of ferric iron per ml and is stable indefinitely.

##### Procedure:

Use the ash solution of the sample prepared by dry ashing for colour development. Into three separate stoppered measuring cylinders, pipette the solutions as given below.

	Blank (ml)	Standard (ml)	Sample (ml)
Standard iron solution (r ml = 0.r mg of fe)	0.0	r.0	0.0
Sample ash solution	0.0	0.0	5.0
Water	5.0	4.0	0.0
Conc. H <sub>2</sub> SO <sub>4</sub>	0.5	0.5	0.5
Potassium persulphate	r.0	r.0	r.0
Potassium thiocyanate	2.0	2.0	2.0

In each of the above, make up the volume to 15 ml with water, Measure the colour at 480 nm setting blank at 100% transmission.

$$\text{Iron (mg/ 100g)} = \frac{\text{OD of sample} \times 0.1 \times \text{Total volume of ash solution}}{\text{OD of standard} \times 5 \times \text{Wt of sample taken of ashing}} \times 100$$

#### 3.12.2.4.5 Total chlorophyll content (SPAD Value)

The total chlorophyll content was estimated by using ‘*Chlorophyll Spade Meter*’ (Minolta SPAD 502, Konica Inc. Tokyo, Japan) from the fully open leaf of five selected observational plants and average mean was worked out.

#### 3.12.2.4.6 Physiological loss in weight (%)

Sample preparation and procedure of packaging and storage is following.

##### Sample preparation

The vegetables were cleaned, separated the edible portion and remove soil residues.

##### Procedure of packaging and storage

The fresh sample of leafy vegetable (100g) was placed in low density polythene bag (300 gauge thickness with size 8" x 12"). After making holes bags were heat-sealed under ambient atmosphere and storage at ambient storage (at average temperature 17.33-25.15<sup>0</sup>C and 68.58-80.25% average relative humidity) and in refrigerator (0-4 <sup>0</sup>C temperature and 90-95% relative humidity).

These samples were weighed daily and weights of respective samples were recorded. The physiological loss in weight was calculated by using formula.

$$\text{PLW (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where,

PLW - Physiological loss in weight.

W<sub>1</sub> - Initial weight of sample at harvest.

W<sub>2</sub> - Weight of sample after unit storage period.

#### **3.12.2.4.7 Shelf life (days)**

The number of days from harvesting till the produce remain in consumable condition at ambient storage and refrigerator storage were counted and recorded as shelf life (days) for that treatment.

#### **3.12.2.5 Economics**

The expenditure incurred on different inputs and labour cost was recorded as per the recent market rates of inputs required for particular treatment and the data was analyzed by the technique of analysis of variance.

##### **3.12.2.5.1 Cost of cultivation (Rs/ha)**

The cost of cultivation (Rs./ha) of each treatment was worked out by considering the present price of inputs, charges for cultivation, labour, land and other charges, required for that particular treatments. Details on cost of cultivation of leafy vegetables under different growing conditions were given in Appendix-III.

##### **3.12.2.5.2 Gross monetary returns (Rs/ha)**

The total value of crop was calculated in terms of rupees as per prevailing market rates of produce during harvest period and gross returns Rs/ ha were, calculated by multiplying the total yield of an hectare area with prevailing price of produce.

##### **3.12.2.5.3 Net monetary returns (Rs/ha)**

Net returns per hectare were worked out by subtracting the cost of cultivation from gross returns per hectare.

##### **3.12.2.5.4 Benefit: Cost ratio**

The benefit: cost ratio was calculated by using the following formula

$$\text{Benefit: Cost ratio} = \frac{\text{Gross monetary returns (Rs)}}{\text{Cost of cultivation (Rs)}}$$

#### **3.12.3 Statistical analysis of data**

The statistical analysis of collected data was done by the standard procedure. The analysis of variance was carried out according to factorial randomized block design (FRBD). The significance of treatment differences was tested by 'F' test on the basis of null hypothesis. The appropriate standard error (S.Em.±) was computed in each case. Co-efficient of variance per cent was also worked out for all the characters.

The results have been calculated at probability level 5 per cent according to Panse and Sukhatme (1985).

# EXPERIMENTAL RESULTS



## **CHAPTER-IV**

### **EXPERIMENTAL RESULTS**

The present investigation was under taken with a view to determine the influence of different growing conditions on growth, yield and quality of leafy vegetables during *Kharif* season in the month of 20 August to 08 October, 2016 at Department of Horticulture, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani. The data collected on various characters were analyzed statistically by using Factorial Randomized Block Design (FRBD). The results pertaining to each aspect are described with statistical inferences and are presented in this chapter under following heads.

#### **4.1 Effect of meteorological parameters**

##### **4.2 Effect on growth parameters**

##### **4.3 Effect on yield parameters**

##### **4.4 Effect on quality parameters**

##### **4.5 Economics**

#### **4.1 Effect of meteorological parameters**

The data regarding influence of growing condition on different meteorological parameters are presented in Table 7 and graphically depicted in Fig. 2, 3 and 4.

It is seen from the data, that growing condition had a significant effect on meteorological parameters during the experimental period.

##### **4.1.1 Effect on temperature ( $^{\circ}\text{C}$ )**

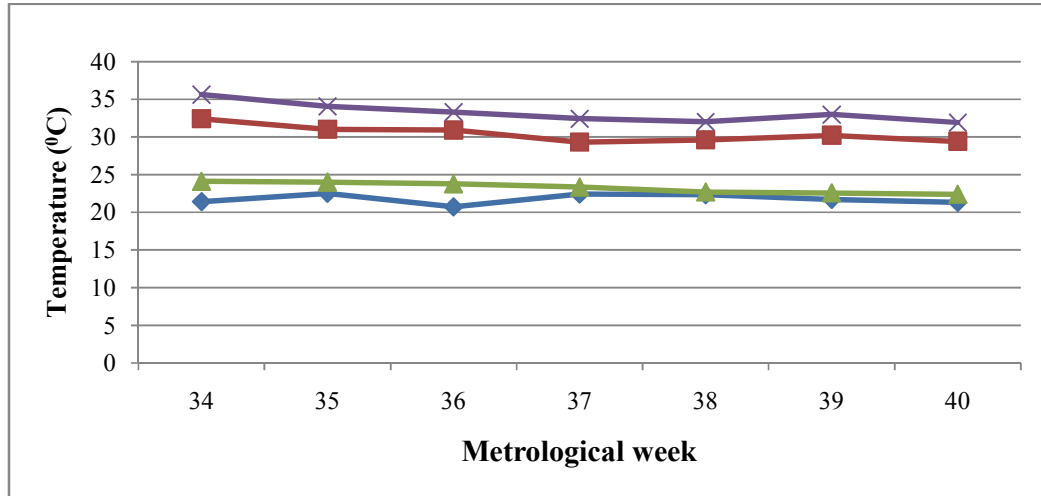
The data clearly revealed that, temperature was ranged between (23.26-33.27  $^{\circ}\text{C}$ ) under polyhouse growing conditions, while, it was ranged between (21.76-30.40  $^{\circ}\text{C}$ ) under open field growing conditions during experimental period. The higher temperatures were recorded under polyhouse condition as compared to open field.

##### **4.1.2 Effect on relative humidity (%)**

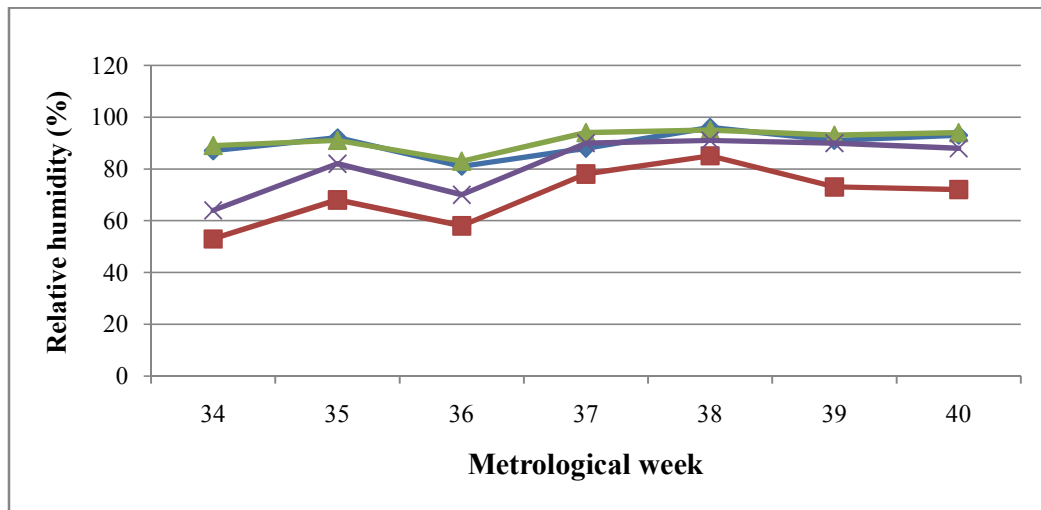
The data clearly revealed that, relative humidity was ranged between (91.28-82.13%) were recorded under polyhouse growing situation, while, it was ranged in between (89.70-69.56 %) in open field conditions during experimental period.

**Table 7. Effect of growing conditions on weather parameters during experimental period.**

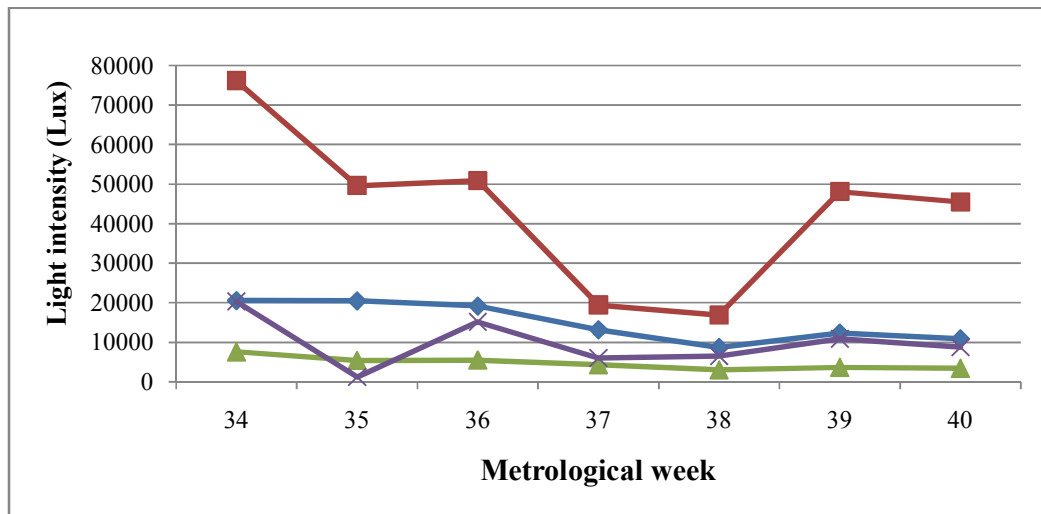
MW	Period	Average temperature ( <sup>0</sup> C)				Average relative humidity (%)				Average light intensity (Lux)			
		G <sub>1</sub> Open field		G <sub>2</sub> Polyhouse		G <sub>1</sub> Open field		G <sub>2</sub> Polyhouse		G <sub>1</sub> Open field		G <sub>2</sub> Polyhouse	
		am	pm	am	pm	Am	pm	am	pm	am	pm	am	pm
34	20-26 Aug.	21.4	32.4	24.1	35.61	87	53	89	64	20528	76114	7557	20285
35	27Aug.-02 Sept.	22.5	31	24	34.04	92	68	91	82	20457	49614	5385	12014
36	03-09 Sept.	20.7	30.9	23.78	33.29	81	58	83	70	19128	50851	5471	15142
37	10-16 Sept.	22.4	29.3	23.35	32.4	88	78	94	90	13157	19428	4314	6028
38	17-23 Sept.	22.3	29.6	22.69	32	96	85	95	91	8685	16885	3028	6500
39	24-30 Sept.	21.6	30.2	22.57	32.95	91	73	93	90	12300	48100	3642	10842
40	01-07 Oct.	21.3	29.4	22.4	31.89	93	72	94	88	10869	45457	3409	8726
<b>Mean</b>		<b>21.76</b>	<b>30.4</b>	<b>23.26</b>	<b>33.27</b>	<b>89.70</b>	<b>69.56</b>	<b>91.28</b>	<b>82.13</b>	<b>15017</b>	<b>43781</b>	<b>4686</b>	<b>11404</b>



**Fig.2. Variation in temperature (°C) influenced due to growing conditions.**



**Fig.3. Relative humidity (%) influenced due to growing conditions.**



**Fig.4. Influence of growing conditions on light intensity (Lux).**

#### **4.1.3 Effect on light intensity (Lux)**

As regards to light intensity it was maximum under open field and it was low in polyhouse condition. Maximum values of light intensities were recorded during third week of August, while it was minimum during third week of September under both the growth conditions.

#### **4.2 Effect on growth**

The data on germination and growth attributes of different leafy vegetables as influenced by different growing conditions is presented in Table 8 and depicted in Fig.5.

##### **4.2.1 Germination (%)**

The seed germination of different leafy vegetables sown under different growing conditions was non significantly influenced. It indicates that the differences in various characters were due to the treatment effects.

##### **Effect of growing conditions**

The data showed that, the maximum (90.07) germination percentage was observed under polyhouse condition and it was minimum (86.14 %) in open field condition.

##### **Effect of leafy vegetables**

Among the leafy vegetables tried the maximum germination percentage was recorded in amaranthus (91.99), followed by fenugreek (90.02), while it was minimum (82.93) in coriander.

##### **Interaction effect**

The interaction effect of growing conditions on germination percentage of leafy vegetables was non significant. However, the amaranthus under polyhouse recorded maximum germination (94.01%) and it was minimum (80.66%) in coriander under open field condition.

##### **4.2.2 Days to potential germination**

##### **Effect of growing conditions**

The data clearly showed that, the maximum (9.40) days required for potential

germination were observed under open field condition, while minimum (7.75) days were required in polyhouse condition.

#### **Effect of leafy vegetables**

Among leafy vegetables maximum days to potential germination (18.70) was required for coriander, followed by beet leaf (5.57), while, it was minimum (4.73) in amaranthus.

#### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on days to potential germination was found significant. In the treatment combination of polyhouse produced amaranthus required minimum (4.13) days to potential germination, followed by fenugreek grown under polyhouse (4.70) condition, While, it was maximum (20.37 days) in coriander in open field condition.

#### **4.2.3 Height of plant (cm)**

The data on height of the plant (Table 8) indicated significant differences due to growing conditions and among different leafy vegetables.

#### **Effect of growing conditions**

Significant effect of growing condition on height was observed. The maximum (44.28 cm) height of plant was observed under polyhouse condition and minimum (27.62 cm) was recorded in open field condition.

#### **Effect of leafy vegetables**

The significant differences were also observed among leafy vegetables. The maximum plant height was recorded in amaranthus (55.90 cm), followed by beet leaf (36.16 cm), while it was minimum (18.70 cm) in coriander.

#### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on plant height was found significant. Treatment combination of amaranthus in polyhouse has recorded maximum (70.93 cm) plant height which was followed by beet leaf under polyhouse (42.65 cm), while it was minimum (12.27 cm) in coriander in open field condition.

#### **4.2.4 Number of branches per plant**

The significant differences in number of branches per plant with respect to growing conditions were noticed.

##### **Effect of growing conditions**

The maximum number of branches per plant (1.93) was recorded under polyhouse condition and minimum (1.05) was observed in open field condition.

##### **Effect of leafy vegetables**

Among leafy vegetables maximum number of branches per plant were recorded in amaranthus (2.62), followed by beet leaf (1.40), while it was minimum (0.95) in coriander.

##### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on number of branches per plant was found significant. The amaranthus grown under polyhouse condition recorded maximum (3.39) number of branches per plant followed by amaranthus in open field (1.85), while it was minimum (0.62) in treatment combination of fenugreek grown under open field condition.

#### **4.2.5 Number of leaves per plant**

The numbers of leaves per plant were significantly influenced due to different growing conditions and also among different vegetables.

##### **Effect of growing conditions**

The maximum (28.03) number of leaves per plant was observed under polyhouse condition and minimum (19.64) was observed in open field condition.

##### **Effect of leafy vegetables**

Among leafy vegetables maximum number of leaves per plant was recorded in amaranthus (39.43), followed by fenugreek (26.98), while, it was minimum (9.37) in beet leaf.

##### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on number of leaves per plant was found significant. Treatment combination of amaranthus in

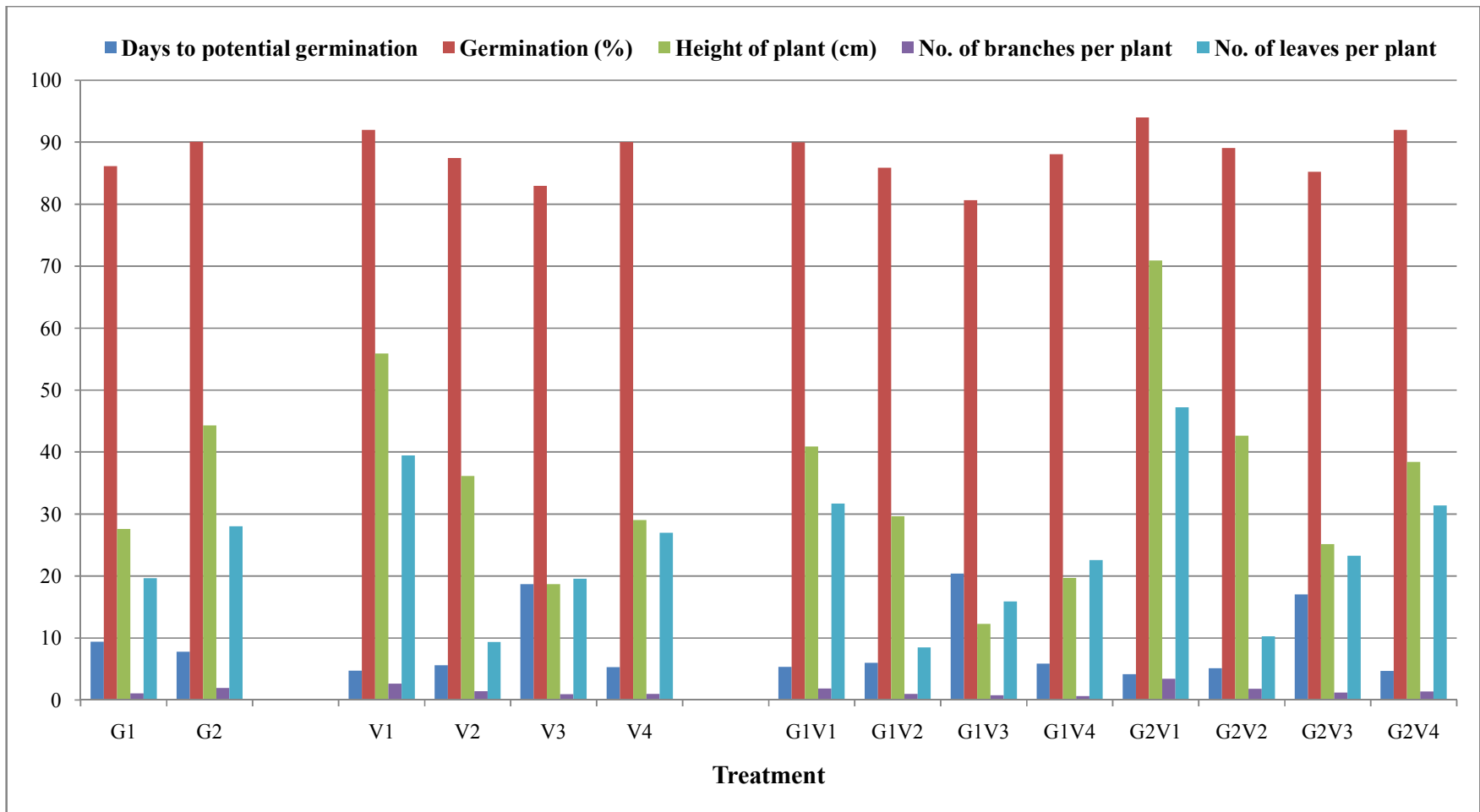
polyhouse recorded maximum (47.20) number of leaves per plant followed by amaranthus (31.66) in open field, while, it was minimum (8.47) in beet leaf in open field condition.

**Table 8. Effect of growing conditions on germination and growth attributes of leafy vegetables.**

Treatment	Germination (%)	Days to potential germination	Height of plant (cm)	No. of branches per plant	No. of leaves per plant
<b>Factor A: Growing conditions (G)</b>					
G <sub>1</sub> : Open field	86.14	9.40	27.62	1.05	19.64
G <sub>2</sub> : Polyhouse	90.07	7.75	44.28	1.93	28.03
SE <sub>±</sub>	2.86	0.39	1.13	0.04	0.70
CD at 5%	NS	1.20	3.44	0.14	2.13
<b>Factor B: Leafy vegetables (V)</b>					
V <sub>1</sub> : Amaranthus	91.99	4.73	55.90	2.62	39.43
V <sub>2</sub> : Beet leaf	87.47	5.57	36.16	1.40	9.37
V <sub>3</sub> : Coriander	82.93	18.70	18.70	0.95	19.57
V <sub>4</sub> : Fenugreek	90.02	5.29	29.04	1.00	26.98
SE <sub>±</sub>	4.04	0.56	1.60	0.06	0.99
CD at 5%	NS	1.71	4.86	0.19	3.01
<b>Growing conditions (G) x Leafy vegetables (V)</b>					
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	89.97	5.33	40.86	1.85	31.66
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	85.86	5.99	29.66	0.99	8.47
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	80.66	20.37	12.27	0.72	15.88
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	88.04	5.88	19.68	0.62	22.56
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	94.01	4.13	70.93	3.39	47.20
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	89.07	5.15	42.65	1.80	10.27
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	85.20	17.03	25.13	1.18	23.26
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	92.00	4.70	38.40	1.37	31.39
SE <sub>±</sub>	5.72	0.79	2.27	0.09	1.40
CD at 5%	NS	2.41	6.88	0.28	4.26

#### 4.2.6 Leaf attributes

The data related to different leaf attributes influenced by growing conditions, among different leafy vegetables and interaction effect is presented in Table 9 and depicted in Fig.6.



**Fig.5. Effect of growing conditions on germination and growth attributes of different leafy vegetables.**



**PLATE 5. GROWTH OF LEAFY VEGETABLES UNDER OPEN FIELD**



**PLATE 6. GROWTH OF LEAFY VEGETABLES UNDER POLYHOUSE**

The data clearly showed that, different leaf attributes like leaf length, leaf width, leaf area and numbers of stomata were significantly influenced due to different growing conditions.

#### **4.2.6.1 Leaf length (cm)**

The significant variations in leaf length were observed among vegetables grown under different conditions.

##### **Effect of growing conditions**

The data indicated that, the maximum (6.21 cm) leaf length was observed under polyhouse condition and it was minimum (4.56 cm) in open field condition.

##### **Effect of leafy vegetables**

The significant differences were also noticed among leafy vegetables. The maximum leaf length (11.31 cm) was recorded in beet leaf, followed by amaranthus while, it was minimum (2.70 cm) in coriander.

##### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on leaf length was found significant. Treatment combination of beet leaf in polyhouse recorded maximum (12.83 cm) leaf length followed by beet leaf in open field condition while, it was minimum (2.19 cm) in coriander under open field condition.

#### **4.2.6.2 Leaf width (cm)**

There were significant differences in leaf width among leaf vegetables grown under different growing conditions.

##### **Effect of growing conditions**

The maximum (4.47 cm) leaf width was observed under polyhouse condition and it was minimum (2.97 cm) in open field condition.

##### **Effect of leafy vegetables**

Among different leafy vegetables maximum leaf width (7.27 cm) was recorded in beet leaf, followed by amaranthus (2.89 cm) while, it was minimum (1.95 cm) in fenugreek.

### **Interaction effect**

The interaction effect on leaf width was found significant. Treatment combination of beet leaf in polyhouse recorded maximum (8.61 cm) leaf width followed by beet leaf in open field (5.92 cm), while it was minimum (1.79 cm) in fenugreek.

#### **4.2.6.3 Leaf area (cm<sup>2</sup>)**

The leaf area of different leafy vegetables grown under different growing condition was significantly influenced.

#### **Effect of growing conditions**

The maximum (30.32 cm<sup>2</sup>) leaf area was observed under polyhouse condition and minimum (15.56 cm<sup>2</sup>) was observed in open field condition.

#### **Effect of leafy vegetables**

Among the leafy vegetables maximum (47.66 cm<sup>2</sup>) leaf area was recorded in beet leaf, followed by amaranthus (37.14 cm<sup>2</sup>), and it was minimum (2.92 cm<sup>2</sup>) in fenugreek.

### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on leaf area was found significant. The treatment combination of beet leaf in polyhouse recorded maximum (63.73 cm<sup>2</sup>) leaf area followed by amaranthus in polyhouse (48.43 cm<sup>2</sup>), and it was minimum (2.10 cm<sup>2</sup>) in treatment combination of fenugreek in open field condition.

#### **4.2.6.4 Numbers of stomata /mm<sup>2</sup>**

The number of stomata was also significantly influenced by growing conditions.

#### **Effect of growing conditions**

The maximum number (24.00/mm<sup>2</sup>) of stomata was observed under polyhouse condition and minimum (21.00/mm<sup>2</sup>) were recorded in open field condition.

#### **Effect of leafy vegetables**

There was significant difference in number of stomata were observed among

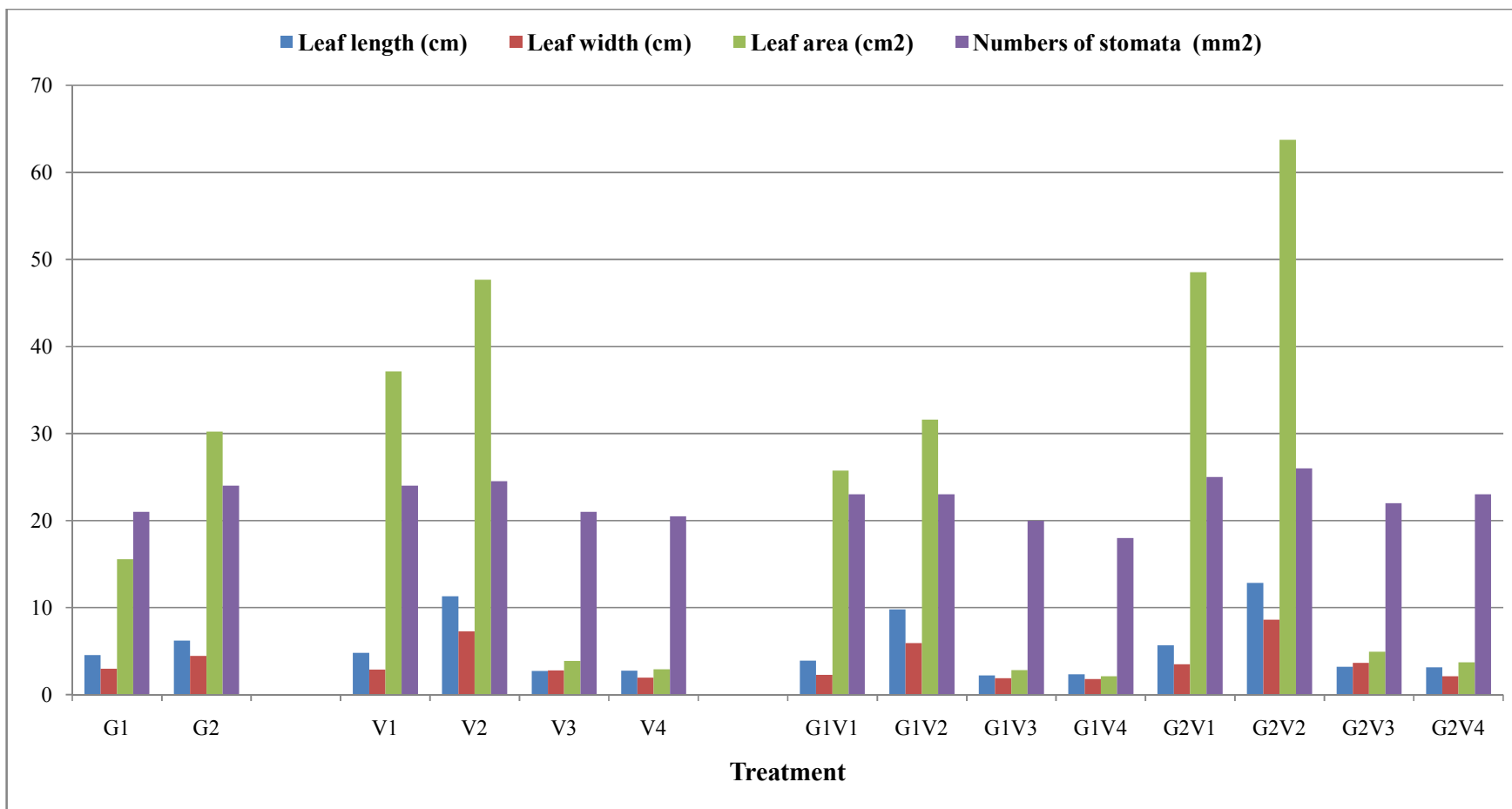
the leafy vegetables. Among the leafy vegetables maximum (24.50/mm<sup>2</sup>) number of stomata were recorded in beet leaf which was statistically at par with amaranthus (24.00/mm<sup>2</sup>) while, it was minimum (20.50/mm<sup>2</sup>) in fenugreek.

**Table 9. Effect of growing conditions on leaf attributes of leafy vegetables.**

Treatment	Leaf length (cm)	Leaf width (cm)	Leaf area (cm <sup>2</sup> )	Numbers of stomata (/mm <sup>2</sup> )
<b>Factor A: Growing conditions (G)</b>				
G <sub>1</sub> : Open field	4.56	2.97	15.56	21.00
G <sub>2</sub> : Polyhouse	6.21	4.47	30.22	24.00
SE <sub>±</sub>	0.21	0.14	1.01	0.73
CD at 5%	0.65	0.43	3.08	2.23
<b>Factor B: Leafy vegetables (V)</b>				
V <sub>1</sub> : Amaranthus	4.78	2.89	37.14	24.00
V <sub>2</sub> : Beet leaf	11.31	7.27	47.66	24.50
V <sub>3</sub> : Coriander	2.70	2.78	3.86	21.00
V <sub>4</sub> : Fenugreek	2.75	1.95	2.91	20.50
SE <sub>±</sub>	0.0	0.20	1.44	1.04
CD at 5%	0.93	0.62	4.36	3.16
<b>Growing conditions (G) x Leafy vegetables (V)</b>				
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	3.89	2.27	25.74	23.00
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	9.80	5.92	31.60	22.99
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	2.19	1.91	2.81	20.00
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	2.36	1.79	2.10	18.00
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	5.68	3.51	48.53	24.99
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	12.83	8.61	63.73	26.00
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	3.20	3.65	4.91	22.00
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	3.13	2.12	3.72	22.99
SE <sub>±</sub>	0.43	0.28	2.03	1.47
CD at 5%	1.31	0.87	6.17	4.47

### Interaction effect

The interaction effect of growing conditions and leafy vegetables on number of stomata was found significant. Treatment combination of beet leaf under polyhouse condition recorded maximum (26.00/mm<sup>2</sup>) number of stomata which was statistically at par with treatment combinations of amaranthus in polyhouse (24.99/mm<sup>2</sup>),



**Fig.6. Effect of growing conditions on leaf attributes of different leafy vegetables.**

amaranthus in open field (23.00/mm<sup>2</sup>), beet leaf in open field (22.99/mm<sup>2</sup>), fenugreek in polyhouse (22.99/mm<sup>2</sup>) and coriander in polyhouse (22.00/mm<sup>2</sup>), while, it was minimum (18.00/mm<sup>2</sup>) in fenugreek grown under open field condition.

#### 4.2.7 Days required for horticultural maturity

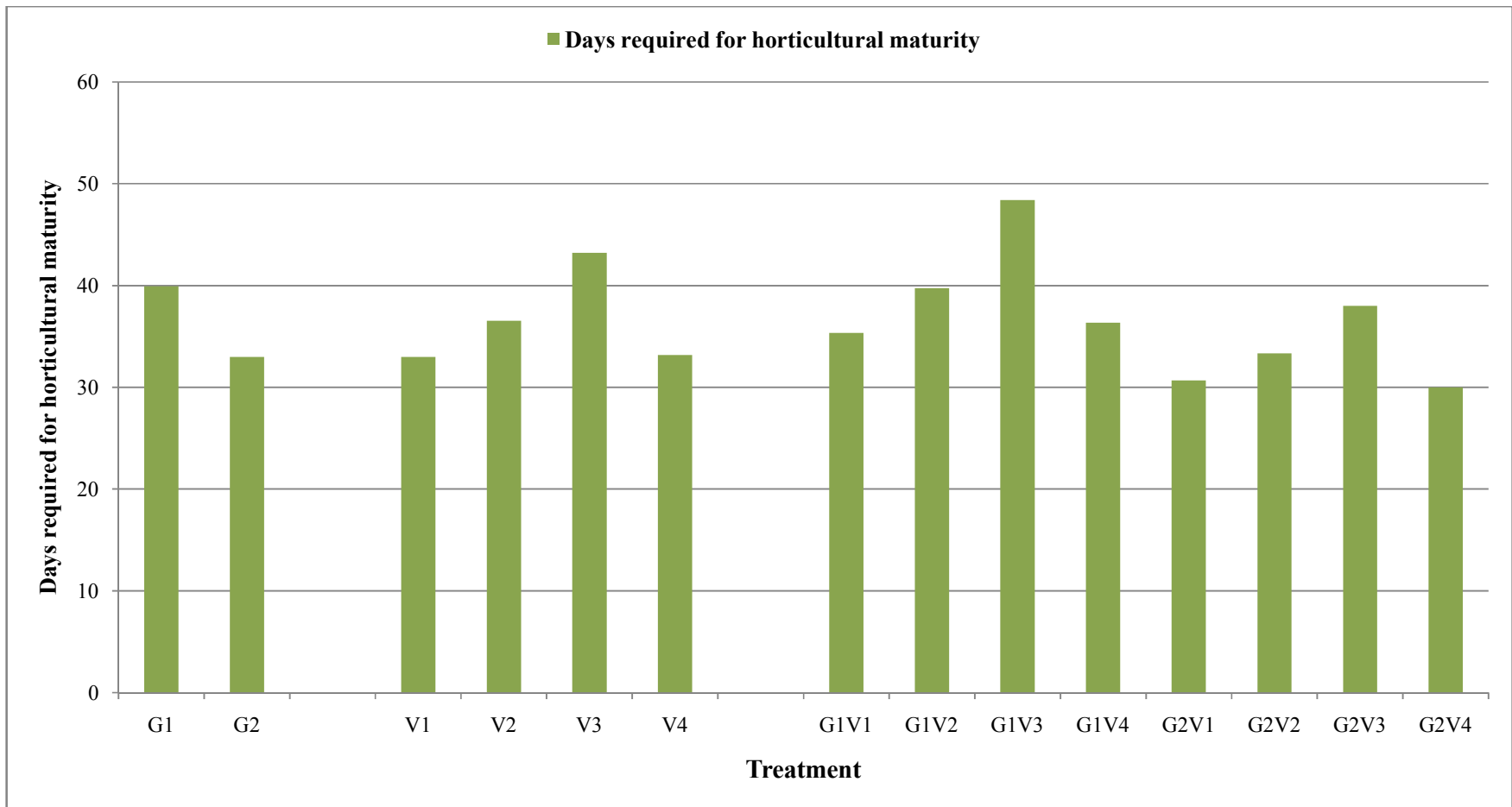
The data related to days required for horticultural maturity as influenced by growing conditions, leafy vegetables and interaction effect is presented in Table 10 and depicted in Fig.7. The data revealed that growing conditions had a significant effect on days required for horticultural maturity in different vegetables crops.

**Table 10. Effect of growing conditions on days required for horticultural maturity of different leafy vegetables.**

Treatment	Days required for horticultural maturity
<b>Factor A: Growing conditions (G)</b>	
G <sub>1</sub> : Open field	39.95
G <sub>2</sub> : Polyhouse	33.00
SE <sub>±</sub>	1.28
CD at 5%	3.88
<b>Factor B: Leafy vegetables (V)</b>	
V <sub>1</sub> : Amaranthus	33.00
V <sub>2</sub> : Beet leaf	36.55
V <sub>3</sub> : Coriander	43.20
V <sub>4</sub> : Fenugreek	33.16
SE <sub>±</sub>	1.81
CD at 5%	5.49
<b>Growing conditions (G) x Leafy vegetables (V)</b>	
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	35.33
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	39.74
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	48.41
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	36.33
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	30.67
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	33.36
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	37.99
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	30.00
SE <sub>±</sub>	2.56
CD at 5%	7.76

#### Effect of growing conditions

Data revealed that, the minimum (33.00) day were required for horticultural maturity under polyhouse condition and maximum (39.95) were observed under open field condition.



**Fig.7. Effect of growing conditions on days required for horticultural maturity of different leafy vegetables.**

### **Effect of leafy vegetables**

There was a significant difference in days required for horticultural maturity among the leafy vegetables. The minimum days (33.00) were required for amaranthus, followed by fenugreek (33.16), and maximum (43.20) in coriander.

### **Interaction effect**

The interaction effect on days required for horticultural maturity of different leafy vegetables was found significant. Treatment combination fenugreek in polyhouse recorded minimum (30.00) days required for horticultural maturity, followed by amaranthus in polyhouse, while, it was maximum in treatment combination open field in coriander (48.41).

### **4.2.8 Root-shoot characters**

The data related to length of whole plant, length of shoot, length of root and root: shoot ratio as influenced by growing conditions, leafy vegetables and interaction effect is presented in Table 11 and depicted in Fig.8 and 9.

#### **4.2.8.1 Length of whole plant (cm)**

Data clearly revealed that, the total length of the plant was significantly influenced due to growing condition. Significant differences were also observed among different vegetables and the interaction effect of growing condition on leafy vegetables was also significant.

### **Effect of growing conditions**

The data showed that, the maximum (56.11 cm) length of whole plant was observed under polyhouse condition and minimum (33.21 cm) in open field condition.

### **Effect of leafy vegetables**

Among leafy vegetables maximum (69.46 cm) length of whole plant was recorded in amaranthus, followed by beet leaf (46.57 cm) and it was minimum (25.03 cm) in coriander.

### **Interaction effect**

The interaction effect on length of whole plant was found significant. Amaranthus under polyhouse recorded maximum (87.29 cm) length of whole plant

which was followed by beet leaf in polyhouse condition and it was minimum (17.09 cm) in coriander under open field condition.

#### **4.2.8.2 Length of shoot (cm)**

The length of shoot was also significantly influenced due to growing conditions and also among different leafy vegetables.

##### **Effect of growing conditions**

It is observed from the data that, the maximum (43.31 cm) length of shoot was observed under polyhouse condition and it was minimum (25.14 cm) under open field condition.

##### **Effect of leafy vegetables**

Among the leafy vegetables maximum (54.77 cm) length of shoot was recorded in amaranthus, followed by beet leaf (35.63 cm) and it was minimum (18.29 cm) in coriander.

##### **Interaction effect**

The interaction effect on length of shoot was found significant. Treatment combination, amaranthus in polyhouse, recorded maximum (69.44 cm) length of shoot followed by beet leaf in polyhouse (42.00 cm), amaranthus in open field, and it was minimum (12.11 cm) in coriander in open field condition.

#### **4.2.8.3 Length of root (cm)**

The root length of different leafy vegetables was significantly influenced due to different growing conditions.

##### **Effect of growing conditions**

It is seen from the data that, the maximum (12.80 cm) length of root was observed under polyhouse condition and minimum (8.07 cm) in open field condition.

##### **Effect of leafy vegetables**

Among the leafy vegetables maximum (14.69 cm) length of root was recorded in amaranthus, followed by beet leaf (10.94 cm) and it was minimum (6.74 cm) in coriander.

### Interaction effect

The interaction effect on length of root was found significant. Treatment combination, amaranthus in polyhouse condition recorded maximum (17.85 cm) length of root followed by beet leaf in polyhouse (13.90 cm), and it was minimum (4.90 cm) in coriander in open field.

**Table 11. Effect of growing conditions on biomass characters of different leafy vegetables.**

Treatment	Length of whole plant (cm)	Length of shoot (cm)	Length of root (cm)	Root: shoot ratio (Length basis)
<b>Factor A: Growing conditions (G)</b>				
G <sub>1</sub> : Open field	33.21	25.14	8.07	0.32
G <sub>2</sub> : Polyhouse	56.11	43.31	12.80	0.29
SE <sub>±</sub>	1.34	1.06	0.28	0.01
CD at 5%	4.08	3.21	0.87	NS
<b>Factor B: Leafy vegetables (V)</b>				
V <sub>1</sub> : Amaranthus	69.46	54.77	14.69	0.26
V <sub>2</sub> : Beet leaf	46.57	35.63	10.94	0.30
V <sub>3</sub> : Coriander	25.03	18.29	6.74	0.36
V <sub>4</sub> : Fenugreek	37.57	28.19	9.38	0.33
SE <sub>±</sub>	1.90	1.50	0.40	0.01
CD at 5%	5.77	4.54	1.23	0.05
<b>Growing conditions (G) x Leafy vegetables (V)</b>				
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	51.61	40.09	11.52	0.28
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	37.25	29.27	7.98	0.27
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	17.09	12.19	4.90	0.40
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	26.87	18.99	7.88	0.41
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	87.29	69.44	17.85	0.25
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	55.90	42.00	13.90	0.33
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	32.96	24.39	8.57	0.35
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	48.27	37.39	10.88	0.29
SE <sub>±</sub>	2.79	2.12	0.57	0.02
CD at 5%	8.17	6.43	1.74	0.07

#### 4.2.8.4 Root: shoot ratio

Root: shoot ratio on length basis showed non significantly differences among

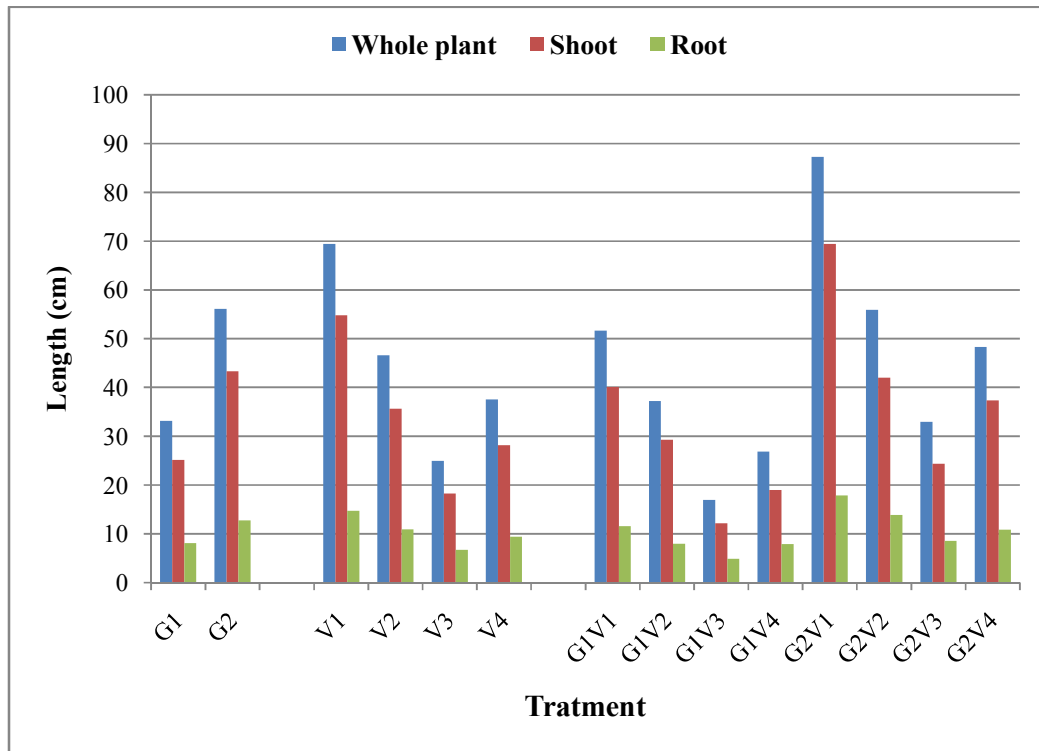


Fig.8. Effect of growing conditions on biomass characters of different leafy vegetables.

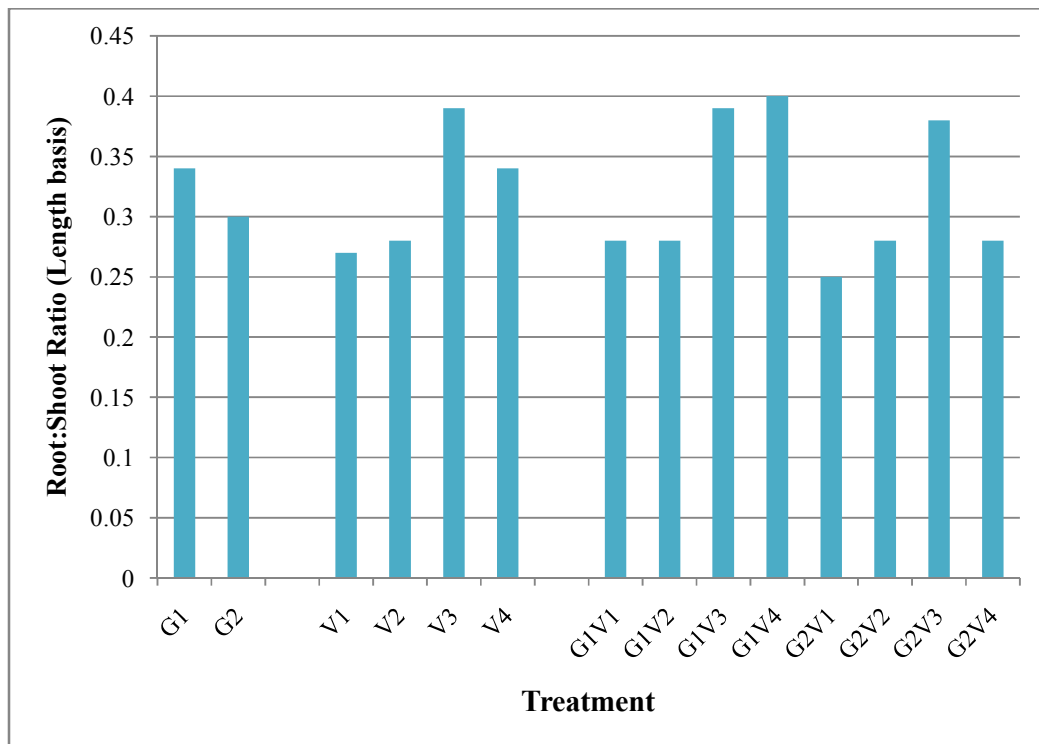


Fig.9. Effect of growing conditions on root: shoot ratio (length basis) of different leafy vegetables.

growing conditions. It indicates that the differences in various characters were due to the treatment effects.

#### **Effect of growing conditions**

It is observed that, the maximum (0.32) root: shoot ratio was recorded under open field condition and it was minimum (0.29) in polyhouse condition.

#### **Effect of leafy vegetables**

There were significant differences in root: shoot ratio among the leafy vegetables. The maximum root: shoot ratio (0.36) was recorded in coriander which was statistically at par with fenugreek (0.33), and it was minimum (0.26) in amaranthus.

#### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on root: shoot ratio was found significant. Treatment combination, fenugreek in open field condition recorded maximum (0.41) root: shoot ratio which was statistically at par with treatment combination coriander in open field (0.40) and coriander in polyhouse (0.35), while it was minimum (0.25) in treatment combination amaranthus under polyhouse.

### **4.3 Effect on yield**

The mean data on the biomass traits *viz.*, fresh weight of whole plant (g), fresh weight of shoot (g), fresh weight of root (g), root: shoot ratio (fresh weight basis), in different leafy vegetables influenced by growing conditions were recorded during the experimentation and are presented in Table 12 and depicted in Fig.10 and 11.

#### **4.3.1 Fresh weight of whole plant (g)**

The data clearly shown that, there were significant differences among different biomass characters of vegetables under different growing conditions.

#### **Effect of growing conditions**

It seen from the data that, the maximum fresh weight of whole plant (30.33g) was observed under polyhouse condition and it was minimum (15.82g) in open field condition.

### **Effect of leafy vegetables**

Among leafy vegetables maximum (38.79g) fresh weight of whole plant was recorded in amaranthus which was statistically at par with beet leaf (36.05g), and it was minimum (8.52g) in coriander.

### **Interaction effect**

The interaction effect on fresh weight of whole plant was found significant. Amaranthus grown in polyhouse recorded maximum (50.36g) fresh weight of whole plant which was statistically at par with beet leaf under polyhouse (47.21g), and it was minimum (4.60g) in fenugreek in open field condition.

### **4.3.2 Fresh weight of shoot (g)**

Fresh weight of shoot was also significantly influenced in different vegetables under different growing conditions.

### **Effect of growing conditions**

It is observed that, the maximum (26.87g) fresh weight of shoot was recorded under polyhouse condition and it was minimum (14.30g) in open field condition.

### **Effect of leafy vegetables**

Among leafy vegetables maximum (34.82g) fresh weight of shoot was recorded in amaranthus which was statistically at par with beet leaf (32.28g), and it was minimum (7.37g) in coriander.

### **Interaction effect**

The interaction effect on fresh weight of shoot was found significant. Amaranthus grown under polyhouse recorded maximum (44.87g) fresh weight of shoot which was statistically at par with beet leaf in polyhouse (41.98g), and it was minimum (4.14g) in fenugreek in open field.

### **4.3.3 Fresh weight of root (g)**

The fresh weight of root was also significantly influenced due to growing conditions in different leafy vegetables.

### **Effect of growing conditions**

The maximum (3.46g) fresh weight of root was recorded under polyhouse

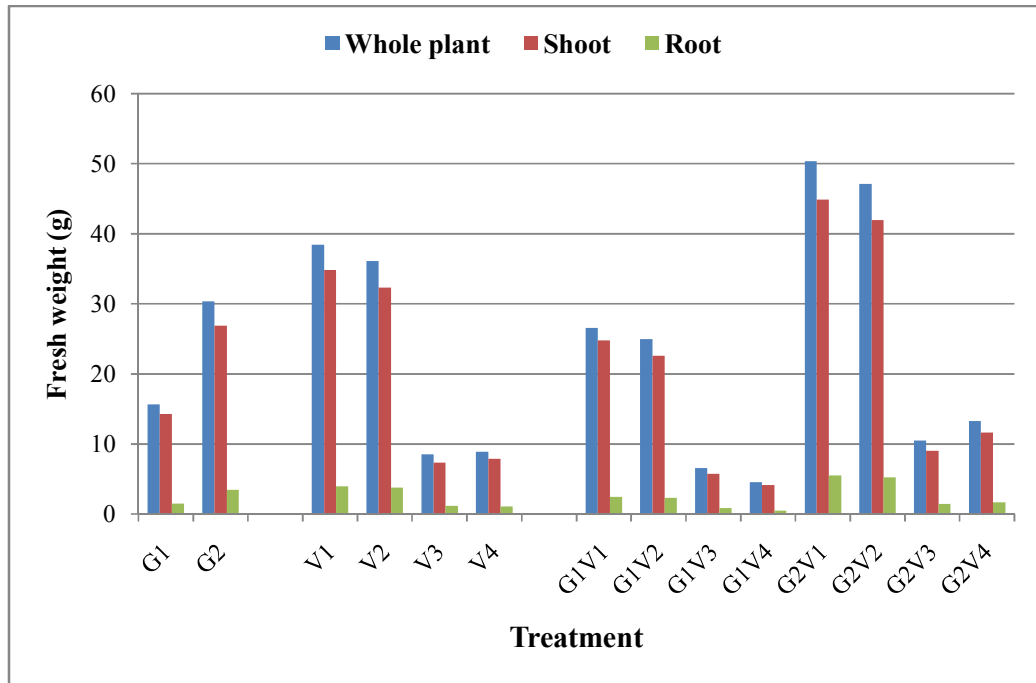
condition and it was minimum (1.52g) in open field condition.

### Effect of leafy vegetables

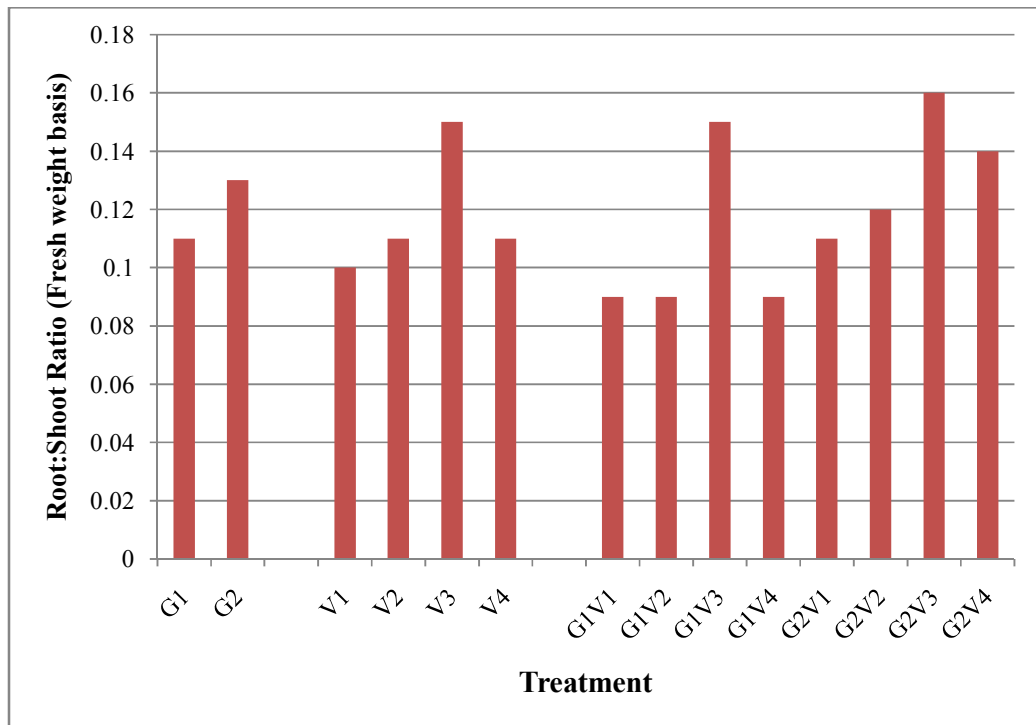
Among leafy vegetables maximum (3.97g) fresh weight of root was recorded in (V<sub>1</sub>) amaranthus, which was statistically at par with beet leaf (3.77g), while, it was minimum (1.08g) in fenugreek.

**Table 12. Effect of growing conditions on biomass production of different leafy vegetables.**

Treatment	Fresh weight of whole plant (g)	Fresh weight of shoot (g)	Fresh weight of root (g)	Root: shoot ratio (Fresh weight basis)
<b>Factor A: Growing conditions (G)</b>				
G <sub>1</sub> : Open field	15.82	14.30	1.52	0.10
G <sub>2</sub> : Polyhouse	30.33	26.87	3.46	0.12
SE <sub>±</sub>	0.85	0.76	0.09	0.004
CD at 5%	2.60	2.32	0.28	0.012
<b>Factor B: Leafy vegetables (V)</b>				
V <sub>1</sub> : Amaranthus	38.79	34.82	3.97	0.11
V <sub>2</sub> : Beet leaf	36.05	32.28	3.77	0.11
V <sub>3</sub> : Coriander	8.52	7.37	1.15	0.15
V <sub>4</sub> : Fenugreek	8.95	7.87	1.08	0.13
SE <sub>±</sub>	1.21	1.08	0.13	0.006
CD at 5%	3.68	3.28	0.40	0.017
<b>Growing conditions (G) x Leafy vegetables (V)</b>				
Amaranthus in open field	27.21	24.76	2.45	0.09
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	24.89	22.58	2.31	0.10
Coriander in open field	6.56	5.72	0.84	0.14
Fenugreek in open field	4.60	4.14	0.46	0.11
Amaranthus in polyhouse	50.36	44.87	5.49	0.12
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	47.21	41.98	5.23	0.12
Coriander in polyhouse	10.48	9.03	1.45	0.16
Fenugreek in polyhouse	13.29	11.60	1.69	0.14
SE <sub>±</sub>	1.71	1.53	0.18	0.008
CD at 5%	5.20	4.64	0.56	0.024



**Fig.10. Effect of growing conditions on fresh biomass production of different leafy vegetables.**



**Fig.11. Effect of growing conditions on root: shoot ratio (fresh weight basis) of different leafy vegetables**

### **Interaction effect**

The interaction effect on fresh weight of root was found significant. Amaranthus under polyhouse condition recorded maximum (5.49g) fresh weight of root which was statistically at par with beet leaf under polyhouse (5.23g), while it was minimum (0.46g) in fenugreek under open field.

#### **4.3.4 Root: shoot ratio (Fresh weight basis)**

Fresh significant variations in root: shoot ratio of different vegetables under different growing conditions were observed.

#### **Effect of growing conditions**

It is seen from the data that, the maximum (0.12) root: shoot ratio (Fresh weight basis) was observed under polyhouse condition and it was minimum (0.10) in open field condition.

#### **Effect of leafy vegetables**

Among leafy vegetables maximum (0.15) root: shoot ratio (Fresh weight basis) was recorded in coriander, followed by fenugreek (0.13), while it was minimum (0.11) in beet leaf and amaranthus.

### **Interaction effect**

The interaction effect on root: shoot ratio (fresh weight basis) was found significant. Coriander grown under polyhouse recorded maximum (0.16) root: shoot ratio (fresh weight basis) which was statistically at par with coriander in open field and fenugreek in polyhouse.

#### **4.3.5 Yield per plot (kg)**

The data related to yield per plot (kg) and per hectare (t/ha) of different vegetables as influenced by growing conditions, and interaction effect is presented in Table 13 and depicted in Fig.12. The data clearly showed significant differences among leaf vegetables and growing conditions.

#### **Effect of growing conditions**

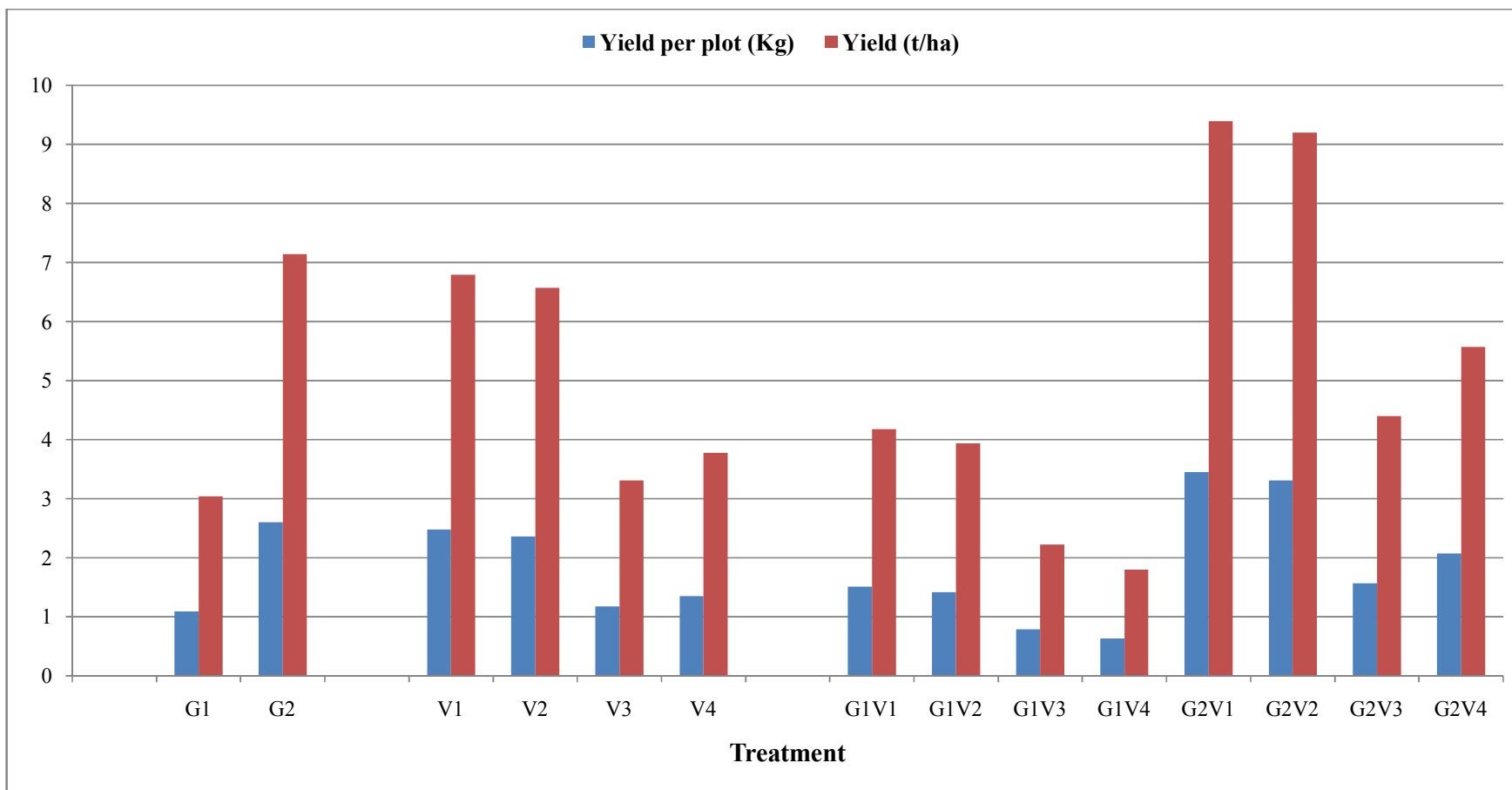
Data reveals that, the maximum (2.60 kg) yield per plot (kg) was recorded under polyhouse condition and it was minimum (1.09 kg) in open field condition.

**Table 13. Effect of growing conditions on yield of different leafy vegetables.**

Treatment	Yield per plot (Kg)	Yield (t/ha)
<b>Factor A: Growing conditions (G)</b>		
G <sub>1</sub> : Open field	1.09	3.04
G <sub>2</sub> : Polyhouse	2.60	7.14
SE <sub>±</sub>	0.06	0.17
CD at 5%	0.19	0.51
<b>Factor B: Leafy vegetables (V)</b>		
V <sub>1</sub> : Amaranthus	2.48	6.79
V <sub>2</sub> : Beet leaf	2.36	6.57
V <sub>3</sub> : Coriander	1.18	3.31
V <sub>4</sub> : Fenugreek	1.35	3.78
SE <sub>±</sub>	0.08	0.24
CD at 5%	0.27	0.72
<b>Growing conditions (G) x Leafy vegetables (V)</b>		
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	1.51	4.18
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	1.42	3.94
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	0.79	2.22
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	0.63	1.80
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	3.45	9.39
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	3.31	9.20
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	1.57	4.40
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	2.07	5.57
SE <sub>±</sub>	0.12	0.33
CD at 5%	0.38	1.02

**Table 14. Percent increase in yield of different vegetable grown in polyhouse over open field.**

Factor B: Leafy Vegetables (V)	Factor A: Growing conditions (G)		Yield in % Increase over G <sub>1</sub> (Open field) (Kg/ Plot)
	Yield per plot (Kg)		
	Open field (G <sub>1</sub> )	Polyhouse (G <sub>2</sub> )	
V <sub>1</sub> : Amaranthus	1.51	3.45	128.47
V <sub>2</sub> : Beet leaf	1.42	3.31	133.09
V <sub>3</sub> : Coriander	0.79	1.57	98.73
V <sub>4</sub> : Fenugreek	0.63	2.07	228.57



**Fig.12. Effect of growing conditions on yield of different leafy vegetables.**

### **Effect of leafy vegetables**

Among the leafy vegetables maximum yield per plot (2.48 kg) was recorded in amaranthus which was statistically at par with beet leaf (2.36 kg), and it was minimum (1.18 kg) in coriander.

### **Interaction effect**

The interaction effect on yield per plot (kg) was found significant. Treatment combination, amaranthus under polyhouse condition recorded maximum (3.45 kg) yield per plot (kg) which was statistically at par with treatment combination of beet leaf in polyhouse, while it was minimum (0.63 kg) in fenugreek in open field.

### **4.3.6 Yield (t/ha)**

The significant variations in yield of different leafy vegetables under different growing conditions were observed.

### **Effect of growing conditions**

The maximum (7.14 t/ha) yield (t/ha) was recorded under polyhouse condition and minimum (3.04 t/ha) in open field condition.

### **Effect of leafy vegetables**

Among leafy vegetables maximum yield (6.79 t/ha) was recorded in treatment amaranthus which was statistically at par with beet leaf (6.57 t/ha), and it was minimum (3.31 t/ha) in coriander.

### **Interaction effect**

The interaction effect on yield (t/ha) was found significant. Amaranthus grown under polyhouse recorded maximum (9.39 t/ha) yield which was statistically at par with beet leaf under polyhouse condition (9.20 t/ha), and it was minimum (1.80 t/ha) in fenugreek grown in open field condition.

The data presented in table 14 regarding per cent increase in yield of different vegetables grown in polyhouse over open field revealed that, maximum % increase in yield Kg per plot was recorded in fenugreek (228.57 Kg/plot), followed by beet leaf (133.09 Kg/plot). Which minimum % increase in Kg/plot was recorded in coriander (98.73 Kg/plot).

#### **4.3.7 Dry weight of whole plant (g)**

The data related to dry weight of whole plant, dry weight of shoot and root and root: shoot ratio on dry weight basis as influenced by growing conditions, leafy vegetables and interaction effect is presented in Table 15.

##### **Effect of growing conditions**

It is seen from the data that, the maximum (6.94 g) dry weight of whole plant was observed under polyhouse condition and it was minimum (3.15 g) in open field condition.

##### **Effect of leafy vegetables**

Among leafy vegetables maximum dry weight of whole plant (7.30 g) was recorded in treatment amaranthus which was statistically at par beet leaf (6.78 g), and it was minimum (2.68 g) in coriander.

##### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on dry weight of whole plant was found significant. Treatment combination, amaranthus in polyhouse recorded maximum (9.90 g) dry weight of whole plant which was statistically at par with treatment combination of beet leaf in polyhouse (9.44 g), while it was minimum in treatment combination, fenugreek in open field (1.67 g).

#### **4.3.8 Dry weight of shoot (g)**

The significant differences are observed in dry weight of shoot of different vegetables grown under different growing conditions.

##### **Effect of growing conditions**

It was observed that, the maximum (6.37g) dry weight of shoot recorded under polyhouse condition and minimum (2.80g) was observed in open field condition.

##### **Effect of leafy vegetables**

Among leafy vegetables maximum dry weight of shoot was recorded in amaranthus (6.62g) followed by beet leaf (6.07g) and minimum (2.46g) in coriander.

##### **Interaction effect**

The interaction effect on dry weight of shoot was found significant. The veg.

amaranthus in polyhouse recorded maximum (9.09g) dry weight of shoot which was statistically at par with beet leaf in polyhouse (8.58g), while, it was minimum in fenugreek under open field.

#### 4.3.9 Dry weight of root (g)

The dry weight of root was also significantly influenced due to growing conditions among vegetables tried.

**Table 15. Effect of growing conditions on dry matter production of different leafy vegetables.**

Treatment	Dry weight of whole plant (g)	Dry weight of shoot (g)	Dry weight of root (g)	Root: shoot ratio (Dry weight basis)
<b>Factor A: Growing conditions (G)</b>				
G <sub>1</sub> : Open field	3.15	2.80	0.35	0.12
G <sub>2</sub> : Polyhouse	6.94	6.37	0.57	0.09
SE <sub>±</sub>	0.16	0.15	0.01	0.004
CD at 5%	0.52	0.47	0.05	0.011
<b>Factor B: Leafy vegetables (V)</b>				
V <sub>1</sub> : Amaranthus	7.30	6.62	0.68	0.10
V <sub>2</sub> : Beet leaf	6.78	6.07	0.71	0.11
V <sub>3</sub> : Coriander	2.86	2.46	0.22	0.09
V <sub>4</sub> : Fenugreek	3.43	3.20	0.23	0.07
SE <sub>±</sub>	0.24	0.21	0.02	0.005
CD at 5%	0.73	0.66	0.07	0.015
<b>Growing conditions (G) x Leafy vegetables (V)</b>				
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	4.70	4.15	0.55	0.13
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	4.12	3.56	0.56	0.16
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	2.12	1.93	0.19	0.10
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	1.67	1.55	0.12	0.08
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	9.90	9.09	0.81	0.09
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	9.44	8.58	0.86	0.10
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	3.23	2.98	0.25	0.08
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	5.19	4.85	0.34	0.07
SE <sub>±</sub>	0.34	0.31	0.03	0.007
CD at 5%	1.03	0.94	0.09	0.021

#### Effect of growing conditions

The data showed that, the maximum (0.57g) dry weight of root was recorded

under polyhouse condition and it was minimum (0.35g) in open field condition.

#### **Effect of leafy vegetables**

Among leafy vegetables maximum dry weight of root (0.71g) was recorded in beet leaf, followed by amaranthus (0.68g), while, it was minimum (0.22g) in coriander.

#### **Interaction effect**

The interaction effect on dry weight of root was found significant. Beet leaf grown in polyhouse recorded maximum (0.86g) dry weight of root which was statistically at par with treatment combination amaranthus in open field (0.81g), while, it was minimum (0.12g) in fenugreek in open field.

#### **4.3.10 Root: shoot ratio (dry weight basis)**

The differences in root: shoot ratios on dry weight basis were noticed.

#### **Effect of growing conditions**

The maximum (0.12) root: shoot ratio (dry weight basis) was recorded under open field condition and it was minimum (0.09) in polyhouse condition.

#### **Effect of leafy vegetables**

Among leafy vegetables maximum root: shoot ratio (0.11) (dry weight basis) was recorded in beet leaf, followed by coriander (0.09), while, it was minimum in fenugreek (0.07).

#### **Interaction effect**

The interaction effect on root: shoot ratio (dry weight basis) was found significant. Beet leaf in open field recorded maximum (0.16) root: shoot ratio (dry weight basis), while, it was minimum (0.08) in fenugreek in open field.

### **4.4 Effect on quality**

The mean data on the quality characters of amaranthus, beet leaf, coriander and fenugreek influenced by growing conditions were recorded and computed during the experiment and are presented in Table 16 and Fig.13, 14, 15 and 16.

#### **4.4.1 Vitamin 'A' content (IU/100g)**

It is seen from the data that, the vitamin A content of different leafy vegetables

was not influenced due to growing conditions.

#### **Effect of growing conditions**

It is seen that, the maxi. (8268.52) vitamin A content (IU/100g) was recorded in vegetable produced in polyhouse condition and mini. under open field condition.

#### **Effect of leafy vegetables**

There were significant differences in vitamin A content of leafy vegetables. Among leafy vegetables maximum vitamin A content (IU/100g) was recorded in treatment coriander (10460.49), followed by beet leaf (9342.51) and it was minimum in fenugreek (3384.93).

#### **Interaction effect**

The interaction effect on vitamin A content (IU/100g) was found significant. The coriander grown under polyhouse recorded maximum (10821.00 IU/100g) vitamin 'A' content, followed by coriander grown under open field (10099.99) and beet leaf produced under polyhouse (9615.01), while it was minimum (3120.80) in fenugreek grown under open field condition.

#### **4.4.2 Vitamin 'C' content (mg/100g)**

The vitamin C contents were not significantly influenced due to growing conditions; however significant differences were observed among different leafy vegetables and due to interaction.

#### **Effect of growing conditions**

It is seen from the data that, there were no significant difference in vitamin C content due to growing conditions however the maximum (84.15 mg/100g) vitamin C content was recorded in vegetable produced under polyhouse condition.

#### **Effect of leafy vegetables**

There were significant differences in vitamin C content in different leafy vegetables. Among leafy vegetables maximum vitamin C content (133.31 mg/100g) was recorded in coriander and it was minimum (49.61 mg/100g) in fenugreek.

#### **Interaction effect**

The interaction effect on vitamin C content (mg/100g) was found significant.

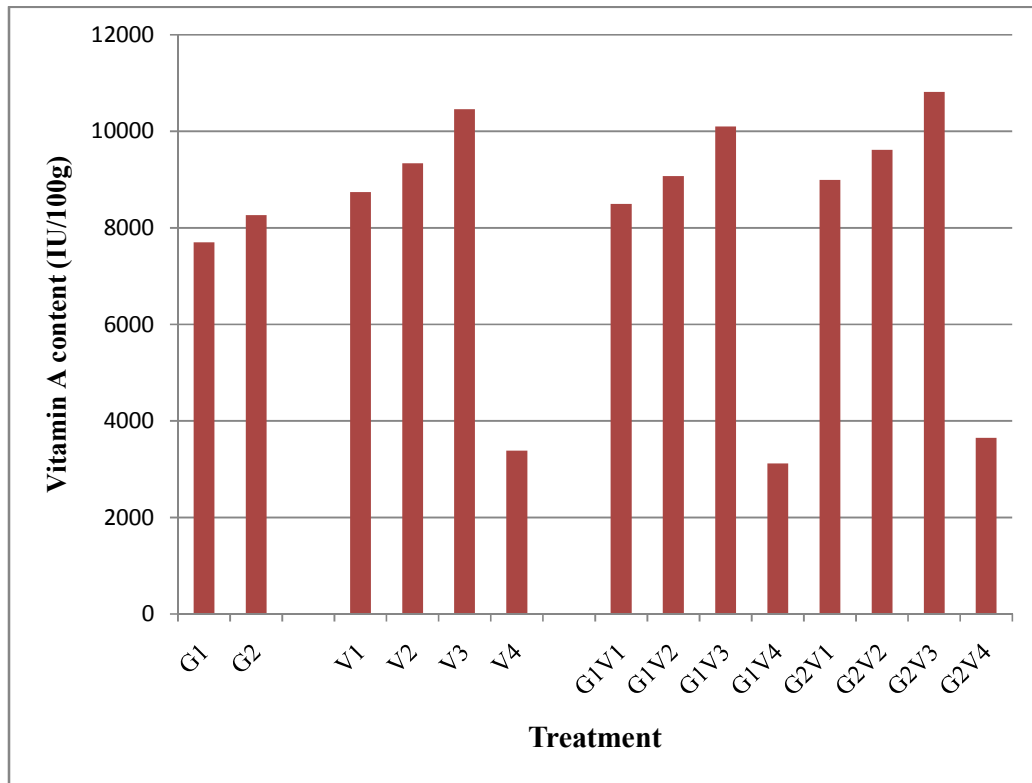
Coriander grown under polyhouse recorded maximum (134.78 mg/100g) vitamin C content which was statistically at par with coriander under open field, and it was minimum (48.19 mg/100g) in fenugreek under open field.

**Table 16. Effect of growing conditions on nutritive value of different leafy vegetables.**

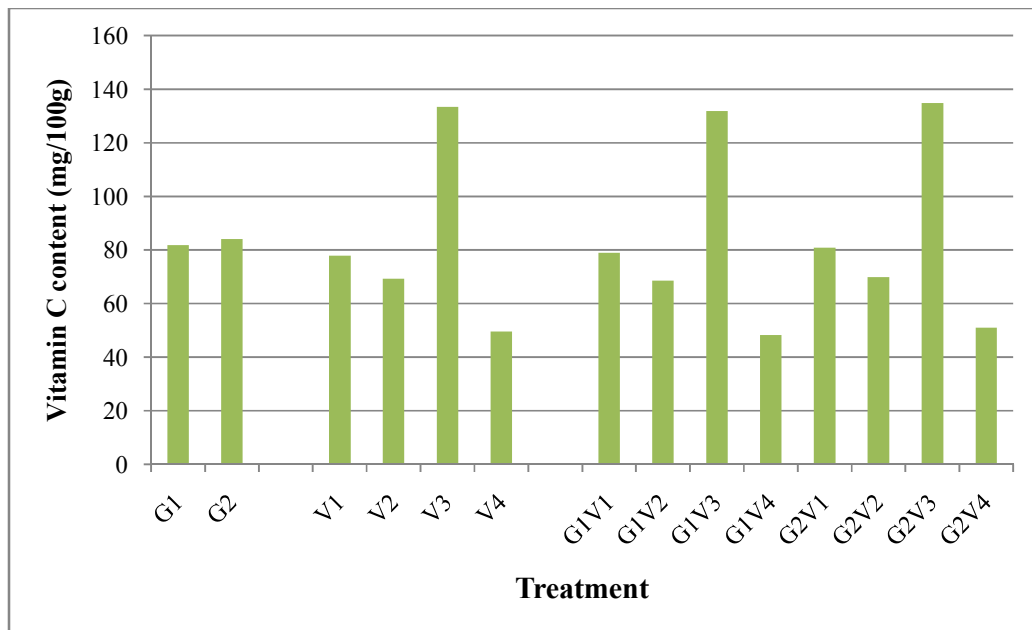
Treatment	Vitamin 'A' content (IU/100 g)	Vitamin 'C' content (mg/100 g)	Calcium (Ca) content (mg/100 g)	Iron (Fe) content (mg/100g)	Total chlorophyll content (SPAD Value)
<b>Factor A: Growing conditions (G)</b>					
G <sub>1</sub> : Open field	7697.45	81.89	309.25	16.09	34.47
G <sub>2</sub> : Polyhouse	8268.52	84.15	324.15	17.95	38.90
SE <sub>±</sub>	291.24	3.15	9.78	0.54	1.16
CD at 5%	883.34	NS	29.67	1.65	3.53
<b>Factor B: Leafy vegetables (V)</b>					
V <sub>1</sub> : Amaranthus	8744.00	77.91	373.81	19.35	35.09
V <sub>2</sub> : Beet leaf	9342.51	69.26	353.50	15.49	34.22
V <sub>3</sub> : Coriander	10460.4	133.31	163.99	17.09	30.32
V <sub>4</sub> : Fenugreek	3384.93	49.61	375.49	16.16	47.13
SE <sub>±</sub>	411.88	4.45	13.83	0.77	1.64
CD at 5%	1249.24	13.52	41.96	2.34	4.99
<b>Growing conditions (G) x Leafy vegetables (V)</b>					
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	8499.00	78.97	365.99	18.00	32.96
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	9070.00	68.58	345.67	14.85	32.03
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	10099.9	131.84	157.00	16.20	27.13
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	3120.80	48.19	368.32	15.32	45.77
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	8989.00	80.85	381.63	20.70	37.23
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	9615.00	69.94	361.32	16.13	36.40
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	10821.0	134.78	170.99	17.98	33.50
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	3649.07	51.03	382.66	16.99	48.48
SE <sub>±</sub>	582.48	6.30	19.56	1.09	2.32
CD at 5%	1766.69	19.12	59.34	3.31	7.06

#### 4.4.3 Calcium (Ca) content (mg/100g)

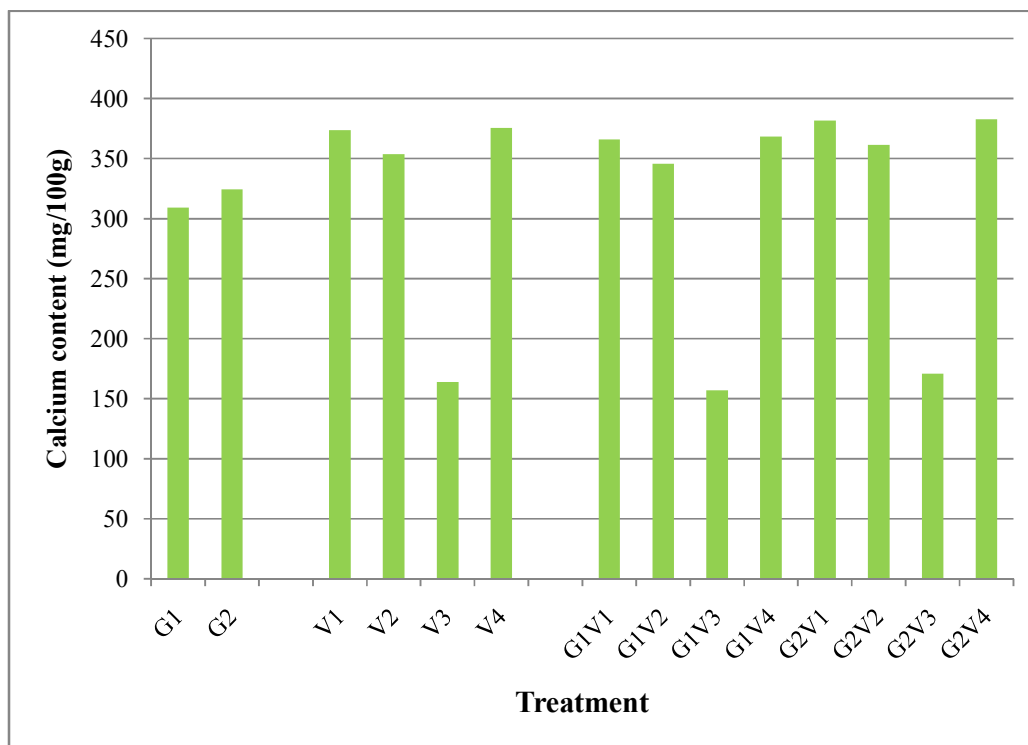
It is seen from the data that, the calcium content in different vegetables was not significantly influenced due to growing conditions however significant differences



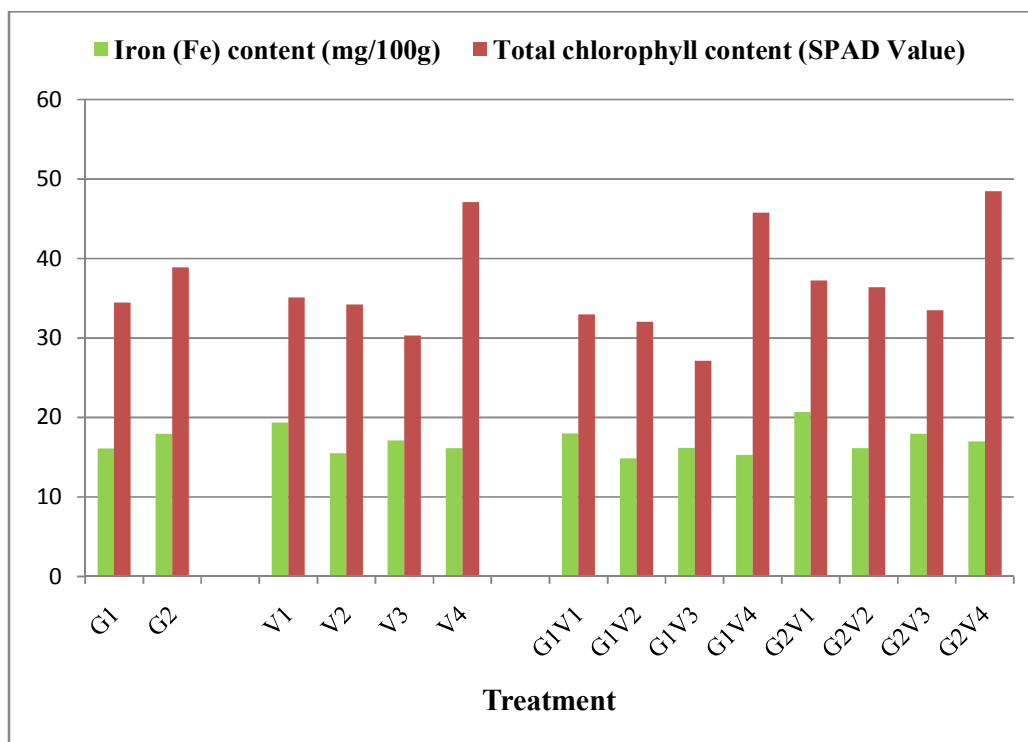
**Fig.13. Effect of growing conditions on vitamin A content of different leafy vegetables.**



**Fig.14. Effect of growing conditions on vitamin C content of different leafy vegetables.**



**Fig.15. Effect of growing conditions on calcium content of different leafy vegetables.**



**Fig.16. Effect of growing conditions on iron and chlorophyll content of different leafy vegetables.**

were observed among different vegetables.

#### **Effect of growing conditions**

Calcium content was not significantly influenced due to growing conditions; however maximum (324.15 mg/100g) calcium content was recorded in G<sub>2</sub> condition.

#### **Effect of leafy vegetables**

The calcium content was significantly differed in different vegetables. Among leafy vegetables maximum calcium content (375.49 mg/100g) was recorded in fenugreek which was statistically at par with amaranthus (373.81 mg/100g) and beet leaf (353.50 mg/100g) while, it was minimum (163.99 mg/100g) in coriander.

#### **Interaction effect**

The interaction effect on calcium content was found significant. Fenugreek grown under polyhouse condition recorded maximum (382.66 mg/100g) calcium content which was statistically at par with rest of the treatment except coriander grown in both the condition.

#### **4.4.4 Iron (Fe) content (mg/100g)**

The iron content (mg/100g) in different vegetables differed significantly due to growing conditions and also due to interactions

#### **Effect of growing conditions**

It is seen from the data that, the maximum (17.95 mg/100g iron content was observed in vegetable grown under polyhouse condition and it was minimum (16.09) in open field condition.

#### **Effect of leafy vegetables**

Among leafy vegetables maximum iron content (19.35 mg/100g) was recorded in amaranthus, followed by coriander (17.09 mg/100g) and it was minimum in beet leaf (15.49 mg/100g).

#### **Interaction effect**

The interaction effect on iron content was found significant. Amaranthus under polyhouse recorded maximum (20.17 mg/100g) iron content, followed by

amaranthus under open field (18.00), while it was minimum in treatment combination beet leaf in open field (14.85).

#### **4.4.5 Total chlorophyll content (SPAD value)**

The data related to total chlorophyll content (SPAD value) as influenced by growing conditions, leafy vegetables and interaction effect is presented in Table 16 and depicted in Fig.16.

##### **Effect of growing conditions**

The maximum (38.19) total chlorophyll content (SPAD value) was observed under polyhouse condition and minimum (34.47) was observed in open field condition.

##### **Effect of leafy vegetables**

Among leafy vegetables maximum total chlorophyll content (SPAD value) was recorded in fenugreek (47.13) followed by amaranthus (35.09), while it was minimum in coriander (30.32).

##### **Interaction effect**

The interaction effect of growing conditions and leafy vegetables on total chlorophyll content (SPAD value) was found significant. Treatment combination fenugreek in polyhouse recorded maximum (48.48) total chlorophyll content (SPAD value) which was statistically at par with treatment combination fenugreek in open field (45.77), while it was minimum in treatment combination coriander in open field (27.13).

#### **4.4.6 Physiological loss in weight (%)**

The data related to physiological loss in weight (%) in different leafy vegetables produced under different growing conditions, under different storage conditions are presented in Table 17.

##### **Effect of growing conditions**

It is seen from the data that growing condition has significant effect on physiological loss of vegetables. At ambient storage the minimum (12.34, 22.02, 33.62 and 45.85 %) physiological loss in weight was observed in the vegetable produced under polyhouse condition (at 3, 6, 9 and 12 DAS respectively) and

maximum 20.24, 33.94, 47.33 and 61.22 % at 3, 6, 9 and 12 DAS respectively loss was observed in vegetable produced under open field condition.

However, at refrigerator storage the minimum 6.84, 9.42, 11.75 and 14.76 % at 3, 6, 9 and 12 DAS respectively physiological loss in weight was observed vegetable produced under polyhouse condition and maximum (9.93, 14.23, 17.36 and 21.34) loss was observed (at 3, 6, 9 and 12 DAS respectively) in vegetable produced under open field condition.

### **Effect of leafy vegetables**

At ambient storage at 3 DAS of storage among leafy vegetables minimum (11.54 %) physiological loss in weight was recorded in beet leaf, followed by coriander (15.62 %), while it was maximum (20.31 %) in fenugreek. Among leafy vegetables minimum physiological loss in weight (20.46 %) at the end of 6 days storage was recorded in beet leaf, followed by coriander (26.31 %), while it was maximum (36.60 %) in fenugreek. At 9 day of storage among leafy vegetables minimum (32.96 %) physiological loss in weight was recorded in beet leaf, followed by coriander (36.85 %), while it was maximum (53.21 %) in fenugreek. At 12 DAS of storage under ambient storage among leafy vegetables minimum (48.14 %) physiological loss in weight was recorded in coriander, followed by beet leaf (48.24 %), while it was maximum (64.54 %) in fenugreek.

Under refrigerator storage condition at 3 DAS minimum (5.99 %) physiological loss in weight was recorded in beet leaf, followed by coriander (6.42), while it was maximum (13.58 %) in fenugreek. At 6 DAS minimum (8.46 %) physiological loss in weight was recorded in beet leaf, followed by coriander (9.05), while it was maximum (17.68) in fenugreek. The minimum (10.81) physiological loss in weight at 9 DAS was recorded in coriander (10.81 %), followed by beet leaf (11.25 %), while it was maximum (20.24 %) in fenugreek. At 12 DAS under refrigerator condition minimum (13.59 %) physiological loss in weight was recorded in coriander, followed by beet leaf (14.76 %), while, it was maximum (23.82 %) in fenugreek.

### **Interaction effect**

The interaction effect on physiological loss in weight (%) was found significant. At ambient storage at 3 DAS beet leaf grown under polyhouse recorded minimum (8.76 %) physiological loss in weight, followed by coriander grown under

**Table 17. Effect of growing conditions on physiological loss in weight (%) of leafy vegetables under different storage conditions.**

Treatment	Physiological loss in weight (%)							
	Ambient storage				Refrigerator storage			
	3	6	9	12	3	6	9	12
<b>Factor A: Growing conditions (G)</b>								
G <sub>1</sub> : Open field	20.24	33.94	47.33	61.22	9.93	14.23	17.36	21.34
G <sub>2</sub> : Polyhouse	12.34	22.02	33.62	45.85	6.84	9.42	11.75	14.76
SE <sub>±</sub>	0.57	0.98	1.40	1.83	0.29	0.41	0.48	0.61
CD at 5%	1.74	2.98	4.26	5.55	1.88	1.25	1.47	1.86
<b>Factor B: Leafy vegetables (V)</b>								
V <sub>1</sub> : Amaranthus	17.68	28.63	38.90	53.19	7.45	12.10	15.92	20.02
V <sub>2</sub> : Beet leaf	11.54	20.46	32.96	48.24	5.99	8.46	11.25	14.76
V <sub>3</sub> : Coriander	15.62	26.31	36.85	48.14	6.42	9.05	10.81	13.59
V <sub>4</sub> : Fenugreek	20.31	36.60	53.21	64.54	13.58	17.68	20.24	23.82
SE <sub>±</sub>	0.81	1.39	1.99	2.58	0.41	0.58	0.68	0.86
CD at 5%	2.46	4.21	6.03	7.84	1.24	1.78	2.68	2.63
<b>Growing conditions (G) x Leafy vegetables (V)</b>								
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	21.05	34.47	47.64	62.26	8.47	14.56	18.41	23.67
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	14.31	24.26	36.37	55.16	7.89	10.80	14.31	17.54
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	22.21	35.96	47.70	59.45	8.46	11.38	13.49	16.96
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	23.38	41.22	57.60	68.01	14.89	20.16	23.23	27.18
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	14.32	22.80	30.22	44.13	6.63	9.63	13.44	16.37
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	8.76	16.65	29.43	41.33	4.09	6.12	8.14	11.97
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	9.02	16.65	26.00	36.83	4.38	6.72	8.18	10.23
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	17.24	31.98	48.83	61.11	12.27	15.19	17.25	20.26
SE <sub>±</sub>	1.50	1.96	2.81	3.66	0.58	0.83	0.97	1.22
CD at 5%	3.48	5.96	8.53	11.10	1.76	2.51	2.94	3.72

polyhouse (9.02 %), while it was maximum (23.38 %) fenugreek grown under open field which was statistically at par with coriander grown under open field (22.21 %). At 6 DAS minimum (16.65 %) physiological loss in weight in beet leaf and coriander grown under polyhouse, followed by amaranthus grown under polyhouse (22.80 %), while it was maximum (41.22 %) in fenugreek grown under open field which was statistically at par with coriander grown under open field (35.96 %). At 9 DAS minimum (26.00 %) physiological loss in weight was recorded in coriander grown under polyhouse, followed by beet leaf grown under polyhouse (29.43 %), while it was maximum (57.60 %) in fenugreek grown under open field. At 12 DAS coriander grown under polyhouse recorded minimum (36.83 %) physiological loss in weight, followed by beet leaf grown under polyhouse (41.33 %), while it was maximum (68.01 %) in fenugreek grown under open field which was statistically at par with amaranthus grown under open field (62.26), fenugreek grown under polyhouse (61.11) and coriander grown under open field (59.45).

Under cold storage condition at 3 DAS storage minimum physiological weight loss (4.09) was noticed in beet leaf produced under polyhouse, followed by coriander grown under polyhouse (4.38 %), and maximum (14.89 %) physiological loss in weight was recorded in fenugreek grown under open field. At 6 DAS of storage minimum (6.12 %) physiological loss in weight was recorded in beet leaf produced under polyhouse, followed by coriander grown under polyhouse (6.72 %), and it was maximum (20.16 %) was recorded in fenugreek grown under open field.

At refrigerator storage 9 DAS minimum (8.14 %) physiological loss in weight was recorded in beet leaf produced under polyhouse, followed by coriander grown under polyhouse (8.18 %), and maximum (23.23 %) physiological loss in weight was recorded in fenugreek produced under open field.

At 12 DAS of storage minimum (10.23 %) physiological weight loss was noticed in coriander produced under polyhouse, followed by beet leaf grown under polyhouse (11.97 %), and it was maximum (27.18 %) in fenugreek produced under open field which was statistically at par with amaranthus grown under open field (23.37 %).

#### **4.4.7 Shelf life (Days)**

The data related to shelf life (days) of different leafy vegetables produced

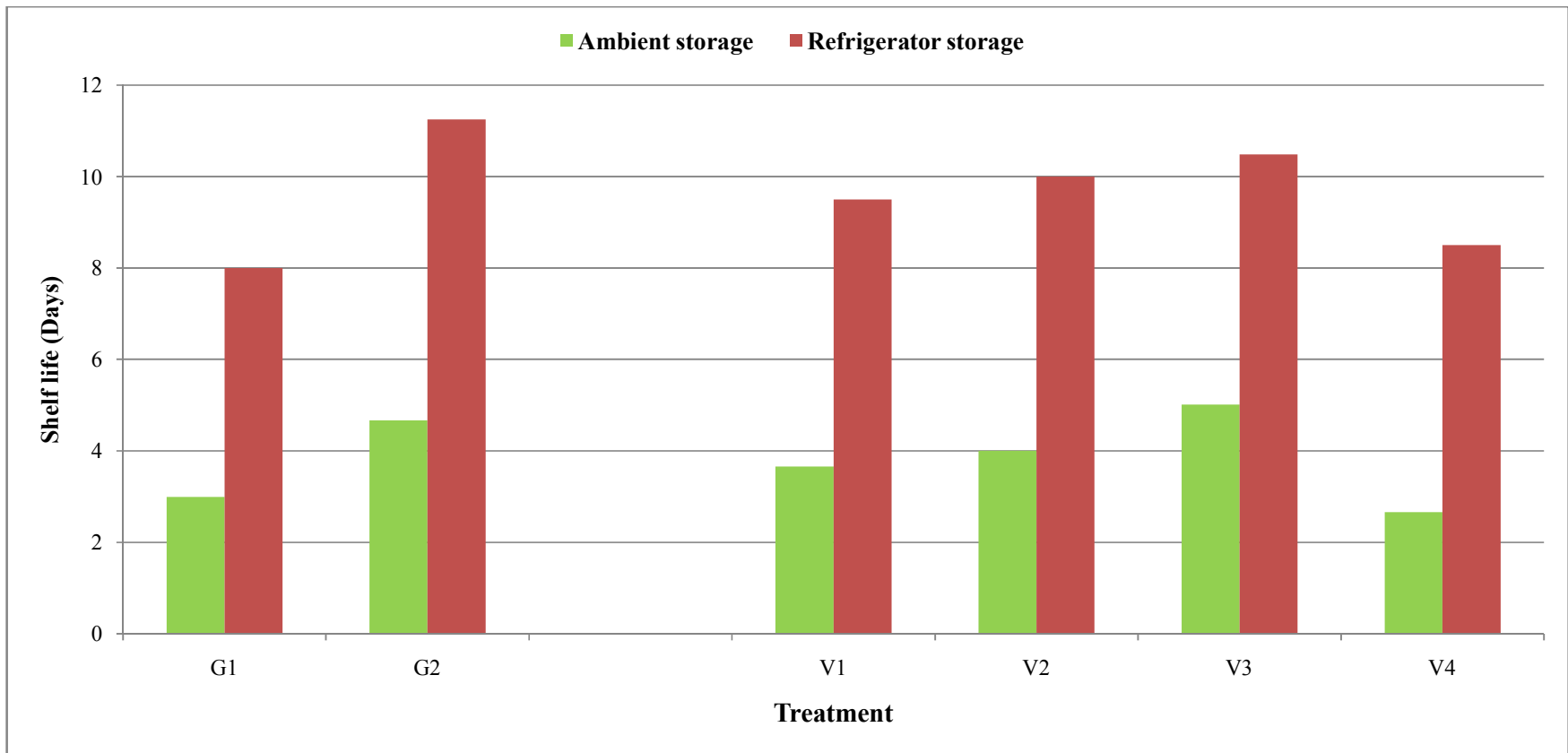
under different growing conditions, and stored in different storage conditions are presented in Table 18 and depicted in Fig. 17.

**Table 18. Effect of growing conditions on self life (days) of leafy vegetables under different storage conditions**

Treatment	Shelf life (Days)	
	Ambient storage	Refrigerator storage
<b>Factor A: Growing conditions (G)</b>		
G <sub>1</sub> : Open field	2.99	8.00
G <sub>2</sub> : Polyhouse	4.67	11.25
SE $\pm$	0.13	0.31
CD at 5%	0.40	0.96
<b>Factor B: Leafy vegetables (V)</b>		
V <sub>1</sub> : Amaranthus	3.66	9.50
V <sub>2</sub> : Beet leaf	4.00	10.00
V <sub>3</sub> : Coriander	5.01	10.49
V <sub>4</sub> : Fenugreek	2.66	8.50
SE $\pm$	0.19	0.44
CD at 5%	0.57	1.36
<b>Growing conditions (G) x Leafy vegetables (V)</b>		
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	3.00	8.00
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	2.99	8.00
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	3.99	8.99
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	1.99	7.00
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	4.32	11.00
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	5.00	12.00
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	6.03	11.99
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	3.32	10.00
SE $\pm$	0.27	0.63
CD at 5%	0.81	1.92

#### Effect of growing conditions

The maximum (4.67 and 11.25 days) shelf life was observed under vegetables produced under polyhouse condition (at ambient and refrigerator storage respectively)



**Fig.17. Effect of growing conditions on self life (days) of leafy vegetables under different storage conditions.**

and it was minimum (2.99 and 8.00 days) at ambient and refrigerator storage respectively in vegetables produced under open field condition.

### **Effect of leafy vegetables**

At ambient storage among leafy vegetables maximum (5.01 days) shelf life was recorded in coriander, followed by beet leaf (4.00 days), while, it was minimum (2.66 days) in fenugreek.

At refrigerator storage among leafy vegetables maximum shelf life (10.49 days) was recorded in coriander which was statistically at par with beet leaf, while it was minimum (8.50 days) in fenugreek.

### **Interaction effect**

The interaction effect on shelf life (days) of vegetables was found significant. At ambient storage maximum (6.03 days) shelf life was recorded in coriander produced under polyhouse, followed by beet leaf grown under polyhouse (5.00 days), while it was minimum (1.99 days) in fenugreek grown under open field.

At refrigerator storage maximum (12.00 days) shelf life was recorded in beet leaf produced under polyhouse which was statistically at par with coriander grown under polyhouse (11.99 days), amaranthus grown under polyhouse (11.00 days) and fenugreek grown under polyhouse (10.00 days), while, it was minimum (7.00 days) in fenugreek grown under open field.

## **4.5 Economics**

The economics of different leafy vegetables influenced due to different growing conditions is presented in Table 19 and graphically depicted in Fig.18 and 19.

### **4.5.1 Cost of cultivation (Rs./ha)**

The data clearly showed that, there were lot of variations in cost of cultivation among different growing conditions. It is observed that, the minimum (Rs.66,598 /ha) cost of cultivation was required under open field condition and it was maximum (Rs.1,62,848 /ha) in polyhouse condition. Among leafy vegetables minimum cost of cultivation (Rs.1,11,600 /ha) was recorded in amaranthus, followed by beet leaf (Rs.1,13,180 /ha), while it was maximum (Rs.1,17,282 /ha) in coriander. Amaranthus produced under open field recorded minimum (Rs.63,475 /ha) cost of cultivation,

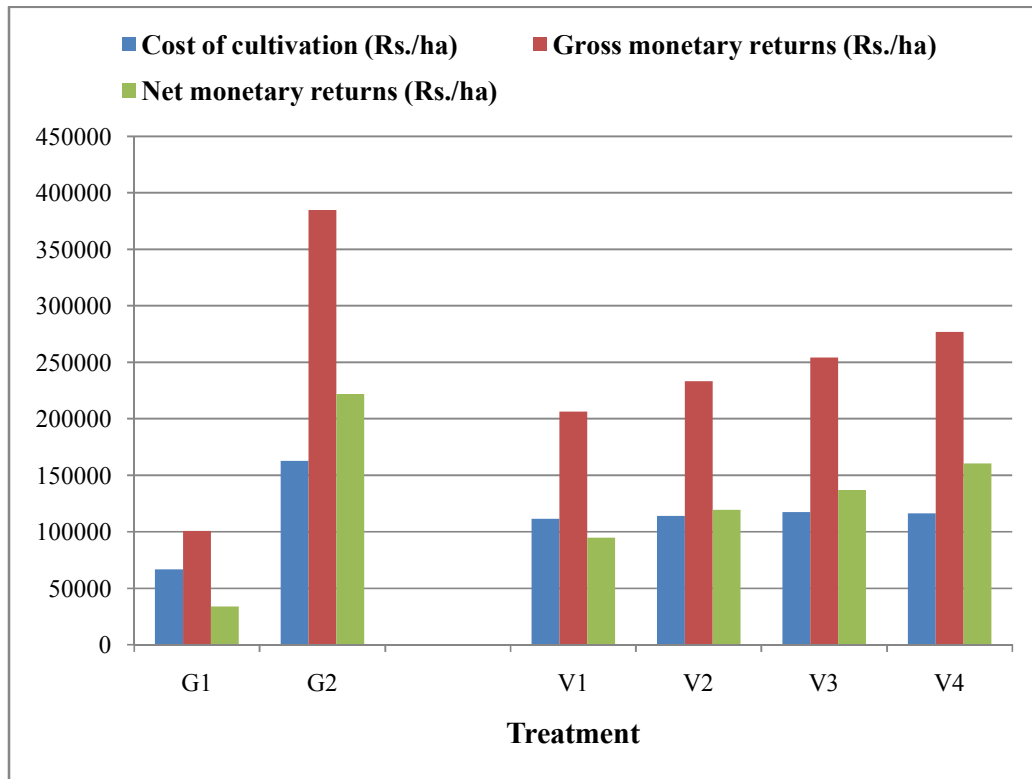
which was closely followed by beet leaf grown under open field (Rs.65,705 /ha), while it was maximum (Rs.1,65,047 /ha) in coriander produced under open field.

**Table 19. Effect of growing conditions on economics of different leafy vegetables.**

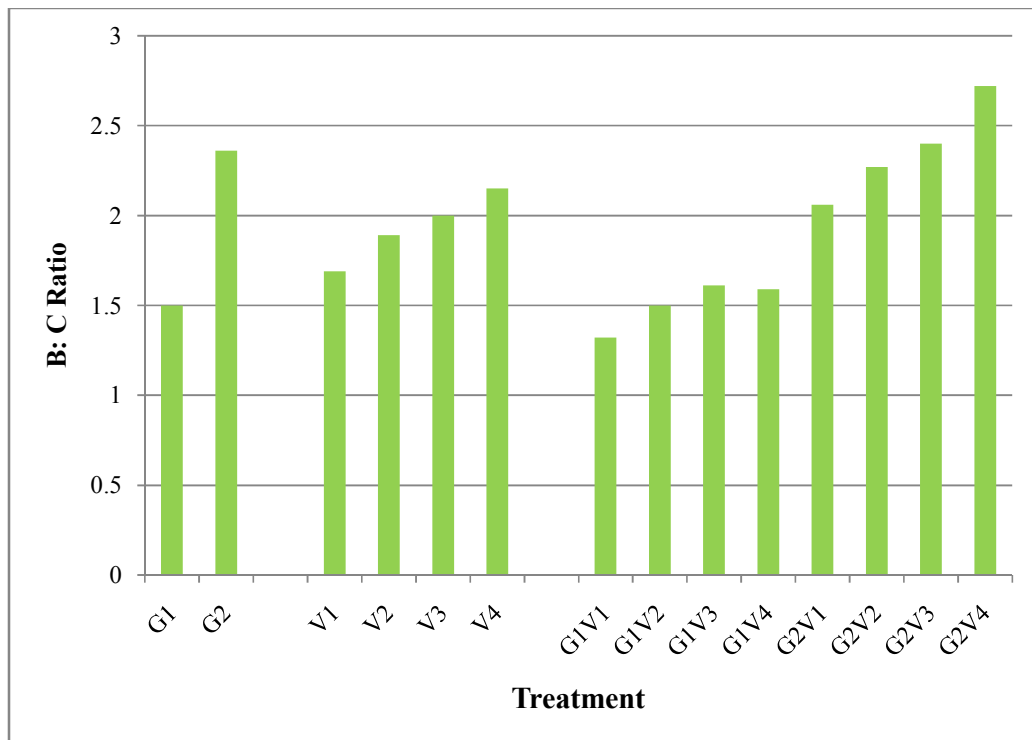
Treatment	Cost of cultivation (Rs./ha)	Gross monetary returns (Rs./ha)	Net monetary returns (Rs./ha)	Benefit: Cost Ratio
<b>Factor A: Growing condition (G)</b>				
G <sub>1</sub> : Open Field	66598	100450	33850	1.50
G <sub>2</sub> : Polyhouse	162848	384875	222027	2.36
<b>Factor B: Leafy vegetables (V)</b>				
V <sub>1</sub> : Amaranthus	111600	206400	94800	1.69
V <sub>2</sub> : Beet leaf	113830	233250	119420	1.89
V <sub>3</sub> : Coriander	117282	254200	136918	2.00
V <sub>4</sub> : Fenugreek	116180	276800	160620	2.15
<b>Growing condition (G) x Leafy vegetables (V)</b>				
G <sub>1</sub> V <sub>1</sub> : Amaranthus in open field	63475	83800	20325	1.32
G <sub>1</sub> V <sub>2</sub> : Beet leaf in open field	65705	98500	32795	1.50
G <sub>1</sub> V <sub>3</sub> : Coriander in open field	69157	111500	42343	1.61
G <sub>1</sub> V <sub>4</sub> : Fenugreek in open field	68055	108000	39945	1.59
G <sub>2</sub> V <sub>1</sub> : Amaranthus in polyhouse	159725	329000	169275	2.06
G <sub>2</sub> V <sub>2</sub> : Beet leaf in polyhouse	161955	368000	206045	2.27
G <sub>2</sub> V <sub>3</sub> : Coriander in polyhouse	165407	396900	232493	2.40
G <sub>2</sub> V <sub>4</sub> : Fenugreek in polyhouse	164305	445600	282295	2.72

#### 4.5.2 Gross monetary returns (Rs./ha)

The data clearly showed that, the gross monetary returns (Rs./ha) were influenced due to growing conditions. It is seen from the data that, the maximum (Rs.3,84,875 /ha) gross monetary returns was observed under polyhouse condition and minimum (Rs.1,00,450 /ha) in open field condition. Among leafy vegetables maximum gross monetary returns (Rs.2,76,800 /ha) was recorded in fenugreek, followed by coriander (Rs.2,54,200 /ha) and beet leaf (Rs.2,33,250 /ha), while it was minimum (Rs.2,06,400 /ha) in amaranthus. Fenugreek produced under polyhouse recorded maximum (Rs.4,45,600 /ha) gross monetary returns, followed by coriander



**Fig.18. Effect of growing conditions on economics of different leafy vegetables.**



**Fig.19. Effect of growing conditions on B: C ratio of different leafy vegetables.**

grown under polyhouse (Rs.3,96,900 /ha), while, it was minimum (Rs.83,800 /ha) in amaranthus grown under open field.

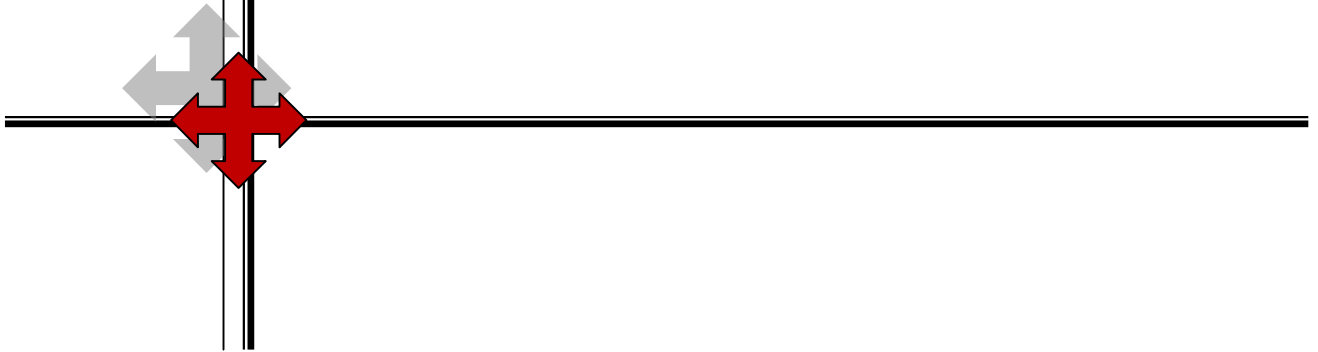
#### **4.5.3 Net monetary returns (Rs./ha)**

The maximum (Rs.2,22,027 /ha) net monetary returns was obtained under polyhouse condition whereas minimum (Rs.33,850 /ha) was obtained in open field condition. Among leafy vegetables maximum net monetary returns (Rs.1,60,620 /ha) was recorded in fenugreek, followed by coriander (Rs.1,36,918 /ha), while it was minimum (Rs.94,800 /ha) in amaranthus. Fenugreek produced under polyhouse recorded maximum (Rs.2,82,295 /ha) net monetary returns, followed by coriander grown under polyhouse (Rs.2,32,493 /ha), while, it was minimum (Rs.20,325 /ha) in amaranthus grown under open field.

#### **4.5.4 B: C Ratio**

The data clearly showed that the B: C ratio as influenced by growing conditions. The highest (2.36) B: C ratio was recorded under polyhouse condition and it was minimum (1.50) in open field condition. Among leafy vegetables maximum B: C ratio was recorded in fenugreek (2.15), followed by coriander (2.00) and it was minimum (1.69) in amaranthus. Fenugreek produced under polyhouse recorded maximum (2.72) B: C ratio followed by coriander grown under polyhouse (2.40), while, it was minimum (1.32) in amaranthus grown under open field.

# DISCUSSION



## **CHAPTER-V**

### **DISCUSSION**

The results of the present experiment entitled “Influence of different growing conditions on growth, yield and quality of leafy vegetables” are presented in previous chapter and discussed in this chapter under different headings. The experimental results showed significant variations among the experimental treatments. In this chapter, the efforts have been made to establish cause and relationship among various parameters, which were significantly influenced by different treatments. In doing so, the relevant findings of researchers have also been quoted in order to support the results of present study. The results obtained during the investigation have been discussed and interpreted critically in the light of review of literature. The entire discussion has been divided in different heads as below.

#### **5.1 Effect of meteorological parameters**

#### **5.2 Effect on growth parameters**

#### **5.3 Effect on yield parameters**

#### **5.4 Effect on quality parameters**

#### **5.5 Economics**

#### **5.1 Effect of meteorological parameters**

The data regarding different meteorological parameters influenced due to growing condition clearly indicated that, the temperature was high under polyhouse condition, while, it was low under open field growing conditions. The light absorption and less ventilation in polyhouse might have increased inside temperature of the polyhouse. The higher temperature during daytime was due to tapping of short wave radiation in the polyhouse. Nimje and Shyam (1993) also obtained similar results. The relative humidity was high under polyhouse condition, while, it was low under open field growing conditions. The possible reason for this might be that the polyhouse was filled with the vegetation and plants were well watered, the ground surface of the polyhouse was always wet. During night, certain quantum of water from soil gets evaporated. Since polyhouse was covered with ultra violet stabilized sheet and also due to absence of solar radiation, the escape of water vapour from the polyhouse to outside was comparatively less during night. Besides, at early morning, when sun

starts shining, there will be more transpiration from the leave. Both these factors together caused higher relative humidity inside the polyhouse. Since, in this study, polyhouse was naturally ventilated, this effect does not prolong for longer period, but it occurred hardly for an hour after sunrise. Similar, results reported by Umesha *et al.*, (2011) under naturally ventilated polyhouse house and open field. Light is a prerequisite of plant growth. Plant matter is produced by the process of photosynthesis, which takes place only when light is absorbed by the chlorophyll (green pigment) in the green parts of the plant, mostly in the leaves. The results revealed that, the light intensity inside the polyhouse was found to be much lower than in open field. Further, it was also observed that, during morning and evening hours, there was low light intensity. These results are in accordance with those of Albright (1990) who observed that, the light intensity was less in polyhouse. A fully grown leafy vegetables benefits from any increase in natural light intensity, provided the plants are well supplied with water, nutrient, carbon dioxide, and the air temperature is presented from becoming too high. Similar, results reported by Umesha *et al.*, (2011) under naturally ventilated polyhouse and open field. The light intensity was maximum in open field as compared to polyhouse. It might be due to the sun rays are maximum in open field as compared to polyhouse condition. Similar, results also reported by Kotadia *et al.*, (2012) under shade net house and open field.

## **5.2 Effect on growth attributes**

The data on germination and growth attributes of different leafy vegetables as influenced by different growing conditions.

### **5.2.1 Germination (%)**

The seed germination of different leafy vegetables sown under different growing conditions was not significantly influenced. It indicates that, the differences in various characters were due to the treatment effects. The results showed that the maximum (90.07 %) germination percentage was observed under polyhouse condition and it was minimum (86.14 %) in open field condition. It was due to optimum temperature and humid atmosphere in natural ventilated poly house, this finding is supported by Jeeva and Sathiyamurthy (2001). Among the leafy vegetables tried the maximum germination percentage was recorded in amaranthus (91.99 %), followed by fenugreek (90.02 %), while it was minimum (82.93 %) in coriander.

Similar, results were obtained by Isaac (2015), who reported that, germination was rapid in amaranthus varieties, while, it was slowest in coriander under polyhouse. It is understood that coriander seeds require seed treatment procedure to stimulate germination, while, these were not compulsory in the other crops included in the study. In the open field, crop establishment was very poor and could not be raised successfully due the heavy rains. The results are in close conformity with the findings of Dixit (2007), who reported that, the germination percentage in different leafy vegetables was found 10-20% more under greenhouse condition as compared to open field. Similar results have also been obtained by Karetha *et al.*, (2014) in coriander.

### **5.2.2 Days to potential germination**

The days to potential germination of different leafy vegetables sown under different growing conditions was significantly influenced. The minimum (7.75) days required for potential germination were observed under polyhouse condition, while maximum (9.40) days were required in open field condition. Among leafy vegetables minimum days (4.73) to potential germination was required for amaranthus, followed by fenugreek (5.29), while, it was maximum (18.70) in coriander. The interaction effect of growing conditions and leafy vegetables on days to potential germination was found significant. The treatment combination of polyhouse + amaranthus required minimum (4.13) days to potential germination, followed by fenugreek grown under polyhouse (4.70), while, it was maximum (20.37 days) in coriander in open field condition. This might be due to the fact that light is the most important factor influencing the growth of leafy vegetables. Very high light intensity in open field has been reported to be injurious to the leafy vegetables. Similar, trend of results was also noticed by Kotadia *et al.*, (2012).

### **5.2.3 Height of plant (cm)**

The data on height of the plant indicated significant differences due to growing conditions and among different leafy vegetables. Significant effect of growing condition on height was observed. The maximum (44.28 cm) height of plant was observed under polyhouse condition and minimum (27.62 cm) was recorded in open field condition. Among the leafy vegetables maximum plant height was recorded in amaranthus (55.90 cm), followed by beet leaf (36.16 cm), while it was minimum (18.70 cm) in coriander. The interaction effect of growing conditions and leafy

vegetables on plant height was found significant. Treatment combination amaranthus in polyhouse has recorded maximum (70.93 cm) plant height which was followed by beet leaf in polyhouse (42.65 cm), while it was minimum (12.27 cm) in treatment combination coriander in open field. This may be due to enhanced photosynthesis and respiration due to the favorable micro-climatic conditions in the polyhouse condition. This agrees with results of Ramesh and Arumugam (2010) on vegetables grown under polyhouse.

#### **5.2.4 Number of branches per plant**

The significant differences in number of branches per plant with respect to growing conditions were noticed. The maximum number of branches per plant (1.93) was recorded under polyhouse condition and minimum (1.05) was observed in open field condition. Among the leafy vegetables maximum number of branches per plant were recorded in amaranthus (2.62), followed by beet leaf (1.40), while it was minimum (0.95) in coriander. The interaction effect of growing conditions and leafy vegetables on number of branches per plant was found significant. The amaranthus grown under polyhouse condition recorded maximum (3.39) number of branches per plant followed by amaranthus in open field (1.85), while it was minimum (0.62) in treatment combination of fenugreek grown under open field condition. This might be due to the favourable micro-climatic conditions. Similar, results were reported by Ramesh and Arumugam (2010) observed increases in numbers of branches per plant under polyhouse, in tomato, eggplant and chillies.

The results are in close conformity with the findings of Dixit (2007) found that the higher number of branches per plant were recorded under protected environment and the same traits were recorded lowest in outdoor cultivation. Similar, results have also been obtained by Cheema *et al.*, (2013), Rana *et al.*, (2014) in tomato; Rao *et al.*, (2013) in capsicum; in tomato and Sam and Regeena *et al.*, (2016) in tomato and capsicum.

#### **5.2.5 Number of leaves per plant**

The numbers of leaves per plant were significantly influenced due to different growing conditions and also among different vegetables. The maximum (28.03) number of leaves per plant was observed under polyhouse condition and minimum (19.64) was observed in open field condition. Among the leafy vegetables maximum

number of leaves per plant was recorded in amaranthus (39.43), followed by fenugreek (26.98), while, it was minimum (9.37) in beet leaf. The interaction effect of growing conditions and leafy vegetables on number of leaves per plant was found significant. Treatment combination of amaranthus in polyhouse recorded maximum (47.20) number of leaves per plant, followed by amaranthus in open field, while, it was minimum (8.47) in beet leaf in open field condition. This might be due to taller plants, increased number of branches per plant and the beneficial micro-climate in the polyhouse. Similar, results were reported by Nimje and Shyam (1993) and Rajasekar *et al.*, (2012) in sweet pepper and eggplant. The results are in close conformity with the findings of Dixit (2007) observed more number of leaves per plant under protected environment and the same traits were recorded lowest in outdoor cultivation. Similar, results were also obtained by Kotadia *et al.*, (2012), Kaddi (2014) and Isaac (2015).

### **5.2.6 Leaf attributes**

The results clearly showed that, different leaf attributes like leaf length, leaf width, leaf area and number of stomata was significantly influenced due to different growing conditions.

#### **5.2.6.1 Leaf length (cm)**

The significant variations in leaf length were observed among vegetables grown under different conditions. The maximum (6.21 cm) leaf length was observed under polyhouse condition and it was minimum (4.56 cm) in open field condition. The significant differences were also noticed among leafy vegetables. The maximum leaf length (11.31 cm) was recorded in beet leaf, followed by amaranthus while, it was minimum (2.70 cm) in coriander. The interaction effect of growing conditions and leafy vegetables on leaf length was found significant. Treatment combination of beet leaf in polyhouse recorded maximum (12.83 cm) leaf length followed by beet leaf in open field condition. While, it was minimum (2.19 cm) in coriander under open field condition.

The results are in close conformity with the findings of Dixit (2007) they have studied the, spinach, amaranthus, fenugreek and coriander vegetables and found that the length of leaves recorded higher under protected environment and the same traits

were recorded lowest in outdoor cultivation. Similar results have also been obtained by Karetha *et al.*, (2014).

#### **5.2.6.2 Leaf width (cm)**

There were significant differences in leaf width among leaf vegetables grown under different growing conditions. The maximum (4.47 cm) leaf width was observed under polyhouse condition because of low light intensity that cells expanding more to receive light for photosynthesis. Similar, results reported by Sampet (1993). The lowest leaf width was recorded (2.97 cm) in open field condition. This may be due to less favourable climatic conditions. This finding is supported by Dixit (2007) and Prabhu *et al.*, (2009). Among different leafy vegetables maximum leaf width (7.27 cm) was recorded in beet leaf, followed by amaranthus (2.89 cm), while it was minimum (1.95 cm) in fenugreek. The interaction effect on leaf width was found significant. Treatment combination of beet leaf grown under polyhouse recorded maximum (8.61 cm) leaf width, followed by beet leaf grown under open field (5.92 cm), while it was minimum (1.79 cm) in fenugreek grown under open field.

The results are in close conformity with the findings of Dixit (2007) also reported higher width of leaves under protected environment and the same traits were recorded lowest in outdoor cultivation. Similar, results have also been obtained by Karetha *et al.*, (2014).

#### **5.2.6.3 Leaf area (cm<sup>2</sup>)**

The leaf area of different leafy vegetables grown under different growing condition was significantly influenced. The maximum (30.32 cm<sup>2</sup>) leaf area was observed under polyhouse condition and minimum (15.56 cm<sup>2</sup>) was observed in open field condition. Among, the leafy vegetables maximum (47.66 cm<sup>2</sup>) leaf area was recorded in beet leaf, followed by amaranthus (37.14 cm<sup>2</sup>), and it was minimum (2.92 cm<sup>2</sup>) in fenugreek. The interaction effect of growing conditions and leafy vegetables on leaf area was found significant. The treatment combination of beet leaf in polyhouse recorded maximum (63.73 cm<sup>2</sup>) leaf area followed by amaranthus in polyhouse (48.43 cm<sup>2</sup>), and it was minimum (2.10 cm<sup>2</sup>) in treatment combination of fenugreek in open field. This might be due to leaf physiology and increased number of stomatoes and photosynthesis. These results agree with Papadopoulos and Ormrod (1991) in tomato.

The results are in close conformity with the findings of Wolff and Coltman (1990) reported that, the specific leaf area of ‘Green Mignonette’ and ‘Amaral 400’ lettuce, Chinese cabbage, green mustard cabbage, head cabbage, and green bunching onions was increased as percent shade increased. Similar, results were obtained by Kotadia *et al.*, (2012), Rajasekar *et al.*, (2013), Karetha *et al.*, (2014) and Sam and Regeena (2016) in different vegetables.

#### **5.2.6.4 Numbers of stomata /mm<sup>2</sup>**

The number of stomata was also significantly influenced by growing conditions. The maximum number (24.00/mm<sup>2</sup>) of stomata was observed under polyhouse condition and minimum (21.00/mm<sup>2</sup>) were recorded in open field condition. There was significant difference in number of stomata were observed among the leafy vegetables. Among, the leafy vegetables maximum (24.50/mm<sup>2</sup>) number of stomata were recorded in beet leaf which was statistically at par with amaranthus (24.00/mm<sup>2</sup>) while, it was minimum (20.50/mm<sup>2</sup>) in fenugreek. The interaction effect of growing conditions and leafy vegetables on number of stomata was found significant. Treatment combination of beet leaf produced under polyhouse condition recorded maximum (26.00/mm<sup>2</sup>) number of stomata which was statistically at par with treatment combinations of amaranthus grown under polyhouse (24.99/mm<sup>2</sup>), amaranthus grown under open field (23.00/mm<sup>2</sup>), beet leaf produced under open field (22.99/mm<sup>2</sup>), Fenugreek grown under polyhouse (22.99/mm<sup>2</sup>) and coriander grown under polyhouse (22.00/mm<sup>2</sup>), while, it was minimum (18.00/mm<sup>2</sup>) in fenugreek grown under open field condition. This might due to the high temperature and relative humidity and less light intensity under polyhouse.

These results are in close conformity with the findings of Isaac (2015) revealed that, the increased number of stomatoes under naturally ventilated polyhouse in different leafy vegetables.

#### **5.2.7 Days required for horticultural maturity**

The results indicated that, the minimum (33.00) day were required for horticultural maturity under polyhouse condition and maximum (39.95) were observed under open field condition. There was a significant difference in days required for horticultural maturity among the leafy vegetables. The minimum days (33.00) were required for amaranthus, followed by fenugreek (33.16), and maximum

(43.20) in coriander. The interaction effect on days required for horticultural maturity of different leafy vegetables was found significant. Treatment combination fenugreek in polyhouse recorded minimum (30.00) days required for horticultural maturity, followed by amaranthus in polyhouse, while, it was maximum in treatment combination open field in coriander (48.41). This might due to the optimum temperature accompanied by low relative humidity inside hasten early maturity. Similar results reported by Lekshmi and Celine (2015) in tomato under polyhouse.

The results are in close conformity with the findings of Baudoin and Nisen (1990) reported that, the growing in a greenhouse enables the plants to mature at up to 30% faster than field-grown crops.

## **5.2.8 Root-shoot characters**

### **5.2.8.1 Length of whole plant (cm)**

The results clearly revealed that, the total length of the plant was significantly influenced due to growing condition. Significant differences were also observed among different vegetables and its interaction effect of growing condition on leafy vegetables was also significant. The maximum (56.11 cm) length of whole plant was observed under polyhouse condition and minimum (33.21 cm) in open field condition. Among, leafy vegetables maximum (69.46 cm) length of whole plant was recorded in amaranthus, followed by beet leaf (46.57 cm) and it was minimum (25.03 cm) in coriander. The interaction effect on length of whole plant was found significant. Amaranthus under polyhouse recorded maximum (87.29 cm) length of whole plant which was followed by beet leaf in polyhouse condition and it was minimum (17.09 cm) in coriander under open field condition. The results are close conformity with the findings of Dhulkhandi *et al.*, (1995).

### **5.2.8.2 Length of shoot (cm)**

The length of shoot was also significantly influenced due to growing conditions and also among different leafy vegetables. It is observed from the data that, the maximum (43.31 cm) length of shoot was observed under polyhouse condition and it was minimum (25.14 cm) under open field condition. Among, the leafy vegetables maximum (54.77 cm) length of shoot was recorded in amaranthus, followed by beet leaf (35.63 cm) and it was minimum (18.29 cm) in coriander. The interaction effect on length of shoot was found significant. Treatment combination of

amaranthus in polyhouse, recorded maximum (69.44 cm) length of shoot followed by beet leaf in polyhouse (42.00 cm), and it was minimum (12.11 cm) in coriander in open field condition. The results are close conformity with the findings of Dhulkhandi *et al.*, (1995).

#### **5.2.8.3 Length of root (cm)**

The root length of different leafy vegetables was significantly influenced due to different growing conditions. The maximum (12.80 cm) length of root was observed under polyhouse condition and minimum (8.07 cm) in open field condition. Among, the leafy vegetables maximum (14.69 cm) length of root was recorded in amaranthus, followed by beet leaf (10.94 cm) and it was minimum (6.74 cm) in coriander. The interaction effect on length of root was found significant. Treatment combination amaranthus in polyhouse condition recorded maximum (17.85 cm) length of root followed by beet leaf in polyhouse (13.90 cm), and it was minimum (4.90 cm) in coriander in open field. This might be due to rise temperature inside polyhouse. Similar results reported by Malhotra and Kumar (2000) and Kotadia *et al.*, (2012). The results also close conformity with the findings of Rao *et al.*, (2013) reported that the root zone of capsicum more under shade net as compared to open field.

#### **5.2.8.4 Root: shoot ratio**

Root: shoot ratio on length basis was non significant among growing conditions, however, there were significant differences in root: shoot ratio among the leafy vegetables. The maximum root: shoot ratio (0.36) was recorded in coriander which was statistically at par with fenugreek (0.33), and it was minimum (0.26) in amaranthus. The variations in root: shoot ratios among leafy vegetable may be due to genetic variations of the particular vegetable. The interaction effect of growing conditions and leafy vegetables on root: shoot ratio was found significant. Treatment combination of fenugreek in open field recorded maximum (0.41) root: shoot ratio which was statistically at par with treatment combination coriander in open field (0.40) and coriander in polyhouse (0.35), while it was minimum (0.25) in treatment combination amaranthus under polyhouse. These differences could be attributed to the effect of growing environment on particular vegetable. However, pursual of literature fails to throw light on the findings of present investigation.

## **5.3 Effect on yield**

### **4.3.1 Fresh weight of whole plant (g)**

The maximum fresh weight of whole plant (30.33g) was observed under polyhouse condition and it was minimum (15.82g) in open field condition. Among, the leafy vegetables maximum (38.79g) fresh weight of whole plant was recorded in amaranthus which was statistically at par with beet leaf (36.05g), and it was minimum (8.52g) in coriander. The interaction effect on fresh weight of whole plant was found significant. Amaranthus grown in polyhouse recorded maximum (50.36g) fresh weight of whole plant which was statistically at par with beet leaf under polyhouse (47.21g), and it was minimum (4.60g) in fenugreek in open field. Similar results were obtained by Isaac (2015) who reported that, the yield per plant in g in palak was 80.9, coriander 47.81, lettuce 3.39, green amaranthus 69.33, and red amaranthus 74.98 reported in naturally ventilated polyhouse. The greater plant height might have helped in the production of more number of branches per plant and number of leaves per plant, which ultimately resulted in the production of fresh weight of plant. This finding is supported by Pan *et al.*, (2003) in coriander.

Similar, results obtained by Rajasekar *et al.* (2013) reported that, the yield per plant of tomato, eggplant, chilli, raddish, cucumber, coriander, amaranthus is higher under shade net house than open field. The results are close conformity with the findings of Ganesan (2001) and Rana *et al.*, (2014) in tomato, Singh *et al.*, (2011b) in sweet pepper and Karistsapol *et al.*, (2013) in broccoli

### **4.3.2 Fresh weight of shoot (g)**

Fresh weight of shoot was also significantly influenced in different vegetables under different growing conditions. The maximum (26.87g) fresh weight of shoot was recorded under polyhouse condition and it was minimum (14.30g) in open field condition. Among, the leafy vegetables maximum (34.82g) fresh weight of shoot was recorded in amaranthus which was statistically at par with beet leaf (32.28g), and it was minimum (7.37g) in coriander. The interaction effect on fresh weight of shoot was found significant. Amaranthus grown under polyhouse recorded maximum (44.87g) fresh weight of shoot which was statistically at par with beet leaf in polyhouse (41.98g), and it was minimum (4.14g) in fenugreek in open field. The favourable growing condition in polyhouse might have helped for better growth

resulting in to higher weight of shoots of vegetables. The results are close conformity with the findings of Dhulkhandi *et al.*, (1995) reported that the higher weight of shoot in fenugreek, coriander, spinach and lettuce grown under continuous daylight condition.

### **5.3.3 Fresh weight of root (g)**

The fresh weight of root was also significantly influenced due to growing conditions in different leafy vegetables. The maximum (3.46g) fresh weight of root was recorded under polyhouse condition and it was minimum (1.52g) in open field condition. Among leafy vegetables maximum (3.97g) fresh weight of root was recorded in (V<sub>1</sub>) amaranthus, which was statistically at par with beet leaf (3.77g), while, it was minimum (1.08g) in fenugreek. The interaction effect on fresh weight of root was found significant. Amaranthus under polyhouse condition recorded maximum (5.49g) fresh weight of root which was statistically at par with beet leaf under polyhouse (5.23g), while it was minimum (0.46g) in fenugreek under open field. The results are close conformity with the findings of Dhulkhandi *et al.*, (1995) reported that the more fresh weight of root in fenugreek, coriander, spinach and lettuce grown under continuous daylight condition.

### **5.3.4 Root: shoot ratio (Fresh weight basis)**

The maximum (0.12) root: shoot ratio (Fresh weight basis) was observed under polyhouse condition and it was minimum (0.10) in open field condition. Among leafy vegetables maximum (0.15) root: shoot ratio (Fresh weight basis) was recorded in coriander, followed by fenugreek (0.13), while it was minimum (0.11) in beet leaf and amaranthus. The interaction effect on root: shoot ratio (fresh weight basis) was found significant. Coriander grown under polyhouse recorded maximum (0.16) root: shoot ratio (fresh weight basis) which was statistically at par with coriander in open field and fenugreek in polyhouse. High root: shoot ratio in coriander may be due genetic make up of the plant species.

The results are close conformity with the findings of Dhulkhandi *et al.*, (1995) reported that the root: shoot ratio (fresh weight basis) in fenugreek, coriander, spinach and lettuce respectively under continuous daylight condition.

### **5.3.5 Yield per plot (kg)**

The maximum yield per plot (2.60 kg) was recorded in vegetables grown under

polyhouse condition due to light compensation for higher photosynthesis, and may be due to moderate light intensity. Similar, results were reported by Priya *et al.*, (2002) in sweet paper. Among, the leafy vegetables maximum yield per plot (2.48 kg) was recorded in amaranthus which was statistically at par with beet leaf (2.36 kg), and it was minimum (1.18 kg) in coriander. The amaranthus under polyhouse condition recorded maximum yield per plot (3.45 kg) which was statistically at par with beet leaf in polyhouse, while it was observed minimum (0.63 kg) in fenugreek in open field. This might due to environmental factors especially optimum temperature, relative humidity and light intensity provided to the plants grown under protected condition. The results are close conformity with the findings of Dhulakhandi *et al.*, (1995) who reported that, higher yield of fenugreek 0.775 kg/m<sup>2</sup>, spinach 1.007 kg/m<sup>2</sup>; coriander 1.371 kg/m<sup>2</sup> and lettuce 0.888 kg/m<sup>2</sup> under green house.

Similar, results are also obtained by Dixit (2007), Rajasekar *et al.*, (2013) and Isaac (2015) in different leafy vegetables in naturally ventilated polyhouse, which supports present findings.

### **5.3.6 Yield (t/ha)**

The yield variations were recorded among vegetables and due to growing conditions. The maximum (7.14 t/ha) yield was recorded under polyhouse condition and minimum (3.04 t/ha) under open field condition. This might due to favourable conditions in polyhouse might have increased photo-synthetic activity of plants resulting in to accumulation of more carbohydrates in the plant body resulting for increased yield in the polyhouse than open field condition. Similar results reported by Rajasekar *et al.* (2013) who reported that, higher yields under polyhouse conditions may be due to high photosynthetic rate due to favourable effects of protected condition resulting into more production and accumulation of carbohydrates resulting in high biomass production. Among leafy vegetables maximum yield (6.79 t/ha) was recorded in treatment amaranthus which was statistically at par with beet leaf (6.57 t/ha), and it was minimum (3.31 t/ha) in coriander. The interaction effect on yield (t/ha) was found significant. Amaranthus grown under polyhouse recorded maximum (9.39 t/ha) yield which was statistically at par with beet leaf under polyhouse condition (9.20 t/ha), and it was minimum (1.80 t/ha) in fenugreek grown in open field condition. This might due to genetic make up of the species and favourable environmental condition under polyhouse. Similar results reported by Sam and

Regeena (2016). This might be also be due to more plant height, number of branches, number of leaves and leaf area in polyhouse which produced more carbohydrates through photosynthesis and ultimately increased yield. Similar results also reported by Kotadia *et al.*, (2012).

The results are close conformity with the findings of Baudoin and Nisen (1990) reported that the total fruit yield of tomato plants were significantly enhanced by plastic covering. Wittwer and Castilla (1995) also reported that, the greenhouse crops can be protected out-of-season on year-round their yields are higher than those grown in open fields. Similar trend of results was also been reported by Dixit (2007). Who reported 2-3 times more yield of leafy vegetables under greenhouse than that of outdoor cultivation.

The data presented in table 14 regarding per cent increase in yield of different vegetables grown in polyhouse over open field revealed that, maximum % increase in yield Kg per plot was recorded in fenugreek (228.57 Kg/plot), followed by beet leaf (133.09 Kg/plot). Which minimum % increase in Kg/plot was recorded in coriander (98.73 Kg/plot).

### **5.3.7 Dry weight of whole plant (g)**

The maximum dry weight of whole plant (6.94 g) was observed in vegetables produced under polyhouse condition and it was minimum (3.15 g) in vegetables grown under open field condition. Among leafy vegetables maximum dry weight of whole plant (7.30 g) was recorded in amaranthus which was statistically at par with beet leaf (6.78 g), and it was minimum (2.68 g) in coriander. The interaction effect of growing conditions and leafy vegetables on dry weight of whole plant was found significant. Amaranthus grown in polyhouse recorded maximum (9.90 g) dry weight of whole plant which was statistically at par with beet leaf in polyhouse (9.44 g), while it was minimum in fenugreek grown under open field. This might be due to more plant height, number of branches, number of leaves and leaf area in polyhouse grown vegetables which produced more carbohydrates through photosynthesis and ultimately increased production of dry weight of plant. Similar results were obtained by Weerakkody and Ando (1994) and Karetha *et al.*, (2014).

### **5.3.8 Dry weight of shoot (g)**

The maximum dry weight of shoot (6.37g) was recorded in vegetables grown

under polyhouse condition and minimum (2.80g) was observed in vegetables produced under open field condition. Among leafy vegetables maximum dry weight of shoot was recorded in amaranthus (6.62g) followed by beet leaf and it was minimum (2.46g) in coriander. The interaction effect on dry weight of shoot was found significant. The amaranthus grown in polyhouse recorded maximum (9.09g) dry weight of shoot which was statistically at par with beet leaf in polyhouse, while, it was minimum in fenugreek under open field. More dry weight in vegetables produced under polyhouse could be attributed to more fresh weight of shoot.

### **5.3.9 Dry weight of root (g)**

The maximum dry weight of root (0.57g) was recorded in vegetables grown under polyhouse condition and it was minimum (0.35g) in vegetables grown open field condition. Among leafy vegetables maximum dry weight of root (0.71g) was recorded in beet leaf, followed by amaranthus (0.68g), while, it was minimum (0.22g) in coriander. The interaction effect on dry weight of root was found significant. Beet leaf grown in polyhouse recorded maximum (0.86g) dry weight of root which was statistically at par with amaranthus grown under polyhouse, while, it was minimum (0.12g) in fenugreek grown in open field. Pursual of literature fails to throw light on this aspect of study.

### **5.3.10 Root: shoot ratio (dry weight basis)**

The maximum (0.12) root: shoot ratio (dry weight basis) was recorded under open field condition and it was minimum (0.09) in polyhouse condition. Among leafy vegetables maximum root: shoot ratio (0.11) (dry weight basis) was recorded in beet leaf, followed by coriander (0.09), while, it was minimum in fenugreek (0.07). The interaction effect on root: shoot ratio (dry weight basis) was found significant. Beet leaf in open field recorded maximum (0.16) root: shoot ratio (dry weight basis), while, it was minimum (0.08) in fenugreek in open field. Differences among the vegetables could be attributed to genetic differences among the vegetables.

## **5.4 Effect on quality**

### **5.4.1 Vitamin 'A' content (IU/100g)**

The maximum (8268.52) vitamin A content (IU/100g) was recorded in vegetables produced under polyhouse condition. This could be attributed to that the growing conditions might not have any favourable effect on vitamin 'A' production.

There were significant differences in vitamin A content of different leafy vegetables. Among leafy vegetables, the maximum vitamin A content (IU/100g) was recorded in amaranthus (10460.49), followed by beet leaf (9342.51), while, it was minimum in fenugreek (3384.93). The interaction effect on vitamin A content (IU/100g) was found significant. The amaranthus grown under polyhouse recorded maximum (10821.00 IU/100g) vitamin 'A' content, followed by amaranthus produced under open field condition, while, it was minimum (3120.80) in fenugreek grown under open field condition. Similar results obtained by Lekshmi and Celine (2015) who observed that, maximum vitamin A content in tomato produced under net house conditions.

#### **5.4.2 Vitamin 'C' content (mg/100g)**

The vitamin C contents were not significantly influenced due to growing conditions; however, significant differences were observed among different leafy vegetables and due to interaction. Among leafy vegetables maximum vitamin C content (133.31 mg/100g) was recorded in coriander and it was minimum (49.61 mg/100g) in fenugreek. The interaction effect on vitamin C content was found significant. Coriander grown under polyhouse recorded maximum (134.78 mg/100g) vitamin C content which was statistically at par with coriander under open field, and it was minimum (48.19 mg/100g) in fenugreek under open field. Similar results obtained by Lekshmi and Celine (2015) and Smitha (2002) in tomato produced under protected conditions.

#### **5.4.3 Calcium (Ca) content (mg/100g)**

The calcium content in different vegetables was not significantly influenced due to growing conditions however; significant differences were observed among different vegetables. Among leafy vegetables maximum calcium content (375.49 mg/100g) was recorded in fenugreek which was statistically at par with amaranthus (373.81 mg/100g) and beet leaf (353.50 mg/100g) while, it was minimum (163.99 mg/100g) in coriander. The interaction effect on calcium content was found significant. Fenugreek grown under polyhouse condition recorded maximum (382.66 mg/100g) calcium content which was statistically at par with rest of the treatment expect coriander grown in both the conditions.

#### **5.4.4 Iron (Fe) content (mg/100g)**

The iron content in different vegetables differed significantly due to growing conditions and also due to interactions. The maximum (17.95 mg/100g) iron content was observed in vegetables grown under polyhouse condition and it was minimum (16.09) in open field condition. Among leafy vegetables maximum iron content (19.35 mg/100g) was recorded in amaranthus followed by coriander (17.09 mg/100g) and, it was minimum in beet leaf (15.49 mg/100g). Amaranthus grown under polyhouse recorded maximum (20.70 mg/100g) iron content followed by amaranthus in open field (18.00) and coriander under polyhouse (17.98), while, it was minimum (14.85) in beet leaf grown in open field.

#### **5.4.5 Total chlorophyll content (SPAD value)**

The maximum values of total chlorophyll content (38.19 SPAD value) was observed in vegetables grown under polyhouse condition and minimum (34.47) was observed in vegetables grown in open field condition. Among different leafy vegetables maximum total chlorophyll content (SPAD value) was recorded in fenugreek (47.13) followed by amaranthus (35.09), while it was minimum in coriander (30.32). The interaction effect of growing conditions and leafy vegetables on total chlorophyll content (SPAD value) was found significant. The fenugreek grown in polyhouse recorded maximum (48.48) SPAD value total chlorophyll content which was statistically at par with fenugreek grown under open field, while it was minimum (27.13) in coriander grown in open field. Similar results obtained by Asha and Nair (1992) and Moniruzzaman *et al.*, (2009).

#### **5.4.6 Physiological loss in weight (%)**

The results showed that growing condition has a significant effect on physiological loss of vegetables. At ambient storage the minimum (12.34, 22.02, 33.62 and 45.85 %) physiological loss in weight was observed in the vegetables produced under polyhouse condition (at 3, 6, 9 and 12 DAS respectively) and maximum 20.24, 33.94, 47.33 and 61.22 % at 3, 6, 9 and 12 DAS respectively loss was observed in vegetables produced under open field condition. Under refrigerator storage the minimum 6.84, 9.42, 11.75 and 14.76 % at 3, 6, 9 and 12 DAS respectively physiological loss in weight was observed vegetables produced under polyhouse condition and maximum (9.93, 14.23, 17.36 and 21.34) loss was observed

(at 3, 6, 9 and 12 DAS respectively) in vegetables produced under open field condition.

At ambient storage, the minimum loss in weight was recorded in beet leaf and it was maximum in fenugreek at 3, 6 and 9 DAS. At 12 DAS of storage minimum (48.14 %) physiological loss in weight was recorded in coriander, while it was maximum (64.54 %) in fenugreek. Under refrigerator storage condition also minimum weight loss was observed in beet leaf and it was maximum in fenugreek during storage period.

At ambient storage at 3 and 6 DAS beet leaf grown under polyhouse recorded minimum physiological loss in weight, while it was maximum was observed in fenugreek grown under open field. At 9 and 12 DAS, minimum physiological loss in weight was recorded in coriander grown under polyhouse, while it was maximum in fenugreek grown under open field. Under cold storage condition at 3, 6 and 9 DAS storage minimum physiological weight loss was noticed in beet leaf produced under polyhouse, and maximum (14.89 %) physiological loss in weight was recorded in fenugreek grown under open field. At 12 DAS of storage minimum (10.23 %) physiological weight loss was noticed in coriander produced under polyhouse, followed by beet leaf grown under polyhouse (11.97 %), and it was maximum (27.18 %) in fenugreek produced under open field. Similar results were obtained by Sam and Regeena (2016) who observed that, the PLW of tomato and capsicum was minimum in poly house produced crops than open field crops.

#### **5.4.7 Shelf life (Days)**

The maximum shelf life (4.67 and 11.25 days) was observed under vegetables produced under polyhouse condition and it was minimum (2.99 and 8.00 days) at ambient and refrigerator storage respectively in vegetables produced under open field condition at ambient and refrigerator storage respectively.

Among leafy vegetables at ambient storage maximum shelf life (5.01 days) was recorded in coriander, followed by beet leaf, while, it was minimum (2.66 days) in fenugreek. At refrigerator storage, among leafy vegetables maximum shelf life (10.49 days) was recorded in coriander which was statistically at par with beet leaf, while it was minimum (8.50 days) in fenugreek.

The interaction effect on shelf life (days) of vegetables was found significant. At ambient storage maximum (6.03 days) shelf life was recorded in coriander produced under polyhouse, followed by beet leaf grown under polyhouse (5.00 days), while it was minimum (1.99 days) in fenugreek grown under open field. At refrigerator storage maximum (12.00 days) shelf life was recorded in beet leaf produced under polyhouse which was statistically at par with coriander grown under polyhouse (11.99 days), amaranthus grown under polyhouse (11.00 days) and fenugreek grown under polyhouse (10.00 days), while it was minimum (7.00 days) in fenugreek grown under open field. Similar results were also obtained by Kurubetta and Patil (2009) reported that, the quality parameter like shelf life (8.62 days) in capsicum was significantly more when produced under naturally ventilated polyhouse than under naturally ventilated shadow hall. Similar results have also been obtained by Malshe *et al.*, (2016) in bell paper and in tomato by Sam and Regeena (2016).

## **5.5 Economics**

The economics of different leafy vegetables was influenced due to different growing conditions.

### **5.5.1 Cost of cultivation (Rs./ha)**

There was lot of variation in cost of cultivation among different growing conditions. It is observed that, the minimum cost of cultivation (Rs.66,598 /ha) was required under open field condition and it was maximum (Rs.1,62,848 /ha) in polyhouse condition. Among leafy vegetables minimum cost of cultivation (Rs.1,11,600 /ha) was recorded in amaranthus, followed by beet leaf (Rs.1,13,180 /ha), while it was maximum (Rs.1,17,282 /ha) in coriander. Amaranthus produced under open field recorded minimum (Rs.63,475 /ha) cost of cultivation, which was closely followed by beet leaf grown under open field (Rs.65,705 /ha), while it was maximum (Rs.1,65,047 /ha) in coriander produced under open field. Similar results obtained by Sonwal *et al.*, (2004). These finding are also in agreement with the finding of Murthy *et al.* (2009), Vinh *et al.*, (2010) and Sreedhara *et al.*, (2013). Kishore *et al.*, (2014) also reported that, the production cost under polyhouse was about 1.5 times higher than the open field condition.

### **5.5.2 Gross monetary returns (Rs./ha)**

The gross monetary returns were differed due to growing conditions. The results

showed that, the maximum gross monetary returns (Rs.3,84,875 /ha) was observed under polyhouse condition and minimum (Rs.1,00,450 /ha) in vegetable produced in open field condition. Among leafy vegetables maximum gross monetary returns (Rs.2,76,800 /ha) was recorded in fenugreek, followed by coriander (Rs.2,54,200 /ha) and beet leaf (Rs.2,33,250 /ha), while it was minimum (Rs.2,06,400 /ha) in amaranthus. Fenugreek produced under polyhouse recorded maximum (Rs.4,45,600 /ha) gross monetary returns, followed by coriander grown under polyhouse (Rs.3,96,900 /ha), while it was minimum (Rs.83,800 /ha) in amaranthus grown under open field. Similar results obtained by Sreedhara *et al.*, (2013). The results are close conformity with the findings of Kumar *et al.*, (2015) and Kumar *et al.*, (2016).

### **5.5.3 Net monetary returns (Rs./ha)**

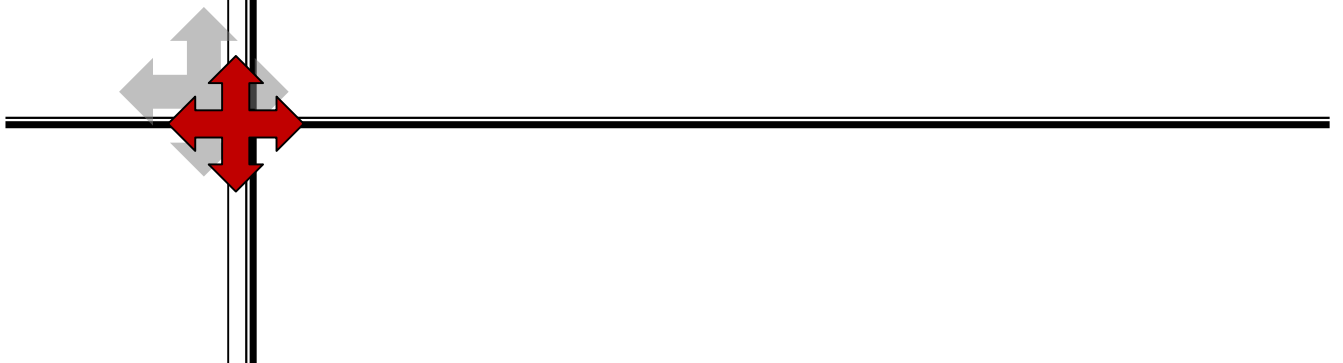
The maximum net monetary returns (Rs.2,22,027 /ha) was obtained from the vegetable produced under polyhouse condition whereas, minimum (Rs.33,850 /ha) was obtained from vegetables grown in open field condition. Among leafy vegetables maximum net monetary returns (Rs.1,60,620 /ha) was recorded in fenugreek, followed by coriander (Rs.1,36,918 /ha), while it was minimum (Rs.94,800 /ha) in amaranthus. Fenugreek produced under polyhouse recorded maximum (Rs.2,82,295 /ha) net monetary returns, followed by coriander grown under polyhouse (Rs.2,32,493 /ha), while it was minimum (Rs.20,325 /ha) in amaranthus grown under open field. Maximum returns in fenugreek could be attributed to high market price for the produce. This could be also attributed to comparatively low supply of fenugreek during rainy season due to less area and production. Similar results obtained by Sharma *et al.*, (1992) studied the profitability of vegetable crops under polyhouse conditions and reported that vegetable crops provided higher net returns under polyhouse conditions. These results are close in conformity with the findings of Murthy *et al.*, (2009), Kishore *et al.*, (2014), Kumar *et al.*, (2015), Spehia (2015), Bhargava *et al.*, (2016) and Kumar *et al.*, (2016).

### **5.5.4 B: C Ratio**

The highest (2.36) B: C ratio was recorded under polyhouse condition and it was minimum (1.50) in open field condition. High B: C ratio under polyhouse could be due to high yield of quality produce. Low B: C ratio for amaranthus in open field could be due low market rates and poor quality of the produce. Among leafy

vegetables maximum B: C ratio was recorded in fenugreek (2.15) followed by coriander (2.00), and it was minimum (1.69) in amaranthus. Fenugreek produced under polyhouse recorded maximum (2.72) B: C ratio followed by coriander grown under polyhouse (2.40). High B: C ratio in fenugreek may be due to high market rates due to less supply, while, it was minimum (1.32) in amaranthus grown under open field. Similar results were also obtained by Sonwal *et al.*, (2004); Singh *et al.*, (2007) and Bhargava *et al.*, (2016).

# SUMMARY AND CONCLUSIONS



## CHAPTER-VI

### SUMMARY AND CONCLUSIONS

The present experiment entitled “Influence of different growing conditions on growth, yield and quality of leafy vegetables” was conducted at Department of Horticulture, VNMKV, Parbhani during *Kharif* season of 2016. The main aim of present study was to see the effect of growing conditions on growth, yield and quality of leafy vegetables and to findout more profitable leafy vegetable suitable for growing under polyhouse condition. The experiment was laid out in Factorial Randomized Block Design (FRBD) with four leafy vegetables grown under two different conditions and replicated thrice. The results of the present investigation are summarized as below.

#### 6.1 Summary

##### 6.1.1 Metrological parameters

The results showed that, under polyhouse condition the maximum temperature was ranged between 31.89- 35.61<sup>0</sup>C, relative humidity between 83.00- 95% and light intensity between 1214- 20285 Lux. Under open field condition the maximum temperature was ranged between 29.30- 32.40<sup>0</sup>C, relative humidity between 53.00- 85% and light intensity between 16885- 76114 Lux. The mean highest temperature (33.27<sup>0</sup>C) and relative humidity (91.28%) was recorded under polyhouse growing condition, while, it was lower in open field condition. However, the mean light intensity was highest (43,781 Lux) under open field growing conditions. While, it was lower (4,686 Lux) under polyhouse conditions during the experimental period.

##### 6.1.2 Growth attributes

Regarding the growth attributes of different vegetables it was observed that, the different growth parameters were significantly influenced due to growing conditions. The high germination percentage, and the higher values of growth attributes *viz.* plant height, No. of branches per plant, No. of leaves per plant, leaf length, leaf width, leaf area, No. of stomata, length of whole plant, length of shoot, length of root, dry weight of whole plant, dry weight of shoot, dry weight of root and minimum days to potential germination (7.75) and days required for horticultural maturity (30.00) were recorded under polyhouse condition as compaired to open field

conditions, except root: shoot ratio which was recorded maximum under open field condition. Among the leafy vegetables, amaranthus recorded higher germination percentage, and showed better performance with respect to most of the growth attributes of the plant. It has also taken less number of days (4.73) for potential germination and days required to horticultural maturity (33.00). However, the higher leaf length, leaf width, leaf area and No. of stomata were observed in beet leaf. In the interaction effect of growing condition and the leafy vegetables it is also observed that the polyhouse grown amaranthus has shown better results in respect of most of the growth parameters, while, beet leaf produced under polyhouse recorded maximum leaf length, leaf width, leaf area, No. of stomata and fenugreek produced under polyhouse required minimum (30.67) days to horticultural maturity and maximum root: shoot ratio (0.41 length basis) was recorded in fenugreek grown under open field.

### **6.1.3 Yield parameters**

With regards to the yield parameters it was observed that, the different yield parameters were significantly influenced due to growing conditions. The higher yield and yield attributes *viz.* fresh weight of whole plant, fresh weight of shoot, fresh weight of root, yield per plot (2.60 Kg) and yield 7.14 t/ha was recorded under polyhouse condition as compared to open field conditions. Among the leafy vegetables amaranthus recorded higher yield attributes and yield. The amaranthus produced under polyhouse condition recorded maximum fresh weight of whole plant (50.36g), fresh weight of shoot (44.87g), fresh weight of root (5.49g), yield per plot (3.45 Kg) and yield 9.49 t/ha.

### **6.1.4 Quality parameters**

Different quality parameters were also significantly influenced due to growing conditions. The vegetables produced under polyhouse condition have recorded the higher values of the quality parameters, *viz.* vitamin A (8268.52 IU/100 g), vitamin C (84.15 mg/100 g), calcium content (324.15 mg/100 g), Iron content (17.95 mg/100 g), total chlorophyll content (38.90 SPAD value), shelf life (4.67 and 11.25 days at ambient and refrigerator storage) and less PLW (45.85 and 14.76 % at ambient and refrigerator storage) as compared to vegetable produced under open field conditions. Among the leafy vegetables coriander recorded higher vitamin A (10460.49 IU/100g),

vitamin C (133.31 mg/100g) and shelf life (5.01 and 10.49 days at ambient and refrigerator storage) and lees PLW (48.14 and 13.59 % at ambient and refrigerator storage). The higher Iron content (19.35mg/100g) was observed in amaranthus. The fenugreek recorded higher calcium content (375.49 mg/100g) and total chlorophyll content (47.13 SPAD value) than other leafy vegetables. The results of interaction effect with respect to the quality of vegetables showed that the high vitamin A (10821 IU/100g), vitamin C (134.78 mg/100g) and shelf life (6.03 and 12.00 days at ambient and refrigerator storage respectively) and less PLW (36.83 and 10.33 % at ambient and refrigerator storage respectively) was recorded in coriander produced under polyhouse. The higher Iron content (20.70 mg/100g) was recorded in amaranthus produced under polyhouse. The fenugreek produced under polyhouse recorded high calcium content (382.66 mg/100g) and total chlorophyll content (48.48 SPAD value).

#### **6.1.5 Economics**

The cost of cultivation of leafy vegetables was maximum (Rs.1,62,848/ha) under polyhouse growing condition and recorded maximum values of gross monetary (Rs.3,84,875/ha), Net monetary (Rs.2,22,027/ha) returns and B: C ratio (2.36). Among the leafy vegetables low cost of cultivation (Rs.66,598/ha) was required for amaranthus. While, the highest gross monetary returns (Rs.2,76,800/ha), Net monetary returns (Rs.1,60,620/ha) and B: C ratio (2.15) was recorded in fenugreek. The fenugreek produced under polyhouse recorded the maximum values of gross monetary (Rs.4,45,600/ha), Net monetary (Rs.2,82,295/ha) returns and B: C ratio (2.72) and it was followed by coriander grown under polyhouse condition.

#### **6.2 CONCLUSION**

The critical evaluation of the results of the present study indicated that the growing conditions had a significant effect on different metrological parameters. The high temperature, more humidity and lower light intensity was observed under polyhouse growing condition as compared to open field condition. The growing conditions had also a significant effect on germination, growth, yield and quality of different leafy vegetables. The polyhouse growing condition has provided better growing situation for germination, growth and high production of quality produce resulting in high monetary returns and higher B: C ratio. However, the high cost of

production is required for polyhouse growing condition. Among leafy vegetables highest B: C was recorded by fenugreek which was closely followed by coriander.

Hence, for judging the suitability and profitability of leafy vegetables during rainy season under polyhouse conditions the order of preference should be given as fenugreek followed by coriander, beet leaf and amaranthus. As these results are based on one season trial, it is suggested to conduct few more trials to arrive at concrete conclusion.



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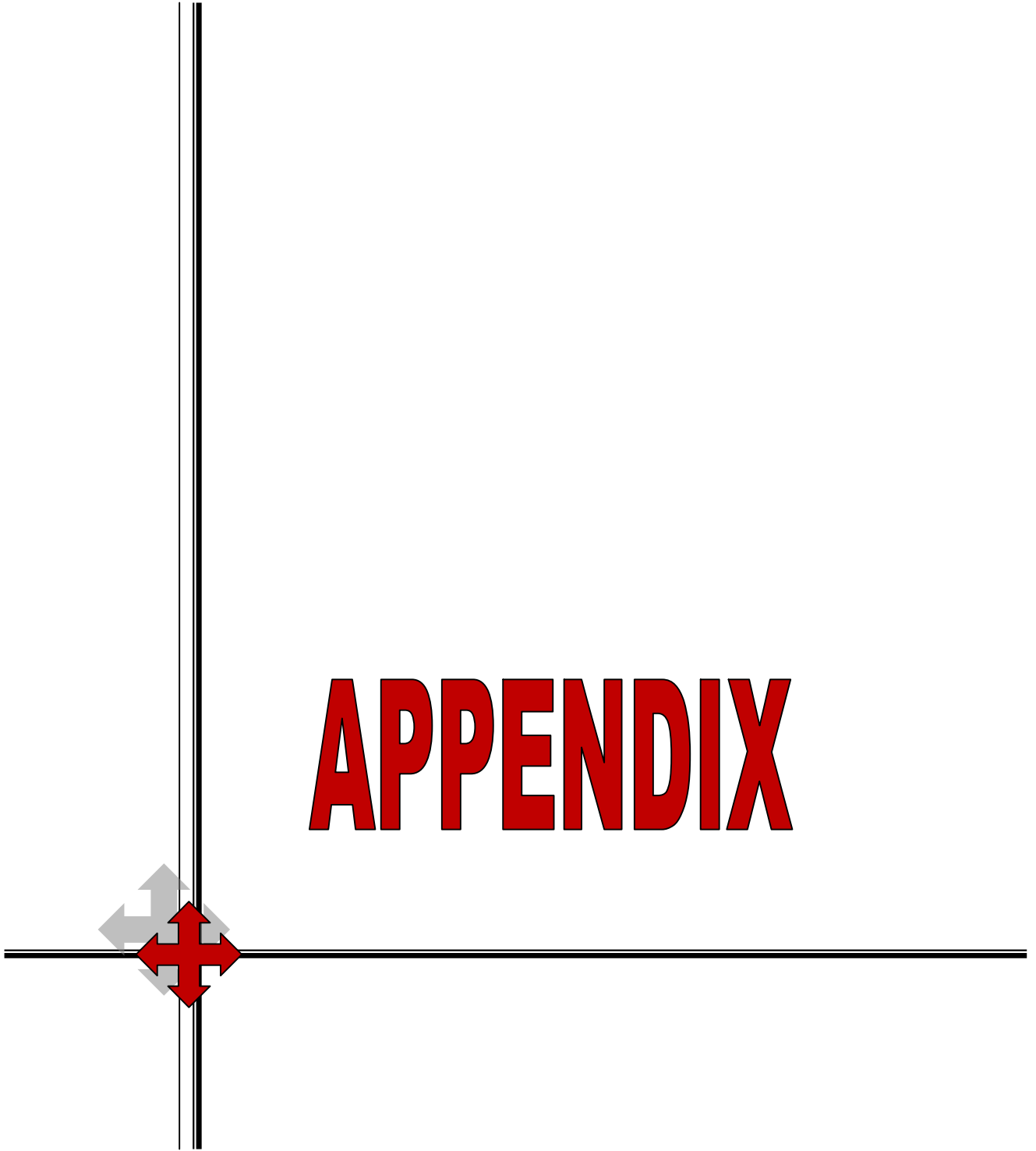
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# APPENDIX



## APPENDIX

**Appendix-I. Weekly weather data during the course of investigation under open field.**

Met. Week	Date	Rain Fall (mm)	Rainy days (No.)	Temperature (°C)		Humidity (%)		EVP (mm)	BSS (Hrs.)	WV (Kmph)
				Max.	Min.	Max.	Min.			
34	20-26 Aug.	13.0	2.0	32.4	21.4	87	53	5.2	8.0	4.4
35	27-02 Sept.	71.5	5.0	31.0	22.5	92	68	4.2	4.2	3.6
36	03-09 Sept.	1.5	0.0	30.9	20.7	81	58	5.3	8.8	5.0
37	10-16 Sept.	101.6	3.0	29.3	22.4	88	78	3.6	1.7	4.6
38	17-23 Sept.	109.1	4.0	29.6	22.3	96	85	2.9	2.5	3.4
39	24-30 Sept.	96.9	4.0	30.2	21.7	91	73	3.3	3.7	4.7
40	01-07 Oct.	109.5	3.0	29.4	21.3	93	72	3.4	5.3	3.9
<b>Total/Mean</b>		<b>503.10</b>	<b>21.00</b>	<b>30.40</b>	<b>21.76</b>	<b>89.70</b>	<b>69.56</b>	<b>3.98</b>	<b>4.88</b>	<b>4.22</b>

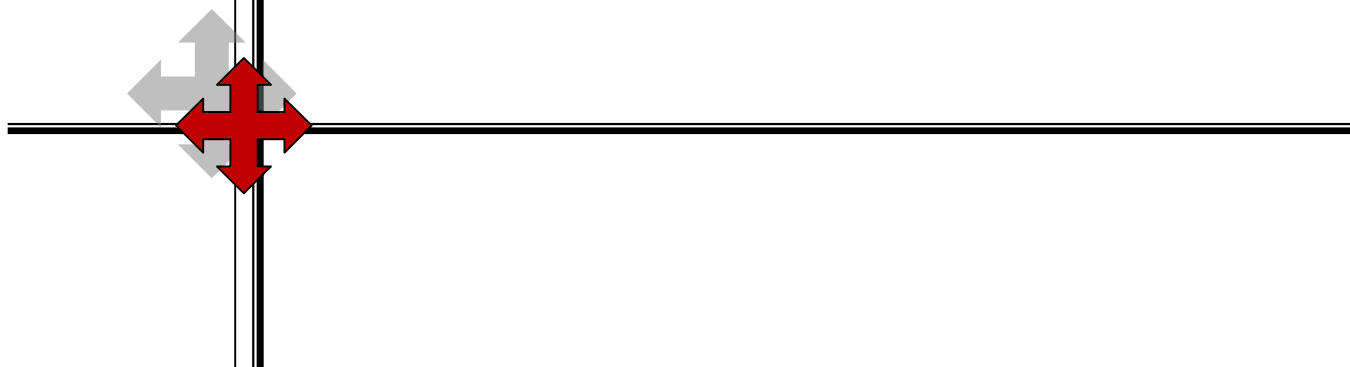
**Appendix-II. Schedule of cultural operations.**

Sr. No.	Particulars		Date of cultural operations		
			Open field	Polyhouse	
1	Field preparation	Ploughing/ digging		01/07/2016	01/07/2016
		Harrowing		13/07/2016	13/07/2016
				20/07/2016	20/07/2016
		Cleaning of field		17/07/2016	17/07/2016
		Application of FYM		19/07/2016	19/07/2016
		Soil sterilization		-	23/07/2016
Layout and preparation of plot		03/08/2016	03/08/2016		
2	Seed and sowing	Rubbing of coriander seed		17/08/2016	17/08/2016
		Seed treatment and sowing		20/08/2016	20/08/2016
3	Fertilizer application	Basal dose	All crops	20/08/2016	20/08/2016
		Remaining half dose of 'N'	Amaranthus, Beet leaf, Fenugreek	02/09/2016	02/09/2016
			Coriander	09/09/2016	09/09/2016
4	Intercultural operations	Thinning	Amaranthus, Beet leaf, Fenugreek	26/08/2016	26/08/2016
			Coriander	09/09/2016	09/09/2016
		Weeding		02/09/2016	09/09/2016
				09/09/2016	
		Plant protection	Insecticide + Fungicide	02/09/2016	09/09/2016
09/09/2016					
5	Irrigation	Pre sowing		-	30/07/2016
		At sowing		20/08/2016	20/08/2016
		After sowing		-	26/08/2016
				-	02/09/2016
				09/09/2016	09/09/2016
				-	16/09/2016
				-	23/09/2016
				-	30/09/2016
-					
6	Harvesting and marketing		07/10/2016	07/10/2016	
			08/10/2016	08/10/2016	

**Appendix-III. Details on cost of cultivation of leafy vegetables under different growing conditions.**

Sr. No.	Particulars	Open field	Poly-house
<b>Cost structure</b>			
A) Common cost			
1	Field preparation	5250	10000
2	Bed preparation	2000	4000
3	Manures	8000	8000
4	Irrigation	1000	5000
5	Plant protection	5000	3000
6	Weed control	3000	1500
7	Harvesting	12000	20000
8	Subtotal (1 to 7)	32250	55500
9	Interest on working capital	7000	13000
10	Variable cost (8+9)	39250	68500
11	Marketing cost	8000	18000
12	Depreciation and interest on fixed capital	-	50000
13	Rental value of land	10000	17000
14	Subtotal (10 to 13)	57250	153500
B) Other cost			
15	Seed cost		
	1) Amaranthus	220	220
	2) Beet leaf	2450	2450
	3) Coriander	4400	4400
	4) Fenugreek	4800	4800
16	Fertilizer cost		
	1) Amaranthus	6005	6005
	2) Beet leaf	6005	6005
	3) Coriander	7507	7507
	4) Fenugreek	6005	6005

**VITAE**



## VITAE

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### MR. GARDE ANGAD PRAKASH

A candidate of the degree of  
MASTER OF SCIENCE (HORTICULTURE)

In  
**Vegetable Science**

2018

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