"INTERCROPPING STUDIES IN BANANA (*Musa paradisiaca* L.) CV. 'GRAND NAINE' UNDER DRIP IRRIGATION"

A

THESIS

SUBMITTED TO THE

FACULTY OF AGRICULTURE

NAVSARI AGRICULTURAL UNIVERSITY

NAVSARI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR

THE AWARD OF THE DEGREE

OF

MASTER OF SCIENCE

(AGRICULTURE)

IN

HORTICULTURE

BY

MAHANT HIMANSHUBHAI DINESHBHAI

B.Sc. (Agri.)

DEPARTMENT OF HORTICULTURE

N. M. COLLEGE OF AGRICULTURE

NAVSARI AGRICULTURAL UNIVERSITY

NAVSARI – 396 450

MAY-2011

Registration No.: 04-0622-2009

INTERCROPPING STUDIES IN BANANA (*Musa paradisiaca* L.) CV. 'GRAND NAINE' UNDER DRIP IRRIGATION

Name of Student	Major Advisor
Mr. Himanshu Mahant	Dr. S. J. Patil

DEPARTMENT OF HORTICULTURE
N. M. COLLEGE OF AGRICULTURE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI – 396 450

ABSTRACT

The experiment on "Intercropping studies in banana (*Musa paradisiaca* L.) cv. 'Grand Naine' under drip irrigation" was conducted at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari during the month of October 2009 to September 2010 to explore the possibility of increasing monetary return from banana based intercropping system by optimizing vegetables and planting pattern combination.

A field experiment was conducted in Randomized Block Design with four replications which included nine treatment combinations with banana comprising (1) Area under intercrops like A_1 - 25% (Cauliflower) and 27% (Onion & Garlic) (Without lateral shifting), A_2 - 33% (With lateral shifting in between rows), A_3 - combination of both above described and (2) Three intercrops *viz.*, onion, garlic and cauliflower. Sole crops were grown outside the experimental plot as control. Effects of intercropping pattern were assessed by recording influence of treatments on growth, yield, and quality parameters along with LER and economic feasibility of the system.

Experimental results revealed that growth parameters *viz.*, plant height, girth of pseudostem, number of leaves and leaf area of banana reduced due to intercropping at 3rd and 5th months after planting. However, banana when intercropped with onion, garlic and cauliflower showed similar growth as in sole banana. In contrast to these traits, days required to inflorescence emergence and harvesting did not influence significantly due to various treatments.

Yield and yield attributes also affected due to imposition of intercrops and reduction were increased under cauliflower. However, intercropping remain non-significant for yield attributes *viz.*, number of hands per bunch, average weight of finger, number of finger per bunch, length and girth of finger. However, treatment banana + garlic (A_2) gave higher yield attributing characters. Maximum bunch weight as well as yield were recorded under banana + garlic (A_2). Among intercrops, cauliflower caused severe reduction in banana yield under all planting patterns. Quality of banana remained unaffected due to intercropping. Here also garlic (A_2) intercropping under all planting patterns recorded higher quality than sole banana.

In different intercropping patterns (area under coverage) A_1 intercropping pattern recorded maximum growth, yield and yield attributes in all three intercrops individually.

Economic assessment of the intercropping system indicated that banana with onion (A_3) most profitable system under drip irrigation. Which recorded higher banana equivalent yield, land equivalent ratio and net realization while, benefit cost ratio was maximum under banana with garlic (A_3).

Dr. S. J. Patil
Associate Professor (Fruit Science)
ASPEE College of Horticulture and Forestry
Navsari Agricultural University
Navsari – 396 450.

CERTIFICATE

This is to certify that the thesis entitled **"INTERCROPPING STUDIES IN BANANA (*Musa paradisiaca* L.) CV. 'GRAND NAINE' UNDER DRIP IRRIGATION"** submitted by Mr. **MAHANT HIMANSHUBHAI DINESHBHAI** in partial fulfilment of the requirement for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **HORTICULTURE** of Navsari Agricultural University, Navsari is a record of bona fide research work carried out by him under my guidance and the thesis has not previously formed on the basis for the award of any degree, diploma or other similar title.

Place: Navsari
Date: 16th May, 2011

Major Advisor

(S. J. Patil)

DECLARATION

This is to declare that the whole of the research work now submitted in this thesis for the partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** is the result of investigation done by me under direct guidance and supervision of **Dr. S. J. Patil**, Associate Professor (Fruit Science), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

Place : Navsari

Date : 16th May, 2011

H.D. Mahant

(Mahant Himanshu D.)

Countersigned by

Dr. S. J. Patil

Associate Professor (Fruit Science)

ASPEE College of Horticulture and Forestry

Navsari Agricultural University

Navsari – 396 450

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ACKNOWLEDGEMENTS

I express my infinite sense of gratitude to the Lord Saibaba for continuously providing me spiritual energy, which has inspired me to reach at the highest excellence during my academic career

Indeed the words at my command are not adequate to convey the depth of my feeling and gratitude to my Major Advisor **Dr. S. J. Patil, Associate Professor (Fruit Science), ASPEE College of Horticulture & Forestry, Navsari Agricultural University, Navsari** *for his most valuable and inspiring guidance with his friendly nature, love and affection, for his attention and magnanimous attitude right from the first day, constant encouragement, enormous help and constructive criticism throughout the course of this investigation and preparation of this manuscript.*

I feel a great pleasure in getting this proud privilege offering my sincerest and devoted thanks to my Minor Advisor **Dr. S. R, Patel,** *Professor (Plant Physiology), NARP, Navsari Agricultural University, Navsari and other members of my advisory committee* **Dr. B. R, Parmar,** *Associate Professor, (Horticulture) and* **Dr. J. D. Awadaria,** *Associate Professor (Agricultural Statistics), N. M. College of Agriculture for their worthy suggestions, ever willing help and unbiased attitude throughout the course of this investigation.*

I acknowledge with thanks for the facilities provided by **Dr. C. L. Patel,** *Ret. Principal, N. M. College of Agriculture and* **Dr. R, G. Patil,** *Research Scientist, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari during the course of my studies. I also acknowledge the authority of Navsari Agricultural University for providing me* **Junior Research Fellowship** *during post graduation.*

I express my heartfelt thanks to **Dr. B. N. Kolambe** *(Research Scientist),* **Dr. K. G. Patel** *(Associate Professor),* **Dr. V. S. Patel** *(Associate Professor) and* **Dr. A. R, Kaswala** *(Assistant Professor) Organic Farm of ACHF,* **Er. B. M. Solia, Er. N. G. Savani,** *and* **Dr. D. R, Prajapati**

Associate Research Scientist, Soil and Water Management Research Unit, Manojbhai, Mukeshbhai, Atikbhai, Satishbhai, Sandipbhai, Kalpeshbhai, Jitu, Dharmesh, Ramanbhai, Shailesh, Lambu and all staff members of SWMRU, and Department of Horticulture, N. M. College of Agriculture for providing me all the facilities and guidance required for the research work.

I wouldn't like to forget the incredible cooperation of my best friends Hiren Kotadia, Bhavesh Patel, Boby, Rajvirsinh Mahida, Bijendrasinh Mahida and Pushprajsinh Solanki for the excellent company, love, support and encouragement.

Though thank is a taboo in friendship, my conscience does not permit to refrain myself from expressing my heartfelt feeling towards my beloved friends Vinay, Jinesh, Nirav, Ryan, Bhavin, Ashish, Sunil, Pratik, Naresh, Jenish, Diptibhabhi, Rinu, Hetal, Nilam, Bhavya, Dr.Kaushal, Dr.Virendra, Dr.Ukani, Ketan, Mukesh, Rajpalsinh, Hemantbhai, Tusharbhai, Pankajbhai, Rahulbhai, Dhirajbhai, Prakashbhai, Italiyabhai, Devid, Nitin, Mukund, Vipul and all other friends who gave direct and indirect sympathetic touch for completion of my research work and their jolly company made my life richer.

Diction is not enough to express my gratitude to my father Mr. Dineshbhai M. Mahant, mother Mrs. Bhanuben D. Mahant, younger sister Jagrutiben, Amitaben, niece Pooja, Bhakti, nephew Dev, Prasun, jiju Sanjaybhai, Nirajbhai, cousin Big B, Niralibhabhi, Ketanbhai, Hiren and other family members whose selfless love, constant encouragement, obstinate sacrifices, sincere prayers, expectations and blessings have always been vital source of inspiration in my life.

Now, as I carry this in my hand, I carry with me memories that will enrich my nostalgia.

Place: Navsari

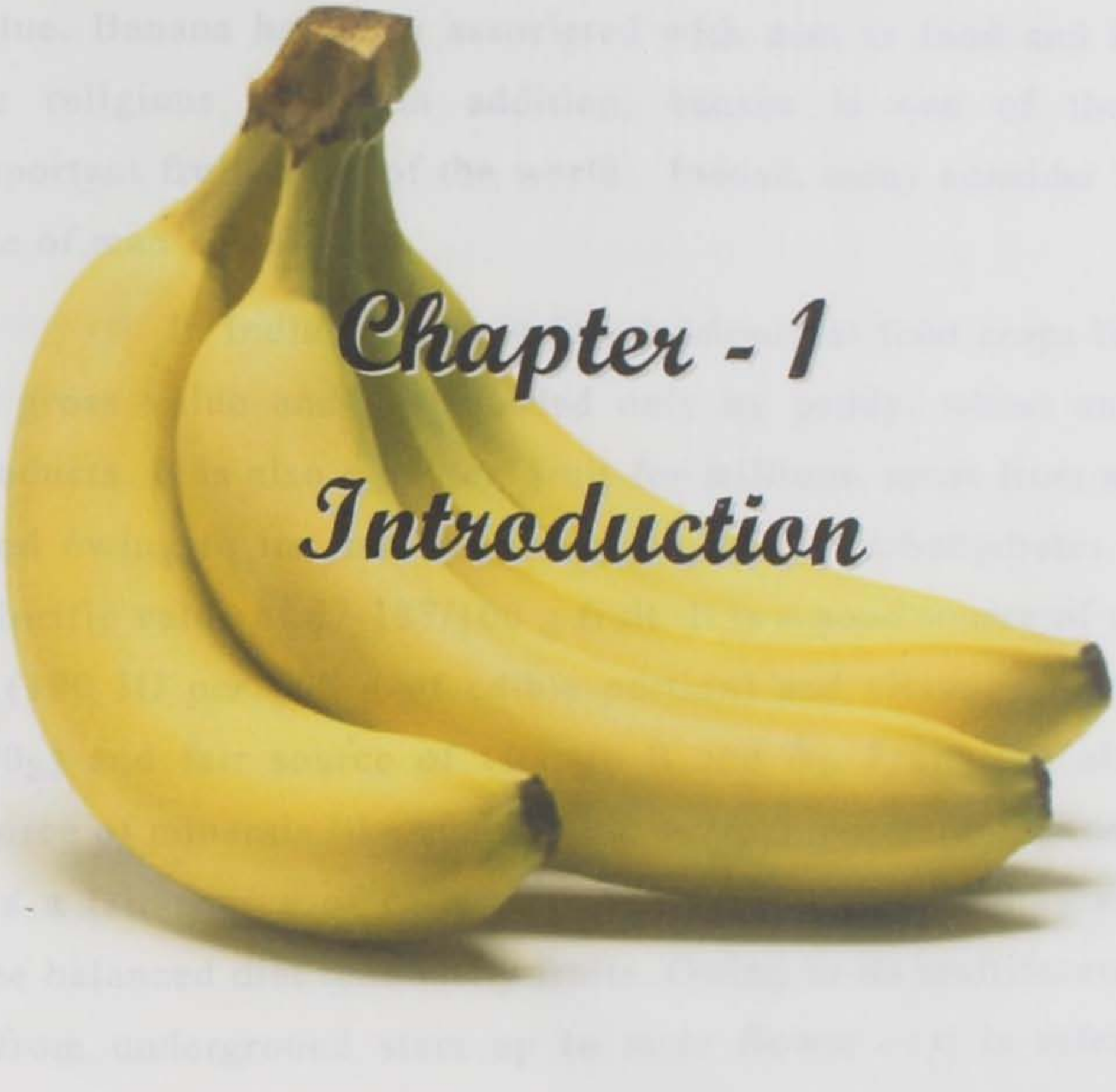
Date: 16th May, 2011

H.D.Mahant

(Mahant Himanshu D.)

ABBREVIATIONS

SN	Abbreviation	Meaning
1	Anon	Anonymous
2	℃	Degree centigrade
3	C.D.	Critical difference
4	cv.	Cultivar
5	C.V.	Co-efficient of variance
6	*et al.*	*Et allii*, (and others)
7	R.B.D.	Randomized Block Design
8	Fig.	Figure
9	g	Gram
10	ha	Hectare
11	hrs	Hours
12	kg	Kilogram
13	S.Em.	Standard error of mean
14	Temp.	Temperature
15	Var.	Variety
16	*viz.*	Such as
17	%	per cent
18	CD	Critical difference
19	DAP	Days after planting
20	etc.	etceteras
21	FYM	Farm yard manure
22	NS	non significant
23	t	tonnes
24	^{0} Brix	Degree brix



Chapter - 1

Introduction

I. INTRODUCTION

Banana (*Musa paradisiaca* L.) is a large herbaceous perennial monocotyledonous and monocarpic crop. Banana belongs to the family Musaceae in the order Scitamineae. Banana is known as "Apple of Paradise". Its origin is the tropical region of South-East Asia. Banana crop have nutritional, medicinal and industrial value. Banana has been associated with man as food and is used for religious work. In addition, banana is one of the most important fruit crops of the world. Indeed, many consider banana one of man's first food.

In India, banana is fourth important food crops in terms of gross value and is exceeded only by paddy, wheat and milk products. It is also a dessert fruit for millions, apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67-137/100 g fruit. It is a good source of vitamin A (190 IU per 100 g of edible portion) and vitamin-C (100 mg/ 100g) and fair source of vitamin B and B_2. Fruits are also rich source of minerals like magnesium, sodium, potassium, phosphorus and a fair source of calcium and iron. It makes healthy and salt free balanced diet than many fruits. Owing to its multifaceted uses - from underground stem up to male flower – it is referred as *Kalpatharu* (a plant of virtues). One hectare of banana yields 37.5 million calories of energy as compared to 2.5 million calories from wheat and multifarious uses. About 24 bananas each weighing around 100 g would provide the energy requirement (2400 calories per day) of a man (Singh, 2002).

India is the largest banana consumer and producing country in the world followed by Brazil, contributing about 15 per cent of the total world production. Among the fruits, banana holds first position in production and productivity in India. It ranks second in area after mango. In India, annual production of banana is 26.21 million tones from an area of 7.09 lakh hectares spread all over the country (Anon., 2009c). Banana covers 12.50 per cent of the total area under fruits, contributing nearly one third of total fruit production in the country. In India, Tamil Nadu, Maharashtra, Karnataka, Kerala, Assam and Gujarat are the leading banana producing states. The highest productivity is 62.0 tones ha^{-1} in Maharashtra followed by Gujarat 58.7 t ha^{-1} in the year 2008-09 (Anon., 2009c).

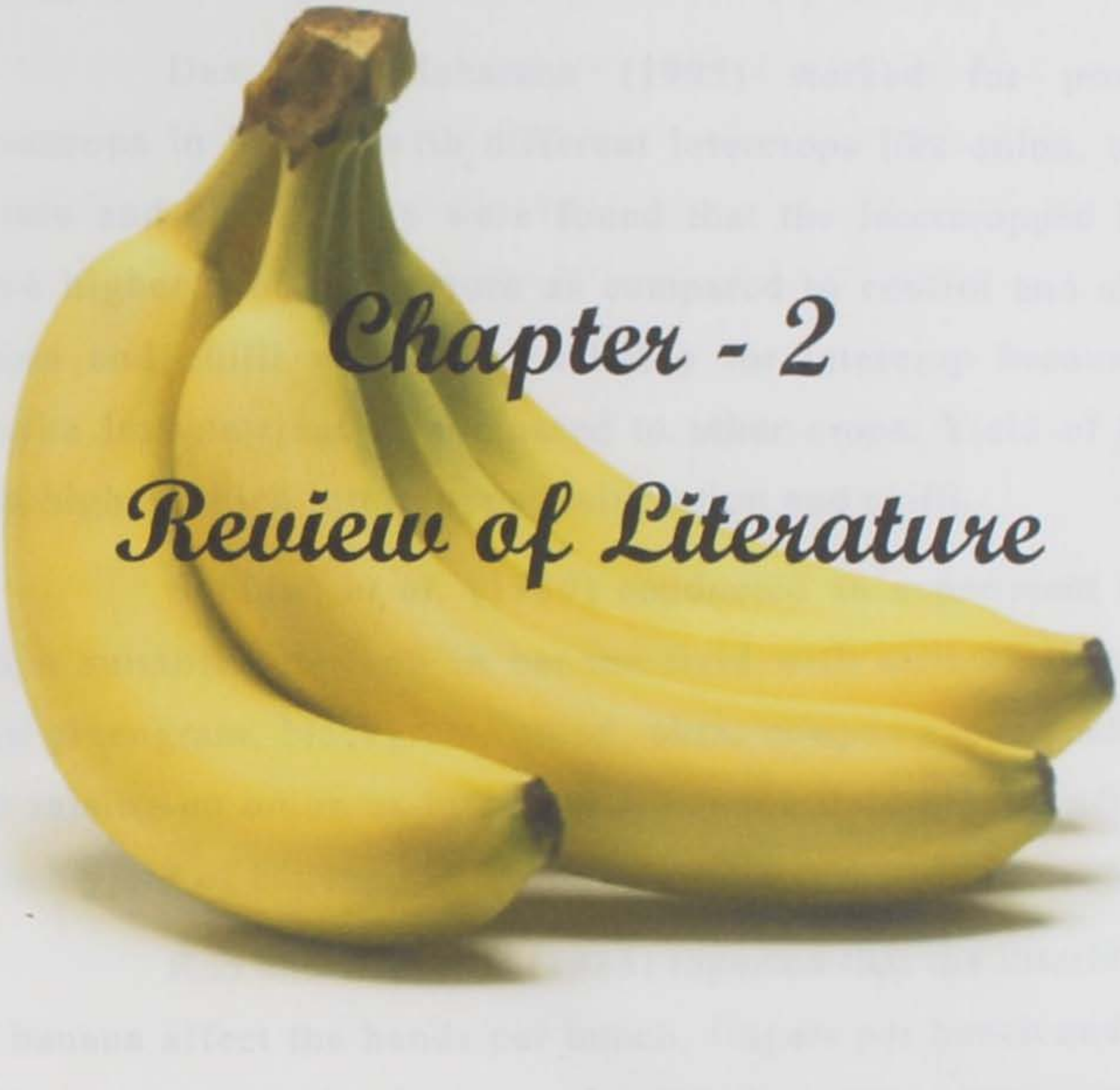
In Gujarat, banana covers an area of 61,919 hectares with production of 37,79,811 metric tones. The largest area is covered under Bharuch district with an area of 14,400 hectares with the highest production of 9,36,288 metric tones. Navsari district covers an area of 450 hectares with a production of 25,200 metric tones annually (Anon., 2009b). Banana is cultivated in the districts of Bharuch, Surat, Anand, Narmada, Junagadh, Vadodara, Navsari and Valsad because of favorable agro-climatic conditions and abundant supply of well and canal irrigation water. It is also very important crop of these districts because annual rainfall received in this region is around 70 inches. It is one of the most important fruit crop of South Gujarat region. District wise area and production estimated of banana fruit crop in the year 2009-10 is shown in appendix-I.

India is one of the horticultural rich countries of the world, produces large varieties of fruits, and banana is one of these. Since the last 50 years, a considerable research work has been done in the country on various aspects such as varieties, irrigation, weed management, spacing, post harvest technology etc. for increasing yield and quality of banana fruits. The varied agro-climatic conditions provide an enormous scope for the cultivation of tropical and subtropical fruits to maintain the inflow of almost all varieties throughout the years.

Initial growth of banana is slow which offers an opportunity to take short duration intercrop like onion, garlic, cauliflower, cabbage *etc*. There has been an increase in the grower interest in using intercropping, growing two or more crops simultaneously on the same land in the development of new cropping system for their land. Intercropping could reduce management inputs and results in sustainable systems that more effectively use and even potentially replenish natural resources used during crop production for long term management of farmland. Some benefits of intercropping to grower are risk minimization, effective use of available resources, efficient use of labours, increased production per unit area of land, control erosion and food security. However, with adoption of drip method of irrigation in banana, it is possible to grow intercrop in between the rows. If intercrop is to be grown in between rows, then separate lateral is to be installed which increase the cost of system. So, there is need to develop intercropping system in drip irrigated banana which will enhance the water use efficiency as well as net

income. Keeping this aim in mind an oriented research has been carried out on popular variety of banana cv. 'Grand Naine' with following objectives:

1. Find out suitable intercrop in drip irrigated banana.
2. Workout land equivalent ratio for different intercrops in drip irrigated banana.
3. Compute economics of different treatments in drip irrigated banana.



Chapter - 2

Review of Literature

II. REVIEW OF LITERATURE

Research work on intercropping in banana in India as well as in abroad is very meagre. However, available research works on this aspect in main crop and in related crop carried out at various places in India as well as in abroad have been reviewed briefly in this chapter,

Das and Maharana (1995) worked for profitable intercrops in banana with different intercrops like onion, tomato, potato and chilli. They were found that the intercropped banana gave higher economic return as compared to control and also the onion and chilli were more suitable for intercrop because they uptake less nutrient as compared to other crops. Yield of banana was higher which intercropped with onion and chilli.

Subbiah *et al.* (1980) conducted an experiment to find out a suitable intercrop in banana field with different intercrops like greengram, blackgram, onion, okra, cowpea and revealed that the raising an onion as intercrop in banana field did not affect the bunch yield of banana.

Rao and Edmunds (1983) reported that the intercropping of banana affect the hands per bunch, fingers per bunch and finger weight significantly, but not the bunch weight. The associated growth of intercrops significantly reduces the girth of the pseudostem at five months after planting and increased days to shooting and days to harvesting of the banana. The yield differences within cowpeas and sweet potato were non-significant

due to cropping system; but maize interplanted with cowpeas yielded 16.5% higher than with sweet potato.

Chundawat *et al.* (1982) conducted an intercropping trial in banana cv. Basrai with turmeric, mango turmeric and yam was undertaken in soil series of *Vertic Ustocrepts* and *Typic Chromustarts* of South Gujarat. None of the intercrops reduced the vegetative growth and fruiting of banana. However, yields of mango turmeric and yam were not sufficiently high to compensate for the extra cost on the fertilizers and planting material. The results suggested that intercropping of banana with turmeric would prove profitable to the banana farmers of South Gujarat.

An experiment was conducted during the year 2000-01 at the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar to study the suitability of elephant foot yam as an intercrop in banana. The results revealed that intercropping of elephant foot yam in banana did not affect on the yield and yield attributing characters of banana and also give high economic returns as compared to sole banana (Nedunchezhiyan *et al.*, 2002).

Singh (2010) conducted a trial on evaluation and economics of different intercrops like okra, pumpkin and bitter gourd in banana. He revealed that the yield, yield attributing characters and B: C ratio found higher in intercropped banana as compared to sole banana. Banana + pumpkin gives highest yield (62.19 t/ha) and B: C ratio (2.41) than sole banana yield (51.63 t/ha) and B: C ratio (1.45).

An experiment was conducted at GAU, Navsari to study the feasibility of intercropping in banana with turmeric under mini sprinkler and revealed that the yield and economics of intercropped banana is significantly higher than the sole banana (Anon., 2001a).

An experiment was conducted at GAU, Paria to study the irrigation and intercrop management in banana with different intercrops like Long melon, Bottle gourd, Cucumber and report revealed that higher yield (85.37 t/ha) and economics (172.4 '000/ha) were obtained in intercrop with Bottle gourd than the other intercropped banana and sole banana (Anon., 2001b).

Rahman *et al.* (2006) worked on suitable banana based intercrop combination and reveal that highest yield and all the growth parameter found in sole banana crop as compared to intercropped banana, but the land equivalent ratio and economic was higher in all intercropping than sole cropping. The combination of banana (Ranginsagar) + potato gave the highest LER (1.68) and BCR (1.95) than the sole crop LER (1) and BCR (1.84).

Randhawa and Sharma (1972) suggested that when banana plants planted at 2.5 × 2.5 m or 2.5 × 2.0 m, two short duration crops with combination of cereal and legume, cereal and vegetable, cereal and oil seeds can be taken. With closer spacing of 1.6 × 1.6 m, as in Maharashtra, only one crop of radish followed by short duration legume like green gram is possible during the initial 3-5 months after planting, the most remunerative

combination being *moong*-ginger for northern and eastern zone giving a net profit of Rs. 7312 and field beans-squashes for southern zone giving Rs. 3330 from the intercrops. The growth habit of banana can permit taking only one crop during the early part of growth.

An investigation carried by Ashokan *et al.* (1988) to study the relative uptake of ^{32}P by cassava, banana, elephant foot yam and groundnut in intercropping systems. The result showed that the yield and dry matter (g/plant) production of banana does not affected by intercropping.

Ouma (2009) studied that banana are extensively grown where they are mainly intercropped with short term crops. There has been an increase in the grower interest in using intercropping, growing two or more crops simultaneously on the same land in the development of new cropping systems for their land. Intercropping could reduce management inputs and result in sustainable systems that more effectively use and even potentially replenish natural resources used during crop production for long term management of farmland. Benefits of intercropping to grower are risk minimization, effective use of available resources, efficient use of labour, increased production per unit area of land, erosion control and food security.

Elangovan *et al.* (1980) conducted a trial on intercropping of onion in chill and revealed that the plant height of chilli was not affected significantly by the growth of onion but yield of sole crop is higher than the intercropped chilli.

Meenakshi *et al.* (1974) revealed that intercropping of coriander, onion, palak and radish in *rabi* season with solanaceous vegetable crops is always profitable.

The result generated from an experiment conducted at Bhagalpur (Bihar) indicated that among different intercrops in mango orchard, *rabi* vegetable onion produced maximum yield (26.68 q/ha) which was superior to rest of the crops. That also gave higher net return *i.e.* 83762.98 Rs.ha^{-1} (Singh *et al.* 2001)

A field experiment was carried out on crop land use efficiency in sequential intercropping systems with vegetables by Prabhakar and Shukla (1990) at IIHR (Bangalore). In sequential intercropping systems with vegetables, onion based intercropping system gave higher economic return and crop land use efficiency as compared to other systems.

Rodge and Yadlod (2009) conducted a trial to study intercropping in vegetables and reported that intercropping with onion gave higher net profit as compared to sole crop and other intercrops.

An experiment was conducted at CSSRS, NAU, Danti, (Ubharat) to study intercropping in castor. Castor was intercropped with brinjal, barley, wheat and onion. The results showed that different intercropping treatments were produce significant impact on castor equivalent yield. Castor equivalent yield 4336 kg/ha was significantly higher with the treatment T_5 (*i.e.* intercropping of castor with onion) than rest of the intercrops (Anon., 2009d).

Mahadevaswamy and Martin (2003) were conducted field experiment at TNAU, Coimbatore to study the effect of aggregatum onion intercropping in wide row spaced sugarcane on the total productivity and economic advantage. They reported that onion did not affect the yield of base crop of sugarcane. The intercropping of aggregatum onion significantly increases the total productivity as well as gross and net returns as compared to sole crop of sugarcane.

An investigation was carried out by Mollah *et al.* (2007) to study the performance of intercropping groundnut with garlic and onion. The results showed that groundnut intercropped with onion and garlic produced higher groundnut equivalent yields (2.67 and 2.94 t/ha, respectively) with higher gross margin. It also gave higher B:C ratio.

The results generated from an experiment conducted at Rajshahi (Bangladesh) indicated that mustard intercropped with garlic and onion gave highest mustard equivalent yield as compared to sole mustard. Mustard blocks intercropped with garlic gave highest cost-benefit ratio which followed by onion intercropped blocks. Sole mustard blocks produced lowest cost-benefit ratio in both the seasons (Sarker *et al.*, 2007).

Morsy *et al.* (2009) conducted a trial on effect of garlic and onion extracts or their intercropping on suppressing damping-off, powdery mildew disease and growth characteristics of cucumber. They reported that intercropped cucumber produced

more numbers of leaves and flowers per plant as compared to sole cucumber during both the years.

An investigation was carried out by Randhawa *et al.* (1999) to study the interactive relationship between growth and yield characters of autumn sugarcane and associated cultures and revealed that among different treatments, sugarcane alone produced the highest cane yield of 149.94 t/ha but it did not differ significantly from that of either lentil or peas or garlic intercropped in sugarcane. But the net income from garlic based intercrop sugarcane gave maximum (50711 Rs/ha), while the minimum (39052 Rs/ha) was noted in sugarcane alone treatment.

Jayakumar *et al.* (2008) study the influence of intercropping and sources of nitrogen on yield attributes, yield and economics of cotton at Coimbatore and revealed that onion based intercropping dose not gave more results as compared to blackgram based intercropping.

The investigation was carried out by Singh *et al.* (1998) on economic prospects of vegetable intercropping in young eucalypts plantation at Pantnagar. The results showed that vegetable intercropping did not cause any adverse effect on the yield and income of eucalypts. Increased growth of eucalypts caused marked reduction in the yield of all the intercrops during second year; the maximum being in onion followed by others. Onion as intercrop gave good net income of Rs. 10,527 during first year but proved a failure in second year.

The results generated from an experiment conducted at Hawaii, indicated that yield increase linearly with evapotranspiration and ranged from 67 t/ha to 130 t/ha. The high drip irrigation level had double the normal accepted yield for a properly managed and sprinkle irrigated banana field. Drip irrigation lines also placed at five different locations around the banana mat using a complete randomized block experiment to determine the effect of different wetting patterns on banana yield. All five treatments received water application equal to pan evaporation and none of the treatments had statistically different yields (Stephon *et al.* 1985).

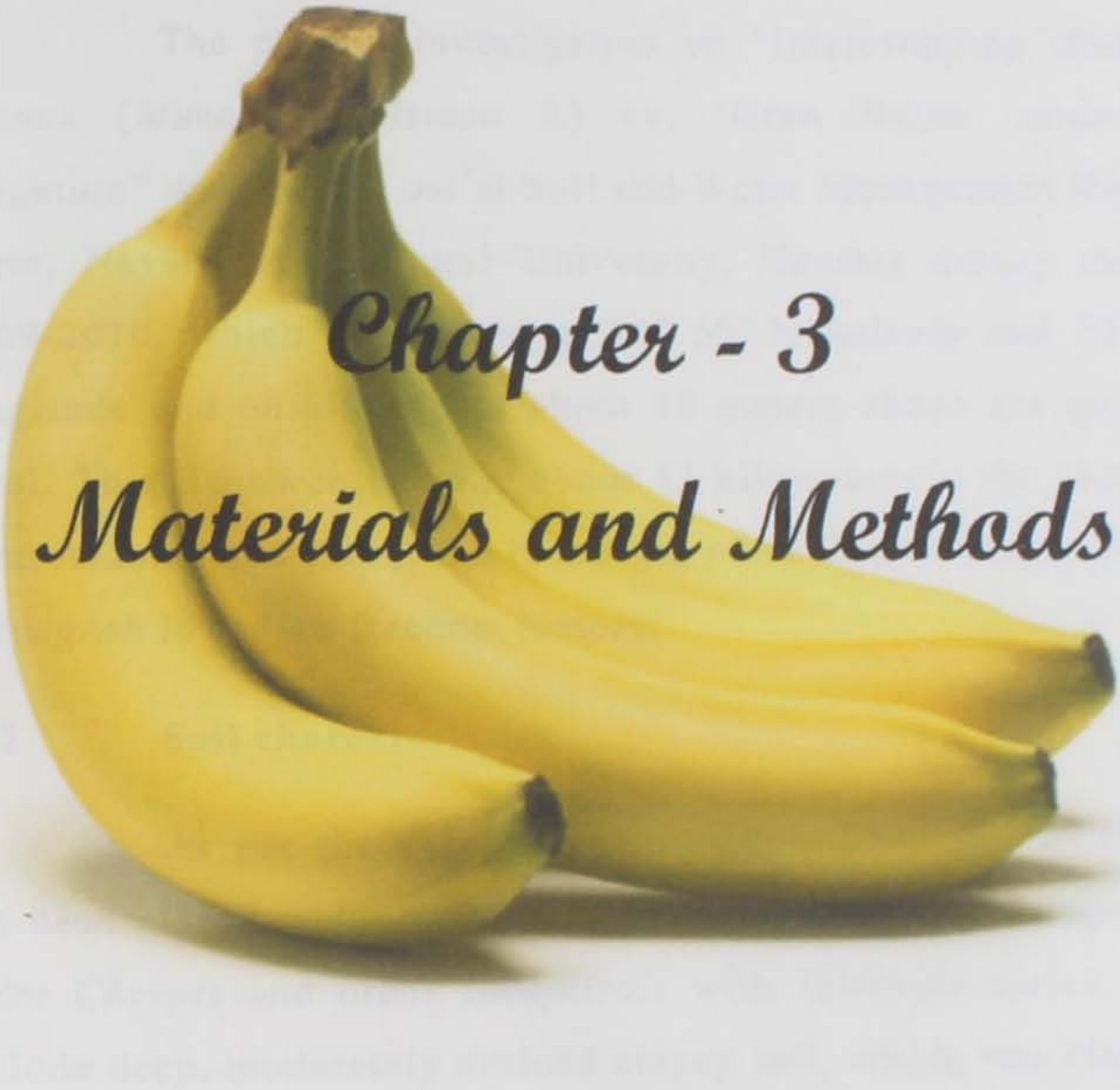
Berad *et al.* (1998) revealed that the normal planting (1.8 × 1.5 m) with application of 100:40:200 g N, P_2O_5 and K_2O per plant (recommended dose) in solid form; but only N (urea) through drip performed well in respect of all yield attributes and registered 15% more yield (68.5 t/ha) and 7% more net returns (Rs. 109130 per ha) as compared to surface irrigation with same planting technique and fertilizer dose. Use of liquid fertilizer registered 25% saving in fertilizer as compared to solid one, but high cost (about 3.5 times) of liquid fertilizers over solid has significantly lessened their economic viability substantially. Normal planting was proved better by increasing yield (8%) and monetary returns (13%) over paired planting (0.9 m-2.7 × 1.5 m), but never the less paired planting reduced drip system cost by 30%, labour cost by 15 to 20% and allowed mechanized and easy cultivation. Drip method of irrigation was found efficient with 47.88% saving in water and 30-35% saving in labour.

An investigation was carried out by Sivanappan (1979) and reported that the drip irrigation system not only saves water, but also increase the yield of banana and other vegetables. The germination and growth of the crop is better with drip irrigation also it increases the fertilizer use efficiency with minimum weed problem. Result indicated that the drip irrigation method can play an important role in improving economy in the areas having limited water resources for vegetable and fruit crops.

Sivanappan *et al.* (1976) conducted trial on drip irrigation in banana and showed that no significant difference in yield between control and drip plots, but the water used in drip method was only about one-fourth of the control. In drip irrigation high capital investment but due less weed problem and less water requirement it is equal to control.

The results generated from an experiment conducted at GAU, Navsari indicated that the sole crop (bottle gourd) showed better performance on various growth parameters such as length of main vine (8.5 m), number of branches from the main vine (29.9), number of flower bud initiation (10.00) at 39 days after sowing, number of male flowers (33.66) and female flowers (14.00). Further, the sole crop treatment recorded the maximum length of fruit (34.25 cm), girth of fruit (26.33 cm) as well as yield of fruits (19.84 t/ha). However, number of flower bud initiated, girth of fruit and yield of sole bottle gourd fruits were at par with bottle gourd + onion. The maximum monetary return (56.66 thousand Rs./ha) was fetched in the bottle gourd + cabbage which was at par

with bottle gourd + cabbage + onion (54.72 thousand Rs./ha) and bottle gourd + onion (52.00 thousand Rs./ha) Borad (1993).



Chapter - 3

Materials and Methods

III. MATERIAL AND METHODS

The details of experimental material used, methods followed, observations taken and the techniques adopted during the course of this investigation are described here under.

3.1 Experimental site

The present investigation on "Intercropping studies in banana (*Musa paradisiaca* L) cv. 'Gran Naine' under drip irrigation" was carried out at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari during the year 2009-2010, which is situated at 20° 57' N latitude and 72°54' E longitude and on altitude of about 10 meters above the mean sea level. This Research Farm is about 11 kilometers in the east away from Arabian sea shore, the historical place Dandi famous for *Salt Satyagrah* in Indian freedom history.

3.2 Soil characteristics

As per the seventh approximation, the soil of Navsari has been placed under the great group of *Vertic Ustocherepts*, Sub order *Chrepts* and order *Inceptisols* with Jalalpore series, which include deep, moderately drained clayey soil, which was classified earlier as "deep black soil". The soil of experimental site is black, deep, and rich in organic matter and potash having good water holding capacity with good drainage. The soil was considered quite suitable for banana crop under South Gujarat conditions.

The soil samples were taken randomly from five different places covering the complete experimental block with the help of augar up to 30cm depth. The soil analysis was done as per the standard procedures. The physical and chemical properties of the soil of experimental block have been presented in Table-3.1 and Table-3.2.

Table-3.1 : Physico-chemical properties of the experimental soil

Sr. No.	Properties	Values
A.	**Physical properties**	
	1. Particle size distribution (Piper, 1956)	
	a. Sand (%)	9.47
	b. Silt (%)	24.94
	c. Clay (%)	65.59
	2. Texture	Clay
B.	**Chemical properties** (Jackson, 1967)	
	1. pH (1:2.5 Soil water suspension)	7.3
	2. EC (dS m^{-1})	0.94
	3. Organic carbon (g kg^{-1})	4.15
	4. Available N (Kg ha^{-1})	198.47
	5. Available P_2O_5 (Kg ha^{-1})	35.81
	6. Available K_2O (Kg ha^{-1})	418.25

Table-3.2 : Geographical location of experimental site

Agro climatic zone	South Gujarat heavy rainfall zone
Agroecological situation	AES III
Longitude	72°54' East
Latitude	20°57' North
Altitude	10 m
Climate	Sub humid
Max. Temperature	27.9 to 44.0°C
Min. Temperature	12.2 to 27.2°C
Annual rainfall	1500-1800 mm
Number of rainy days	95
Wind velocity	16.4 km/hr.
Pan evaporation	2.5 to 7.1 mm/day
Relative humidity	50-100%
Water table	6-12 m

3.3 Climate and weather

The climate of this region is typically tropical characterized by hot summer, moderately cold winter and humid and warm monsoon. In general, the monsoon sets during the second fortnight of June and ends by the second fortnight of September. Pre-monsoon rains in the last week of May and or first week of June are most uncommon. The total precipitation received during the monsoon of 2010 was 2184 mm distributed in 95 rainy days.

Winter commences from October onwards and ends by the middle of February. The temperature falls down from the beginning of November. December and January are the coldest months of the year. The summer season commences from the middle of February and ends by the first week of June. April and May are the hottest months of summer.

The mean monthly meteorological data on maximum and minimum temperatures, rainfall, relative humidity and sunshine hours during the course of investigation recorded at observatory of the N.M. College of Agriculture, Navsari Agricultural University, Navsari are presented in Appendix- II.

3.4 Location

The experiment was laid out in Plot No -19 of the Block-E at the Soil and Water Management Research Farm, N.A.U., Navsari during the year 2009- 2010.

3.5 Land preparation

The experimental plot was prepared by deep ploughing, harrowing and leveling. The pits of 30 cm x 30 cm x 30 cm were dug out at a distance of 2.4 m x 1.2 m and well enriched fine texture Bio-compost @ 5 kg per pit was applied at the time of planting.

3.6 Planting material

Well hardened, healthy tissue cultured plants of Grand Nain banana having 5-6 leaf stage were used for planting.

For intercrops, seedlings were prepared on the farm. Healthy seedlings of onion and cauliflowers were used for transplanting and clove of garlic was used for planting per dibble.

3.7 Planting time

Planting of banana was done on 1st October 2009 while, intercrops were planted on 26th October 2009.

3.8 Application of fertilizers

Each plant of banana was fed with 180g N; 90g P_2O_5; 120g K_2O (*i.e.* 40% saving of N & K). Complete dose of phosphorus and 40 per cent nitrogen and potash were applied at 1st and 2nd months after planting in two equal split doses by ring method. While, remaining dose of nitrogen and potash *i.e.* 60 per cent were applied in 6 equal splits at 15 days interval after 3rd month through drip irrigation system.

Intercrops *viz.*, onion, garlic and cauliflower were fed with 80:60:40 kg/ha (*i.e.* 66 per cent of RDN & K). Complete dose of phosphorus was applied as basal. While, nitrogen and potash were applied through drip system in five equal splits at 10 days interval of planting. The fertilizers N, P and K were applied in the form of urea, single superphosphate and muriate of potash, *respectively*.

3.9 Cultural practices

The cultural practices were adopted according to the recommendations for the cultivation of banana crop.

Weeding was done manually to keep the experimental plot weed free; desuckering was also done manually with the help

of sharp sickles. The dry and diseased leaves were removed regularly in order to keep the field clean and hygienic. Propping was done after inflorescence emergence with the help of bamboo poles or wooden stakes to support the plants. Tipping (removal of male flower bud) was done after complete opening of bunch.

3.10 Irrigation

One surface irrigation was applied immediately after planting of banana. Drip irrigation system was operated every alternate day @ 0.6 PEF at 1.2 kg/cm^2 pressure. Water applied to different intercropping patterns were given below

	Banana + A_1	Banana + A_2		Banana + A_3		Sole banana
		Banana	A_2	Banana	A_3	
Water applied (%)	100	66	33	66	33	100

3.11 Experimental details

3.11.1 Salient features of variety:

It is a tall mutant of 'Dwarf Cavendish'. It is gaining popularity among growers of South Gujarat. It is more vigorous and robust with well-spaced hands, fingers of bigger size and heavy bunches.

Treatment details:

A: Area under intercrops (A):

A_1 = 25% (Cauliflower) – 27% (Onion & Garlic)
(Without lateral shifting)

A_2 = 33% (With lateral shifting in between rows)

A_3 = 58-60% (A_1+A_2)

B: Intercrops (I):

I_1 = Onion

I_2 = Garlic

I_3 = Cauliflower

Sole banana: Outside the experimental plot

(a) Treatment combinations

T_1 = Banana + Onion (A_1)

T_2 = Banana + Onion (A_2)

T_3 = Banana + Onion (A_3)

T_4 = Banana + Garlic (A_1)

T_5 = Banana + Garlic (A_2)

T_6 = Banana + Garlic (A_3)

T_7 = Banana + Cauliflower (A_1)

T_8 = Banana + Cauliflower (A_2)

T_9= Banana + Cauliflower (A_3)

T_{10}= Sole Banana

(b) Design : Randomized Block Design

(for individual intercrops: Completely Randomized Design)

(c) Replications : Four

(d) Number of plants per treatment : Four

(e) Total number of treatments : 10

(f) Plot size : Gross : 7.2 m x 24.0 m

Net : 2.4 m x 4.8 m

(g) Spacing : Banana : 2.4 m x 1.2 m

Onion : 10 cm x 15 cm

Garlic : 10 cm x 15 cm

Cauliflower : 40 cm x 30 cm

(h) Crop and variety : Banana : Grand Naine

Onion : Puna Red

Garlic : Local

Cauliflower : Maharani

(i) Total experimental area : 0.3 ha

Plate-I : General view of experimental site

Observations recorded:

Banana

3.12.1 Observations on growth parameters:

3.12.1.1 Height of pseudostem (cm)

The height pseudostem of was measured from ground level to the uppermost point of contact of petioles of two youngest leaves (Lahav, 1972) at monthly interval starting from third month to inflorescence emergence.

3.12.1.2 Girth of pseudostem (cm)

The girth of the pseudostem was measured 20 cm above ground level (Lahav, 1972) at monthly interval starting from third month to inflorescence emergence.

3.12.1.3 Number of functional leaves

The numbers of fully opened leaves per plant were counted at monthly interval starting from third month to inflorescence emergence.

3.12.1.4 Total leaf area (m^2)

The length of third leaf from top was measured from the base of leaf-petiole to the tip, and breadth was measured at the maximum breadth of the leaf blade at monthly interval starting from third month to inflorescence emergence. The leaf area was

worked out as the multiplication of the product of length and breadth of the leaf with leaf area factor *i.e.* 0.8 (Obiefuna and Nadubizu, 1979).

3.12.2 Observations on duration of crop:

3.12.2.1 Days required for inflorescence emergence

The number of days taken from planting to flowering was recorded and then averaged.

3.12.2.2 Days taken from inflorescence emergence to harvest

The number of days taken from planting to harvesting was recorded and then averaged.

3.12.2.3 Total crop duration (days)

The total crop duration was calculated by adding for inflorescence emergence after planting and days taken from inflorescence to harvest and mean was calculated.

3.12.3 Observations on yield and yield attributing characters:

3.12.3.1 Number of hands per bunch

After emergence of all the female hands, the number of hands per bunch were counted and mean number of hands per bunch were calculated.

3.12.3.2 Number of fingers per bunch

Number of fingers per bunch were counted from each bunch after complete opening of inflorescence and mean number of fingers per bunch were calculated.

3.12.3.3 Bunch weight (kg)

The bunches were harvested when the fruit skin colour changed from green to light green and the ridges on the fruits disappeared. The bunches were weighed immediately after harvest and average was work out.

3.12.3.4 Average weight of finger (g)

For recording average weight of finger in grams the bunch weight per plant was divided by total number of fingers per bunch.

3.12.3.5 Length of finger (cm)

Length of finger from third hand was measured with the help of thread and was placed on scale and average length of finger was expressed in cm.

3.12.3.6 Girth of finger (cm)

Girth of finger from third hand was measured with the help of vernier calliper and average girth of finger was expressed in cm.

3.12.3.7 Yield (t/ha)

The yield data per plant was recorded and multiplied by multiple factor placed on area basis to give the final data for total yield in tones per hectare.

3.12.4 Quality parameters of fruits:

3.12.4.1 Pulp: skin ratio

The ripen fruits, which were used for recording the quality, were used to calculate pulp: skin ratio. Pulp to skin ratio was calculated by dividing respective pulp weight by respective skin weight.

3.12.4.2 Total Soluble Solids (T.S.S.)

The TSS value of the fruit was recorded by using hand refractometer having range of 0-32° Brix.

3.12.4.3 Acidity (%)

The method described by Ranganna (1979) was adopted for estimation of titrable acidity. Weighed amount of pulp was transferred to a volumetric flask and the volume was made up with distilled water to a known amount. After 30 minutes, the suspension was filtered through Whatman No. 1 filter paper and the filtrate was used subsequently.

An aliquot was taken and titrated against standard sodium hydroxide using phenolphthalein as an indicator. Titrable

acidity was expressed as percentage malic acid equivalent adopting the following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali}}{\text{Volme of sample taken for estimation}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. Wt. of Malic acid}}{1000} \times 100$$

3.12.4.4 Total sugars (%)

For estimation of total sugars, the filtrate obtained in the above estimation was used. An aliquot from the filtrate was taken and to one-fifth of its volume, hydrochloric acid (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 per cent sodium hydroxide using phenolphthalein as an indicator and the final volume was made. The solution was filtered through Whatman No. 1 filter paper and titration was carried out using filtrate as detailed for reducing sugars.

The total sugar content was expressed as percentage in terms of invert sugars according to the formula.

$$\text{Total sugar (\%)} = \frac{\text{Glucose Eq. of Fehling's solutions (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of pulp taken}} \times \frac{\text{Volume made up after inversion}}{\text{Aliquot taken for inversion}} \times 100$$

4.12.4.5 Reducing sugars (%)

The titrimetric method of Lane and Eynon described by Ranganna (1979) was adopted for estimation of reducing sugar.

The method is based on the principle that invert sugar or reducing sugar reduces the copper in the Fehling's solution to red insoluble cuprous oxide. Sugar in a sample was estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution. Before using the mixture (1:1) of Fehling's solution, A and B was standardized against standard glucose for obtaining glucose equivalent and to arrive at a conversion factor.

Procedure:

A weighed amount of the pulp was taken in a volumetric flask and 2 milliliter of 45 per cent basic lead acetate solution was added for clarification. After 10 minutes, the solution was deleaded by adding potassium oxalate crystals in excess (added till excess of crystals remained undissolved) and the volume was made up to a known amount with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was taken in a burette and titrated against boiling Fehling's mixture (5 ml of Fehling's solution A + 5 ml of Fehlings solution B) till the blue colour faded. Then 1 ml of methylene blue indicator (1%) was added and titration was continued till the contents attained a brick red colour and titre value was noted. The percentage of reducing sugar was calculated according to following formula.

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose Eq. (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of the pulp}} \times 100$$

3.12.4.6 Shelf life (days)

The shelf life of the fruit was noted by keeping the fruits at room temperature. The shelf life of fruits were recorded as the days taken from harvesting to optimum eating stage.

3.12.4.7 Ascorbic acid (Vitamin-C) content (mg/100 g pulp)

Titrimetric method described by Ranganna (1979) was adopted for estimation of the ascorbic acid.

Procedure

Ten grams of homogenized pulp was taken and transferred to 100 ml volumetric flask. The volume was made up with 4% oxalic acid solution. After 30 minutes, the suspension was filtered through Whatman No.1 filter paper. Before actual titration the 2,6-Dichlorophenol indophenol (Dye solution) was standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. Five ml of the aliquot was taken from the filtrate and titrate against standardized dye solution through a burette. The titration was continued till the light pink colour persisted for 15 seconds. The ascorbic acid content was calculated adopting the following formula.

$$\text{Mg of ascorbic acid/100 g Pulp} = \frac{\text{Titrate x Dye factor x Volume Madeup}}{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample taken for estiamtion}} \times 100$$

ONION

3.13.1 Biometric observations

Five plants were selected from each plot as observational plant and were labeled and observations were recorded and the average values were tabulated.

3.13.1.1 Plant height (cm)

The height of each observational plant was measured from the ground level up to the tip of leaf. The average height of plant was worked out at 30 days interval starting from 30 days after transplanting up to harvesting.

3.13.1.2 No. of leaves per plant

The number of functional leaves present on each observational plant was counted and the average numbers of leaves per plant were calculated at 30 days interval starting from 30 days after transplanting up to harvesting.

3.13.1.3 Leaf area (cm^2)

The length of leaf was measured from the base of leaf petiole to the tip and breadth was measured at the maximum breadth of leaf blade at one month interval from until harvesting. The leaf area was worked out as the multiplication of the product of length and breadth of the leaf with leaf area factor (0.8) suggested by Obiefuna and Ndubizu, 1979.The total leaf area per

plant was worked out as the multiplication of the leaf area and total number of leaves per plant.

3.13.1.4 Leaf area index (cm^2) (LAI)

The leaf area index was worked out by dividing the average leaf area per plant with land area *i.e.*, spacing, using formula suggested by Hunt (1982). It was calculated by using the formula

$$LAI = \frac{\text{Leaf area per plant } (cm^2)}{\text{Ground area per plant } (cm^2)}$$

3.13.1.5 Plant dry matter production (g $plant^{-1}$)

For estimating plant dry weight, ten onion plants were taken from the sample row (after 30 days of transplanting), after removing the soil particles, the sample were first sun dried and finally oven dried at 60 $\pm 2^0$ C till the constant weight.

3.13.2 Yield parameters

3.13.2.1 Bulb weight (g)

After harvesting the weight of fresh bulb was recorded. The average weight of five observational bulbs was considered as average weight of fresh bulb.

3.13.2.2 Neck thickness (cm)

Neck thickness of observational plants were measured by vernier caliper at 30 days interval starting from 30 days after transplanting up to harvesting.

3.13.2.3 Equatorial diameter of bulb (cm)

Equatorial diameter was measured with the help of vernier caliper of five observational bulbs and average was worked out.

3.13.2.4 Volume of bulb (cm^3)

The volume of five randomly selected bulbs were recorded by water displacement method in which water removed by the bulbs were measured by using measuring cylinder and the average value expressed in cm^3.

3.13.2.5 Bulb Yield (t/ha)

The weight of total harvested bulbs/ha was calculated on hectare basis for each treatment.

3.13.3 Quality parameters

3.13.3.1 Total soluble solids %

Total soluble solids (T.S.S.) was determined with hand refrectometer and the values corrected at 20^0 Brix.

GARLIC

3.14.1 Biometric observations

Five plants were selected from each plot as observational plant and were labeled and observations were recorded and the average values were tabulated.

3.14.1.1 Plant height (cm)

The height of each observational plant was measured from the ground level up to the tip of leaf. The average height of plant was worked out at 30 days interval starting from 30 days after planting up to harvesting.

3.14.1.2 Number of leaves

The number of functional leaves present on each observational plant was counted and the average numbers of leaves per plant were calculated at 30 days interval starting from 30 days after planting up to harvesting.

3.14.1.3 Leaf area per plant (cm^2)

The length of leaf was measured from the base of leaf petiole to the tip and breadth was measured at the maximum breadth of leaf blade at one month interval from until harvesting. The leaf area was worked out as the multiplication of the product of length and breadth of the leaf with leaf area factor (0.8) suggested by Obiefuna and Ndubizu, 1979.The total leaf area per plant was worked out as the multiplication of the leaf area and total number of leaves per plant.

3.14.1.4 Leaf area index (cm^2) (LAI)

The leaf area index was worked out by dividing the average leaf area per plant with land area *i.e.*, spacing, using

formula suggested by Hunt (1982). It was calculated by using the formula

$$LAI = \frac{\text{Leaf area per plant } (cm^2)}{\text{Ground area per plant } (cm^2)}$$

3.14.1.5 Plant dry matter production (g plant^{-1})

For estimating plant dry weight, ten garlic plants were taken from the sample row (after 30 days of sowing), after removing the soil particles, the sample were first sun dried and finally oven dried at 60 $\pm 2^0$ C till the constant weight.

3.14.2 Yield parameters

3.14.2.1 Bulb weight (g)

After harvesting the weight of fresh bulb was recorded. The average weight of five observational bulbs were considered as average weight of fresh bulb.

3.14.2.2 Equatorial diameter of bulb (cm)

Equatorial diameter was measured with the help of vernier capliper of five observational bulbs and average was worked out.

3.14.2.3 Number of cloves per bulb

After cured weight the number of cloves per bulb was counted and average was calculated.

3.14.2.4 Clove length (cm)

The length of clove was measured in centimeter scale and average was calculated.

3.14.2.5 Clove breath (cm)

The breath of each clove was measured by vernier caliper at middle of the clove and average was calculated.

3.14.2.6 Clove weight (g)

The weight of each clove was recorded and average was calculated.

3.14.2.7 Bulb Yield (t/ha)

The weight of total harvested cured bulbs/ha was calculated on hectare basis for each treatment.

3.14.3 Quality parameters

3.14.3.1 Total soluble solids (%)

Total soluble solids (T.S.S.) was determined with hand refrectometer having range of 35-42° Brix.

CAULIFLOWER

3.15.1 Growth characters

3.15.1.1 Plant height (cm)

The height of each observational plant was measured from the ground level up to the tip of leaf. The average height of plant was worked out at 30 days interval starting from 30 days after transplanting up to harvesting.

3.15.1.2 Plant spread (sq. cm)

Plant spread of plant was measured in two opposite directions, *i.e.* north – south and east – west (NS-EW) with the help of meter scale at 30 and 60 DATP and at harvest and spread of plant in sq. cm was calculated.

3.15.1.3 Number of unfolded leaves per plant

The number of functional leaves present on each observational plant was counted and the average numbers of leaves per plant were calculated at 30 days interval starting from 30 days after transplanting up to harvesting.

3.15.1.4 Days for curd initiation

The numbers of days required for curd initiation for five tagged plants from each treatment were counted and averages were calculated.

3.15.1.5 Days for curd maturity

The five plants which were tagged for curd initiation same were used for curd maturity. The days were counting from curd initiation to curd maturity and average was calculated.

3.15.2 Yield and yield attributes

3.15.2.1 Weight of curd (g)

Fresh curd weight of each tagged plants were taken after the removal of leaves and stem and average was calculated.

3.15.2.2 Curd diameter (cm)

The curd diameter was measured with measuring tape by measuring two way axial circumferences of each cauliflower curd to five tagged plants and average was expressed in cm.

3.15.2.3 Yield of curd (t/ha)

The data of the yield per net plot was recorded and multiplied by multiple factor computed on area basis to give the final data for total yield in quintal per hectare.

3.15.3 Quality parameter

3.15.3.1 Total soluble solids (%)

The curd was chopped and crushed with the mixture and juice was extracted with the help of muslin cloth and the data were recorded directly with the help of hand refrectometer.

3.16 Land equivalent ratio (LER)

Land equivalent ratio denotes the relative land area under sole crop required to produce the same yield as obtained under a mix or an intercropping system at the same management level. It is calculated as sum total of the ratio of yield of each component crop in an intercropping system to its corresponding yield when grown as a sole crop (Ofroi and Stern, 1987).

$$LER = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

Where, Y_{ab} and Y_{ba} = Individual yield in intercropping (kg ha^{-1})

Y_{aa} and Y_{bb} = Yield as sole crop (kg ha^{-1})

3.17 Banana equivalent yield

Banana equivalent yield was worked out for all the treatments by following formula

$$\text{BEY (kg/ha)} = \text{Yield of Banana (kg/ha)} + \frac{\text{Yield of intercrop (kg/ha)} \times \text{price of intercrop (Rs/kg)}}{\text{Price of banana (Rs/kg)}}$$

3.18 Economics

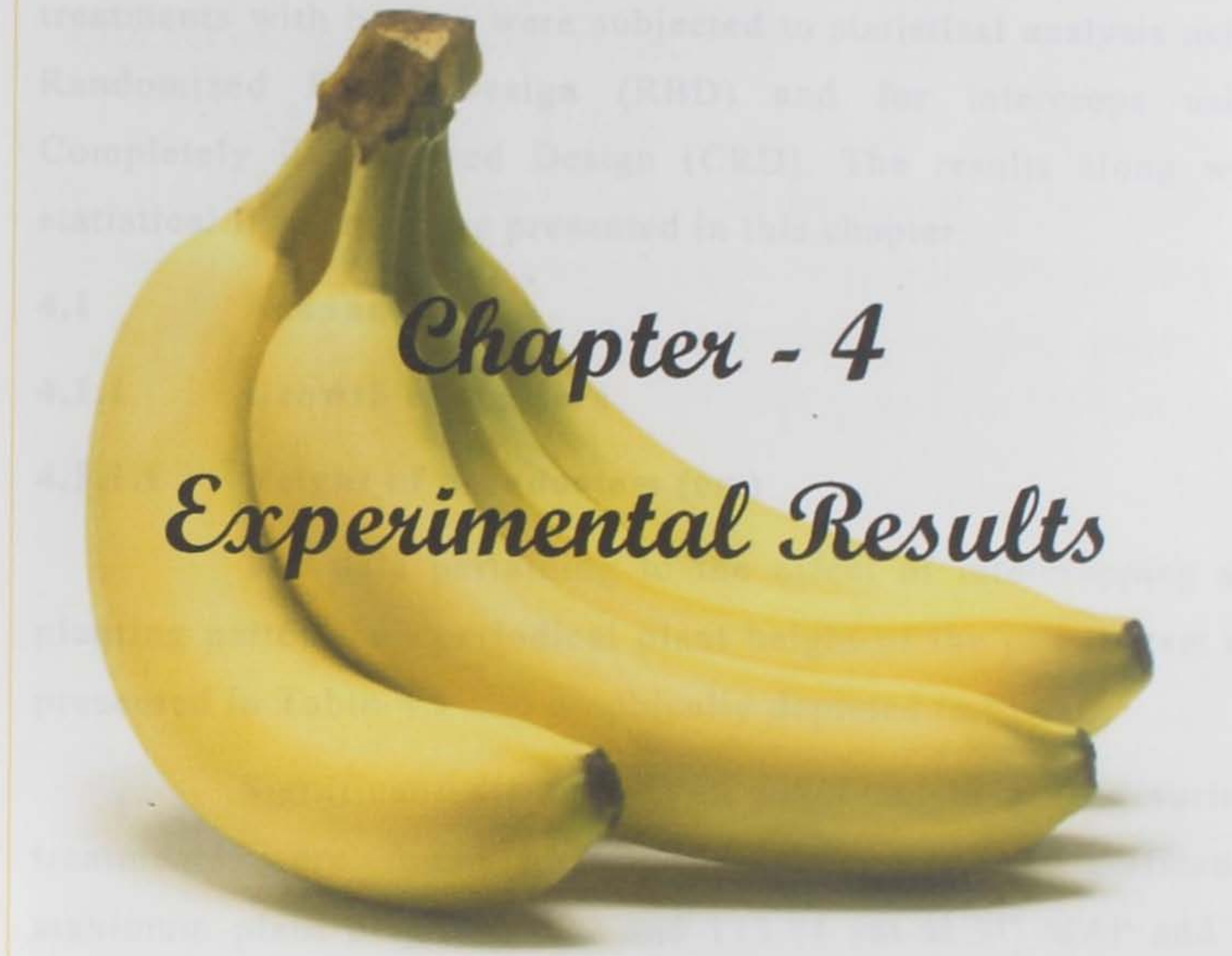
The gross income in terms of rupees per hectare was worked out on the basis of mean yield for each treatment and the prevailing market prices of banana bunch. The economics of intercropping system was worked out by considering the prevailing market prices for different inputs and produces. The total cost of different treatments were worked out by considering prices of planting material, fertilizers, labour employed for treatments and cultivation cost. The net income was worked out by deducting total cultivation cost from the gross income per hectare for respective treatment and recorded accordingly.

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Net income}}{\text{Total cost of production}}$$

3.19 Statistical analysis

The data recorded for growth parameters, yield attributes and yield of main crop along with net return, land equivalent ratio and banana equivalent yield etc. were subjected to analysis of variance as described by Panse and Sukhatme (1967).

The methods of analysis of variance for randomized block design was used and treatment effect of all characters studied were further compared by employing "F" test. To test significance of results, 5% level of significance used. The critical differences were calculated, when differences were found significant by the "F" test. The co-efficient of variation was also worked out for all characters in order to estimate the precision.



Chapter - 4

Experimental Results

IV. EXPERIMENTAL RESULTS

The present investigation on "Intercropping studies in banana (*Musa paradisica* L.) cv. 'Grand Naine' under drip irrigation" was conducted at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari during the year 2009-2010. The data collected during experimentation on various treatments with banana were subjected to statistical analysis using Randomized Block Design (RBD) and for intercrops using Completely Randomized Design (CRD). The results along with statistical inferences are presented in this chapter.

4.1 Banana

4.1.1 Growth characters

4.1.1.1 Height of pseudostem (cm)

The data pertaining to the effect of intercropping and planting patterns on periodical plant height of the pseudostem are presented in Table-4.1 and graphically depicted in Fig.-1.

Significant differences in plant height due to various treatments were found at initial growth stages. Significantly maximum plant height (39.20 and 113.31 cm at 3rd MAP and 5th MAP, respectively) were recorded under sole banana treatment (T_{10}) which was at par with T_5 treatment banana + garlic (A_2) (36.16 and 108.09 cm), T_6 treatment banana + garlic (A_2) (34.51 and 105.44 cm), T_4 treatment banana + garlic (A_1) (34.24 and 104.15 cm), T_2 treatment banana + onion (A_2) (34.06 and 102.44 cm) and T_1 treatment banana + onion (A_1) (33.82 and 101.23 cm)

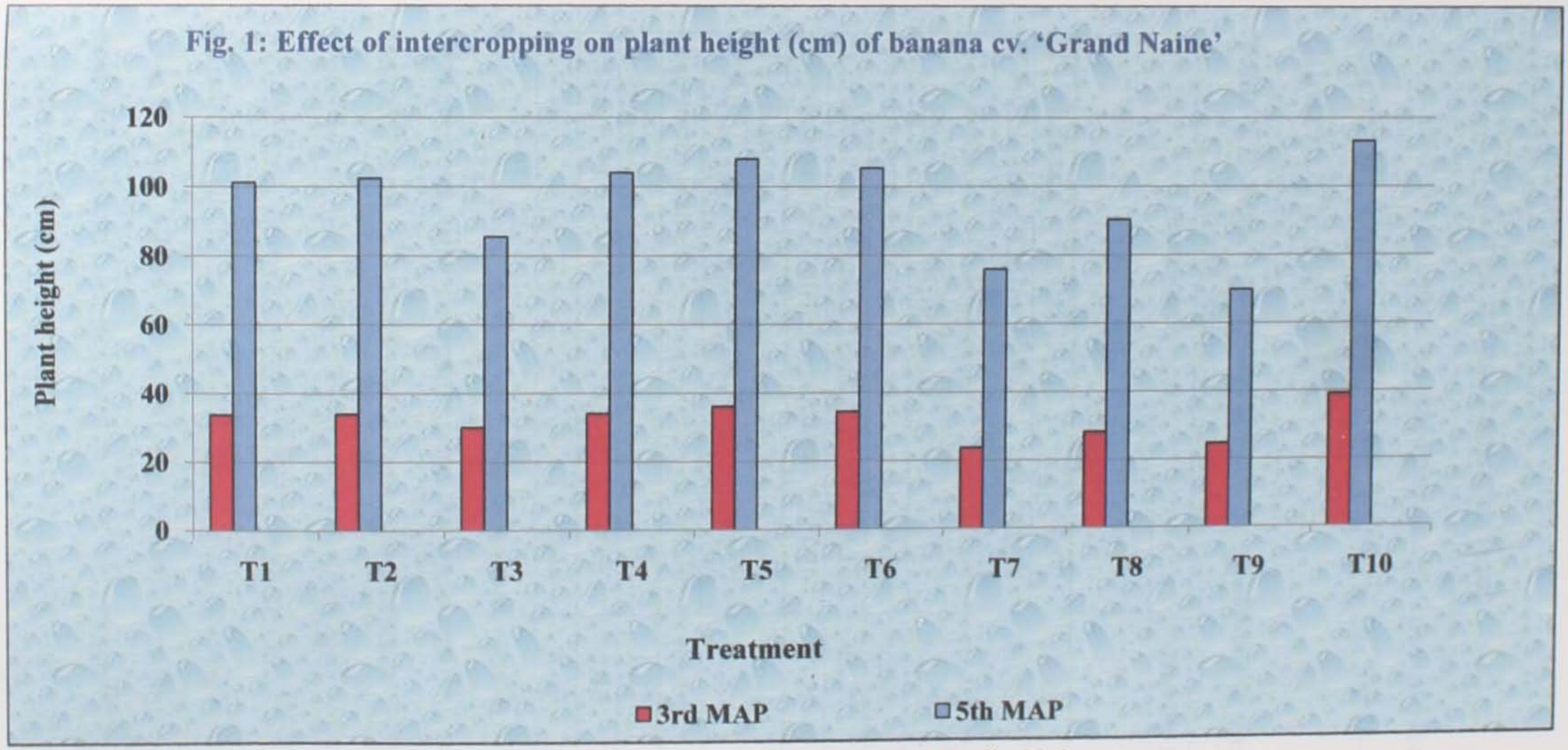
treatments. The data of Table-4.1 indicated that maximum reduction on plant height due to intercrop was observed with T_7 treatment banana + cauliflower (A_1) (23.82 cm) which was remain at par with T_9 treatment banana + cauliflower (A_3) (24.76 cm) and T_8 treatment banana + cauliflower (A_2) (28.21 cm) at 3rd MAP. At 5th MAP minimum height was observed with T_9 treatment banana + cauliflower (A_3) (69.94 cm) which was remain at par with T_7 treatment banana + cauliflower (A_1) (76.04 cm).

An appraisal of data presented in Table-4.1 revealed that the difference in plant height of banana at 7th MAP and at inflorescence emergence was found to be non-significant. Highest plant height was observed under T_5 treatment banana + garlic (A_2) (216.14 and 243.20 cm) at 7th MAP and at inflorescence emergence, respectively.

Table-4.1: Effect of intercropping on pseudostem height (cm) of banana cv. 'Grand Naine'

Treatments	Months after planting (MAP)			
	3rd	5th	7th	At inflorescence emergence
T_1 =Banana + Onion (A_1)	33.82	101.23	209.06	235.71
T_2 =Banana + Onion (A_2)	34.06	102.44	212.14	242.55
T_3 =Banana + Onion (A_3)	30.10	85.57	203.43	229.17
T_4 =Banana + Garlic (A_1)	34.24	104.15	209.51	237.96
T_5 =Banana + Garlic (A_2)	36.16	108.09	216.14	243.20
T_6 =Banana + Garlic (A_3)	34.51	105.44	206.65	232.45
T_7 =Banana + Cauliflower (A_1)	23.82	76.04	201.18	224.25
T_8 =Banana + Cauliflower (A_2)	28.21	90.44	205.38	230.95
T_9 =Banana + Cauliflower (A_3)	24.76	69.94	187.49	222.57
T_{10}=Sole Banana	39.20	113.31	211.94	239.13
S. Em $\pm$	1.95	4.50	8.13	8.96
CD at 5 %	5.65	13.08	NS	NS
CV %	12.37	9.42	7.88	7.66

Fig. 1: Effect of intercropping on plant height (cm) of banana cv. 'Grand Naine'



· T_1 = Banana + Onion (A_1)
T_2 = Banana + Onion (A_2)
T_3 = Banana + Onion (A_3)
T_4 = Banana + Garlic (A_1)
T_5 = Banana + Garlic (A_2)
T_6 = Banana + Garlic (A_3)
T_7 = Banana + Cauliflower (A_1)
T_8 = Banana + Cauliflower (A_2)
T_9= Banana + Cauliflower (A_3)
T_{10}= Sole Banana

4.1.1.2 Girth of pseudostem (cm)

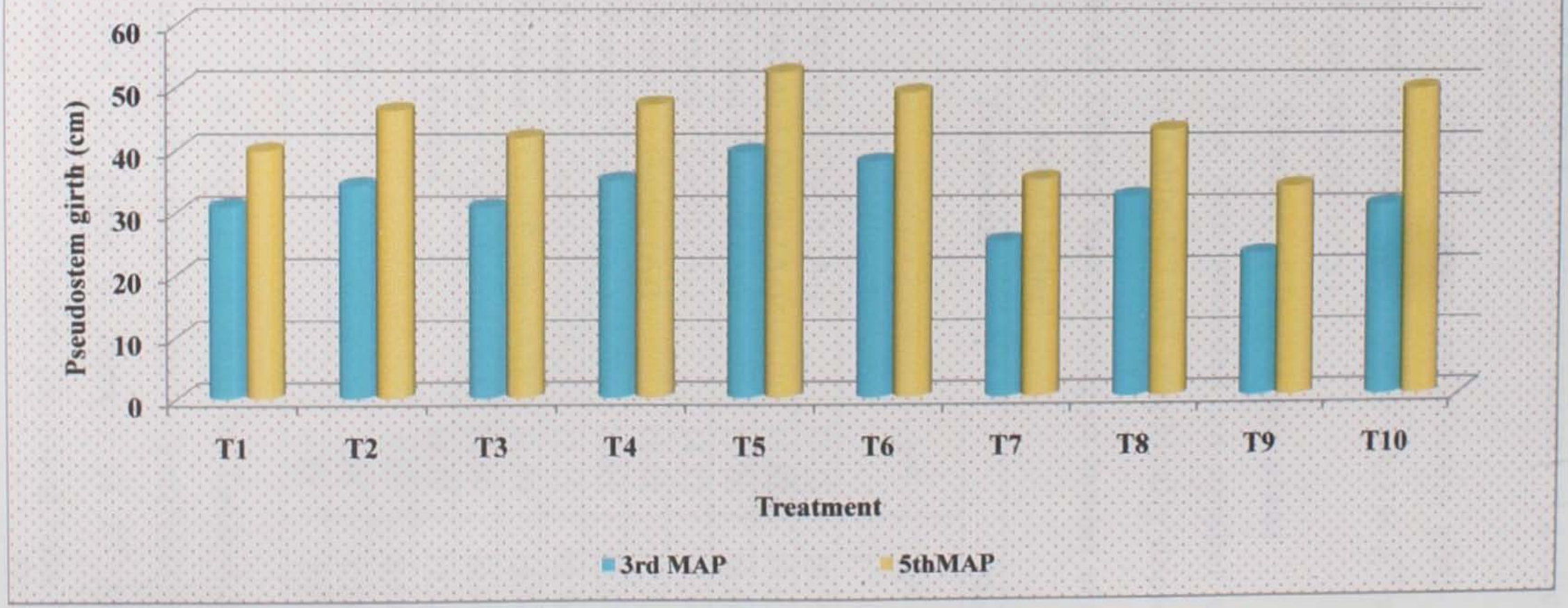
The data pertaining to the pseudostem girth at different stages of plant growth are presented in Table–4.2 and graphically illustrated in Fig.-2.

Table-4.2: Effect of intercropping on pseudostem girth (cm) of banana cv. 'Grand Naine'

Treatments	Months after planting (MAP)			
	3rd	5th	7th	At inflorescence emergence
T_1 =Banana + Onion (A_1)	30.97	39.89	65.25	67.13
T_2 =Banana + Onion (A_2)	34.34	46.38	66.53	70.06
T_3 =Banana + Onion (A_3)	30.86	42.03	64.46	62.90
T_4 =Banana + Garlic (A_1)	35.18	47.38	65.30	68.72
T_5 =Banana + Garlic (A_2)	39.70	52.48	66.78	71.72
T_6 =Banana + Garlic (A_3)	38.15	49.25	64.92	66.52
T_7 =Banana + Cauliflower (A_1)	25.26	35.29	64.38	62.05
T_8 =Banana + Cauliflower (A_2)	32.46	43.15	64.71	65.87
T_9 =Banana + Cauliflower (A_3)	23.12	34.03	64.02	61.27
T_{10}=Sole Banana	38.20	49.74	65.78	69.87
S. Em $\pm$	1.71	1.89	1.85	2.44
CD at 5 %	4.96	5.48	NS	NS
CV %	10.42	8.59	5.68	7.31

The data on pseudostem girth indicated significant differences due to intercrops at only initial stages of crop growth *i.e.*, 3rd and 5th MAP. Highest pseudostem girth at 3rd and 5th MAP were recorded under T_5 treatment banana + garlic (A_2) (39.70 and 52.48 cm, respectively) which was at par with T_{10} treatment sole banana (38.20 and 49.47 cm), T_6 treatment banana + garlic (A_3) (38.15 and 49.25 cm) and T_4 treatment banana + garlic (A_1) (35.18 and 47.38 cm) at 3rd and 5th MAP, respectively. At 7th MAP and inflorescence emergence the maximum pseudostem girth was

Fig. 2: Effect of intercropping on pseudostem girth (cm) of banana cv. 'Grand Naine'



T_1 = Banana + Onion (A_1)
T_2 = Banana + Onion (A_2)
T_3 = Banana + Onion (A_3)
T_4 = Banana + Garlic (A_1)
T_5 = Banana + Garlic (A_2)
T_6 = Banana + Garlic (A_3)
T_7 = Banana + Cauliflower (A_1)
T_8 = Banana + Cauliflower (A_2)
T_9= Banana + Cauliflower (A_3)
T_{10}= Sole Banana

obtained with T_5 treatment banana + garlic (A_2) (66.78 and 71.72 cm, respectively).

The minimum pseudostem girth was recorded under T_9 treatment banana + cauliflower (A_3) at 3rd and 5th MAP (23.12 and 34.03 cm, respectively).

4.1.1.3 Number of leaves per plant

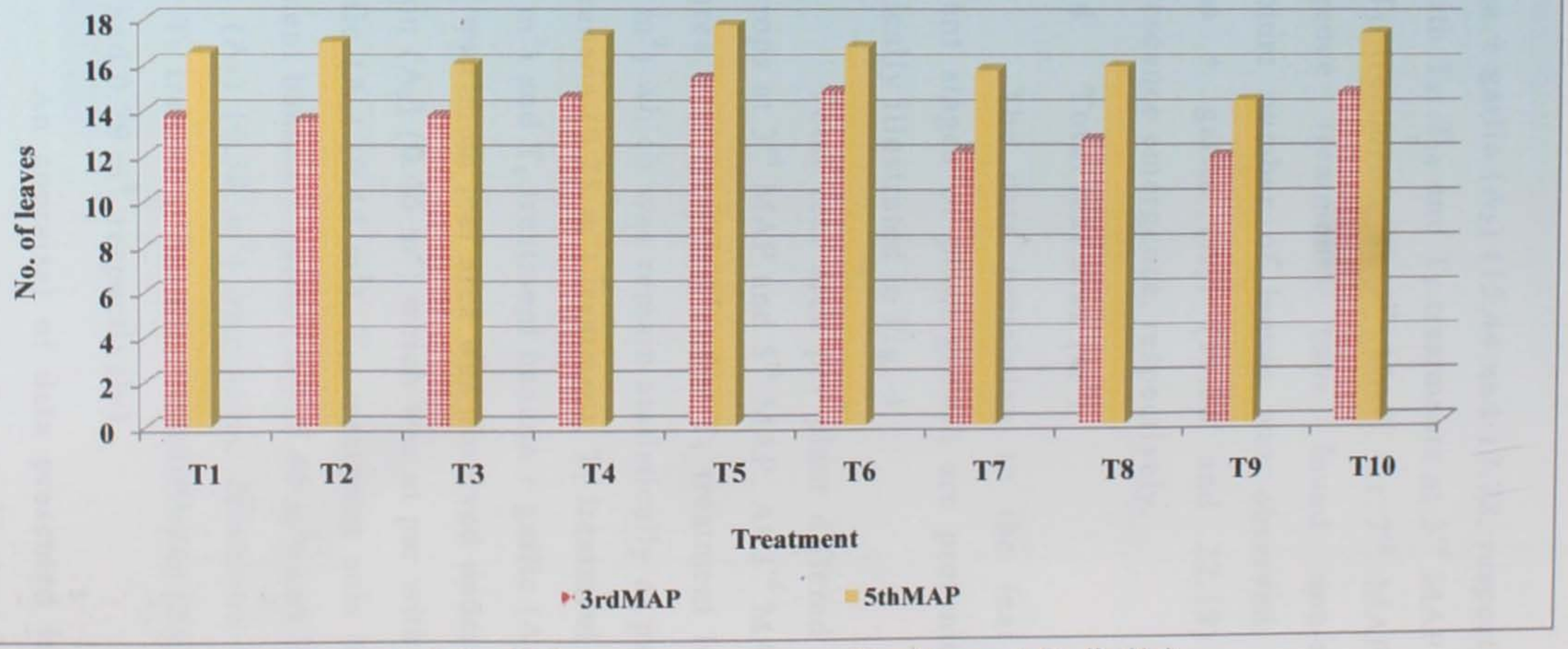
The data recorded on number of leaves per plant are presented in Table-4.3 and graphically depicted in Fig.-3.

Table-4.3: Effect of intercropping on number of leaves per plant of banana cv. 'Grand Naine'

Treatments	Months after planting (MAP)			
	3rd	5th	7th	At inflorescence emergence
T_1 =Banana + Onion (A_1)	13.75	16.55	18.99	20.49
T_2 =Banana + Onion (A_2)	13.62	17.03	19.79	21.24
T_3 =Banana + Onion (A_3)	13.76	16.04	18.04	19.48
T_4 =Banana + Garlic (A_1)	14.57	17.34	19.23	20.96
T_5 =Banana + Garlic (A_2)	15.44	17.78	19.86	22.19
T_6 =Banana + Garlic (A_3)	14.85	16.81	18.79	20.29
T_7 =Banana + Cauliflower (A_1)	12.15	15.78	17.88	19.27
T_8 =Banana + Cauliflower (A_2)	12.69	15.94	18.24	19.59
T_9 = Banana + Cauliflower (A_3)	11.99	14.44	16.83	19.20
T_{10}=Sole Banana	14.77	17.44	19.77	21.04
S. Em ±	0.47	0.59	0.72	0.73
CD at 5 %	1.36	1.73	NS	NS
CV %	6.83	7.21	7.68	7.13

A perusal of data in Table-4.3 clearly indicated that various intercropping systems significantly influenced the number of leaves per plant in banana at 3rd MAP and 5th MAP and maximum number of leaves per plant were recorded in T_5 treatment

Fig. 3: Effect of intercropping on number of leaves per plant of banana cv. 'Grand Naine'



T_1 = Banana + Onion (A_1)
T_2 = Banana + Onion (A_2)
T_3 = Banana + Onion (A_3)
T_4 = Banana + Garlic (A_1)
T_5 = Banana + Garlic (A_2)
T_6 = Banana + Garlic (A_3)
T_7 = Banana + Cauliflower (A_1)
T_8 = Banana + Cauliflower (A_2)
T_9= Banana + Cauliflower (A_3)
T_{10}= Sole Banana

banana + garlic (A_2) (15.44 and 17.78, respectively) which was at par with T_6, T_{10} and T_4 treatments at 3rd MAP and T_{10}, T_4, T_2, T_6 and T_1 treatments at 5th MAP. At 7th MAP and inflorescence emergence treatments have found non-significant results. Maximum number of leaves was observed under T_5 treatment banana + garlic (A_2) (19.86 and 22.19) at 7th MAP and inflorescence emergence, respectively.

4.1.1.4 Total leaf area (m^2)

The data pertaining to the leaf area per plant at different stages of plant growth are presented in Table-4.4 and graphically illustrated in Fig.-4.

Total leaf area per plant differed significantly due to intercrops at 3rd MAP and 5th MAP. At 3rd MAP and the maximum leaf area was recorded under T_5 treatment banana + garlic (A_2) (0.26 m^2) which was remain statistically at par with T_{10} treatment sole banana (0.25 m^2) treatment, T_1 treatment banana + onion (A_1) (0.23 m^2) and T_6 treatment banana + garlic (A_3) (0.23 m^2). At 5th MAP, maximum leaf area was observed under T_3 treatment banana + onion (A_3) (0.46 m^2) which was at par with T_5 treatment banana + garlic (A_2) (0.44 m^2), T_{10} treatment sole banana (0.41 m^2), T_4 treatment banana + garlic (A_1) (0.40 m^2) and T_6 treatment banana + garlic (A_3) (0.38 m^2) treatments. Minimum leaf area was found under T_7 treatment banana + cauliflower (A_1) at 3rd and 5th MAP (0.14 and 0.29 m^2, respectively).

An appraisal of data presented in Table-4.4 revealed that the differences in leaf area under various intercropping

systems at 7th MAP and at inflorescence emergence were found to be non-significant. Largest leaf area was recorded under T_5 treatment banana + garlic (A_2) (2.07 and 2.20 m^2) which was followed by T_2 treatment banana + onion (A_2) (2.01 and 2.18 m^2) and T_{10} treatment sole banana (1.96 and 2.14 m^2) at 7th MAP and inflorescence emergence, respectively.

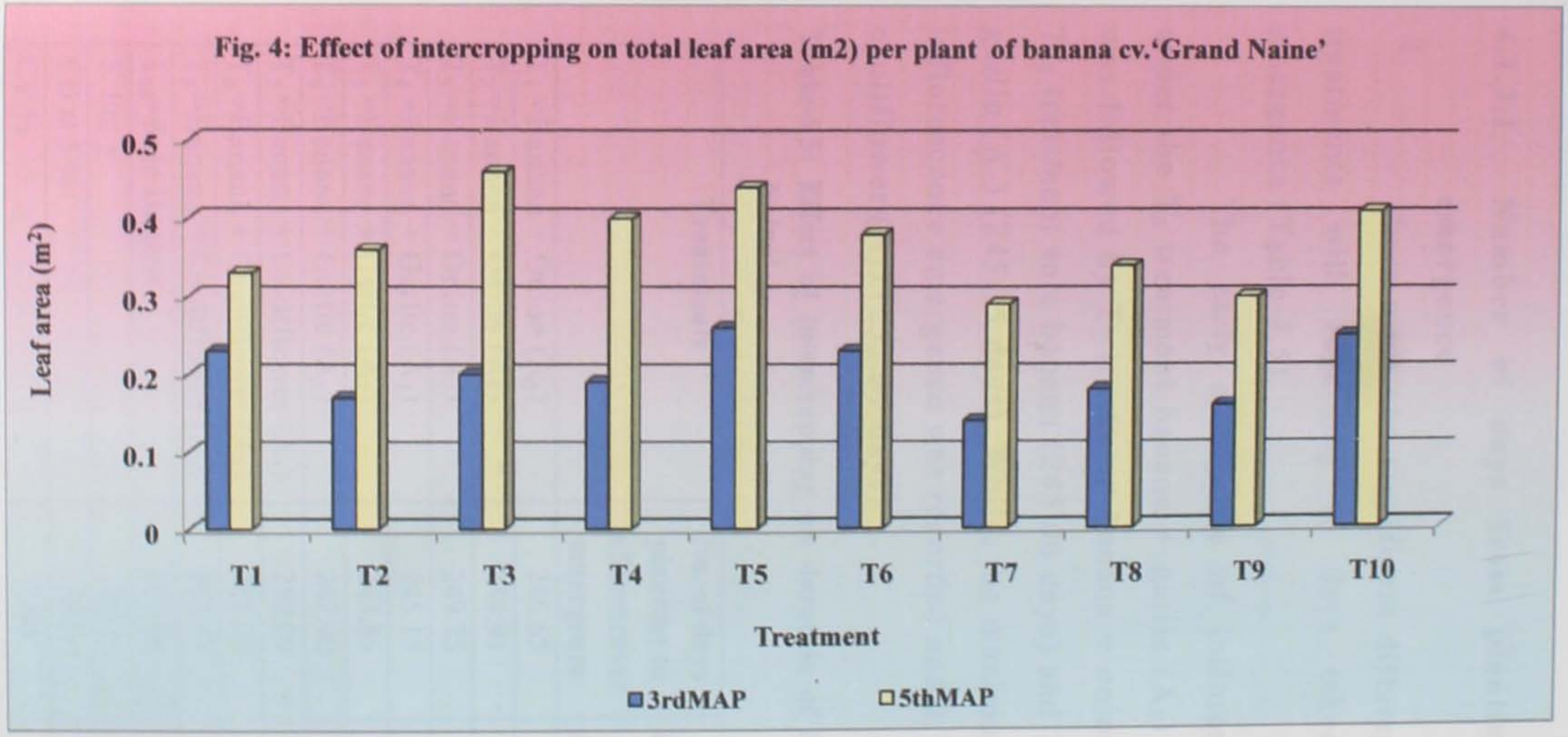
Table-4.4: Effect of intercropping on total leaf area (m^2) per plant of banana cv. 'Grand Naine'

Treatments	Months after planting (MAP)			
	3rd	5th	7th	At inflorescence emergence
T_1 =Banana + Onion (A_1)	0.23	0.33	1.85	2.11
T_2 =Banana + Onion (A_2)	0.17	0.36	2.01	2.18
T_3 =Banana + Onion (A_3)	0.20	0.46	1.79	1.96
T_4 =Banana + Garlic (A_1)	0.19	0.40	1.91	2.12
T_5 =Banana + Garlic (A_2)	0.26	0.44	2.07	2.20
T_6 =Banana + Garlic (A_3)	0.23	0.38	1.81	2.08
T_7 =Banana + Cauliflower (A_1)	0.14	0.29	1.73	1.95
T_8 =Banana + Cauliflower (A_2)	0.18	0.34	1.81	1.97
T_9 =Banana + Cauliflower (A_3)	0.16	0.30	1.70	1.94
T_{10}=Sole Banana	0.25	0.41	1.96	2.14
S. Em $\pm$	0.014	0.029	0.081	0.107
CD at 5 %	0.04	0.08	NS	NS
CV %	14.42	15.75	8.71	10.43

4.1.2 Crop duration (days)

The data pertaining to days taken for inflorescence emergence, bunch harvesting and total crop duration are presented in Table-4.5.

Fig. 4: Effect of intercropping on total leaf area (m2) per plant of banana cv.'Grand Naine'



T_1 = Banana + Onion (A_1)
T_2 = Banana + Onion (A_2)
T_3 = Banana + Onion (A_3)
T_4 = Banana + Garlic (A_1)
T_5 = Banana + Garlic (A_2)
T_6 = Banana + Garlic (A_3)
T_7 = Banana + Cauliflower (A_1)
T_8 = Banana + Cauliflower (A_2)
T_9= Banana + Cauliflower (A_3)
T_{10}= Sole Banana

4.1.2.1 Number of days from planting to inflorescence emergence

There were non-significant differences among different treatments with regarding to days taken for inflorescence emergence (Table-4.5).

The early emergence of inflorescence was recorded under the T_5 treatment banana + garlic (A_2) (243.85 days) which was followed by T_2 treatment banana + onion (A_2) (244.91 days), T_{10} treatment sole banana (245.06 days) and T_4 treatment banana + garlic (A_1) (245.15 days). While, the maximum number of days for inflorescence emergence was recorded under T_9 treatment banana + cauliflower (A_3) (252.57 days).

Table-4.5: Effect of intercropping on duration of banana crop cv. 'Grand Naine'

Treatments	No. of days planting to inflorescence emergence	No. of days inflorescence emergence to harvesting	Total crop duration
T_1 =Banana + Onion (A_1)	246.65	82.30	328.95
T_2 =Banana + Onion (A_2)	244.91	78.34	323.25
T_3 =Banana + Onion (A_3)	249.75	86.08	335.83
T_4 =Banana + Garlic (A_1)	245.15	81.39	326.54
T_5 =Banana + Garlic (A_2)	243.85	77.96	321.82
T_6 =Banana + Garlic (A_3)	247.40	82.71	330.12
T_7 =Banana + Cauliflower (A_1)	250.09	87.32	337.40
T_8 =Banana + Cauliflower (A_2)	248.26	85.19	333.45
T_9 =Banana + Cauliflower (A_3)	252.57	88.20	340.77
T_{10}=Sole Banana	245.06	80.10	325.15
S. Em $\pm$	8.73	3.49	7.87
CD at 5 %	NS	NS	NS
CV %	7.06	8.41	4.76

4.1.2.2 Number of days from inflorescence emergence to harvesting

The days taken for harvesting after inflorescence emergence have non-significance difference to different treatments (Table-4.5). The banana plants intercropped with garlic (A_2) (T_5 - 77.96 days) showed minimum days for harvesting which was followed by T_2 treatment banana + onion (A_2) (78.34 days), T_{10} treatment sole banana (80.10 days) and T_4 treatment banana +garlic (A_1) (81.39 days). The more number of days for harvesting (88.20 days) was found under T_9 treatment banana + cauliflower (A_3).

4.1.2.3 Total crop duration (days)

The data regarding to total crop duration as influenced by intercropping patterns were presented in Table-4.5.

The data clearly revealed that the difference in total crop duration of banana was found to be non-significant. Minimum total crop duration (321.82 days) was observed under T_5 treatment banana + garlic A_2 which was followed by T_2 treatment banana + onion A_2 (323.25 days), T_{10} treatment sole banana (325.15 days) and T_4 treatment banana + garlic A_1 (326.54 days). While, maximum total crop duration was recorded under T_9 treatment banana + cauliflower A_3 (340.77 days).

4.1.3 Yield and yield attributing characters

Data collected on yield attributing characters of banana fruit produced under different intercropping treatments are presented in Table-4.6 and 4.7.

4.1.3.1 Number of hands per bunch

The data regarding number of hands per bunch as influenced by different intercrops are presented in Table-4.6.

There was no significant difference among different intercrops with respect to number of hands per bunch. The banana intercropped with garlic (A_2) - T_5 treatment recorded more number of hands (10.37) per bunch which was followed by T_2 treatment banana + onion (A_2) (10.32), T_{10} treatment sole banana (10.31) and T_4 treatment banana + garlic (A_1) (10.30). The minimum number of hands per bunch was recorded under T_9 treatment banana + cauliflower (A_3) (10.00).

4.1.3.2 Average weight of finger (g)

The data pertaining to average weight of finger as influenced by different intercropping pattern are presented in Table-4.6.

Average weight of finger did not significantly influenced by intercrops. However, higher average weight of finger (162.45 g) was recorded in the banana intercropped with garlic (A_2) (T_5) which was followed by T_2 (160.19 g), T_{10} (159.84 g) and T_4 (158.30 g) treatments. The minimum average weight of finger was recorded under T_9 banana + cauliflower (A_3) (156.05 g).

4.1.3.3 Number of fingers per bunch

The data on number of fingers per bunch as influenced by different intercrops are presented in Table-4.6.

Number of fingers per bunch was not significantly influenced due to the various treatments. The highest number of fingers per bunch was recorded under T_5 treatment banana + garlic (A_2) (180.25) which was followed by T_2 (179.31), T_{10} (177.10) and T_4 (174.55) treatments. Whereas, T_9 treatment banana + cauliflower (A_3) had the least number of fingers (161.57) per bunch.

Table-4.6: Effect of intercropping on Number of hands/bunch, Average weight of finger (g), No. of fingers/bunch, Length of finger (cm) and Girth of finger (cm) of banana cv. 'Grand Naine'

Treatments	No. of hands per bunch	Average weight of finger (g)	No. of fingers per bunch	Length of finger (cm)	Girth of finger (cm)
T_1 =Banana + Onion (A_1)	10.29	158.19	172.78	21.92	13.02
T_2 =Banana + Onion (A_2)	10.32	160.19	179.31	22.15	13.12
T_3 =Banana + Onion (A_3)	10.22	156.56	166.58	21.80	12.78
T_4 =Banana + Garlic (A_1)	10.30	158.30	174.55	22.02	13.08
T_5 =Banana + Garlic (A_2)	10.37	162.45	180.25	22.30	13.25
T_6 =Banana + Garlic (A_3)	10.28	157.90	169.88	21.88	12.96
T_7 =Banana + Cauliflower (A_1)	10.19	156.45	165.52	21.76	12.74
T_8 =Banana + Cauliflower (A_2)	10.24	157.29	168.65	21.81	12.88
T_9 =Banana + Cauliflower (A_3)	10.00	156.05	161.57	21.63	12.65
T_{10}=Sole Banana	10.31	159.84	177.10	22.12	13.11
S. Em $\pm$	0.36	5.76	6.27	0.83	0.46
CD at 5 %	NS	NS	NS	NS	NS
CV %	7.01	7.28	7.30	7.63	7.11

4.1.3.4 Length of the finger (cm)

The data revealed that the length of finger was not significantly altered due to intercrops (Table-4.6). The longest length of finger was obtained in T_5 treatment banana + garlic (A_2) (22.30 cm) which was followed by T_2 (22.15 cm), T_{10} (22.12 cm)

and T_4 (22.02 cm) treatments. The minimum length of finger was obtained under T_9 treatment banana + cauliflower (A_3) (21.63 cm).

4.1.3.5 Girth of finger (cm)

The data presented in Table-4.6 revealed that the girth of finger was not significantly influenced by the various treatments. The maximum finger girth was recorded in T_5 treatment banana + garlic (A_2) (13.25 cm) which was followed by T_2 (13.12 cm), T_{10} (13.11 cm) and T_4 (13.08 cm) treatments. While, the minimum finger girth was noted in T_9 treatment banana + cauliflower (A_3) (12.65 cm).

4.1.3.6 Weight of bunch (kg)

From the data it could be observed that there were significant differences in weight of bunch per plant due to intercrops (Table-4.7).

Maximum bunch weight was recorded in T_5 treatment banana + garlic (A_2) (26.45 kg) which was statistically at par with T_2 treatment banana + onion (A_2) (25.67 kg), T_{10} treatment sole banana (24.68 kg) and T_4 treatment banana + garlic (A_1) (24.41 kg) treatments. Significantly the minimum bunch weight was recorded under T_9 treatment banana + cauliflower (A_3) (21.37 kg) which was statistically at par with T_7 treatment banana + cauliflower (A_1) (21.74 kg), T_3 treatment banana + onion (A_3) (23.26 kg), T_8 treatment banana + cauliflower (A_2) (23.39 kg), T_6 treatment banana + garlic (A_3) (23.49 kg) and T_1 treatment banana + onion (A_1) (23.68 kg).

4.1.3.7 Yield (t/ha)

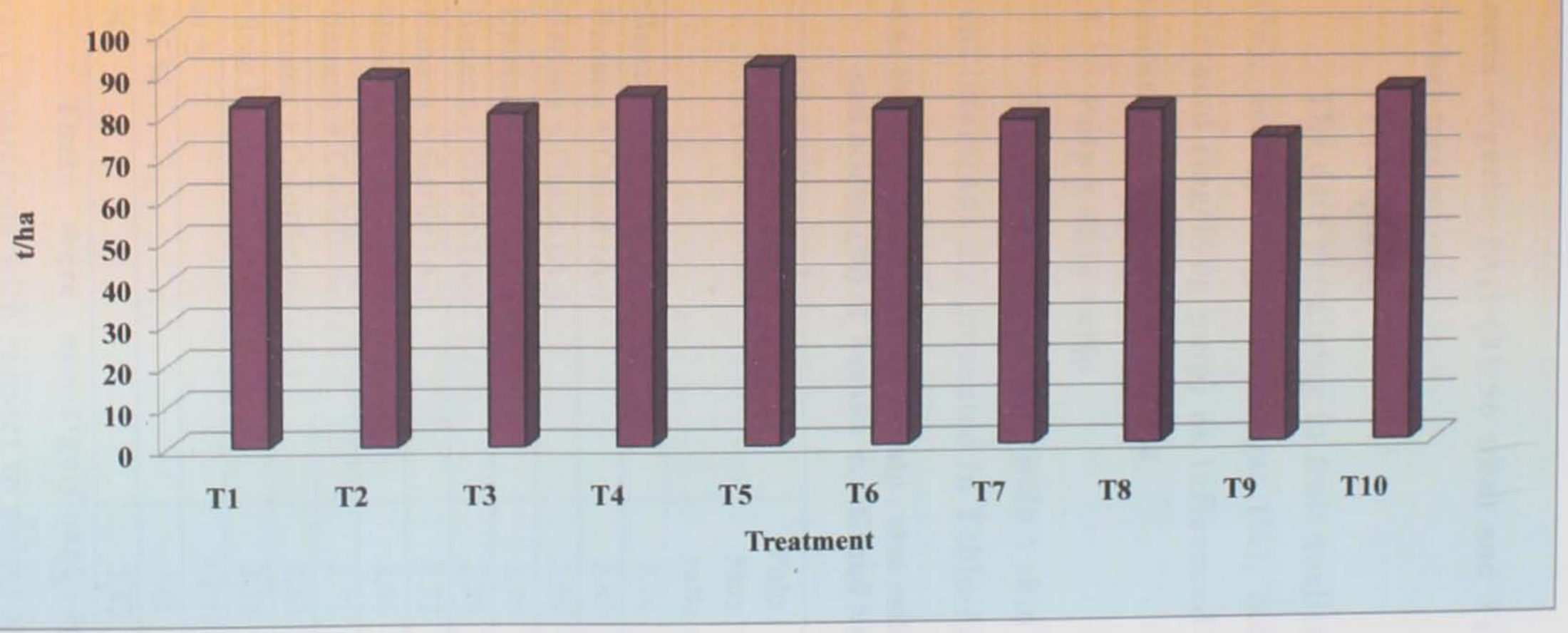
The data related to the yield per hectare as affected by various treatments have been presented in Table-4.7 and shown graphically in Fig-5.

Table-4.7: Effect of intercropping on bunch weight (kg) and yield (t/ha) of banana cv. 'Grand Naine'

Treatments	Weight of bunch (kg)	Yield (t/ha)
T_1 =Banana + Onion (A_1)	23.68	82.22
T_2 =Banana + Onion (A_2)	25.67	89.14
T_3 =Banana + Onion (A_3)	23.26	80.76
T_4 =Banana + Garlic (A_1)	24.41	84.75
T_5 =Banana + Garlic (A_2)	26.45	91.84
T_6 =Banana + Garlic (A_3)	23.49	81.56
T_7 =Banana + Cauliflower (A_1)	22.74	78.95
T_8 =Banana + Cauliflower (A_2)	23.39	81.21
T_9 =Banana + Cauliflower (A_3)	21.37	74.20
T_{10}=Sole Banana	24.68	85.70
S. Em $\pm$	0.95	3.30
CD at 5 %	2.76	9.59
CV %	7.96	7.96

The data revealed that the yield per hectare was significantly influenced due to the various intercropping treatments. The maximum yield (91.84 t/ha) was obtained in T_5 treatment banana + garlic (A_2) which was at par with T_2 banana + onion (A_2) (89.14 t/ha), T_{10} sole banana (85.7 t/ha) and T_4 banana + garlic (A_1) (84.75 t/ha). The minimum yield was noted in T_9 treatment banana + cauliflower (A_3) (74.20 t/ha) which was at par with T_7 banana + cauliflower (A_1) (78.95 t/ha), T_3 banana + onion (A_3) (80.79 t/ha), T_8 banana + cauliflower (A_2) (81.21 t/ha),

Fig. 5: Effect of intercropping on bunch yield (t/ha) of banana cv. 'Grand Naine'



T_1 = Banana + Onion (A_1)
T_2 = Banana + Onion (A_2)
T_3 = Banana + Onion (A_3)
T_4 = Banana + Garlic (A_1)
T_5 = Banana + Garlic (A_2)
T_6 = Banana + Garlic (A_3)
T_7 = Banana + Cauliflower (A_1)
T_8 = Banana + Cauliflower (A_2)
T_9= Banana + Cauliflower (A_3)
T_{10}= Sole Banana

T_6 banana + garlic (A_3) (81.56 t/ha) and T_1 banana + onion (A_1) (82.22 t/ha) treatments.

4.1.4 Fruit quality

The data pertaining to fruit quality *viz.*, pulp: skin ratio, TSS (%), acidity (%), total sugar (%), reducing sugar (%) and ascorbic acid (mg/100g pulp) as influenced by various treatments are presented in Table-4.8 and 4.9.

4.1.4.1 Pulp : Skin ratio

The data regarding to pulp : skin ratio as influenced by different intercrops are presented in Table-4.8.

Table-4.8: Effect of intercropping on pulp : skin ratio, total soluble solids (%) and acidity (%) of banana cv. 'Grand Naine'

Treatments	Pulp : Skin ratio	TSS (%)	Acidity (%)
T_1 =Banana + Onion (A_1)	2.74	21.15	0.379
T_2 =Banana + Onion (A_2)	2.81	21.30	0.384
T_3 =Banana + Onion (A_3)	2.69	21.05	0.372
T_4 =Banana + Garlic (A_1)	2.76	21.20	0.380
T_5 =Banana + Garlic (A_2)	2.89	21.45	0.387
T_6 =Banana + Garlic (A_3)	2.72	21.13	0.375
T_7 =Banana + Cauliflower (A_1)	2.66	21.00	0.371
T_8 =Banana + Cauliflower (A_2)	2.71	21.10	0.374
T_9=Banana + Cauliflower (A_3)	2.63	20.95	0.369
T_{10}=Sole Banana	2.78	21.23	0.382
S. Em $\pm$	0.074	0.572	0.009
CD at 5 %	NS	NS	NS
CV %	5.45	5.41	5.01

There were non-significant differences among the different intercrops with respect to pulp : skin ratio. However, the higher pulp : skin ratio was observed under T_5 treatment banana +

garlic (A_2) (2.89) and the lowest was recorded under T_9 treatment banana + cauliflower (A_3) (2.63).

4.1.4.2 Total soluble solids (TSS %)

Total soluble solids varied non-significantly under different intercropping treatments (Table-4.8). The maximum TSS percentage was recorded with T_5 treatment *i.e.*, banana + garlic (A_2) (21.45 %) which was followed by T_2 (21.30 %), T_{10} (21.23 %) and T_4 (21.20 %) treatments. The lowest TSS was recorded under T_9 treatment banana + cauliflower (A_3) (20.95 %).

4.1.4.3 Acidity (%)

From the data with respect to the acidity content in banana fruit presented in Table-4.8 showed no significant differences due to the treatments.

Lower acidity was found in T_5 treatment banana + garlic (A_2) (0.369 %) which was followed by T_2 (0.371 %), T_{10} (0.372 %), T_4 (0.374 %), T_1 (0.375 %) and T_6 (0.379 %) treatments. The higher acidity was found in treatment T_9 (0.387 %).

4.1.4.4 Total sugar (%)

The data pertaining to total sugar content in banana fruit was not affected by different treatments presented in Table-4.9.

It was observed that there were no significant differences among the treatments. T_5 treatment banana + garlic (A_2) recorded more total sugar (17.64 %) which was followed by T_2 (17.60 %), T_{10} (17.59 %), T_4 (17.54 %) and T_1 (17.51 %) treatments. Whereas, the lower total sugar percentage was recorded under T_9 banana + cauliflower (A_3) (17.30 %).

4.1.4.5 Reducing sugar (%)

The data regarding to reducing sugar as influenced by different intercrops are presented in Table-4.9.

The reducing sugars content of the fruit was not significantly influenced due to the various intercropping treatments. Minimum reducing sugar was recorded under T_5 treatment banana + garlic (A_2) (7.13 %) which was followed by T_2 (7.14 %), T_{10} (7.15 %) and T_4 (7.17 %) treatments. However, the maximum reducing sugar percentage was recorded T_9 treatment banana + cauliflower A_3 (7.30 %).

Table-4.9: Effect of intercropping on total sugar (%), reducing sugar (%) and ascorbic acid (mg/100g pulp) of banana cv. 'Grand Naine'

Treatments	Total Sugar (%)	Reducing sugar (%)	Ascorbic Acid (mg/100g pulp)
T_1 =Banana + Onion (A_1)	17.51	7.19	9.01
T_2 =Banana + Onion (A_2)	17.60	7.14	9.09
T_3 =Banana + Onion (A_3)	17.45	7.27	8.96
T_4 =Banana + Garlic (A_1)	17.54	7.17	9.03
T_5 =Banana + Garlic (A_2)	17.64	7.13	9.10
T_6 =Banana + Garlic (A_3)	17.49	7.21	9.00
T_7 =Banana + Cauliflower (A_1)	17.37	7.27	8.94
T_8 =Banana + Cauliflower (A_2)	17.46	7.25	8.98
T_9=Banana + Cauliflower (A_3)	17.30	7.30	8.93
T_{10}=Sole Banana	17.59	7.15	9.05
S. Em $\pm$	0.239	0.17	0.282
CD at 5 %	NS	NS	NS
CV %	2.74	4.67	6.27

4.1.4.6 Ascorbic Acid (mg/100g pulp)

The ascorbic acid of the fruit was not significantly influenced due to the various treatments (Table-4.9). However, the maximum Ascorbic acid was recorded under treatment T_5 banana + garlic (A_2) (9.10 mg/100g pulp) which was followed by T_2 (9.09 mg/100g pulp), T_{10} (9.05 mg/100g pulp) and T_4 (9.03 mg/100g pulp) treatments. The lowest ascorbic acid was recorded under T_9 treatment banana + cauliflower A_3 (8.93 mg/100g pulp).

4.1.5 Shelf life of fruits (days)

The data on shelf life as influenced by different treatments are presented in Table-4.10.

Table-4.10: Effect of intercropping on shelf life (days) of banana cv. 'Grand Naine'

Treatments	Shelf life of banana (days)
T_1 =Banana + Onion (A_1)	8.62
T_2 =Banana + Onion (A_2)	8.71
T_3 =Banana + Onion (A_3)	8.59
T_4 =Banana + Garlic (A_1)	8.66
T_5 =Banana + Garlic (A_2)	8.73
T_6 =Banana + Garlic (A_3)	8.61
T_7 =Banana + Cauliflower (A_1)	8.58
T_8 =Banana + Cauliflower (A_2)	8.60
T_9 =Banana + Cauliflower (A_3)	8.57
T_{10}=Sole Banana	8.69
S. Em $\pm$	0.32
CD at 5 %	NS
CV %	7.43

The shelf life of the fruit was not significantly influenced due to the various treatments (Table-4.10). However, the maximum shelf life (8.73 days) was observed

under T_5 treatment banana + garlic (A_2) which was followed by T_2 (8.71 days), T_{10} (8.69 days), T_4 (8.66 days), T_1 (8.62 days) and T_6 (8.61 days) treatments. Minimum shelf life was observed under T_9 treatment banana + cauliflower A_3 (8.57 days).

4.2 Onion

4.2.1 Growth parameters

The influence of intercropping patterns on growth characters like plant height (cm), number of leaves, leaf area (cm^2), leaf area index (cm^2) and neck thickness (cm) of onion are presented Table-4.11, 412 and 4.13.

4.2.1.1 Plant height (cm)

The mean data pertaining to periodical plant height at 30 DAT, 60 DAT and at harvest as influenced by different intercropping patterns are presented in Table-4.11.

At 30 DAT, influence of intercropping on plant height was found non-significant. At the stage of 60 DAT and at harvest onion A_1 recorded significantly maximum plant height (63.01 and 67.78 cm, respectively). While, minimum plant height was recorded under sole onion (52.73 and 57.53 cm) which was at par with onion A_2 (53.66 and 58.45 cm) and onion A_3 (54.68 and 58.56 cm) at 60 DAT and at harvest, respectively.

4.2.1.2 Number of leaves per plant

The mean data pertaining to number of leaves as affected by intercrop at 30 DAT, 60 DAT and at harvest are presented in Table-4.11.

At 30 DAT, influence of intercrop on mean number of leaves stability found to be non significant. At 60 and 90 DAT the onion A_1 exhibited maximum number of leaves per plant (12.58 and 13.85, respectively) which was at par with onion A_3 (11.73) at harvest. The less number of leaves were recorded under sole onion (9.23) which was at par with onion A_2 (9.38) and onion A_3 (10.49) at 60 DAT. At harvest, minimum number of leaves were observed under onion A_2 (9.45) which was at par with sole onion (9.80) and onion A_3 (11.73).

Table-4.11: Effect of area under intercrop on plant height (cm) and number of leaves per plant of onion cv. 'Puna Red'

Treatments	Plant height (cm)			Number of leaves per plant		
	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest
A_1 onion	45.66	63.01	67.78	7.32	12.58	13.85
A_2 onion	40.14	53.66	58.45	6.49	9.38	9.45
A_3 onion	42.70	54.68	58.56	7.01	10.49	11.73
Sole onion	41.36	52.73	57.53	6.76	9.23	9.80
S.Em ±	1.55	1.68	1.82	0.24	0.39	0.76
CD at 5 %	NS	8.15	8.83	NS	1.91	3.71
CV %	7.30	6.00	6.01	7.12	7.57	13.64

4.2.1.3 Leaf area (cm^2)

The mean data pertaining to periodical leaf area at 30 DAT, 60 DAT and at harvest as influenced by different intercropping patterns are presented in Table-4.12.

At 30 DAT, influence of intercropping on leaf area was found non-significant. At the stage of 60 DAT and at harvest, onion A_1 recorded significantly maximum leaf area (1060.0 and 1154.4 cm^2, respectively). While, minimum leaf

area was recorded under sole onion (912.2 and 978 cm^2) which was at par with onion A_2 (914.8 and 997.5 cm^2) and onion A_3 (919.2 and 1002.9 cm^2) at 60 DAT and at harvest, respectively.

4.2.1.4 Leaf area index (cm^2)

The mean data pertaining to periodical leaf area index at 30 DAT, 60 DAT and at harvest as influenced by different intercropping patterns are presented in Table-4.12.

At 30 DAT, influence of intercropping on leaf area index was found non-significant. At the stage of 60 DAT and at harvest, onion A_1 recorded significantly maximum leaf area index (6.99 and 7.7 cm^2, respectively). While, minimum leaf area index was recorded under sole onion (6.10 and 6.52 cm^2) which was at par with onion A_2 (6.15 and 6.65 cm^2) and onion A_3 (6.17 and 6.67 cm^2) at 60 DAT and at harvest, respectively.

Table-4.12: Effect of area under intercrop on leaf area (cm^2) and leaf area index (cm^2) of onion cv. 'Puna Red'

Treatments	Leaf area (cm^2)			Leaf area index (cm^2)		
	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest
A_1 onion	694.7	1060.0	1154.4	4.63	6.99	7.70
A_2 onion	639.1	914.8	997.5	4.49	6.15	6.65
A_3 onion	658.9	919.2	1002.9	4.55	6.17	6.67
Sole onion	661.7	912.2	978.0	4.44	6.10	6.52
S. Em ±	19.85	28.58	31.07	0.11	0.16	0.21
CD at 5 %	NS	138.5	150.65	NS	0.80	1.01
CV %	5.98	6.00	6.01	4.92	5.22	6.07

4.2.1.5 Neck thickness (cm)

The data on neck thickness as influenced by intercropping pattern at 30 DAT, 60 DAT and at harvest are presented in Table-4.13.

Different intercropping patterns have non significance difference among the neck thickness at initial stage of growth (30 DAT) but at 60 DAT and at harvest, different treatments were recorded significant difference. Onion A_1 was recorded maximum neck thickness at 60 DAT and at harvest (1.72 and 1.94 cm, respectively). Minimum neck thickness was observed under sole onion (1.42 cm) and onion A_2 (1.42 cm) which was at par with onion A_3 (1.43 cm) at 60 DAT. At harvest, minimum neck thickness was recorded under sole onion (1.53 cm) which was at par with onion A_2 (1.54 cm) and onion A_3 (1.64 cm).

Table-4.13: Effect of area under intercrop on neck thickness (cm) and plant dry matter production (g/plant) of onion cv. 'Puna Red'

Treatments	Neck thickness (cm)			Plant dry matter production (g/plant)		
	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest
A_1 onion	1.20	1.72	1.94	1.17	37.99	94.48
A_2 onion	0.92	1.42	1.54	1.09	30.23	81.40
A_3 onion	1.07	1.43	1.64	1.09	31.58	82.26
Sole onion	1.03	1.42	1.53	1.07	30.25	81.98
S. Em ±	0.06	0.05	0.06	0.055	1.12	2.50
CD at 5 %	NS	0.26	0.28	NS	5.45	12.12
CV %	12.41	7.34	6.92	10.07	6.92	5.88

4.2.2 Yield and yield attributes

The mean data pertaining to dry matter yield (g/plant), bulb diameter (cm), bulb volume (cm^3), average bulb weight (g) and yield (t/ha) of onion as influenced by intercropping pattern are presented in Table-4.13, 4.14 and 4.15.

4.2.2.1 Dry matter yield (g/plant)

The data regarding to dry matter production affected by different intercropping patterns are presented in Table-4.13.

The dry matter yield of onion bulb was significantly influenced due to intercrop at 60 DAT and at harvest. But dry matter production was not affected significantly at 30 DAT. The data showed that higher dry matter production at 60 DAT and at harvest (37.99 and 94.48 g/plant, respectively) were produced with onion A_1. While, minimum dry matter production was recorded under onion A_2 (30.23 and 81.40 g/plant) which was at par with sole onion (30.25 and 81.98 g/plant) and onion A_3 (31.58 and 82.26 g/plant) at 60 DAT and at harvest, respectively.

4.2.2.2 Bulb diameter (cm)

The data on bulb diameter as influenced by intercropping pattern at 60 DAT and at harvest are presented in Table-4.14.

The data presented in Table-4.14 revealed that the diameter of onion bulb significantly affected due to intercropping. Diameter of onion bulb was found highest under onion A_1 (4.02 and 6.08 cm) at 60 DAT and at harvest, respectively. While, minimum bulb diameter was observed under onion A_2 (3.51 and 5.41 cm) which was at par with sole onion (3.53 and 5.42 cm) and onion A_3 (3.55 and 5.45 cm) at 60 DAT and at harvest, respectively.

4.2.2.3 Bulb volume (cm^3)

The data pertaining to bulb volume affected by area under intercrop are presented in Table-4.14.

The data presented in Table-4.14 revealed that there were significant difference among different treatment and the highest bulb volume (36.01 and 86.48 cm^3) were recorded in onion A_1 at 60 DAT and at harvest, respectively. While, minimum bulb volume was observed under onion A_2 (29.24 cm^3) which was at par with sole onion (29.82 cm^3) and onion A_3 (31.63 cm^3) at 60 DAT. At harvest, minimum bulb volume was recorded under sole onion (72.19 cm^3) which was at par with onion A_2 (73.05 cm^3) and onion A_3 (75.55 cm^3).

Table-4.14: Effect of area under intercrop on bulb diameter (cm) and bulb volume (cm^3) of onion cv. 'Puna Red'

Treatments	Bulb diameter (cm)		Bulb volume (cm^3)	
	60 DAT	At Harvest	60 DAT	At Harvest
A_1 onion	4.02	6.08	36.01	86.48
A_2 onion	3.51	5.41	29.24	73.05
A_3 onion	3.55	5.45	31.63	75.55
Sole onion	3.53	5.42	29.82	72.19
S. Em ±	0.09	0.13	0.88	1.80
CD at 5 %	0.45	0.61	4.26	8.73
CV %	5.08	4.52	5.55	4.69

4.2.2.4 Average bulb weight (g)

The data pertaining to average bulb weight of onion as affected by different intercropping pattern recorded at 60 DAT and at harvest are presented in Table-4.15.

The data presented in Table-4.15 clearly indicated that there were significant difference in treatments and highest bulb weight was observed in onion A_1 (35.76 and 87.69 g) at 60 DAT and at harvest, respectively. While, minimum bulb weight was recorded under sole onion (28.79 g) which was at par with onion A_2 (28.99 g) and onion A_3 (30.49 g) at 60 DAT. At harvest,

minimum bulb weight was observed under onion A_2 (72.45 g) which was at par with sole onion (73.41 g) and onion A_3 (75.54 g).

4.2.2.5 Yield (t/ha)

The data pertaining to yield as affected by intercrop are presented in Table-4.15.

The yield was significantly differed due to intercropping patterns. The data showed that onion A_1 produced significantly higher yield (40.35 t/ha) which was at par with onion A_3 (35.19 t/ha), while minimum yield was observed under sole onion (31.96 t/ha) which was found at par with onion A_2 (32.74 t/ha).

Table-4.15: Effect of area under intercrop on bulb weight (g), yield (t/ha) and total soluble solids (%) of onion cv. 'Puna Red'

Treatments	Bulb weight (g)		Yield (t/ha)	Total soluble solids (%)	
	60 DAT	At Harvest		60 DAT	At Harvest
A_1 onion	35.76	87.69	40.35	10.02	10.87
A_2 onion	28.99	72.45	32.74	9.46	10.58
A_3 onion	30.49	75.54	35.19	9.52	10.68
Sole onion	28.79	73.41	31.96	9.41	10.50
S. Em ±	1.01	2.28	1.50	0.29	0.29
CD at 5 %	4.92	11.07	7.29	NS	NS
CV %	6.54	5.91	8.57	6.14	5.43

4.2.3 Quality parameters

4.2.3.1 TSS (%)

The result furnished in Table-4.15 revealed that the different treatments of intercrop failed to produce any significant effect on TSS content in onion bulb. However, it was observed that the onion A_1 (10.02 and 10.87 %) at 60 DAT and at harvest, respectively recorded higher TSS content in bulb, while minimum

A_1

A_2

A_3

Plate-II : Onion as intercrop in banana under drip irrigation

TSS was recorded under sole onion (9.41 and 10.50 %) at 60 DAT and at harvest, respectively.

4.3 Garlic

4.3.1 Growth parameters

The Influence of intercropping on growth characters like plant height (cm), number of leaves, leaf area (cm^2) and leaf area index (cm^2) of garlic are presented Table-4.16 and 4.17.

4.3.1.1 Plant height (cm)

The mean data pertaining to periodical plant height at 30 DAP, 60 DAP and at harvest as influenced by different intercropping patterns are presented in Table-4.16.

At 30 DAP, influence of intercropping on mean plant height was found non-significant. At 60 DAP and at harvest garlic A_1 recorded higher plant height (62.46 and 67.32 cm, respectively). While, minimum plant height was observed in sole garlic (51.48 and 54.32 cm) which was at par with garlic A_2 (51.91 and 54.63 cm) and garlic A_3 (53.65 and 57.30 cm) at 60 DAP and at harvest, respectively.

4.3.1.2 Number of leaves per plant

The mean data pertaining to number of leaves as affected by intercropping pattern at 30 DAP, 60 DAP and at harvest are presented in Table-4.16.

At 30 DAP, influence of intercropping pattern on mean number of leaves found to be non significant. At 60 DAP and at harvest, garlic A_1 exhibited maximum number of leaves per plant (7.14 and 13.06, respectively). While minimum number of leaves were observed under garlic A_2 (5.98 and 10.06) which was at par

with sole garlic (5.99 and 10.25) and garlic A_3 (6.11 and 11.59) at 60 DAP and at harvest, respectively.

Table-4.16: Effect of area under intercrop on plant height (cm) and number of leaves per plant of garlic cv. 'Local'

Treatments	Plant height (cm)			Number of leaves per plant		
	30 DAP	60 DAP	At Harvest	30 DAP	60 DAP	At Harvest
A_1 garlic	30.07	62.46	67.32	5.55	7.14	13.06
A_2 garlic	25.39	51.91	54.63	5.60	5.98	10.06
A_3 garlic	28.39	53.65	57.30	5.83	6.11	11.59
Sole garlic	25.05	51.48	54.32	5.80	5.99	10.25
S. Em ±	1.66	1.71	2.00	0.24	0.20	0.37
CD at 5 %	NS	8.33	9.70	NS	0.97	1.80
CV %	12.19	6.27	6.84	8.45	6.36	6.60

4.3.1.3 Leaf area (cm^2)

The mean data pertaining to periodical leaf area at 30 DAP, 60 DAP and at harvest as influenced by different intercropping patterns are presented in Table-4.17.

At 30 DAP, influence of different intercropping on leaf area was found non-significant. At the stage of 60 DAP and at harvest, garlic A_1 recorded significantly maximum leaf area (209.2 and 262.6 cm^2, respectively). While, minimum leaf area was recorded under garlic A_2 (186.1 and 222.4 cm^2) which was at par with sole garlic (187.2 and 224.2 cm^2) and garlic A_3 (190.8 and 227.4 cm^2) at 60 DAP and at harvest, respectively.

4.3.1.4 Leaf area index (cm^2)

The mean data pertaining to periodical leaf area index at 30 DAP, leaf area index 60 DAP and at harvest as influenced by different intercropping patterns are presented in Table-4.17.

At 30 DAP, influence of intercropping on leaf area index was found non-significant. At the stage of 60 DAP and at harvest garlic A_1 recorded significantly maximum leaf area index (1.40 and 1.75 cm^2, respectively). While, minimum leaf area index was recorded under garlic A_2 (1.23 and 1.48 cm^2) which was at par with sole garlic (1.24 and 1.49 cm^2) and garlic A_3 (1.25 and 1.50 cm^2) at 60 DAP and at harvest, respectively.

Table-4.17: Effect of area under intercrop on leaf area (cm^2) and leaf area index (cm^2) of garlic cv. 'Local'

Treatments	Leaf area (cm^2)			Leaf area index (cm^2)		
	30 DAP	60 DAP	At Harvest	30 DAP	60 DAP	At Harvest
A_1 garlic	101.7	209.	262.6	0.68	1.40	1.75
A_2 garlic	96.6	186.1	222.4	0.65	1.23	1.48
A_3 garlic	96.2	190.8	227.4	0.66	1.25	1.50
Sole garlic	94.6	187.2	224.2	0.65	1.24	1.49
S. Em ±	1.79	3.73	7.19	0.01	0.02	0.04
CD at 5 %	NS	18.10	34.87	NS	0.13	0.21
CV %	3.68	3.86	6.14	5.98	4.08	5.72

4.3.2 Yield and yield attributes

The mean data pertaining to average dry matter yield (g/plant), bulb diameter (cm), clove length (cm) and breadth (cm), number of clove, clove weight (g), bulb weight (g) and yield (t/ha) of garlic as influenced by intercropping pattern recorded are presented in Table-4.18, 4.19 and 4.20.

4.3.2.1 Dry matter production (g/plant)

The dry matter productions of garlic influenced due to intercropping pattern are presented in Table-4.18.

Dry matter yield was not affected significantly at 30 DAP. The data reported in Table-4.18 showed that significantly higher dry matter production was produced under garlic A_1 at 60 DAP and at harvest (6.42 and 28.62 g/plant, respectively). Minimum dry matter production was recorded under sole garlic (5.33 g/plant) and garlic A_2 (5.33 g/plant) which was at par with garlic A_3 (5.47 g/plant) at 60 DAP. At harvest, minimum dry matter production was reported under sole garlic (21.07 g/plant) which was at par with garlic A_2 (21.60 g/plant) and garlic A_3 (23.94 g/plant).

Table-4.18: Effect of area under intercrop on plant dry matter production (g/plant) and bulb diameter (cm) of garlic cv. 'Local'.

Treatments	Plant dry matter production (g/plant)			Bulb diameter (cm)	
	30 DAP	60 DAP	At Harvest	60 DAP	At Harvest
A_1 garlic	0.77	6.42	28.62	1.71	4.18
A_2 garlic	0.70	5.33	21.60	1.30	3.28
A_3 garlic	0.70	5.47	23.94	1.39	3.40
Sole garlic	0.66	5.33	21.07	1.34	3.30
S. Em ±	0.04	0.19	0.86	0.06	0.15
CD at 5 %	NS	0.94	4.18	0.29	0.70
CV %	13.83	6.86	7.24	8.22	8.26

4.3.2.2 Bulb diameter (cm)

The data presented in Table-4.18 of bulb diameter (cm) indicated that different intercropping patterns have recorded significance results. Garlic A_1 was recorded higher bulb diameter at 60 DAP and at harvest (1.71 and 4.18 cm, respectively). While, minimum bulb diameter was recorded under garlic A_2 (1.30 and 3.28 cm) which was at par with sole garlic (1.34 and 3.30 cm) and

garlic A_3 (1.39 and 3.40 cm) at 60 DAP and at harvest, respectively.

4.3.2.3 Length and breadth of clove (cm)

The data pertaining to length and breadth of clove of garlic as influenced by different intercropping patterns are presented in Table-4.19.

Data furnished in Table-4.19 clearly indicated that different area under intercrop has non-significant effect on the length and breadth of garlic cloves. It was noticed that garlic A_1 gave highest length (2.17 cm) and breadth (1.20 cm), while minimum length (2.01 cm) and breadth (1.14 cm) was observed under garlic A_2.

Table-4.19: Effect of area under intercrop on clove length (cm), clove breath (cm), number of clove and clove weight (g) of garlic cv. 'Local'

Treatments	Clove length (cm)	Clove breath (cm)	No. of clove	Clove weight (g)
A_1 garlic	2.17	1.20	14.68	1.47
A_2 garlic	2.01	1.14	14.19	1.39
A_3 garlic	2.08	1.18	14.47	1.41
Sole garlic	2.06	1.16	13.93	1.37
S. Em ±	0.05	0.03	0.39	0.07
CD at 5 %	NS	NS	NS	NS
CV %	4.89	5.96	5.45	10.87

4.3.2.4 Number of cloves per bulb

The mean data on numbers of cloves per bulb as influenced by intercropping patterns are presented in Table-4.19.

It is evident from the data presented in Table-4.19 that intercropping under banana has found non-significant effect on the number of cloves per bulb. The results revealed that garlic A_1 produced higher numbers of cloves per bulb (14.68), while

minimum number of clove per bulb was reported under sole garlic (13.93).

4.3.2.5 Clove weight (g)

The mean data on clove weight in garlic as influenced by intercropping patterns are given in Table-4.19.

The data clearly indicated that intercropping patterns had non-significant effect on the clove weight. The intercropping pattern with garlic A_1 recorded maximum clove weight (1.47 g), while minimum clove weight was observed under sole garlic (1.37 g).

4.3.2.6 Average bulb weight (g)

The mean data pertaining to average bulb weight of garlic as affected by different intercropping pattern at 60 DAP and at harvest are presented in Table-4.20.

It is evident from the data presented in Table-4.20 that intercropping patterns had significant effect on bulb weight. Highest bulb weight was observed in garlic A_1 (5.17 and 20.03 g) at 60 DAP and at harvest, respectively. While, minimum bulb weight was noticed under sole garlic (3.96 g) which was at par with garlic A_2 (4.00 g) and garlic A_3 (4.22 g) at 60 DAP. At harvest, minimum bulb weight was recorded under garlic A_2 (15.23 g) which was at par with sole garlic (15.76 g) and garlic A_3 (16.17 g).

4.3.2.7 Yield (t/ha)

The data regarding on yield as influenced due to intercropping pattern are presented in Table-4.20.

It is evident from the data presented in Table-4.20 that intercropping under banana has found significant effect on the yield. The results revealed that garlic A_1 produced maximum yield (6.88 t/ha) which was at par with sole garlic (5.94 t/ha) and garlic A_3 (6.02 t/ha), while minimum yield was reported under garlic A_2 (5.14 t/ha).

Table-4.20: Effect of area under intercrop on bulb weight (g), yield (t/ha) and total soluble solids (%) of garlic cv. 'Local'

Treatments	Bulb weight (g)		Yield (t/ha)	TSS (%)
	60 DAP	At Harvest		
A_1 garlic	5.17	20.03	6.88	41.43
A_2 garlic	4.00	15.23	5.14	40.83
A_3 garlic	4.22	16.17	6.02	40.25
Sole garlic	3.96	15.76	5.94	39.88
S. Em ±	0.18	0.78	0.23	1.28
CD at 5 %	0.89	3.80	1.11	NS
CV %	8.55	9.34	7.66	6.31

4.3.3 Quality parameters

4.3.3.1 TSS (%)

The result furnished in Table-4.20 revealed that the different treatments of intercrop failed to produce any significant effect on TSS content in garlic. However, it was observed that the garlic A_1 treatment (41.43 %) recorded higher TSS content which was followed by onion A_2 and onion A_3, while minimum TSS was recorded under sole garlic (39.88 %).

4.4 Cauliflower

4.4.1 Growth parameters

The influence of intercropping patterns on growth characters like plant height (cm), number of leaves, plant spread

A_1

A_2

A_3

Plate-III : Garlic as intercrop in banana under drip irrigation

(cm^2) and maturity days of cauliflower are presented Table-4.21 and 4.22.

4.4.1.1 Plant height (cm)

The mean data pertaining to periodical plant height at 30 DAT, 60 DAT and at harvest as influenced by different intercropping patterns are presented in Table-4.21.

After 30 DAT, influence of intercropping on plant height was found non-significant. At the stage of 60 DAT and at harvest, cauliflower A_1 recorded significantly maximum plant height (62.19 and 72.85 cm, respectively). While, minimum plant height was observed under sole cauliflower (52.09 cm) which was at par with cauliflower A_2 (52.37 cm) and cauliflower A_3 (53.09 cm) at 60 DAT. At harvest, minimum plant height was recorded under cauliflower A_2 (59.86 cm) which was at par with sole cauliflower (60.46 cm) and cauliflower A_3 (62.84 cm).

4.4.1.2 Number of leaves per plant

The mean data pertaining to number of leaves as affected by intercropping patterns at 30 DAT, 60 DAT and at harvest are presented in Table-4.21.

At 30 DAT, influence of intercrop on mean number of leaves stability found to be non significant. At 60 DAT and at harvest, the cauliflower A_1 exhibited significantly maximum number of leaves per plant (24.70 and 24.94, respectively). While, minimum number of leaves were observed under sole cauliflower (20.13) which was at par with cauliflower A_2 (20.24) and cauliflower A_3 (20.92) at 60 DAT. At harvest, minimum numbers

of leaves were recorded under cauliflower A_2 (20.48) which was at par with sole cauliflower (20.94) and cauliflower A_3 (21.35).

Table-4.21: Effect of area under intercrop on plant height (cm) and number of leaves per plant of cauliflower cv. 'Maharani'

Treatments	Plant height (cm)			Number of leaves per plant		
	30 DAT	60 DAT	At Harvest	30 DAT	60 DAT	At Harvest
A_1 cauliflower	40.64	62.19	73.85	16.14	24.70	24.94
A_2 cauliflower	38.19	52.37	59.86	15.77	20.24	20.48
A_3 cauliflower	40.55	53.09	62.84	15.75	20.92	21.35
Sole cauliflower	40.23	52.09	60.46	15.75	20.13	20.94
S. Em ±	1.15	1.78	2.26	0.46	0.72	0.72
CD at 5 %	NS	8.63	10.96	NS	3.48	3.51
CV %	5.76	6.48	7.04	5.79	6.68	6.60

4.4.1.3 Plant spread (cm^2)

The data regarding plant spread as influenced by intercropping patterns are presented in Table-4.22.

Different intercropping patterns have non-significance difference among the plant spread at initial stage of growth (30 DAT) but at 60 DAT and at harvest, different treatments were recorded significant difference. At 60 DAT and at harvest, cauliflower A_1 were recorded maximum plant spread (3389.95 and 5827.35 cm^2, respectively), While, minimum plant spread was recorded under sole cauliflower (2629.30 and 4691.70 cm^2) which was at par with cauliflower A_2 (2632.33 and 4788.12 cm^2) and cauliflower A_3 (2681.54 and 4857.46 cm^2) at 60 DAT and at harvest, respectively.

4.4.2 Maturity (days)

The data on days for bud initiation and days for curd maturity are presented in Table-4.22.

Table-4.22: Effect of area under intercrop on plant spread (cm^2), days for bud initiation and days for curd maturity of cauliflower cv. 'Maharani'

Treatments	Plant spread (cm^2)			Days for bud initiation	Days for curd maturity
	30 DAT	60 DAT	At Harvest		
A_1 cauliflower	2242.93	3389.95	5827.35	54.81	78.40
A_2 cauliflower	1732.43	2632.33	4788.12	63.11	83.07
A_3 cauliflower	1806.32	2681.54	4857.46	59.39	82.18
Sole cauliflower	1426.62	2629.30	4691.70	62.97	83.65
S. Em ±	196.17	140.66	184.68	2.17	2.84
CD at 5 %	NS	681.98	895.42	NS	NS
CV %	21.77	9.93	7.33	7.23	6.95

4.4.2.1 Days for bud initiation

The mean data presented in Table-4.22 revealed that the different intercropping pattern has non-significant effect on days required for bud initiation. Minimum days required for bud initiation was recorded under cauliflower A_1 (54.81 days), while maximum days required for bud initiation was noticed under cauliflower A_2 (63.11 days).

4.4.2.2 Days for curd maturity

Data presented in Table-4.22 revealed that the different intercropping system failed to cause any significant effect on the days required for maturity. Minimum days required for curd maturity was recorded under cauliflower A_1 (78.40 days), while

maximum days required for curd maturity was noticed under sole cauliflower (83.65 days).

4.4.3 Yield and yield attributes

The mean data pertaining to curd diameter (cm), average curd weight (g) and curd yield (t/ha) of cauliflower as influenced by intercropping patterns are presented in Table-4.23.

4.4.3.1 Curd diameter (cm)

The data presented in Table-4.23 on curd diameter (cm) indicated that different intercropping patterns have recorded significant difference. Cauliflower A_1 was recorded maximum curd diameter (18.11 cm). While, minimum curd diameter was reported under cauliflower A_2 (14.79 cm) which was at par with sole cauliflower (14.96 cm) and cauliflower A_3 (15.54 cm).

4.4.3.2 Average curd weight (g)

The mean data pertaining to average curd weight of cauliflower as affected by different intercropping pattern are presented in Table-4.23.

It is evident from the data that there were significant difference on curd weight. Highest curd weight was observed in cauliflower A_1 (463.3 g), while minimum curd weight was observed under sole cauliflower (346.8 g) which was at par with cauliflower A_2 (360.8 g) and cauliflower A_3 (399.8 g).

4.4.3.3 Yield (t/ha)

The data regarding yield as influenced due to intercropping pattern are presented in Table-4.23.

The data presented in Table-4.23 clearly indicated that cauliflower A_1 produced significantly higher curd yield (38.62

t/ha) which was at par with cauliflower A_3 (33.32 t/ha). While, minimum yield was observed under sole cauliflower (28.87 t/ha) which was at par with cauliflower A_2 (30.07 t/ha).

4.4.4 Quality parameters

4.4.4.1 TSS (%)

The data on TSS as influenced by different treatment are presented in Table-4.23.

The result furnished in Table-4.23 revealed that the different treatments of intercropping patterns failed to produce any significant effect on TSS content in cauliflower curd. However, it was observed that cauliflower A_1 (9.93 %) recorded higher value of TSS content in curd, while minimum TSS was observed under sole cauliflower (9.23 %).

Table-4.23: Effect of area under intercrop on curd diameter (cm), weight of curd (g), yield (t/ha) and TSS (%) of cauliflower cv. 'Maharani'

Treatments	Curd diameter (cm)	Curd weight (g)	Yield (t/ha)	TSS (%)
A_1 cauliflower	18.11	463.3	38.62	9.93
A_2 cauliflower	14.79	360.8	30.07	9.58
A_3 cauliflower	15.54	399.8	33.32	9.80
Sole cauliflower	14.96	346.8	28.87	9.23
S. Em ±	0.48	14.25	1.53	0.24
CD at 5 %	2.33	69.08	7.44	NS
CV %	6.08	7.30	9.38	5.09

4.5 Banana equivalent yield (t/ha)

The data pertaining to banana equivalent (BEY) yield are presented in Table-4.24.

It is evident from the data presented on Table-4.24 that there were significance among treatments on BEY. Significantly maximum banana equivalent yield (116.95 t/ha) was observed with

A_1

A_2

A_3

Plate-IV : Cauliflower as intercrop in banana under drip irrigation

T_3 treatment banana + onion A_3 which was at par with treatment T_6 banana + garlic A_3 (107.34 t/ha). While, minimum BEY (85.7 t/ha) was recorded under sole banana.

Table-4.24: Effect of intercropping on banana equivalent yield

Treatments	Banana equivalent yield (t/ha)
T_1 = Banana + Onion (A_1)	100.90
T_2 = Banana + Onion (A_2)	107.66
T_3 = Banana + Onion (A_3)	116.95
T_4 = Banana + Garlic (A_1)	98.02
T_5 = Banana + Garlic (A_2)	103.94
T_6 = Banana + Garlic (A_3)	107.34
T_7 = Banana + Cauliflower (A_1)	92.74
T_8 = Banana + Cauliflower (A_2)	95.38
T_9= Banana + Cauliflower (A_3)	101.80
T_{10}= Sole Banana	85.70
S. Em ±	3.58
CD at 5 %	10.40
CV %	7.09

4.6 Land Equivalent Ratio (LER)

The data pertaining to land equivalent ratio as influenced by various intercropping patterns are presented in Table-4.25.

It is evident from the data presented in Table-4.25 that in all the treatments, LER values were found to be greater than one. Maximum LER (1.60) was recorded under T_3 treatment *i.e.* banana + onion A_3 which was followed by T_6 treatment banana + garlic A3 (1.56) and T_9 banana + cauliflower A_3 (1.54). All the treatments have higher LER than sole crops.

Table-4.25: Effect of intercropping on land equivalent ratio

Treatments	Banana yield (t/ha)	Area wise intercrops yield (t/ha)	LER
T_1 = Banana + Onion (A_1)	82.22	10.89	1.30
T_2 = Banana + Onion (A_2)	89.14	10.80	1.38
T_3 = Banana + Onion (A_3)	80.76	21.11	1.60
T_4 = Banana + Garlic (A_1)	84.75	1.86	1.30
T_5 = Banana + Garlic (A_2)	91.84	1.69	1.36
T_6 = Banana + Garlic (A_3)	81.56	3.61	1.56
T_7 = Banana + Cauliflower (A_1)	78.95	9.65	1.26
T_8 = Banana + Cauliflower (A_2)	81.21	9.92	1.29
T_9 = Banana + Cauliflower (A_3)	74.20	19.32	1.54
T_{10}= Sole Banana	85.70	-	1.00
T_{11} = Sole Onion	-	31.96	1.00
T_{12} = Sole Garlic	-	5.94	1.00
T_{13} = Sole Cauliflower	-	28.87	1.00

4.7 Economics

The data on economics of different intercropping systems of banana with onion, garlic and cauliflower are presented in Table-4.26.

Considering the gross income and cost of cultivation with all respects including cost of drip, net income was worked out for experimental period. The benefit cost ratio was also worked out considering net return and cost of cultivation.

The data existing in Table-4.26 clearly indicated that treatment T_3 banana + onion A_3 secured the maximum net realization (Rs. 6,39,768/- ha^{-1}) which was followed by T_6 (Rs. 5,96,131.4/- ha^{-1}) treatment. Higher benefit cost ratio (3.84) was noticed under T_6 banana + garlic A_3 which was followed by T_5 banana + garlic A_2 (3.77) treatment.

Table-4.26: Economics of banana with different intercrop

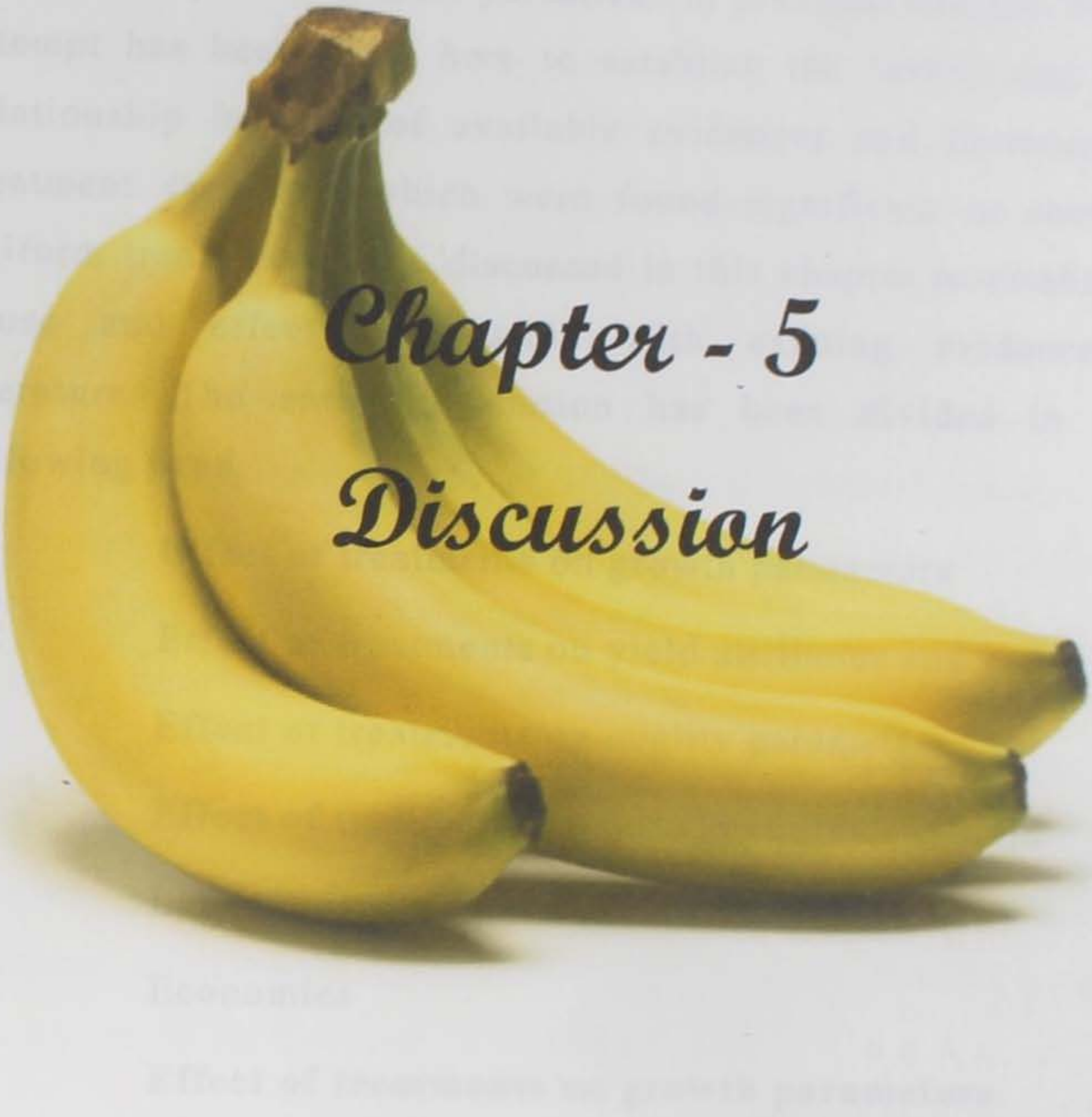
Treatments	Yield (t/ha)		Gross income (Rs./ha)			Cost of cultivation (Rs./ha)	Net return (Rs./ha)	BCR
	Banana	Intercrop	Banana	Intercrop	Total			
T_1 = Banana + Onion (A_1)	82.22	10.89	575540	130680	706220	162463	543757	3.35
T_2 = Banana + Onion (A_2)	89.14	10.80	623980	129600	753580	165610	587970	3.55
T_3 = Banana + Onion (A_3)	80.76	21.11	565320	253320	818640	178872	639768	3.58
T_4 = Banana + Garlic (A_1)	84.75	1.86	593250	93000	686250	151850	534399	3.52
T_5 = Banana + Garlic (A_2)	91.84	1.69	642880	84500	727380	152639	574741	3.77
T_6 = Banana + Garlic (A_3)	81.56	3.61	570920	180500	751420	155289	596131	3.84
T_7 = Banana + Cauliflower (A_1)	78.95	9.65	552650	96500	649150	158539	490611	3.09
T_8 = Banana + Cauliflower (A_2)	81.21	9.92	568470	99200	667670	160335	507335	3.16
T_9= Banana + Cauliflower (A_3)	74.20	19.32	519400	193200	712600	165873	546727	3.30
T_{10}= Sole Banana	85.70	-	599900	-	599900	147600	452300	3.06

Cost of cultivation

Urea : Rs. 250 /50 kg
SSP : Rs. 170 /50 kg
MOP : Rs. 230 /50 kg
Labour : Rs. 100 /day

Selling price (Rs./kg)

Banana : 7
Onion : 12
Garlic : 50
Cauliflower : 10



Chapter - 5

Discussion

V. DISCUSSION

In the present investigation entitled, "Intercropping studies in banana (*Musa paradisica* l.) cv. 'Grand Naine' under drip irrigation", on various parameters were recorded according to the objectives of the study and experimental results interpreted with the help of statistical yardsticks in previous chapter. Now, an attempt has been made here to establish the "effect and cause" relationship in light of available evidences and literature. The treatment variations which were found significant or showing a uniform trend have been discussed in this chapter to establish the cause and effect relationship with existing evidences and literature. The entire discussion has been divided in to the following head.

5.1 Effect of treatments on growth parameters

5.2 Effect of treatments on yield attributes and yields

5.3 Effect of treatments on quality parameters

5.4 Effect of treatments on banana equivalent yield

5.5 Land equivalent ratio

5.6 Economics

5.1 Effect of treatments on growth parameters

5.1.1 Effect of treatments on growth parameters of banana

Banana growth parameters *viz*., plant height, girth of pseudostem, number of leaves plant^{-1}, leaf area, days required for inflorescence emergence and days required from inflorescence

emergence to harvest were influenced due to imposition of intercrop treatments.

A perusal of data on periodical plant height (Table-4.1) and girth of pseudostem (Table-4.2) indicated significant differences among treatments studied at 3rd MAP and 5th MAP. It might be due to intercrop, which also required essential nutrients, space, light and water for growth and development so they are the competitor at initial stage of growth but at 7th MAP and at harvest there is non-significant effect on plant height because at that time the intercrop were harvested. Intercropping significantly reduced the girth of the banana pseudostem at 3rd MAP and 5th MAP, but not at 7th MAP (Table-4.2). Intercropping with cauliflower reduced girth at 3rd MAP and 5th MAP less than the other intercrops. At 7th MAP, the pseudostem girth of the banana without intercrops was significantly less than with intercrops. A possible explanation of girth reduction up to five months under cauliflower is that rapidly growing intercrop exerts a shedding effect on the banana and association of 90-100 days between banana and intercrops may have resulted in competition for water and nutrient supplies. Rainfall after May, however, allowed the banana in various intercrop mixtures to make a recovery in girth. Similar result was also observed by Rao and Edmunds (1983).

Data on number of leaves plant^{-1} (Table-4.3) and leaf area plant^{-1} (Table-4.4) indicated that during early growth stages (3rd MAP and 5th MAP) of banana, different treatments of intercrops influence on these growth parameters significantly but

thereafter such differences were non-significant. This might be due to that, in early stage inter and intra-crop competition was very intense due to growth of component crop of the treatments which induce demand pressure on resources vis-à-vis competition. The periodical increment in banana, number of leaves plant^{-1} and leaf area plant^{-1} indicated that minimum increment over period was observed between 0-5 MAP growth intervals. But at later stage of growth after 7th MAP and at inflorescence emergence, there was no significance difference recorded, it might be due to short duration of intercrop.

It is seen from the data that various growth parameters such as plant height, girth of pseudostem, number of leaves and leaf area were significantly maximum in the plant with the treatment T_5 banana + garlic A_2. Increase in growth may be attributed to the resources given to intercrop which also utilized by main crop (banana). Chundawat *et al.*, (1982) reported that none of the intercrops reduced the vegetative growth of banana.

The results indicated that the early inflorescence emergence and less total crop duration was not significantly altered by the intercrops. Minimum days required from planting to harvesting were observed in banana + garlic A_2 (T_5) as compared to rest of the treatments and control. This might be due to reduced flowering and maturity duration which could be attributed to shorter duration of intercrops (Rao and Edmunds 1983). Similar result was also observed by Chundawat *et al.*, (1982) that the days to maturity was not altered by any intercrop. Devos and Wilson

(1978) were also noticed that no delay in plantain harvest with cocoyam intercropping.

5.1.2 Effect of treatments on growth parameters of intercrop

5.1.2.1 Onion

It is clear from the data presented in previous chapter that intercropping systems had remarkable influence on the crop growth from 60 DAT up to the harvest (Table-4.11, 4.12 and 4.13). Though, at 30 DAT some of the characters *viz.*, plant height, number of leaves, leaf area, leaf area index and neck thickness did not show significant variation under different cropping systems, significant variation in almost all the parameters were observed under various intercropping systems at 60 DAT and at harvest only. Treatment onion A_1 recorded highest values for almost all growth characters, this might be due to high nutrient availability which was given to banana and lesser competition for sun light among the plants at initial stage. All systems of onion A_2 and sole crop showed poor performance in terms of vegetative growth of onion.

5.1.2.2 Garlic

The observation presented in previous chapter of growth parameter *viz.*, plant height, number of leaves, leaf area, leaf area index and plant dry matter accumulation indicated that the intercropping system have non-significant at. initial growth stage *i.e.*, 30 DAP but has recorded significance difference among growth parameter at 60 DAP and at harvest (Table-4.16 and 4.17).

All the growth parameters were observed higher under treatment garlic A_1 which was followed by garlic A_3 system. It might be due to more availability of nutrients to intercrop which was applied to main crop (banana) and garlic also.

5.1.2.3 Cauliflower

The better growth of cauliflower in terms of plant height, number of leaves, plant spread, minimum days curd initiation and curd maturity were influenced by various intercropping systems (Table-4.21 and 4.22). Different intercropping system have non-significant effect on growth parameters at initial growth stage (30 DAP) but has recorded significance difference among growth parameters at 60 DAP and at harvest. Cauliflower A_1 recorded higher growth parameter which was followed by cauliflower A_3. This might be due to intercropping system which was provided more nutrients as compared to A_2 and sole cauliflower.

5.2 Effect of treatments on yield attributes and yield

5.2.1 Effect of treatments on yield attributes and yield of banana

Various yield attributes *viz.*, number of hands per bunch, number of finger per bunch, bunch weight, average weight of finger, length and girth of finger play vital role in increasing productivity of banana. Among the yield attributing characters (Table-4.6 and 4.7) bunch weight was significantly influenced by different intercropping patterns. Treatment T_5 (Banana + garlic A_2) was recorded maximum bunch weight plant^{-1}. Number of hands per

bunch, number of finger per bunch, average weight of finger, length and girth of finger were remained unaffected. However, intercropped banana with garlic A_2 recorded higher yield than sole banana, this is because of higher bunch characters (Table-4.6). Chundawat *et al.*, (1982) revealed that fruiting characters were not altered by any intercrop as production capacity of banana plant is mainly dependent on the vegetative growth before floral initiation and since vegetative growth was not influenced by intercrops at 7 MAP.

Significantly the highest yield (91.84 t/ha) was recorded when banana intercropped with garlic A_2 (T_5). Similar result was also observed by Subbiah *et al.*, (1980) and revealed that raising an onion as intercrop in banana field did not affect the bunch yield of banana. Das and Maharana (1995) have also reported that yield of banana was higher which was intercropped with onion and chilli because nutrient removed by this crops are less. Devos and Wilson (1978) similarly, found no yield reduction with cocoyam intercropping. Singh *et al.*, (2003) reported that intercropping with potato, garlic and pea with autumn planted cane produced higher cane yield than sugarcane mono-cropping.

Nedunchezhiyan *et al.*, (2002) were found that intercropping of elephant foot yam in banana did not affect the bunch characters and yield of banana. Negligible difference was noticed between the bunch characters of sole banana and intercropped banana. This indicated that intercropping elephant foot yam did not competing with main crop for nutrients rather the

left over nutrients from intercropped area is utilized by the banana. This indicates that under intercropping the natural resources were fully utilized. Singh (2010) also reported that intercropping system gave higher yield and yield attributing characters.

5.2.2 Effect of treatments on yield attributes and yields of intercrops

5.2.2.1 Onion

It is clear from the data presented in previous chapter (Tablr-4.13, 4.14 and 4.15) that intercropping systems had remarkable influence on the yield and yield attributes. Yield characters *viz.*, bulb diameter, bulb volume, bulb weight and bulb yield show significant variation under different intercropping systems. Treatment onion A_1 recorded highest values for almost all growth characters, which was followed by onion A_3 system. This might be due to high nutrient and water availability which was given to banana and lesser competition for sun light among the plants at initial stage. Rao and Edmunds (1983) noticed that different intercropping patterns did not affect the yield of intercrops significantly. Onion as intercrop produced maximum yield which was superior to rest of the treatments (Singh, 2001). Increased total productivity by intercropping of onion in sugarcane has been reported by Venkataraman (1977) and Misra (2000).

5.2.2.2 Garlic

The observation presented in previous chapter (Table-4.18, 4.19 and 4.20) of yield parameter *viz.*, clove weight, number of clove, clove length and breadth indicated that the intercropping

system have non-significant effect. Such growth parameters *viz.*, bulb weight and yield were response significant difference to intercropping systems. This was observed higher under treatment garlic A_1 which was followed by garlic A_3 system. It might be due to high availability of nutrients to garlic which was applied to main crop (banana). High bulb weight increases the bulb yield.

5.2.2.3 Cauliflower

The better yield of cauliflower in terms of curd diameter, fresh weight of curd and yield (Table-4.23) were influenced by various intercropping systems. Cauliflower A_1 produces highest yield which was followed by cauliflower A_3. This might be due to high nutrient and water availability to cauliflower A_1 which was given to banana.

5.3 Effect of treatments on quality parameters

5.3.1 Effect of treatments on quality parameters of banana

The data showed that quality character *viz.*, TSS, total sugar, reducing sugar, ascorbic acid, acidity and pulp: skin ratio (Table-4.8 and 4.9) in banana was not affected due to various treatments. All these parameter have non-significant difference through various intercropping systems. Banana + garlic A_5 was recorded higher value of all these quality parameter.

5.3.2 Effect of treatments on quality parameters of intercrops

The result furnished in previous chapter (Table-4.15, 4.20 and 4.23) revealed that the different treatments of intercrop

failed to produce any significant effect on quality parameter in different intercrops *viz*., onion, garlic and cauliflower. However, it was observed that the treatment receiving A_1 recorded higher value as compared other treatment.

5.4 Banana equivalent yield

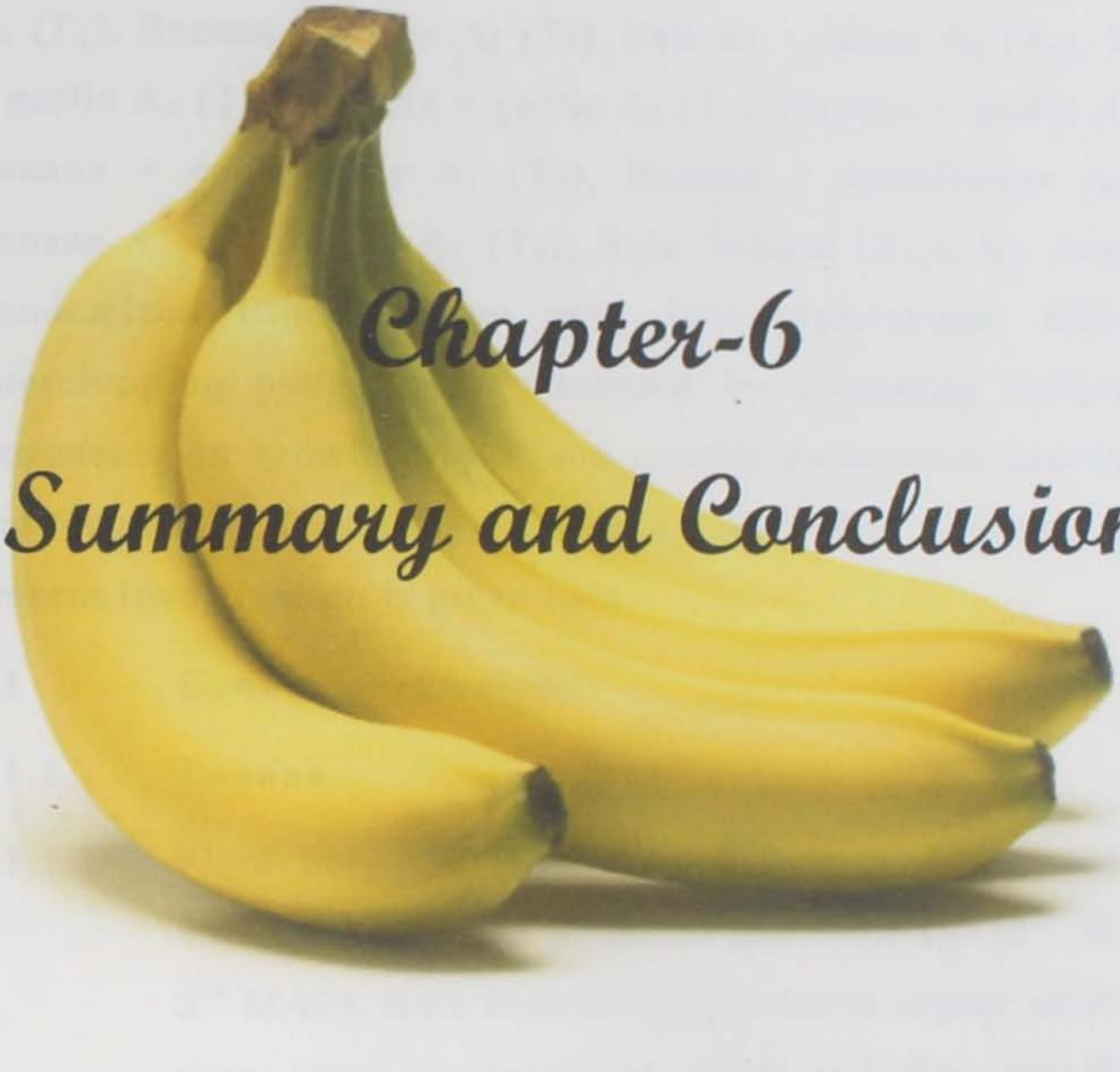
Banana equivalent yield (Table-4.24) was significantly influenced by intercropping. Significantly the highest banana equivalent yield was observed with banana + onion A_3 showing their suitability for intercropping which was at par with banana + garlic A_3. This might be due to A_3 intercropping patterns covers more area under intercrop as compared to A_2 and A_1 which produced more yield and ultimately banana equivalent yield was higher in these treatments. Mollah *et al*., (2007) reported that highest groundnut equivalent yield and benefit cost ratio received from two row onion and garlic in between 40 cm part rows of groundnut than sole groundnut. Sarker *et al*., (2007) revealed that mustard equivalent yield was higher in garlic.

5.5 Land equivalent ratio

Land equivalent ratio was influenced by various intercropping patterns (Table-4.25). LER values were found to be greater than one during experiment. Maximum LER was recorded under treatment T_3 *i.e.* banana + onion A_3. This might be due to A_3 intercropping patterns cover more area under intercrop as compared to A_2 and A_1 which ultimately gave high land equivalent ratio. Minimum LER was noticed under sole crops.

5.6 Economics

Economics of various intercropping system (Table-4.26) revealed that banana + onion A_3 recorded maximum net realization of Rs. 6,39,768 per hectare with BCR of 3.58. This might be due to A_3 intercropping pattern covers more area under intercrop which produce more yield and also price of garlic per kg was maximum as compared to onion and cauliflower ultimately resulted in higher net realization. Das and Maharana (1995) were found that rising intercrops of vegetables under banana like onion, tomato and chilli at initial stage of planting increase the total profit from plot without affecting banana yield. Chundawat *et al.*, (1982) were reported that the intercropping of banana with turmeric would prove profitable to the banana farmers of South Gujarat. Nedunchezhiyan *et al.*, (2002) were also observed that intercropped banana gave higher economic return than sole banana, similar result also reported by Singh (2010) and Anon., (2001a). Maitra *et al.*, (2001) reported that all intercropping systems generated higher returns than sole crop.



Chapter-6

Summary and Conclusion

VI. SUMMARY AND CONCLUSION

An investigation was carried out at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari during *rabi* seasons of 2009-10 to study "Intercropping studies in banana (*Musa paradisiaca* L) cv. 'Gran Naine' under drip irrigation" with ten treatments comprising of Banana + onion A_1 (T_1), Banana + onion A_2 (T_2), Banana + onion A_3 (T_3), Banana + garlic A_1 (T_4), Banana + garlic A_2 (T_5), Banana + garlic A_3 (T_6), Banana + cauliflower A_1 (T_7), Banana + cauliflower A_2 (T_8), Banana + cauliflower A_3 (T_9), Sole banana (T_{10}), by employing Randomized Block Design with four replications. Effects of intercropping pattern were assessed by recording influence of treatments on growth, yield, and quality parameters besides LER and economic feasibility of the system. The summary of the present investigation is given here.

6.1 Growth parameters

6.1.1 Banana

6.1.1.1 Plant height of banana significantly influence due to various treatments at initial growth stage (3rd MAP and 5th MAP). Sole banana T_{10} produced higher plant height than other treatment at three and five months after planting. While, at reproductive stage different treatments fail to cause any significant effect on plant height. Maximum plant height was observed under T_5 treatment banana + garlic A_2.

6.1.1.2 Girth of pseudostem was influenced by various intercrop at 3rd MAP and 5th MAP. Banana intercropped with garlic A_2 (T_5) gave higher girth at 3rd MAP and 5th MAP. All the treatments were failed to influence significantly on girth at 7th MAP and at inflorescence emergence and maximum girth of pseudostem was observed under T_5 treatment banana + garlic A_2.

6.1.1.3 Number of leaves was significantly influenced by different intercrops at initial vegetative growth stage. Garlic A_2 (T_5) based intercropping produce maximum number of leaves at 3rd MAP and 5th MAP. All treatment found non-significant on plant height at 7th MAP and at inflorescence emergence and maximum number of leaves was observed under T_5 treatment banana + garlic A_2.

6.1.1.4 Leaf area per plant was differed due to intercropping at 3rd MAP and 5th MAP. Banana + garlic A_2 (T_5) produced maximum leaf area at 3rd MAP. While, onion A_3 (T_3) based intercropping develop higher leaf area at five months after planting. All the treatments were failed to influence significantly on leaf area at 7th MAP and at inflorescence emergence and maximum leaf area was observed under T_5 treatment banana + garlic A_2.

6.1.1.5 Days required for inflorescence emergence and harvest was not significantly affected by different intercropping patterns. Minimum days required for inflorescence

emergence and harvest were recorded under (T_5) banana + garlic A_2.

6.1.2 Onion

6.1.2.1 Plant height and number of leaves were not significantly influenced by intercropping patterns at one month after transplanting. Onion A_1 recorded maximum plant height and number of leaves at 60 DAT and at harvest.

6.1.2.2 Leaf area, leaf area index and neck thickness were not influenced by different intercropping patterns after one month after transplanting. Onion A_1 was reported highest leaf area, leaf area index and neck thickness at 60 DAT and at harvest.

6.1.3 Garlic

6.1.3.1 Different intercropping patterns fail to cause any significant effect on plant height and number of leaves after one month of planting. Garlic A_1 was noted maximum plant height as well as number of leaves at 60 DAP and at harvest.

6.1.3.2 Leaf area and leaf area index were not influenced by different intercropping patterns after one month after planting. Garlic A_1 was reported more leaf area and leaf area index at 60 DAT and at harvest.

6.1.4 Cauliflower

6.1.4.1 Plant height, number of leaves and plant spread were not significantly influenced by different intercropping

patterns at one month after transplanting. Cauliflower A_1 recorded maximum plant height, number of leaves and plant spread at 60 DAT and at harvest.

6.1.4.2 Different intercropping pattern influence significantly on days required for bud initiation and curd maturity. Minimum days required for bud initiation and curd maturity were observed under cauliflower A_1.

6.2 Yield and yield attributes

6.2.1 Banana

6.2.1.1 Banana yield attributes were not significantly influenced due to intercropping. Banana + garlic A_2 (T_5) gave maximum yield attributes characters *i.e.*, number of hands per bunch, average weight of finger, number of finger per bunch, length and girth of finger.

6.2.1.2 Weight of bunch and yield (t/ha) were significantly differing due to intercrops. Maximum bunch weight and yield were recorded under treatment T_5 banana + garlic A_2.

6.2.2 Onion

6.2.2.1 Dry matter production was not significantly affected by different intercropping patterns at 30 DAT. Significantly maximum dry matter production was observed under onion A_1 at 60 DAT and at harvest.

6.2.2.2 Bulb weight, bulb volume and bulb diameter of onion were significantly affect due to intercrops. Onion A_1

recorded higher bulb volume, bulb diameter and bulb weight at 60 DAT and at harvest.

6.2.2.3 Different treatment cause significant result on yield of onion. Onion A_1 gave significantly higher yield than other treatments.

6.2.3 Garlic

6.2.3.1 Dry matter production of garlic was not significantly affected by different intercropping patterns at 30 DAT. Significantly maximum dry matter production was observed under garlic A_1 at 60 DAT and at harvest.

6.2.3.2 Bulb weight and bulb diameter of garlic were significantly affect due to intercropping patterns. Garlic A_1 recorded maximum bulb diameter and bulb weight at 60 DAT and at harvest.

6.2.3.3 All the treatments were found non-significant on clove characters like clove length, clove breadth, clove weight and number of clove. Garlic A_1 produced maximum clove length, clove breadth, clove weight and number of clove.

6.2.3.4 Intercropping treatment cause significant result on garlic yield. Garlic A_1 gave significantly higher yield than other treatments.

6.2.4 Cauliflower

6.2.4.1 Curd weight and curd diameter of cauliflower were significantly affect due to intercrops. Cauliflower A_1 noted maximum curd diameter and curd weight.

6.2.4.2 Different treatment cause significant result on yield of cauliflower. Cauliflower A_1 gave significantly higher yield than other treatments.

6.3 Quality parameters

6.3.1 Banana

Intercropping in banana was failed to produced any significant result on quality parameters like pulp: skin ratio, TSS, acidity, total sugar, non-reducing sugar and ascorbic acid. However, treatment T_5 gave superior quality parameters.

6.3.2 Onion

All the cropping patterns have non-significant on TSS content of onion. Maximum TSS was observed under onion A_1.

6.3.3 Garlic

Different cropping patterns have non-significant on TSS content of garlic. Maximum TSS was observed under garlic A_1.

6.3.4 Cauliflower

All the cropping patterns have non-significant on TSS content of cauliflower. Maximum TSS was observed under cauliflower A_1.

6.4 Assessment of intercropping system

6.4.1 All three vegetable intercrops with different intercropping patterns significantly increased banana

equivalent yield (BEY) and maximum BEY was observed in banana + onion A_3.

6.4.2 All three vegetable intercrops with different intercropping patterns advantageous for banana as land equivalent yield (LER) value for all treatment combinations were > 1. Maximum LER (1.60) was recorded in banana + onion A_3. Also LER values were more from intercropping system as compared to normal planting.

6.4.3 Net realization from banana increased due to vegetable intercropping. Maximum net return (6,39,768 Rs. ha^{-1}) was obtained by banana + onion A_3 intercropping as compared to sole banana. While maximum benefit cost ratio (3.84) was recorded under banana + garlic A_3.

CONCLUSION

On the basis of present investigation, it is inferred that intercropping of vegetables in banana is more productive and profitable than their sole cultivation without loss in yield. Intercropping of garlic and onion with 60 % coverage (with and without lateral shifting) in banana under drip irrigation were gave maximum gross and net return as well as benefit cost ratio. Growing of vegetables as intercrops either onion or garlic, under banana at initial growth stage of planting increase the total profit without affecting the banana yield.

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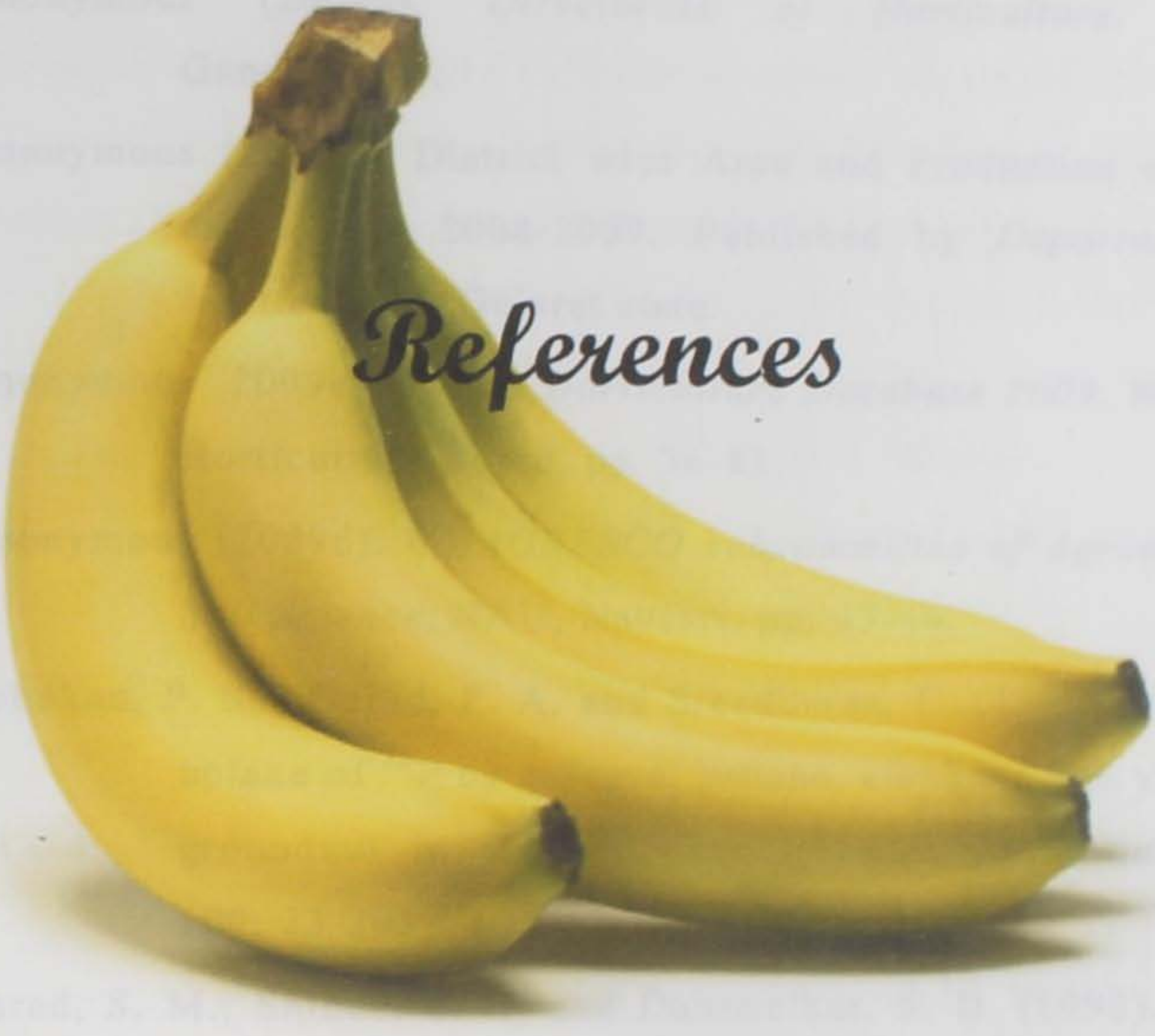

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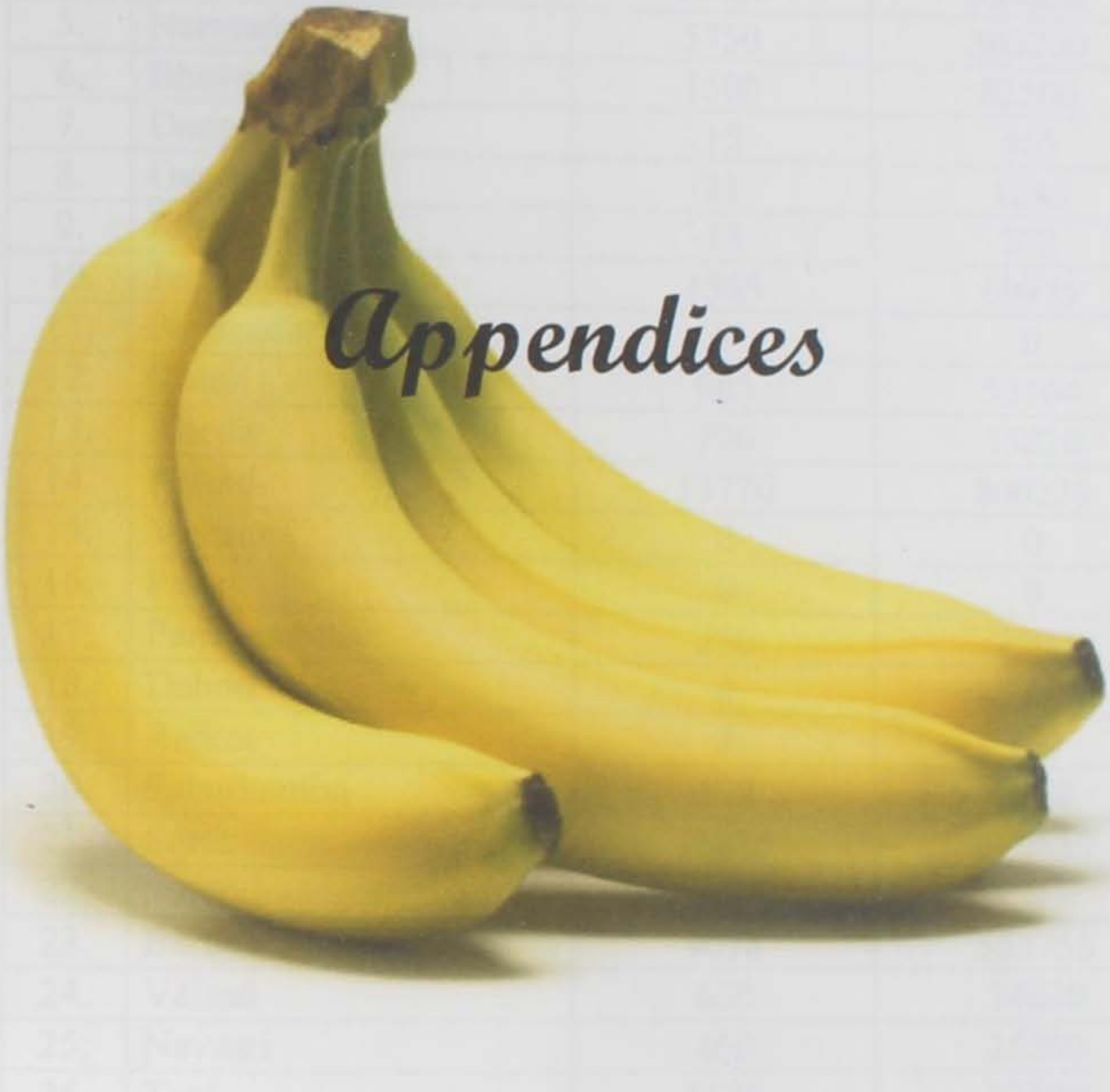

Appendices

APPENDIX - I: District wise area and production of banana in Gujarat state in year 2009 - 10.

No.	District	Area (ha)	Production (MT)
1.	Ahmedabad	92	2410
2.	Amreli	28	900
3.	Banaskantha	0	0
4.	Bharuch	14400	936288
5.	Narmada	5750	362250
6.	Bhavnagar	1500	82500
7.	Dang	15	465
8.	Gandhinagar	31	1240
9.	Jamnagar	19	272
10.	Junagadh	1555	69975
11.	Porbandar	0	0
12.	Kutch	985	52164
13.	Kheda	796	35820
14.	Anand	13770	860220
15.	Mehsana	0	0
16.	Patan	0	0
17.	Panchmahal	250	7500
18.	Dahod	0	0
19.	Rajkot	7	210
20.	Sabarkantha	198	5959
21.	Surat	10815	670530
22.	Surendranagar	0	0
23.	Baroda	9078	553758
24.	Valsad	630	34650
25.	Navsari	450	25200
26.	Tapi	1550	77500
Total		61919	3779811

Source: - Directorate of Horticulture, Gandhinagar (Gujarat state)

APPENDIX – II: Meteorological data during the year 2009 - 2010.

Month	Rain fall	Rainy days	Temperature		Relative Humidity		Wind velocity	Sun shine hours	Evapo. (mm)
			Max.	Min.	AM	PM			
September 2009	240	6	32.4	27.1	77	66	5.6	5.9	3.1
October 2009	084.0	2	33.9	24.8	85	47	4.1	6.5	3.6
November 2009	019.2	2	32.2	22.3	76	43	4.4	8.1	4.4
December 2009	000.0	0	31.2	20.8	80	36	3.4	7.8	3.8
January 2010	000.0	0	30.7	15.6	70	35	4.4	8.0	3.5
February 2010	000.0	0	31.6	15.6	77	34	3.9	7.9	3.6
March 2010	000.0	0	35.1	19.6	83	33	4.9	8.6	5.2
April 2010	000.0	0	35.8	23.8	89	58	7.4	9.5	6.5
May 2010	000.0	0	36.2	27	89	60	11.1	9.9	7.5
June 2010	269.4	6	32.7	26.8	91	74	9.6	3.8	4.8
July 2010	544.6	20	29.7	25.5	94	85	9.2	3	2.4
August 2010	711	8	28.6	25.4	97	86	7.3	2.6	2
September 2010	585	17	30.7	24.7	95	78	5.5	4.3	2.3
October 2010	037	4	33.5	23.7	90	56	6.1	6.4	3.6
November 2010	037	3	31.8	21.7	89	58	5.9	6.8	3.2
December 2010	000.0	0	29.3	14.1	81	38	6.4	8	3.0

Source: Agricultural Meteorological Observatory, N. M. College of Agriculture, NAU, Navsari

CERTIFICATE

This is to certify that I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : 16th May, 2011

H.D.Mahant

(Mahant Himanshu D.)