"STUDIES ON PERFORMANCE OF DIFFERENT GINGER (*Zingiber officinale* Rosc.) GENOTYPES UNDER MARATHWADA CONDITION"

BY

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DISSERTATION

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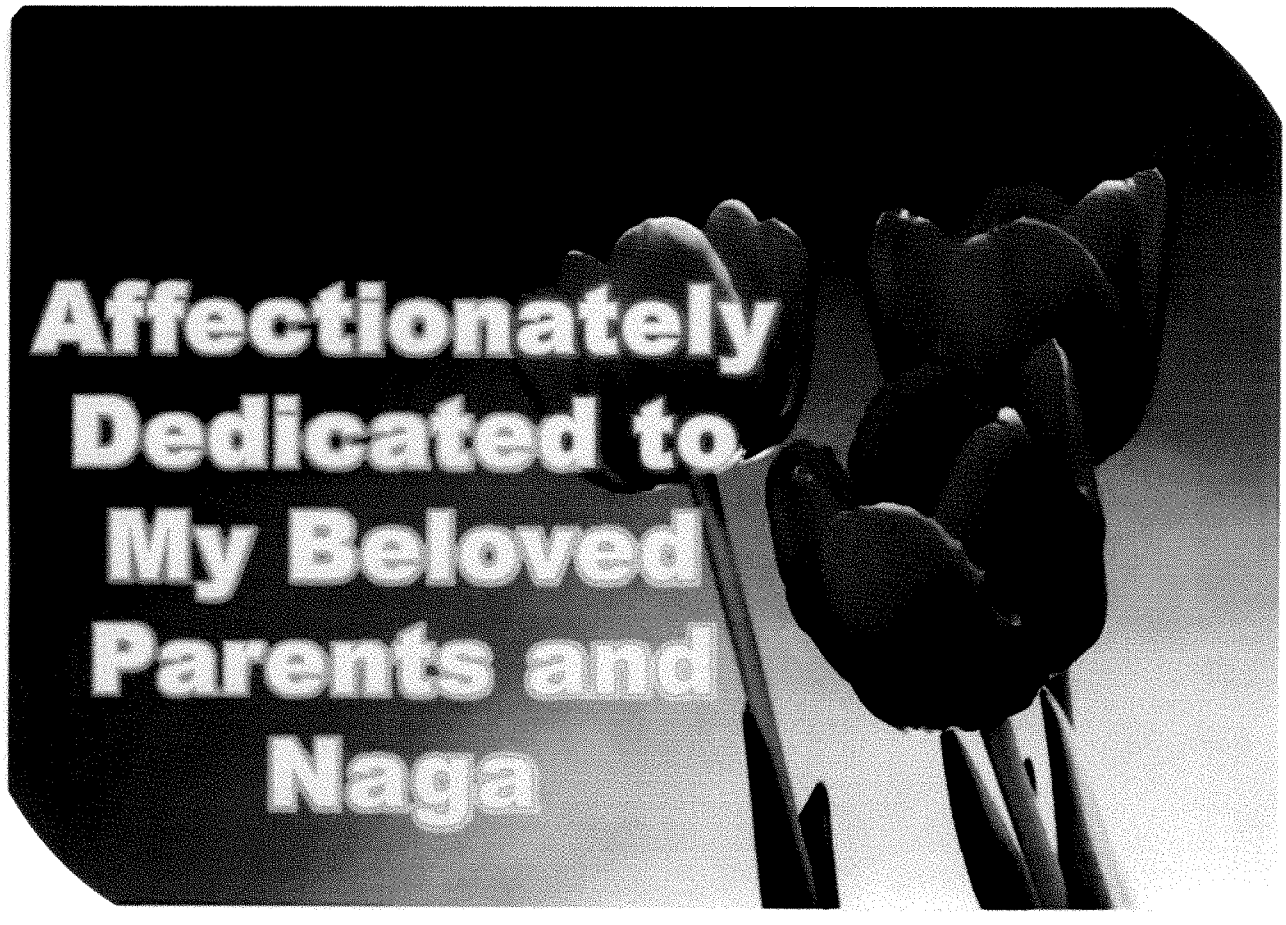
Affectionately
Dedicated to
My Beloved
Parents and
Naga

CANDIDATE'S DECLARATION

I hereby declare that this dissertation

or part thereof, has not been

Previously submitted by

me for a degree of

any other

institution

or

University.

Place: PARBHANI

Date : 31 / 5 / 2013

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CERTIFICATE - I

This is to certify that **Ms. R. SHANTHIPRIYA** has satisfactorily prosecuted her course of research for a period not less than four semesters and that the dissertation entitled **"STUDIES ON PERFORMANCE OF DIFFERENT GINGER (*Zingiber officinale* Rosc.) GENOTYPES UNDER MARATHWADA CONDITION"** submitted by her is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination for the degree of **MASTER OF SCIENCE (Horticulture)** in **VEGETABLE SCIENCE**. I also certify that the dissertation or part thereof has not been previously submitted by her for a degree of any university.

Place : PARBHANI
Date : 31/5/2013

(Prof. B.G.Hiwale)
Research Guide and
Chairman advisory committee

CERTIFICATE - II

This is to certify that the dissertation entitled **"STUDIES ON PERFORMANCE OF DIFFERENT GINGER (*Zingiber officinale* Rosc.) GENOTYPES UNDER MARATHWADA CONDITION"** submitted by **Ms. R. SHANTHIPRIYA** to the Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Horticulture)** in the subject of **VEGETABLE SCIENCE** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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"I am debited to my parents for living and grateful to my teachers for living well"

Alexander the Great

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Place : Parbhani

Date : 31/5/2013

(Shanthipriya R.)

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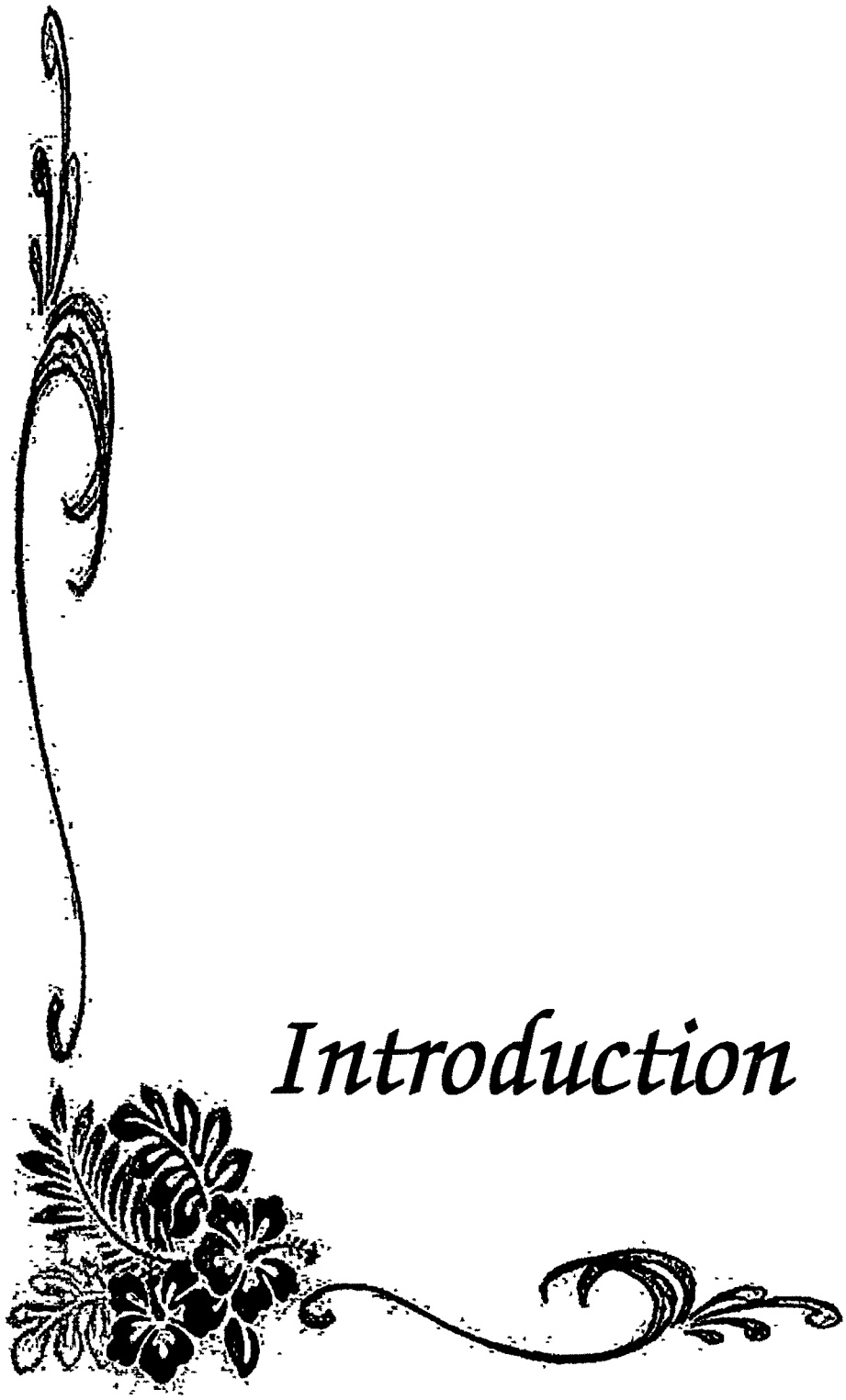
ABBREVIATION

@	At the rate of
%	Percent
C.D	Critical difference
Cm	Centimeter
Cv.	Cultivar
DAP	Days after planting
DMSO	Dimethyl Sulphoxide
et.al	Et. alia, and others
Fig.	Figure
g.	Gram
mg	Milligram
ha	Hectare
m	Meter
Met.	Meteorological
°C	Degree celcius
P^H	Pussance de hydrogen
pp	Pages
q	Quintals
S.E	Standard error
t	Tonnes
Var.	Variety
Viz.	Vide licet, namely
Kg	Kilogram
M^2	Meter square
Cm^2	Centimeter square
NS	Non significant
ppm	Parts per million
Sig.	Significant



Introduction

CHAPTER-I

INTRODUCTION

India has been known as 'Land of spices' from the time of immemorial and has been leading country in the world in production, consumption and export of spices. Spices group play an important status among the cash crop and has an great demand in number of countries of the world. During the recent years, interest in spices production is increasing tremendously as a result of greater appreciation of value of spices and place of spices in nation spices requirement.

Ginger is derived from the underground rhizomes of *Zingiber officinale* Rosc, which is an herbaceous perennial, usually grown as an annual. It is originated in South East Asia, but now it is known in a world wide. It is a plant of very ancient cultivation and is a one of the earliest oriental spice has long been used in Asia. India is the leading producer of ginger in the world and during 2011-12 the India produced 772.2 thousand tonnes of the ginger from an area of 158.1 thousand hectares. Ginger is cultivated in most of the states in India. However states namely Kerala, Meghalaya, Arunachal Pradesh, Mizoram, Sikkim, Nagaland, Maharashtra and Orissa together contribute 70 per cent of the country is total production. (Source; NHB,2012).

India, China, Thailand, Australia, Fiji, Jamaica, Brazil and Nigeria are leading producers. Most of the world trade in ginger is as a dried spice, however fresh rhizomes are also traded. Confectionery ginger constitutes less than 3% of the world trade (by volume), it is important as a value-added product and earns a much higher rate of return compared to the fresh or dried rhizomes. Significant processors and exporters of

confectionery ginger products are Australia, China, Fiji and Thailand. (Selvan and Manojkumar, 2002).

India is the largest producer - but major consumption is within the country. During 2011-12, Indian export of ginger was 15750 hundred tonnes value at Rs. 12131.25 million. China is the largest exporter, Japan and USA are the biggest importers. Though grown ail over India the finest quality ginger comes from Kerala endowed as it is with a congenial climate and a rich earthy soil. Kerala is the largest ginger producing state accounting for about 33 per cent of the total production in India. Indian dry ginger is known in the world market as 'Cochin Ginger' (NUGC) and 'Calicut Ginger' (NUGK). (Thamaraikannan and Sengottuvel, 2013).

The genus *Zingiber* of the family Zingiberaceae consists of about 150 species and the commercially cultivated species is *Zingiber officinale* Rosc, has many fibrous roots, aerial shoots (pseudostem) with leaves and underground stem, rhizome. The first developing branch grows from the apical bud and subsequent growth of the rhizome is due to the development of axillary buds. Ginger flowers are fragile and short lived, produced in peduncle spikes arising directly from the rhizomes. In general ginger dose not flower under sub-tropical or sub-temperate climatic conditions and is shown to be a quantitative short day plant. As ginger rarely sets seed, the general mode of propagation is asexual. (Ravindran *et al.* 2005).

The aroma of ginger due to the volatile oil while the pungency is due to the non volatile constituents like gingerol, shagaol and related compounds. The anti-inflammatory and anti-nausea qualities of ginger have applications in the pharmaceutical industry. Ginger and supplements derived from ginger have received attention for the treatment of chronic

inflammation. Administration of ginger has resulted in decreased symptoms of rheumatoid arthritis (Srivastava and Mustafa, 1992) and gingerol (a component of ginger) has been reported to have anti-inflammatory actions (Kiuchi *et al.* 1992; Tjendraputra *et al.* 2001).

Ginger has been used as a medicine in India from vedic period and is called Maha-aushadhi, meaning the great medicine. Ancient physicians used it as carminative and used it as an aphrodisiac. Ginger contains anti-viral, anti-toxic, and anti-fungal properties, and is used for the prevention of and treatment against the common cold. Ginger act as an antihistamine and aids in the treatment of allergies. Ginger has proven to reduce cholesterol levels and prevent formation of blood clot. It is widely used in the preparation of soft drinks, beverages such as ginger beer, ginger tea, ginger wine, cordials, liquors, gingerale, and in candies, pickles, preserves and bakery products. (Thamaraikannan and Sengottuvel, 2013).

An analysis of fresh ginger shows that it contains moisture 30.9 %, Protein 2.3 %, fat 0.9 %, fibre 2.4 %, and carbohydrates 12.3% per 100 g, in ginger variety of "suprabha" contains dry recovery 20.5 %, crude fibre 4.4 %, oleoresin 8.9 %, essential oil 1.9 %. (Source; Spices Board, 2009).

Ginger is available in two forms, fresh and dried. Ginger is used as medicine but it cannot be eaten as such in fresh form. Dry ginger is used for the manufacture of products like ginger powder, ginger oil and ginger oleoresin. Ginger oil used in pharmaceutical preparations as a carminative and stimulant for alcoholic gastritis etc. The oleoresins account for the pungency, which provides most of the medicinal value of ginger. There are also components of the spice with antiviral activity and zingibain is a powerful protein-digesting enzyme. (Parthasarathy *et al.*2006).

Several commercial cultivars of ginger are cultivated throughout the world especially in India, and many land races and improved cultivars which excel in yield and one or more quality traits are available (Ravindran *et al.* 1994). Yield, percentage recovery of dry ginger from fresh ginger and fibre content are the criteria used to differentiate these types. (Aiyadurai, 1966).

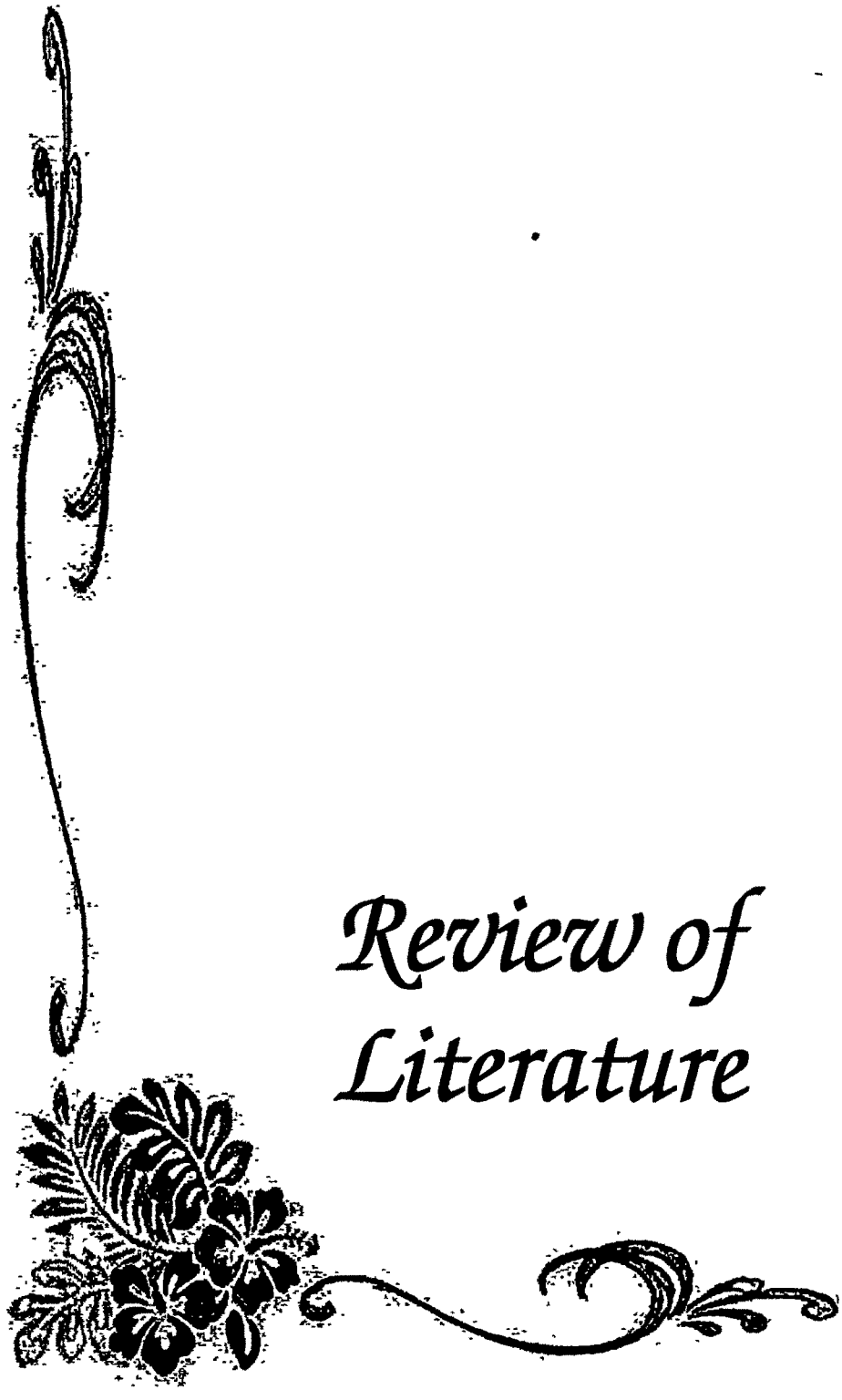
The performance of various varieties under different locations in India evaluated by Thomas and Kannan (1969), Nybe and Nair (1981), Thangaraj *et al.* (1983), Rattan *et al.* (1988), Mohanty *et al.* (1990a) and NRCS (1992). Potential yield and quality of genotypes may vary with agroclimatic conditions, soil fertility and agronomic practices.

The cultivation of ginger is limited in Marathwada region having low yield per hectare due to inadequate information about suitable varieties to this region and agrotechniques. Wide genetic variabilities exist in this crop with regard to the growth, yield and quality. However, very scanty work has been done in the Marathwada region on crop improvement through the selection of desirable types of high potential and better quality.

Hence, the present study was undertaken "studies on performance of different ginger (*Zingiber officinale Rosc.*) genotypes under Marathwada condition" is under taken with the objects to find out the high yield and recovery as well as to find out higher content of oleoresin, essential oil and suitability for processing.

Objectives:

1. To study the growth and yield performance of ginger genotypes.
2. To find out the suitable genotype for commercial cultivation for Marathwada region.



Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

An experiment entitled "Studies on performance of different ginger genotypes under Marathwada condition" was carried out at Department of Horticulture, VNMKV, Parbhani. The findings of research workers regarding ginger varieties are reviewed in this chapter under appropriate headings. Attempts, have been made to put fourth here recently published review in respect of studies, confining as far as possible to the spice crops.

2.1 Performance of varieties in respect of growth

Among the thirty one cultivars evaluated (Anon., 1973a, 1973b) reported that plant height differed significantly for the cultivars.

Muralidharan and Shakunthala (1974) while screening ginger cultivars in the plains of Kerala observed that height of plants ranged from 35.41 cm in the cultivar Nadia to 49.67 cm (Cv. Tafinjiva).

Muralidharan and Shakuntala (1974) recorded maximum average weight of rhizome per clump (286.95 g) for the cultivar S.L.N.2 Clone, a selection from Manantodi, while Thinladium recorded lowest weight of rhizome (116.20 g) followed by Mysore (128.00).

Muralidharan and Shakuntala(1974) observed no significant differences among cultivars in the production of number of leaves per plant. However, cultivar Assam recorded maximum number of leaves (146.75) per plant.

Nybe and Nair (1979) while screening twenty cultivars of ginger, reported significant difference among the cultivars for plant height. Highest plant height was recorded by the cultivar Valluvand (69.90 cm) followed by Bajpai (68.00 cm), Sierraleone (66.40 cm),Tafinjiva (66.00 cm),China (64.80 cm) and Waynad Local (64.40 cm).The cultivar Thingpuri

(53.00 cm) recorded the lowest height followed by Himachal Pradesh (57.17 cm).

Mohanty and Sharma (1979) and Mohanty *et al.* (1981) evaluated ginger cultivars in the hilly eastern region of Orissa and reported the plant height ranging from 29.00 to 61.60 cm. The cultivar Anamika recorded the lowest height and the cultivar UP the maximum height. Mohanty and Sharma (1979) and Mohanty *et al.* (1981) recorded a range of 9.00 to 18.60 numbers of leaves per tiller with a mean of 12.80. Cultivar UP recorded maximum number of (18.60) leaves per tiller.

Nybe and Nair (1979) reported that the number of leaves per tiller and plant varied significantly among the cultivars. The cultivar Valluvanad (20.20) topped the list with respect to number of leaves per tiller. The number of leaves were lowest in Tafingiva (13.82) followed by Ernad-Manjeri (14.31),Arippa (14.57) and Nadia (14.94). With regards to number of leaves per plant, maximum number of leaves were produced by the cultivar Valluvanad (471.19) followed by Waynad-Kunnamangalam (452.97) and Karkal (438.02), where as the cultivar Tafingiva recorded least number of leaves (221.69) followed by Himachal Pradesh (232.83) and Nadia (254.63).

Nybe and Nair (1979) reported that cultivars differed significantly with respect to length of leaf. In this study Erarnad-Manjeri recorded a length of 21.80 cm and was followed by Nadia (20.10 cm), Sierra-leone (19.70 cm), Maran (19.50 cm) and Narasapattam (19.40 cm). Minimum length of 16.20 cm was recorded in the cultivar Thingpuri. The data on breadth of leaves and leaf area index showed that there was no significant difference among the types. However maximum breadth was observed in Ernad-Chernad (2.40 cm) and minimum breadth was in Thingpuri (1.80 cm). Leaf area index varied from 22.70 to 42.30. The cultivar Ernad - Manjeri produced maximum leaf area index followed by

Arippa (34.89), Nadia (34.64) and leaf area was minimum in Thingpuri (22.70).

Sreekumar *et al.* (1980) observed significant difference in number of leaves per plant among cultivars, and the highest number being in Thingpuri (106.70) and the lowest (39.00) in Poona. Sreekumar *et al.* (1980) observed considerable variation in height of the plants among cultivars. The highest plant height was recorded in cultivar China (49.50 cm) followed by Valluvanad (48.70 cm), Thingpuri (46.90 cm), Tura (45.80 cm), Waynad Local (45.40 cm) and the lowest height was recorded for Narasapattam (35.60 cm).

Sreekumar *et al.* (1980) recorded maximum weight of rhizome (317.20 g) for Thingpuri and minimum weight (107.80 g) was recorded in Narasapattam.

Mohanty *et al.* (1981) observed broadest leaves in cultivars viz, China, Tura, Jugijam, Ernad-Chernad, Waynad Local and Kuruppampady (1.90 cm).

Mohanty *et al.*(1981) in a trial for high altitude hilly region of Orissa recorded highest rhizome yield per plant (239.00 g) for the cultivar Rio-de-Janeiro and China followed by Vengera (235.00 g), Ernad-Manjeri (224.00 g), UP (221.00 g), Thingpuri (203.00 g), Waynad-Kunnamangalam (177.00 g) and the lowest weight of rhizome was recorded for the cultivar Vengera Local (54.00 g).

Thangaraj *et al.* (1983) of TNAU, Coimbatore in a trial involving six cultivars recorded maximum plant height in Rio-de-janeiro (52.90 cm), followed by Jorhat (48.18 cm) and Burdwan (47.40 cm). But cultivars Ernad-Manjeri and Nadia were on par with 43.91 and 43.29 cm height respectively. The cultivar Thingpuri recorded the lowest plant height (41.93 cm). Thangaraj *et al.* (1983) reported a range of 23.80 to 49.20 leaves per plant.

Thangaraj *et al.* (1983) among the six cultivars studied, observed maximum number of sprouts (5.70) in Ernad-Manjeri and the lowest number of sprouts were recorded in Thingpuri (2.70).

Rattan *et al.* (1988) while evaluating ten cultivars in Himachal Pradesh recorded significantly higher plant height for SG-666(64.87 cm) followed by Rajgarh Local (58.81 cm) and the cultivar SG-639 recorded lowest plant height (42.15 cm). Rattan *et al.* (1989) in another trial recorded highest plant height in SG-646 (43.45 cm) followed by Rajgarh Local (42.15 cm) and SG-666 (41.15 cm). The cultivar V_2E_5 recorded the lowest plant height (25.20 cm).

Rattan *et al.* (1988) reported highest rhizome weight (222.90 g) was recorded in SG-666 with minimum of (122.40 g) in SG-30.

Rattan *et al.* (1988) recorded significantly higher length of rhizome (18.71 cm) in the cultivar SG-666 followed by SG-212 (16.50 cm), SG-603 (16.07 cm) and the lowest length of rhizome was recorded in SG-639 (12.37 cm). However cultivars did not differ significantly among themselves for width of rhizome. Maximum width of rhizome (6.42 cm) was recorded in SG-666 and the lowest was in SG-639 (4.61 cm). Rattan *et al.* (1989) in another trial involving ten cultivars reported that cultivars differed significantly among themselves for length and width of rhizome. Maximum length (15.10 cm) and width of rhizome (5.75 cm) was recorded in the cultivar Kerala Local, while the cultivar PGS-19 recorded minimum length (9.40 cm) and width (3.30 cm) of rhizome.

Rattan *et al.* (1988) recorded significantly higher number of leaves per plant in the cultivar SG-666 (142.50) with minimum of 89.40 leaves in SG-30.

Rattan *et al.* (1988) recorded significant difference among the cultivars for length of leaf, but there was no significant difference among cultivars in breadth of leaf. Maximum length of leaf (22.09 cm) was

observed in Rajgarh Local followed by SG-666 (22.01 cm) and minimum length of leaf (19.47 cm) was recorded in SG-603. Highest breadth of leaf (2.86 cm) was recorded in SG-666 and minimum breadth of leaf was seen in SG-551 (2.63 cm).

Maity *et al.* (1989) reported range of 52.80 to 65.20 cm in plant height in a varietal trial conducted involving twelve cultivars under climatic conditions of West Bengal.

Arya and Rana (1990) observed significant difference among the eight cultivars for plant height .The maximum plant height was recorded for Awoch (41.90 cm) followed by B-1 (38.50 cm), Himachal Selection(36.70 cm) and the minimum plant height was recorded in Nadia(23.80 cm).

Arya and Rana (1990) observed significant difference in length and breadth of leaf among different cultivars. Maximum length of leaf (20.20 cm) was recorded in Himachal Selection and minimum length of leaf was recorded in the cultivar Awoch (11.30 cm). Breadth of leaf was maximum in Himachal Selection (2.40 cm) and was minimum in B-1 and Nadia (1.30 cm).

Arya and Rana (1990) found a significantly higher number of leaves per tiller in Himachal Selection (16.70) followed by B-1 (13.40), Maran (13.30) and minimum number of leaves were recorded in Nadia (8.30).

Arya and Rana (1990) also recorded significantly higher length of rhizome in Kerala Local (15.20 cm) and Waynad (15.20 cm) followed by Maran (14.80 cm) and Himachal Local (13.90 cm). The diameter of rhizome was maximum (3.30 cm) in Himachal Selection followed by Kerala Local (2.80 cm) and minimum was observed in B-1 (2.40 cm).

Arya and Rana (1990) recorded highest rhizome yield per plant (86.00 g) for the cultivar Himachal Selection followed by Kerala Local (84.00 g). Cultivar B-1 had the lowest weight of rhizome (40.70 g).

Roy and Wamanan (1990) noticed significant difference among cultivars in number of leaves per plant under West Bengal conditions. Cultivar Nadia recorded maximum (163.00) number of leaves followed by China (149.00) and minimum number of leaves were recorded in Thinladium (66.00).

Roy and Wamanan (1990) highest plant height was recorded in Nadia (70.50 cm) followed by China (65.10 cm), Jugijan (63.90 cm) and minimum plant height was noticed in Thinladium (53.80 cm).

Roy and Wamanan (1990), and Saikia and Shadeque (1992) reported significant differences among cultivars for tiller production. In both the trials, Nadia recorded maximum number of tillers (9.21 and 6.80) followed by China (7.97 and 6.38) respectively.

Saikia and Shadeque (1992) while screening cultivars in Assam recorded a range of 49.80 to 64.04 cm. The cultivar Karkal recorded maximum plant height (64.04 cm) followed by Nadia (63.80 cm), China (62.00 cm) and a minimum height was noticed in Thinladium (49.80 cm).

In a report (Anon., 1992) from IISR Calicut, it is reported that the rhizome weight for different cultivars ranged from 112.50 to 667.50 g per plant. The cultivar Nadan recorded highest weight of rhizome per plant followed by Chamal Local (651.50 g) and Bahrica (592.50 g).

Sasikumar *et al.* (1992) reported that the cultivars Sangiguda, PGS-37, PGS-39, Maran and Himachal Pradesh have recorded more than 600 g fresh rhizome yield per plant.

Pandey and Dobhal (1993) recorded a height ranging from 14.25 to 34.70 cm with a mean of 25.02 cm. The genotype BD-16 (34.70 cm) and DKH-34 (33.40 cm) were observed to be taller.

Pandey and Dobhal (1993) in an evaluation of twenty nine germplasm collected from Assam, Meghalaya, Tripura and Nagaland at

Shillong has reported that number of leaves per tiller varied from 9.25 to 16.60 with a mean of 12.59.

Pandey and Dobhal (1993), Ravindran *et al.* (1994) recorded a range of 13.60 to 22.65 cm and 17.00 to 36.20 cm for length of leaf respectively.

Pandey and Dobhal (1993) recorded weight ranging from 67.60 to 203.20 g with a mean of 130.23 g for the conditions of Shillong.

Ravindran *et al.* (1994) while evaluating one hundred germplasm at IISR (Calicut) recorded a range of 55.00 to 770.00 g with a mean of 363.10 g.

Ravindran *et al.* (1994) in a study evaluated one hundred accessions and recorded a range of 17.00 to 52.00 with a mean of 37.10 leaves per tiller.

Sujatha *et al.* (1994) reported highest fresh rhizome yield per plant (356.50 g) in the cultivar Kuruppampady followed by Wayand-Manantodi and Earandan cultivars.

Ravindran *et al.* (1994) in a study at IISR, Calicut involving one hundred germplasm, reported that plant height ranged from 23.13 to 88.60 cm with mean of 59.20 cm.

Kandiannan *et al.* (1996) ginger is grown in tropical and subtropical regions of the world for its spice and medicinal values. Successful production of ginger depends on efficient use of available resources by adopting suitable agronomic practices. Such practices like land preparation, seed selection. Seed rate, seed treatment, planting season, depth of planting, mulching, nutrient management, use of growth regulators, weed control, irrigation, shade management and harvest management are reviewed in detailed. The review also covers climatic requirement for cultivation, soil suitability, establishment and growth, pest and diseases, cropping systems, rationing and economic cultivation.

Prasad *et al.* (1997) studied 15 different cultivars of ginger for their morphological character under coastal karnataka conditions and observed that the cultivar Nadan recorded maximum plant height (51.80 cm), leaf area (57.27 dm^2), leaf area index (11.45), girth of secondary finger (6.27 cm), breadth of rhizome (10.18 cm), higher number of tillers (28.15), leaves (317.05).

Singh and Arunachalam (1999) experiments were conducted to study the effect of NPK dosages on growth and yield of ginger. The frequency of sprouting in ginger rhizome was greater in high and low dose treatments. The number of sprouts per rhizome was greater in high and low dose treatments. The number of sprouts per rhizome varied from one to a maximum of five. The height of the sprouts increased rapidly after two months of sowing. The yield was normally lower in the control plots (125-175 q ha^{1}). However, a maximum yield of 185.5 q ha^{-1} was recorded in low dose treatment. The yield and number of sprouts were closely correlated.

Linky *et al.* (2008) conducted a field experiment at Calicut and observed relationship between vegetative and rhizome characters and final rhizome yield in micropropagated ginger plants over two generations in two varieties viz. var. 'Jamaica' and Var. 'Varada.'

Kandiannan *et al.* (2009) an experiment conducted during 2006-07 at Calicut (Kerala) and observed that individual leaf area estimation of five ginger varieties, *Varada, Rajetha, Mahima, Maran* and *Himachal* by using leaf length and width.

Jaleel and Sasikumar (2011) carried out varietal trial on diversity, characterization and utilization of ginger. Originated in the Indo-Malayan region, is now widely distributed across the tropics of Asia, Africa, America. Cultivated ginger though sterile, exhibits variations in rhizome and vegetative characters.

2.2 Performance of varieties in respect of quality

Krishnamurthy *et al.* (1972) evaluated the samples obtained from seven regions and the highest volatile oil was obtained from samples of Kalimpong and more oleoresin in samples from Nilgiri hills.

Liews *at al.* (1972) reported higher oleoresin and essential oil contents in the cultivar Rio-de-Janerio.

Muralidharan and shakuntala (1974) recorded highest percentage of oleoresin (7.10 %) in kuruppampady followed by mysore (6.38 %), jorhat (6.56 %) and the least (4.74 %) was recorded in Nadia and Poona.

In a report from IISR, Calicut (Anon., 1974) it is reported that oleoresin was highest in jorhat (10.10%) followed by Manantodi (9.30%), Narasapattam (9.00%) and least was in Thingpuri (4.80%).

Sreekumar *et al.* (1980) evaluated twenty cultivars for oleoresin and reported that cultivar Rio-de-janeiro recorded the highest oleoresin (10.80%), where as the lowest was observed in cultivars Poona and China (3.00%).

Nybe and Nair (1981) recorded maximum oleoresin (10.50%) in Rio-de-janeiro followed by Maran (10.00%), Bajpai (9.20%) and the minimum was recorded in Waynad-Manantodi (4.90%) followed by Himachal Pradesh (5.30%), Arippa (5.40%).

Thangaraj *et al.* (1983) also recorded highest oleoresin in Rio-de-janeiro (5.10%) and the least was in Nadia (3.10%).

Rattan *et al.* (1988) reported that ginger oil content varied from 1.00 to 2.00 percent with Rajgarh Local recording highest and SG-603 lowest.

Edison and Kallupurackal (1991) reported an essential oil content of 1.9, 2.0 and 2.1 per cent for cultivars Supraba, Suruchi and Suravi respectively.

Zacharia *et al.* (1993) classified ginger cultivars to three groups based on oleoresin content. Cultivars with oleoresin of above 7.40 per cent (Rio-de-janeiro, Ernad-Chernad, PGS-33, PGS-11, Waynad) as high, between 4.78 to 7.40 percent (Thingpuri, Nadan, jugijan, Karkal, Maran, Tura, Burdwan, Nadia, Ernad-manjeri, Waynad local) as medium and less than 4.78 percent (Tafingiva, Kuruppampady, Anamika) as low.

Korla *et al.* (1993) reported that the cultivars Ausu, Kerala Local, Waynad Local, SG-553 and Maran gave comparatively high essential oil and oleoresin.

Ravindran *et al.* (1994) recorded a oleoresin content ranging from 3.20 to 9.50 percent with a mean of 6.12.

Datta *et al.* (2003) observed quality assessment of ginger cultivars grown under subtropical humid region of West Bengal. Twelve ginger cultivars (Tanda,Rajgarh, Jughijan, Tura, Majulay, Suprabha, Taffingiva,Suravi,UP,Gorubathan,Bhoinse and Local cv) grown under subtropical humid region of West Bengal were assessed for quality. Suravi was superior with respect to oleoresins (10.03%) and essential oil (2.07%), concentration. Oleoresin concentration was estimated minimum (4.15%) with CV.Gorubathan while CV.Taffingiva had minimum (0.73%) essential oil. Quality assessment identified CV.Suravi as the best for subtropical humid region of West Bengal.

Sasikumar *et al.* (2003) IISR Mahima (Acc.117) and IISR Rejatha (Acc.35) two high yielding and high quality ginger varieties, developed through selection from germplasm at the Indian Institute of Spice Research, Calicut are good quality, high yielding ginger varieties. Maturing in 200 days, IISR Mahima has given an average yield of 23.2 t ha^{-1}(fresh) with a dry recovery of 23 %, essential oil 1.72 %, oleoresin 4.48 % and fibre content 3.26 %. Rhizomes of Mahima are bold and this variety is resistant to root-knot nematode also. IISR Rejatha is a medium duration, bold variety

with an average yield of 22.4 t ha^{-1}(fresh), dry recovery 19%, essential oil 2.36%, oleoresin 6.34 % and fibre content 4.0%.

Manjumdar *et al.* (2005) the rhizome and straw yield of ginger; N and P uptake and crude protein content increased significantly up to 100 kg K_2O ha^{-1} while oleoresin content increased significantly with increasing K levels.

Juliani *et al.* (2007) an experiment conducted on chemistry and quality of fresh ginger varieties from Ghana. The essential oils are responsible for the aroma while the non-volatile components are responsible for the pungency with gingerol the most pungent component of fresh ginger. Ghana has a long history of producing ginger rhizomes for local markets. In this study, we evaluated the quality and essential oils and pungent principles of two different types of Ghanian ginger, each from three regions, compared to ginger rhizomes found in the US Market. The essential oils composition variety 2 exhibited the typical ginger oil compositior with geranial, neral and zingiberene as the main components.Variety1 exhibited a distinctly different essential oil composition dominated by zerumbone (85-87%).

Singh *et al.* (2007) conducted experiment on chemical, antioxidant and sprout suppressant studies on ginger essential oil and its oleoresin.

Williams (2008) an experiment conducted on changes in the contents of oleoresin and pungent bioactive principles of Jamaican ginger during maturation.

Silva and Sidny (2008) conducted experiment on the effect of phosphate fertilization on the development and oleoresin production of ginger. Results suggest that the screening and inoculation of arbuscular mycorrhizal fungi in ginger plants is a feasible procedure to increase the oleoresin production of ginger and consequently increase the aggregate value of ginger rhizome production.

Nybe *et al.* (2009) involved in the development of two new ginger varieties from Kerala Agricultural university. Var.'Athira' and Var. 'Karthika'. Athira is a high yielding, high quality clone is characterized by bold rhizomes with less crude fibre and high quality volatile oil, rich in Zingiberene. Karthika is a high yielding , high pungency clone suited for the extraction of oleoresin. The clone is characterized by medium bold rhizomes with high recovery volatile oil and oleoresins.

2.3 Performance of varieties in respect of yield

Thomas (1966) in an evaluation trial at Vellanikkara involving eighteen cultivars reported highest yield in Rio-de-Janeiro (32550 kg ha^{-1}) followed by China (16758 kg ha^{-1}), Ernad-Manjeri (15840 kg ha^{-1}), Manantodi (15135 kg ha^{-1}) and minimum yield was recorded in Thodupuza (6973 kg ha^{-1}) followed by UP (8550 kg ha^{-1}).

It was reported that (Anon., 1974) the cultivars Nadia, Poona, Taiwan, Tura, Waynad-Kunnamangalam, Thinladium, Waynad Local were high yielders, whereas UP and Peechi were low yielders.

Muralidharan and Shakuntala (1974) obtained higher yield for clone S.L.N.2 a selection from Manantodi (23723 kg ha^{-1}) followed by Vengera (23446 kg ha^{-1}) and the lowest yield was recorded in Mysore (8339 kg ha^{-1}) followed by Nadia (11754 kg ha^{-1}).

Nair *et al.* (1976) recorded significantly higher yields in Nadia (4393 kg ha^{-1}) followed by Rio-de- Janeiro and Himachal Pradesh. The lowest yield was recorded in Thingpuri (1033 kg ha^{-1}).

Nybe and Nair (1981) obtained highly significant variations among twenty five ginger cultivars with regard to yield. According to him Nadia (28553 kg ha^{-1}) followed by Maran (25210 kg ha^{-1}) were best and Arippa (2743 kg ha^{-1}) recorded the lowest yield.

Thangaraj *et al.* (1983) evaluated six cultivars at TNAU, Coimbatore and recorded highest yield for Rio-de-Janeiro (7500 kg ha^{-1})

followed by Burdwan (7166 kg ha^{-1}). The cultivars Jorhat and Thingpuri however performed poorly with 3600 and 3500 kg ha^{-1} respectively.

Panigrahi and Patro (1985) and Mohanty *et al.* (1990) while evaluating ginger cultivars for Orissa have reported higher yields in Supraba (22500 and 16155 kg ha^{-1} respectively).

Ratnambal *et al.* (1987) in an evaluation of fourteen cultivars recorded maximum fresh rhizome yield in the cultivars Nadia and Maran. They reported that Maran and Nadia and Ernad are suitable for fresh rhizomes.

In a report from (Anon., 1989) Vellanikkara it is reported that Maran recorded highest yield (14600 kg ha^{-1}) followed by SG-666 (11000 kg ha^{-1}). In a multilocation trial,(Anon., 1992) it is reported higher average yield of 14340 kg ha^{-1} for the cultivar Waynad Local.

Arya and Rana (1990) studied the performance of different cultivars under conditions of Himachal Pradesh and recorded high yield (10963 kg ha^{-1}) for the cultivar Himachal Pradesh followed by Kerala Local (9620 kg ha^{-1}) , Maran (9230 kg ha^{-1}) and the lowest yield was recorded in Awoch (1250 kg ha^{-1}) followed by Ausu (1658 kg ha^{-1}).

Roy and Wamanan (1990) evaluated fifteen ginger cultivars in West Bengal and reported highest fresh ginger yield (24857 kg ha^{-1}) for the cultivar Nadia followed by China (22732 kg ha^{-1}) and the least was recorded in Thinladium. Roy and Wamanan (1990) studied the comparative performance of different varieties and correlation among yield and growth attributes of ginger at Central Crop Research Institute, Guhati, Orissa and reported that the ginger cultivar Nadia produced the highest yield and it is positively correlated with shoot height, leaves per clump and tiller per clump.

In another study Saikia and Shadeque (1992) recorded significantly higher fresh rhizome yield (6700 kg ha^{-1}) for Nadia, followed

by Chekerella (5700 kg ha^{-1}), Maran (5458 kg ha^{-1}) and minimum yield was recorded in Thinladium (2533 kg ha^{-1}).

In report (Anon., 1994) from IISR (Calicut), it is stated that among the fifteen entries evaluated at Peruvamuzai and Muvattupuza farms, the cultivar from north east region recorded an yield potential of 27080 kg ha^{-1}.

Datta *et al.* (2003) observed quality Assessment of ginger cultivars grown under subtropical humid region of West Bengal. Twelve cultivars(Tanda,Rajgarh, Jughijan,Tura, Mazulay, Suprabha, Taffingiva, suravi, UP, Gorubathan, Bhoinse and Local cv.)grown under subtropical humid region of West Bengal were assessed for quality. Dry recovery percent of the cultivars was recorded maximum (26.77 %) with Tura while it was minimum (15.84 %) with Bhoinse. Better recovery was recorded with Suravi (23.45 %), Suprabha (20.60 %),UP (20.48 %), and Gorubathan (20.30 %).

Shaikh *et al.* (2006) an experiment conducted during (2003-2004) to study effect of different planting methods (flat bed, ridges and furrows and raised bed) and three times of earthing up (3,4,5 months after planting) of ginger on yield, nutrient uptake and balance in ginger. Significantly increased green rhizome yield in ginger is obtained where ginger was grown on flat bed (20.34 t ha^{-1}) as compared to raised bed (16.29 t ha^{-1}) and ridges and furrows (12.73 t ha^{-1}). An earthing up given to ginger at four months after planting gave significantly higher green rhizome yield (19.10 t ha^{-1}) compared with the earthing up at three months (14.33 t ha^{-1}) and five months after planting (15.94 t ha^{-1}).

Medhi *et al.* (2007) evaluated thirteen genotypes of ginger and observed the significant difference among the genotypes along with wide

range of variability in all the traits. The variety Jorhat registered the highest yield and plant height followed by ACC-27.

Haque *et al.* (2007) The field experiment on ginger was carried out at South-Eastern Hilly region at Hill Tracts Agricultural Research Station, Ramgarh, Khagrachari during the seasons of 2004-2005 and 2005-2006 to evaluate the response of ginger with different levels of nitrogen (N) (0, 120, 150 and 180 kg ha^{-1}) and potassium (K)(0, 100,130 and 160 kg ha^{-1}). It is revealed that combined application of N and K was found more pronounced than the single effect of N and K. It is also noticed that effect of nitrogen was more distinct than K. The combined effect of N and K had significantly increased the yield and other yield contributing characters of ginger. It was also observed that N and K at highest rate N_{180} K_{160} kg ha^{-1} significantly augmented the ginger yield and other yield parameters. However, the highest plant height (63.7cm and 64.3cm), maximum number of leaves (19.2 and 19.7 $plant^{-1}$) and fingers numbers (16.3 and 16.6 $plant^{-1}$) were recorded at N_{180} K_{160} kg ha^{-1} and significantly different over N_0K_0. Similarly, other yield parameters like ginger weight and rhizome yield was also significantly influenced by combined application of N and K up to N_{180} K_{160} kg ha^{-1}. However, the highest yield (26.3 t ha^{-1} and 27.6 t ha^{-1}) and the two years mean yield 26.95 t ha^{-1} were recorded by said dose of N and K @ N_{180} K_{160} kg ha^{-1}.

Girma and Kindie (2008) an experiment was conducted to study the influence of seed rhizome size on growth, yield and economic return of ginger to determine an optimum seed rhizome size. The experiment was conducted for three years (1995-1997) at Tepi Agriculture Research sub-center using a locally grown ginger cultivar. It consisted of four different sizes of seed rhizomes which were grouped as small (R-4 g), medium (R-8 g), large (R-16 g), very large (R-32 g). An increasing seed rhizome size

significantly increased the major growth and yield component parameters of ginger. Seed rhizome size also significantly affected dry rhizome yield in all three years that the largest seed rhizome size (R-32 g) had significantly higher rhizome yield than the other treatments.

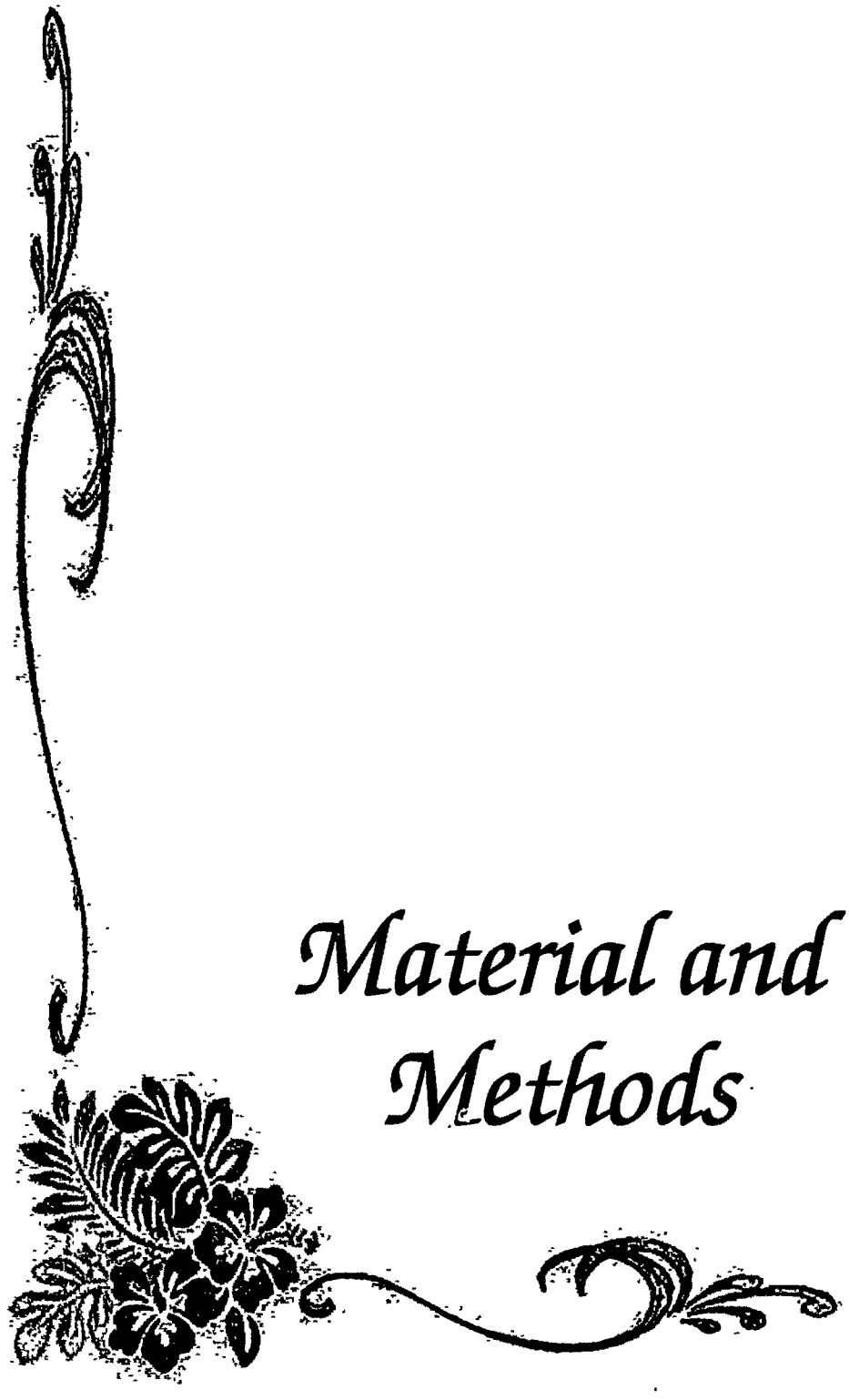
Srinivasan *et al.* (2008) studied that the maximum fresh yield and dry recovery with highest oleoresin are obtained at 225-240 days after sowing. However, harvesting at 210 DAP gives minimum fibre with maximum essential oil.

Govindan *et al.* (2009) field trials were carried out during (2004-05) to study the efficacy of Azospirillum, a nitrogen fixing rhizobacterium as a biofertilizer for ginger at different levels of fertilizer nitrogen. The treatment of Azospirillum with 100 % fertilizer nitrogen was found to be superior to all other treatments in terms of maximum root length, number of fingers, yield and starch content at harvest. Inoculation also resulted in increased protein content of rhizome at all the levels of fertilizer nitrogen.

Anandaraj *et al.* (2010) reported in an IET at Dholi, RG-3 was found to be a promising accession with an yield of 21.34 t ha^{-1} as compared to check variety Nadia (17.81 t ha^{-1}) and could be promoted to CVT. In a trial to study the influence of environment on genotypes of ginger it was observed that the var. Surabhi recorded highest yield (32.60 t ha^{-1}) of fresh rhizome followed by var. Nadia (21.13 t ha^{-1}) at Pasighat. In ginger application of fully organic fertilizers gave highest yield (12.90 t ha^{-1}) followed by integrated fertilizer (11.62 t ha^{-1}) at Dholi centre. Ginger planted in soil treated by bio fumigation using cabbage gave highest yield and registered lowest incidence of soft rot at Dholi and Kumarganj.

Rana and Korla (2010) an experiment conducted on integrated farming with organic and inorganic fertilizer on yield and quality of ginger. Highest rhizome yield (11.59 t ha^{-1}) was recorded with azospirillum alone in comparison to inorganic fertilizers although the differences were non significant. The quality attributes significantly increased by all the organic fertilizer treatments. Maximum dry matter (17.7%), oil (2.0%), and oleoresin (6.98%) was recorded under the application of azospirillum, phosphorus and wood ash. The lowest dry matter was recorded with phosphorus alone when no biofertilizer was applied in comparison to inorganic fertilizers.

Momina *et al.* (2011) an experiment conducted on variability of ginger Accessions for morphological and some quality traits in Ethiopia. Genetic variability study generates very relevant information on the possibility of genetic improvement of crops for yield and quality attributes. The study was objectively designed to assess the genetic variability of thirty six ginger accessions. The experiment was conducted during 2009-2010 main cropping seasons at two locations i.e. Tepi and Bahir Dar. Number of plants per plot, fresh rhizome yield and dry rhizome yield showed high Genetic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) at both the locations.



Material and Methods

CHAPTER-III

MATERIAL AND METHODS

The present investigation was carried out to "Studies on performance of different ginger genotypes under Marathwada condition" was carried out at Department of Horticulture, VNMKV, Parbhani during the year 2011-2012. The trail was laid out in Randomised Block Design with five genotypes replicated four times. The details of material used and methods adopted during the course of investigation are given below under different titles and subtitles.

3.1 Experimental site

The above entitled experiment was conducted on experimental field at Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the year 2011-2012.

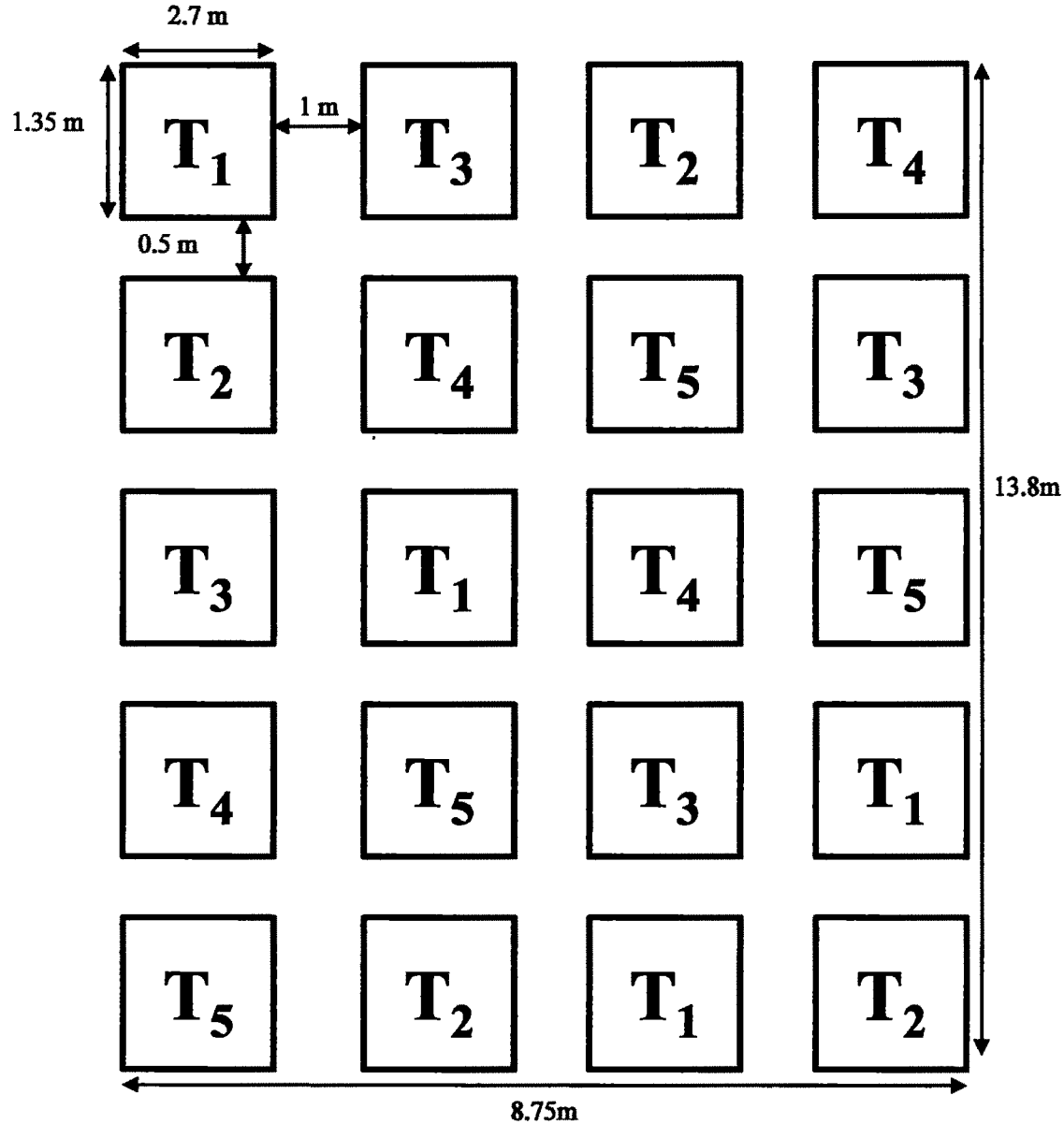
3.2 Geographical location, climate and weather condition of experimental site

3.2.1 Geographical locations

Parbhani is situated at 408.5 m above mean sea level. Geographically it is situated between 19° 16' N latitude and 76° 47' E longitude and comes under subtropical region of India.

3.2.2 Climate

The Parbhani area receives rainfall mainly from South-West monsoon commencing from second week of June to September. The cold weather commences from the middle of November and attains peak in the month of January with maximum temperature of 29°C and minimum of 9.5°C, relating in normal average of 19.5°C, summer is hot and dry with maximum temperature range of 41- 45°C in the month of may. The climate in thus, characterized by cold and mild winter and hot and dry summer.



Design : RBD
Treatments : Five
Replications : Four
Spacing : 45 cm X 22.5 cm

Fig. 1. Plan of Layout

The meteorological data in respect of maximum and minimum temperatures, rainfall and humidity as recorded at the meteorological observatory,VNMKV,Parbhani during the period of experiment were furnished in appendix- I.

3.3 Soil

The experiment was conducted on medium black soil of moderate fertility and good drainage.

3.4 Programme of research work

3.4.1 Experimental details

Crop	:	Ginger (*Zingiber officinale* Rosc.)
Design	:	Randomized Block Design (RBD)
Genotypes	:	Taklinadim, Shilegaon, Paithan, Gangapur Kannad
Replication	:	04 (Four)
Number of genotypes	:	05 (Five)
Spacing	:	45 cm x 22.5 cm
Row to row	:	45 cm
Plant to plant	:	22.5 cm
Plot Size	:	Gross : 2.7 m x 1.35 m Net : 1.8 m x 0.9 m
Total number of plots	:	20
Number of plants per plot	:	36
Distance between two replications	:	1.0 m
Distance between two genotypes	:	0.5 m
Date of sowing	:	15th June,2012
Year of experiment	:	2011-2012
Horticulture practices	:	As per recommendations
Location	:	Department of Horticulture, College of Agriculture, VNMKV, Parbhani

Plate 1. General view of experimental plot.

3.4.2 Treatment details

Symbol	Treatment (genotypes)	Source
T_1	Taklinadim(**TKNM**)	District Aurangabad, Taluka Gangapur
T_2	Shilegaon (**SLGN**)	District Aurangabad, Taluka Gangapur
T_3	Paithan (**PTN**)	District Aurangabad, Taluka Paithan
T_4	Gangapur (**GNP**)	District Aurangabad, Taluka Gangapur
T_5	Kannad (**KND**)	District Aurangabad, Taluka Kannad

3.4.3 Programme of research work

Sr.no	Perticulars	Frequency	Implements used	Date	Days after planting
1	Preparatory				
	Ploughing Harrowing Organic manure application Cleaning Layout and marking	1 2 1 1 1		10 June 12 June 13 June 13 June	
2	Planting				
	Preparation of ridges and furrow Dibbling of rhizome	1 1	Pidger	14 June 15 June	
3	Post planting operations				
	Irrigation Weeding Fertilizer application	15-20 4 to 5 1	 Khurpi	7 to 9 days interval or when required 18 July 27 August 11 october 10August	 33 days 69 days 116 days 55 days
4	Harvesting				
	Digging of rhizomes and cleaning		Kudali/ pick axe	15 February	240 days

TKNM

SLGN

PTN

GNP

KND

Plate 2. Growth stages of different ginger genotypes in field condition.

3.5 Details of cultivation

3.5.1 Preparation of field

Experimental field was prepared by one ploughing and two criss cross harrowing. The field was brought to fine tilth and beds were prepared as per plan of layout in fig.1.

3.5.2 Planting of mother rhizomes

The treatment wise planting of mother rhizomes of different genotypes was carried out on dated 15th June, 2012. Mother rhizomes were planted 10 cm deep in the soil and covered properly with soil and irrigated.

3.5.3 Irrigation

To keep the plot moist, irrigation was given at an interval of 7 to 9 days during period of experimentation, frequency of irrigation depends upon the weather condition and moisture retentive capacity of soil.

3.5.4 Weeding and earthing up

Three weedings were carried out at an interval of 4 weeks from planting.

Earthing up was carried out about two months after planting and second, one month after first earthing up.

3.5.5 Harvesting

Harvesting was carried out at maturity of the crop i.e. after the complete drying up of the plant including the base of the stem. The rhizomes were dugged out with help of Kudali and Pick-axe.

3.6 Observations

Randomly five plants of ginger were selected from each plot for recording observations on various characters under investigation.

TKNM

SLGN

PTN

GNP

KND

Plate 3. Mother rhizomes of different ginger genotypes.

3.6.1 Growth parameter

3.6.1.1 Plant height at 30 days interval (cm)

The height was recorded from ground level to the growing tip of leaf on randomly selected five plants of ginger at 30 days interval and average was worked out.

3.6.1.2 Number of leaves per clump

Number of leaves were counted randomly selected five plants under treatment at an interval of 30 days.

3.6.1.3 Leaf area per plant (cm^2)

Leaf area was calculated after planting at 30 days interval with the help of automatic leaf area meter and average was worked out.

3.6.1.4 Days required for Sprouting

The days required for sprouting were recorded 30 days after planting and average was worked out.

3.6.1.5 Sprouting percentage (%)

The number of sprouts from each plot were recorded 30 days after planting and the percentage was calculate by following formula.

$$\text{Sprouting percentage (\%)} = \frac{\text{Number of sprouts per plot}}{\text{Number of rhizomes sown per plot}} \times 100$$

3.6.1.6 Number of sprouts per plant

Sprouts emerged from the plant were counted after 30 days of planting in observational plants under each treatment and average was worked out.

3.6.1.7 Number of rhizomes per plant

Number of rhizomes was counted per plant and mean were calculated.

3.6.1.8 Length of rhizome(cm)

Length of rhizome were recorded from each randomly selected five rhizomes from each treatment after harvesting.

3.6.1.9 Width of rhizome (cm)

Width of rhizome were recorded after from each randomly selected five rhizomes from each treatment after harvesting.

3.6.1.10 Weight of rhizome (g)

Weight of rhizome were recorded from each randomly selected five rhizomes from each treatment after harvesting.

3.6.2 Quality parameter

3.6.2.1 Chlorophyll a and chlorophyll b content (mg/100g)

Hundred gram of fresh and cleaned leaf was taken and cut in to small pieces. Cut pieces were transferred in to test tube containing 7 ml of dimethyl sulphoxide (DMSO) and heated the test tube at 65^0C for three hour in oven. Extract was collected by discarding the leaf sample. Then volume was made up to 10 ml with DMSO. Optical density of the extract was measured at 645 and 663 using DMSO as blank.

Calculation

Calculate the amount of chlorophyll present in the extract mg chlorophyll per gram tissue using the following equations.

$$\text{mg chlorophyll a / g tissue} = 12.7\,(A663) - 2.69\,(A645) \times \frac{V}{1000 \times w \times a}$$

$$\text{mg chlorophyll b / g tissue} = 22.9\,(A645) - 4.68\,(A663) \times \frac{V}{1000 \times w \times a}$$

Where,

A = absorbance at specific wavelengths,

V = Final volume of chlorophyll extracted in 80% acetone

W = Fresh weight of tissue extracted

A = Path length

3.6.2.2 Moisture percentage (%)

Moisture percentage was estimated by taking 50 g of sample ginger rhizomes collected from each treatment by recording fresh weight and oven dry weight at 60°C for 48 hr at after harvesting. It was calculated by

$$\text{Moisture percentage (\%)} = \frac{\text{Fresh weight} - \text{Dry weight} \times 100}{\text{Fresh weight}}$$

3.6.2.3 Ginger oil percentage (%)

Ginger oil percentage in ginger was estimated by following procedure.

1. Take 25 g of ginger sample.
2. Clean it with tap water and remove the skin.
3. The cleaned ginger was dried in sun up to 1-2 weeks for proper drying.
4. Prepare powder and take 20 to 30 g for extraction of oil by using the clevenger apparatus.

Calculation

$$\text{Ginger oil percentage} = \frac{\text{Amount of oil extracted}}{\text{Amount of raw material used}} \times 100$$

3.6.2.4 Oleoresin percentage (%)

Oleoresin percentage in ginger was estimated by following procedure.

1. Take near about 20 g weight of ginger sample.
2. Put this sample in conical flask containing 50 ml of hexane.
3. Stir this mixture for 150 min.
4. Then this extract was filtered through the filter paper.
5. The residue obtain was extracted twice with 50 ml hexane and filtered.
6. The extracts were combined.
7. Then this solvent is removed by solvent distillation apparatus to get oleoresin.

Calculation

$$\text{Oleoresin content (percentage)} = \frac{\text{Volumes of oil (ml)}}{\text{Weight of sample (g)}} \times 100$$

3.6.3 Yield parameters

3.6.3.1 Rhizome yield per plot (kg)

Rhizome yield per plot were recorded after complete plot harvesting and expressed in kg per plot.

3.6.3.2 Rhizome yield per hactare (q)

Rhizome yield in terms of q/ha was calculated on the basis of total yield per net plot.

3.6.3.3 Crop duration (days)

Crop duration was calculated from the day of planting to the harvesting of the crop.

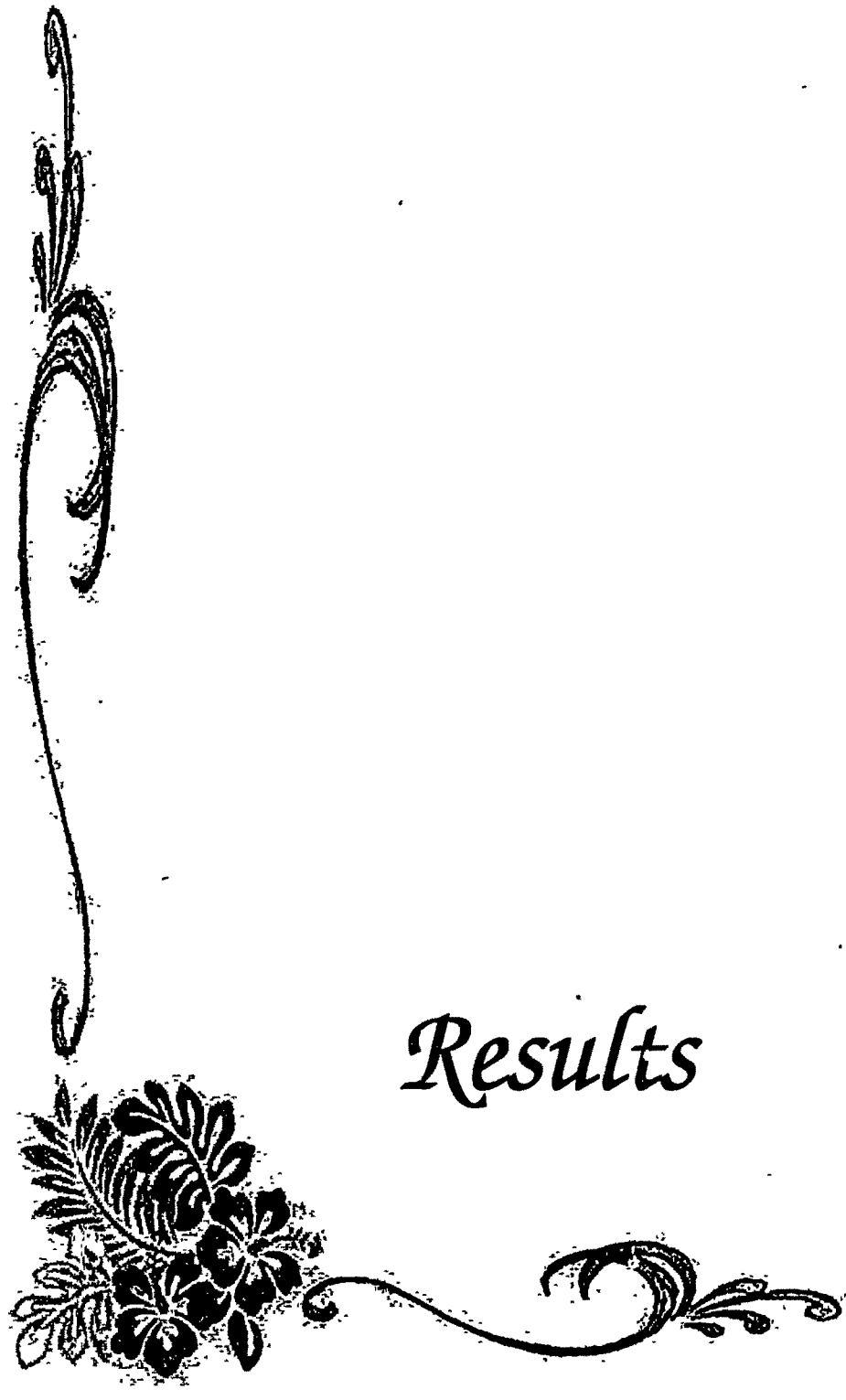
3.6.3.4 Recovery percentage (%)

50 g of fresh rhizome was dried in hot air oven at 60°C until constant weight was obtained. Recovery percentage was calculated using the formulae.

$$\text{Recovery percentage} = \frac{\text{Weight of oven dried ginger}}{\text{Weight of fresh ginger kept for drying}} \times 100$$

3.7 Statistical analysis

Data were statistically analyzed by the technique of analysis of variance as suggested by Panse and Sukhatme (1978).



Results

CHAPTER-IV

RESULTS AND DISCUSSION

The present investigation was carried out to''Studies on performance of different ginger genotypes under Marathwada condition''. The research was conducted in *kharif* season at Department of Horticulture, VNMKV, Parbhani, during 2011-2012 with following objectives.

1) To study the growth and yield performance of different ginger genotypes.
2) To find out the suitable genotype for commercial cultivation.

The observations were recorded on various parameters governing to growth, yield and quality. The results obtained are presented under appropriate headings.

A) Growth parameters
B) Yield parameters
C) Quality parameters

4.1 Growth parameters

Table 3. Plant height, number of leaves per clump, and leaf area per plant observed in different ginger genotypes

Treatment (genotypes)	Plant height(cm)					Number of leaves per clump					Leaf area per plant(cm^2)				
	DAP					DAP					DAP				
	30	60	90	120	150	30	60	90	120	150	30	60	90	120	150
TKNM	18.75	21.55	24.05	27.35	29.90	3.80	5.70	7.90	10.15	12.75	14.53	15.09	16.06	16.44	16.89
SLGN	21.25	24.60	27.65	31.45	34.10	3.75	5.90	8.30	10.80	13.65	15.87	16.39	16.80	17.08	17.46
PTN	23.15	26.45	29.00	32.50	35.00	4.70	6.80	9.25	12.40	14.65	17.43	17.99	18.23	18.54	18.93
GNP	22.20	25.20	28.05	31.65	33.60	4.45	6.55	8.85	11.45	13.75	16.49	17.07	17.33	17.62	18.04
KND	21.75	24.65	27.35	30.25	32.05	4.15	6.15	8.40	11.15	13.50	15.85	16.33	16.72	17.03	17.44
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	0.753	0.884	1.021	0.882	1.074	0.112	0.102	0.186	0.237	0.239	0.315	0.334	0.312	0.293	0.297
CD at 5%	2.318	2.721	3.143	2.714	3.304	0.345	0.314	0.573	0.730	0.737	0.971	1.029	0.962	0.901	0.914

4.1.1 Plant height at 30 days interval (cm)

Plant height was recorded at 30, 60, 90, 120 and 150 days after planting and presented in Table 3 and illustrated in Fig.2.

The data in respect of plant height showed significant differences at all stages of growth. At 30 days after planting, maximum height was recorded in genotype PTN (23.15 cm) followed by genotype GNP (22.20 cm) and KND (21.75 cm) respectively and these genotypes were at par with each other. However, minimum plant height was found in genotype TKNM (18.75 cm) which was at par with genotype SLGN (21.25 cm).

Significantly maximum plant height was recorded in genotype PTN (26.45 cm) followed by GNP (25.20 cm) at 60 days after planting and these genotypes were at par with each other. However, minimum plant height was recorded in genotype TKNM (21.55 cm), which were at par with the genotypes SLGN (24.60 cm) and KND (24.65 cm).

At 90 days after planting the maximum plant height was recorded in genotype PTN (29.00 cm) followed by GNP (28.05 cm) and these genotypes were at par with each other. The minimum plant height was recorded in genotype TKNM (24.05 cm), which were at par with the genotypes KND (27.35 cm) and SLGN (27.65 cm).

In respect of plant height was recorded at 120 days after planting, genotype PTN (32.50 cm) produced significantly maximum height and followed by genotype GNP (31.65cm) and SLGN (31.45 cm), which were at par with each other. However, the minimum height was produced by genotype TKNM (27.35cm), which was at par with genotype KND (30.25cm).

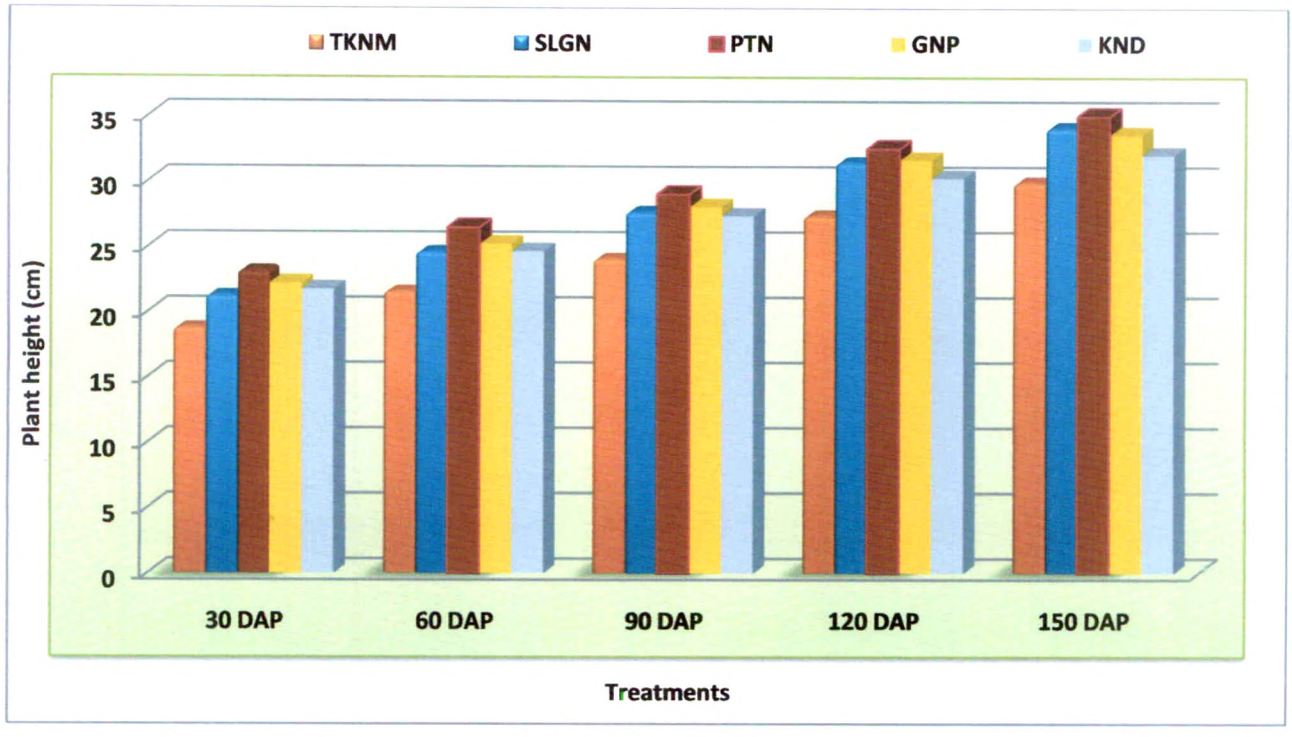


Fig.2. Plant height (cm) at 30 days interval observed in different ginger genotypes.

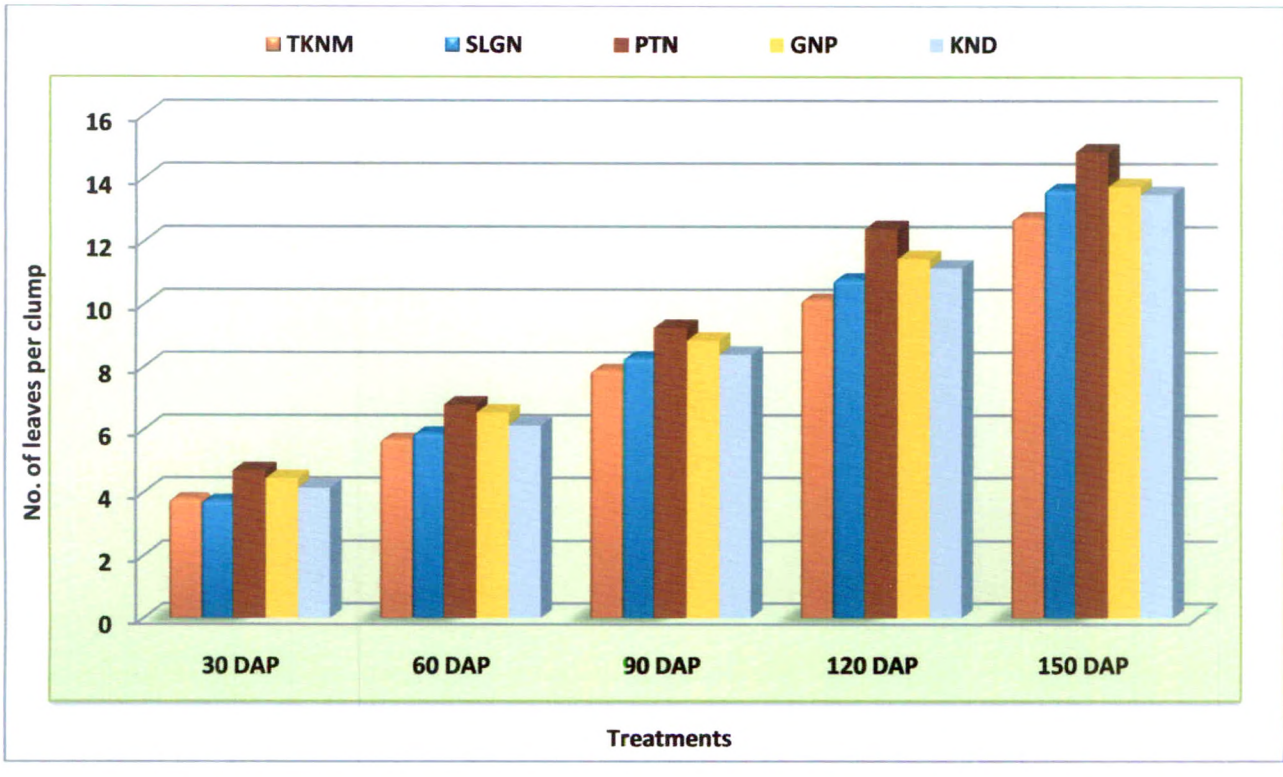


Fig.3. Number of leaves per clump observed in different ginger genotypes.

Plant height was recorded finally at 150 days after planting. This data showed that, the genotype PTN (35.00 cm) followed by genotype SLGN (34.10 cm) and GNP (33.60 cm), which were significantly superior over rest of the genotypes and these genotypes were at par with each other. The minimum height of plant was recorded in genotype TKNM (29.90 cm), which was at par with genotype KND (32.05 cm).

4.1.2 Number of leaves per clump

The data regarding number of leaves per clump was recorded at 30, 60, 90, 120 and 150 days after planting and presented in Table 3 and illustrated in Fig.3

The data in respect of number of leaves per clump showed significant differences at all stages of growth. At 30 days after planting, maximum number of leaves per clump was recorded in genotype PTN (4.70) followed by genotype GNP (4.45) and KND (4.15) respectively and these genotypes were at par with each other. However, minimum number of leaves per clump was recorded in genotype SLGN (3.75), which was at par with genotype TKNM (3.80).

Significantly maximum number of leaves per clump was recorded in genotype PTN (6.80) followed by GNP (6.55) and KND (6.15) at 60 days after planting and these genotypes were at par with each other. However, minimum number of leaves per clump was recorded in genotype TKNM (5.70), which was at par with genotype SLGN (5.90).

At 90 days after planting the maximum number of leaves per clump was recorded in genotype PTN (9.25) followed by genotype GNP (8.85) and these genotypes were at par with each other. The minimum number of leaves per clump was recorded in genotype TKNM (7.90), which were at par with the genotypes SLGN (8.30) and KND (8.40).

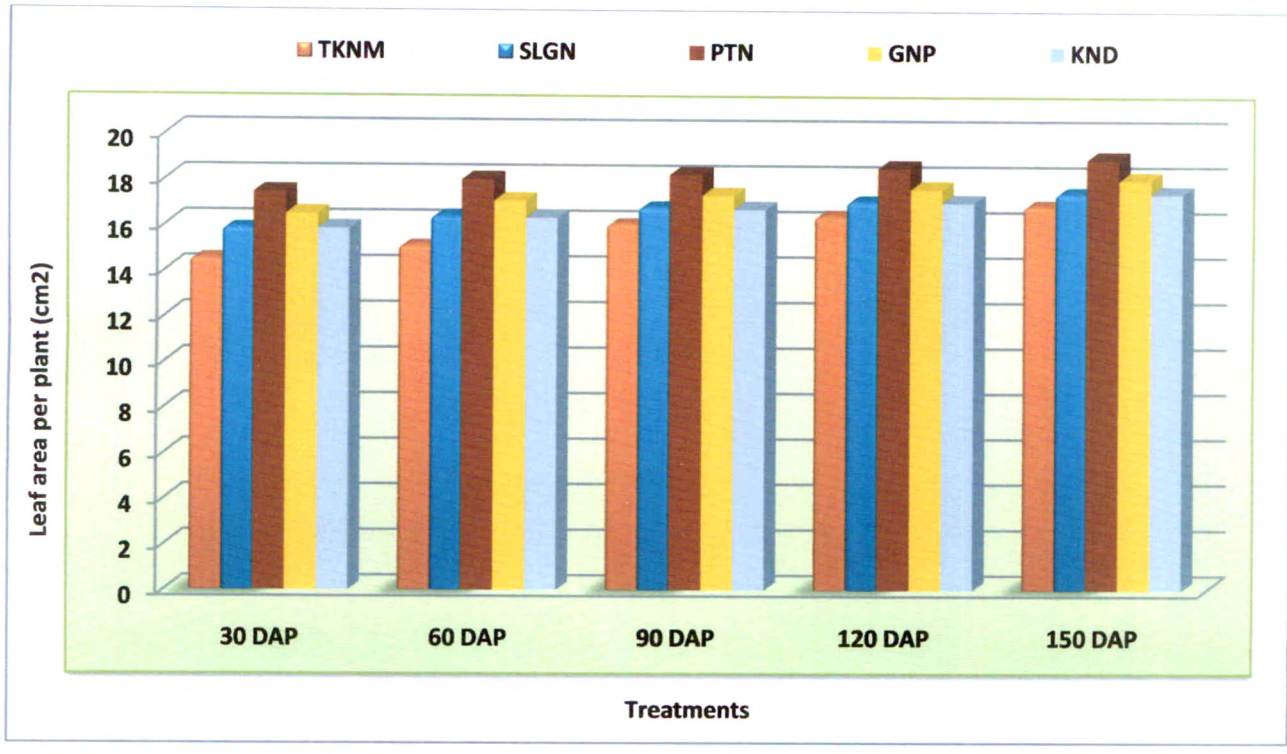


Fig.4. Leaf area per plant (cm^2) observed in different ginger genotypes.

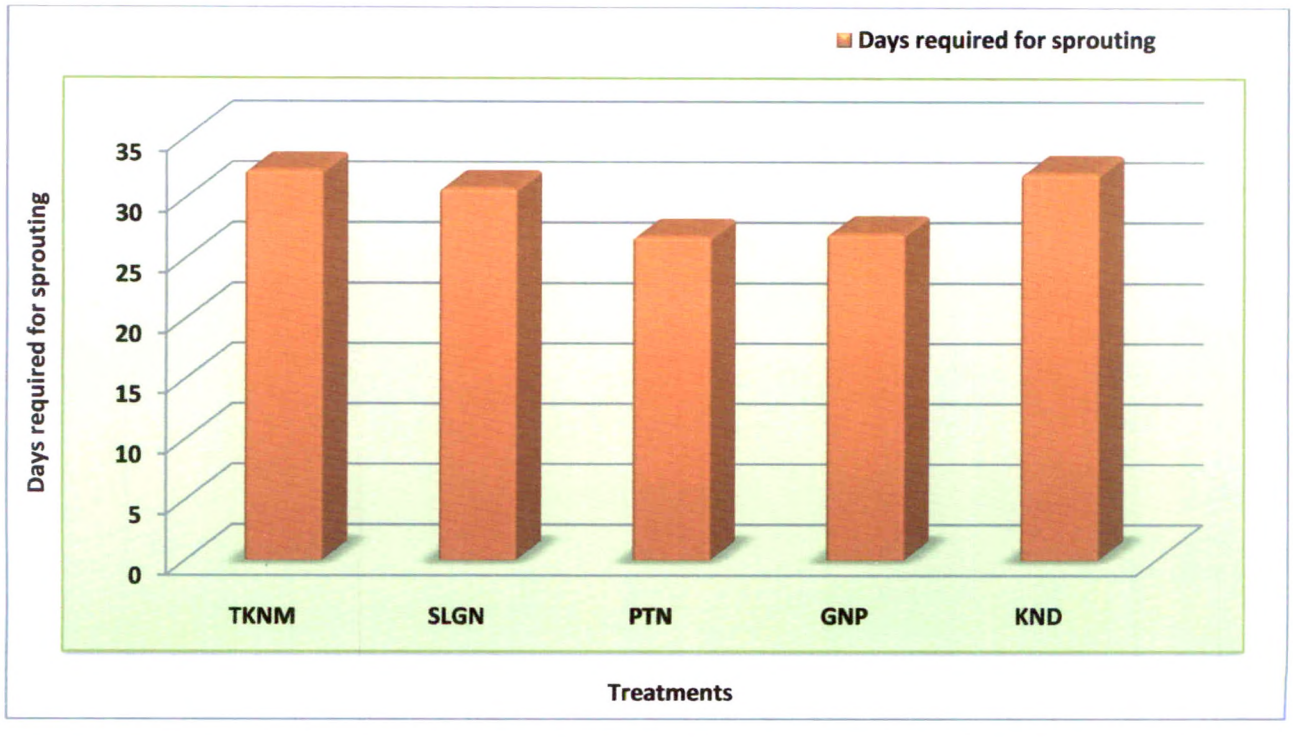


Fig.5. Days required for sprouting observed in different ginger genotypes.

In respect of number of leaves per clump was recorded at 120 days after planting, genotype PTN (12.40) produced significantly maximum number of leaves per clump and followed by genotype GNP (11.45) and KND (11.15), which were at par with each other. However, minimum number of leaves per clump was produced by genotype TKNM (10.15), which was at par with genotype SLGN (10.80).

Number of leaves per clump was recorded finally at 150 days after planting. This data showed that, the genotype PTN (14.85)) produced significantly maximum number of leaves per clump followed by genotype GNP (13.75) and SLGN (13.65), which were at par with each other. The minimum number of leaves per clump was recorded in genotype TKNM (12.75), which was at par with genotype KND (13.50).

4.1.3 Leaf area per plant (cm^2)

The data regarding leaf area per plant was recorded at 30, 60, 90, 120 and 150 days after planting and presented in Table 3 and illustrated in Fig.4

The data in respect of leaf area per plant showed significant differences at all stages of growth. At 30 days after planting, maximum leaf area per plant was recorded in genotype PTN (17.43 cm^2) followed by genotype GNP (16.49 cm^2) and these genotypes were at par with each other. However, minimum leaf area per plant was recorded in genotype TKNM (14.53 cm^2), which were at par with the genotypes KND (15.85 cm^2) and SLGN (15.87 cm^2).

Significantly maximum leaf area per plant was recorded in genotype PTN (17.99 cm^2) followed by genotype GNP (17.07 cm^2) at 60 days after planting and these genotypes were at par with each other. However, minimum leaf area per plant was recorded in genotype TKNM

(15.09 cm^2), which were at par with genotypes KND (16.33 cm^2) and SLGN (16.39 cm^2).

At 90 days after planting the maximum leaf area per plant was recorded in genotype PTN (18.23 cm^2) followed by genotype GNP (17.33 cm^2) and these genotypes were at par with each other, whereas minimum leaf area per plant was recorded in genotype TKNM (16.06 cm^2), which were at par with the genotype KND (16.72 cm^2) and SLGN (16.80 cm^2).

In respect of leaf area per plant was recorded at 120 days after planting, genotype PTN (18.54 cm^2) produced significantly maximum leaf area per plant followed by genotype GNP (17.62 cm^2) and these genotypes were at par with each other. However, minimum leaf area per plant was recorded in genotype TKNM (16.44 cm^2), which were at par with the genotypes KND (17.03 cm^2) and SLGN (17.08 cm^2).

Leaf area per plant was recorded finally at 150 days after planting. This data showed that, the genotype PTN (18.93 cm^2) produced significantly maximum leaf area per plant followed by genotype GNP (18.04 cm^2) and these genotypes were at par with each other. However, minimum leaf area per plant was recorded in genotype TKNM (16.89 cm^2), which were at par with the genotypes KND (17.44 cm^2) and SLGN (17.46 cm^2).

Table 4. Different growth parameters observed in different ginger genotypes

Treatment (genotypes)	Days required for sprouting	Sprouting percentage (%)	Number of sprouts per plant	Number of rhizomes per plant	Length of rhizome (cm)	Width of rhizome (cm)	Weight of rhizome(g)
TKNM	32.25	65.92	2.20	1.45	10.35	5.30	70.79
SLGN	30.75	72.10	3.00	1.50	12.00	6.40	108.98
PTN	26.75	81.90	4.25	2.25	12.65	6.50	111.05
GNP	27.00	86.05	3.25	2.20	12.35	6.30	141.11
KND	32.00	72.17	2.50	1.60	11.40	5.90	107.22
'F' test	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.918	2.595	0.216	0.082	0.191	0.111	0.972
CD at 5%	2.826	7.986	0.667	0.252	0.589	0.341	2.992

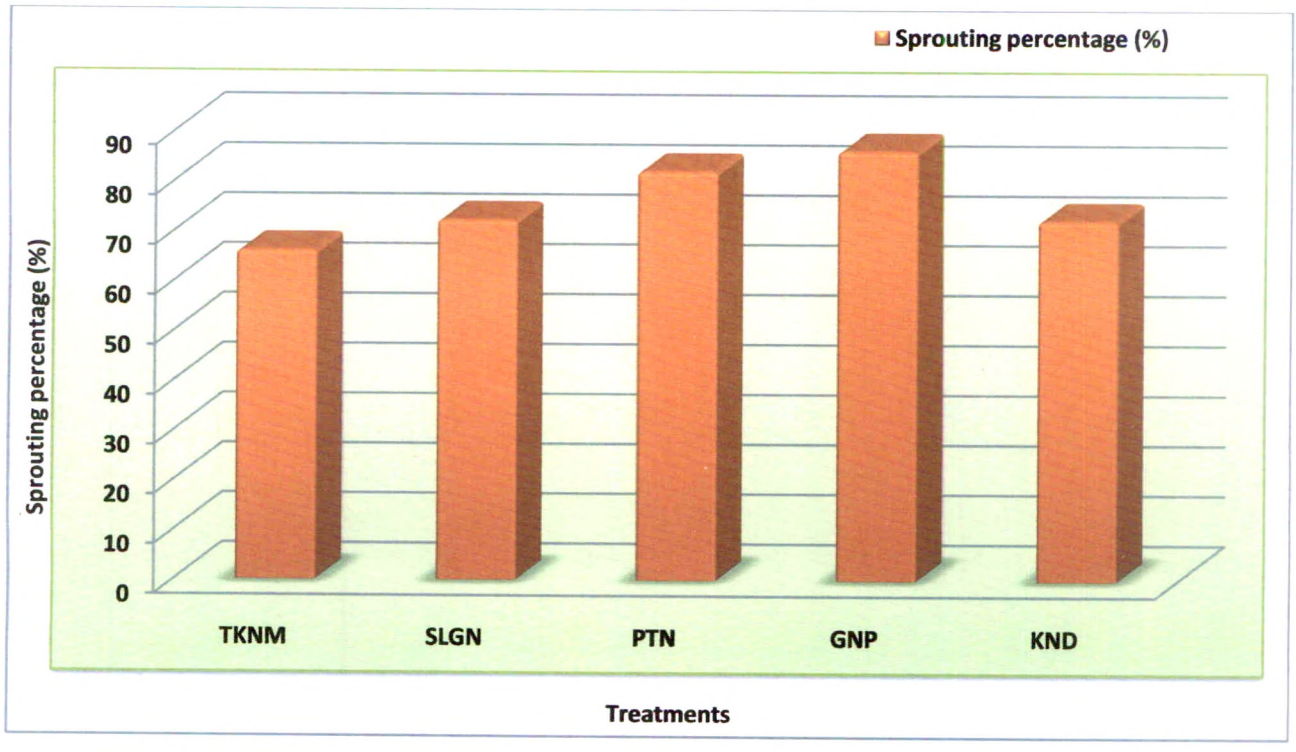


Fig.6. Sprouting percentage (%) observed in different ginger genotypes.

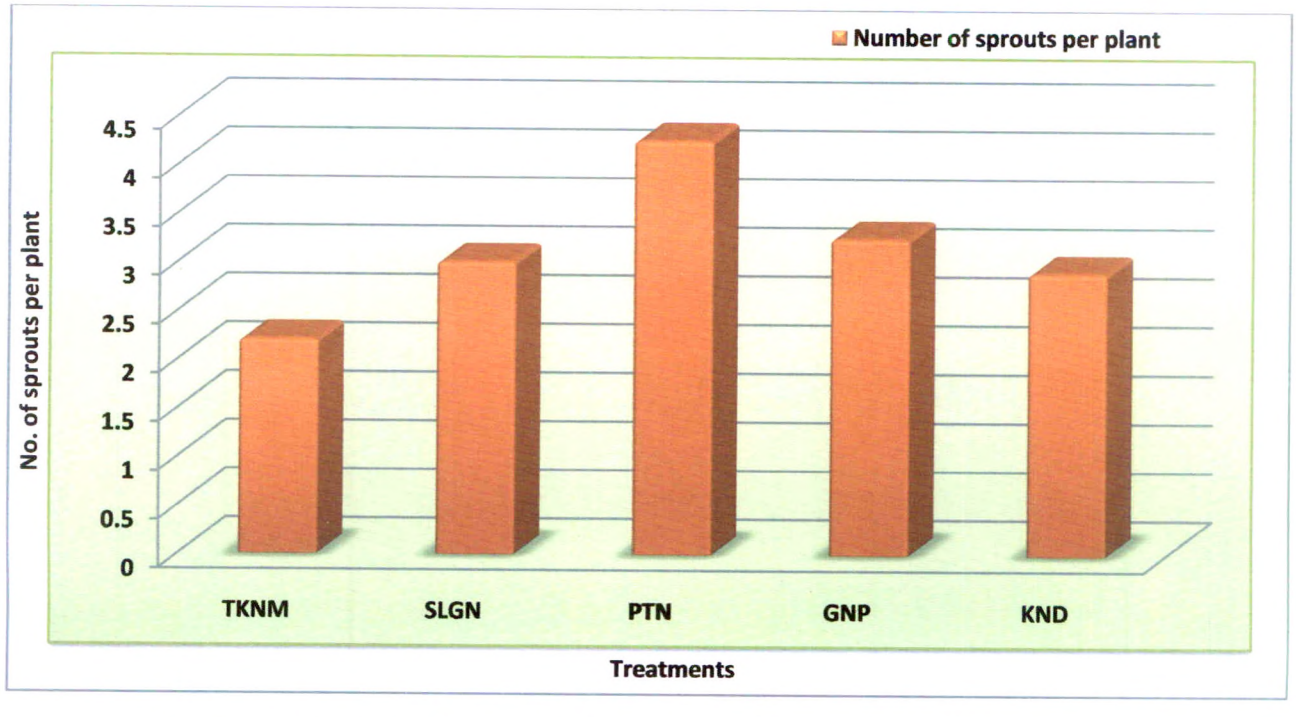


Fig.7. Number of sprouts per plant observed in different ginger genotypes.

4.1.4 Days required for sprouting

Data in respect to days required for sprouting of ginger rhizome is presented in Table 4 and illustrated in Fig.5

The data in respect to days required for sprouting showed significant difference among the genotypes. Maximum days required for sprouting was recorded in genotype TKNM (32.25) followed by KND (32.00) and SLGN (30.75) respectively and these genotypes were at par with each other. However, minimum days required for sprouting was found in genotype PTN (26.75) which was at par with genotype GNP(27.00).The genotype PTN was significantly superior over all other genotypes.

4.1.5 Sprouting percentage (%)

Data in respect to sprouting percentage of ginger rhizome is presented in Table 4 and illustrated in Fig.6

The data in respect to sprouting percentage showed significant difference among the genotypes. Highest sprouting percentage was recorded in genotypes GNP (86.05 %) followed by PTN (81.90 %) and these genotypes at par with each other. However, minimum sprouting percentage was found in genotype TKNM (65.92 %), which were at par with the genotypes SLGN (72.10 %) and KND (72.17 %).

4.1.6 Number of sprouts per plant

Data in respect to number of sprouts per plant of ginger rhizome is presented in Table 4 and illustrated in Fig.7

The data in respect to number of sprouts per plant showed significant difference among the genotypes. Highest number of sprouts per plant was recorded in genotype PTN (4.25) followed by genotype GNP

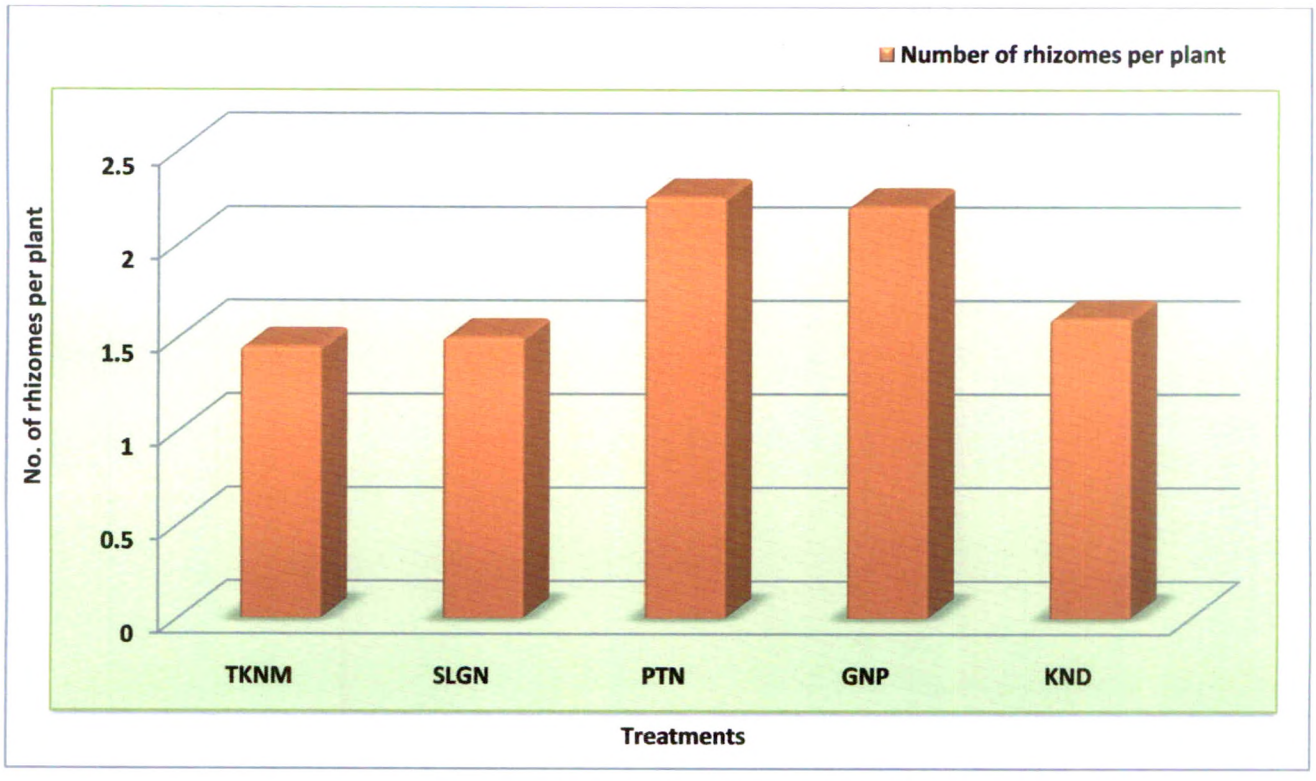


Fig.8. Number of rhizomes per plant observed in different ginger genotypes.

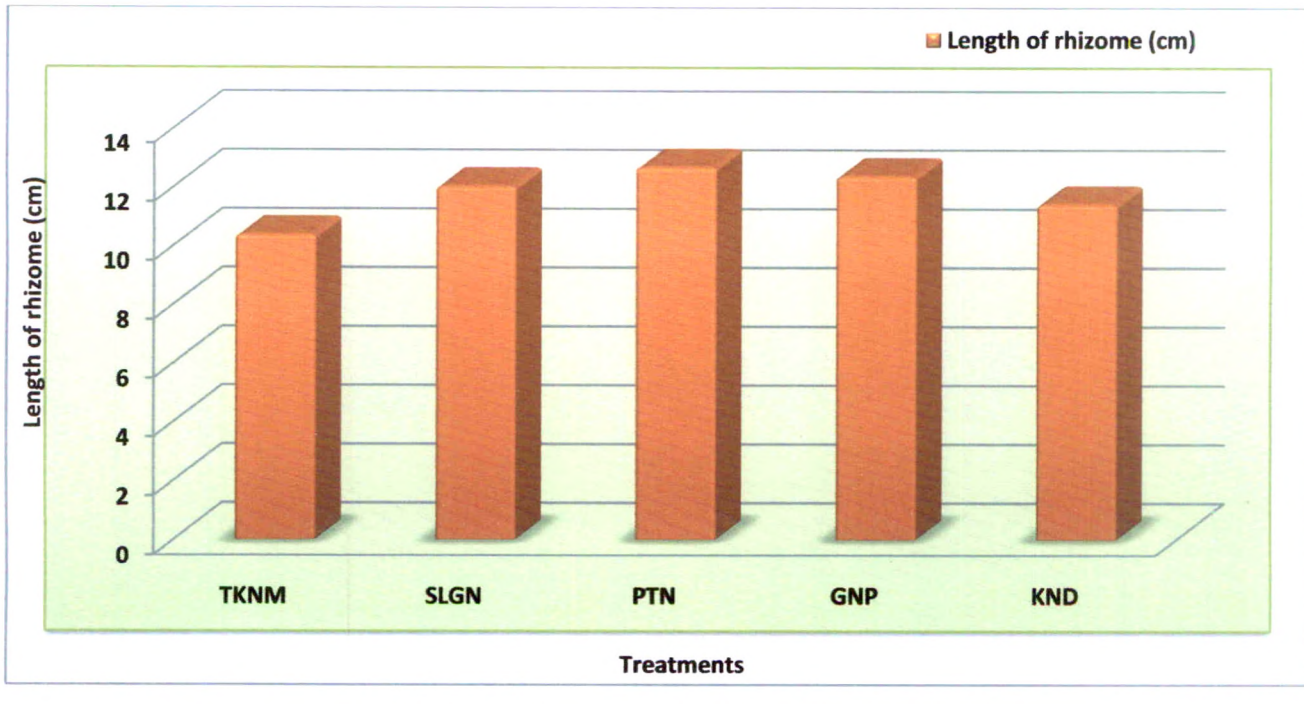


Fig.9. Length of rhizome (cm) observed in different ginger genotypes.

(3.25) and SLGN (3.00), which were at par with each other. However, minimum number of sprouts per plant was recorded in genotype TKNM (2.20), which was at par with genotype KND (2.90).

4.1.7 Number of rhizomes per plant

Data in respect to number of rhizomes per plant was recorded after harvesting and it is presented in Table 4 and illustrated in Fig.8

The data in respect to number of rhizomes per plant showed significant difference among the genotypes. Maximum number of rhizomes per plant was recorded in genotype PTN (2.25) followed by genotype GNP (2.20), which were at par with each other. However, minimum number of rhizomes per plant was recorded in genotype TKNM (1.45), which were at par with the genotypes SLGN (1.50) and KND (1.60).

4.1.8 Length of rhizome (cm)

Data in respect to length of rhizome was recorded after harvesting and it is presented in Table 4 and illustrated in Fig.9

The data in respect to length of rhizome showed significant difference among the genotypes. Maximum length of rhizome was recorded in genotype PTN (12.65 cm) followed by genotype GNP (12.35 cm) and SLGN (12.00 cm), which were at par with each other. However, minimum length of rhizome was recorded in genotype TKNM (10.35 cm), which was at par with genotype KND (11.40 cm).

4.1.9 Width of rhizome (cm)

Data in respect of width of rhizome was recorded after harvesting and it is presented in Table4 and illustrated in Fig.10

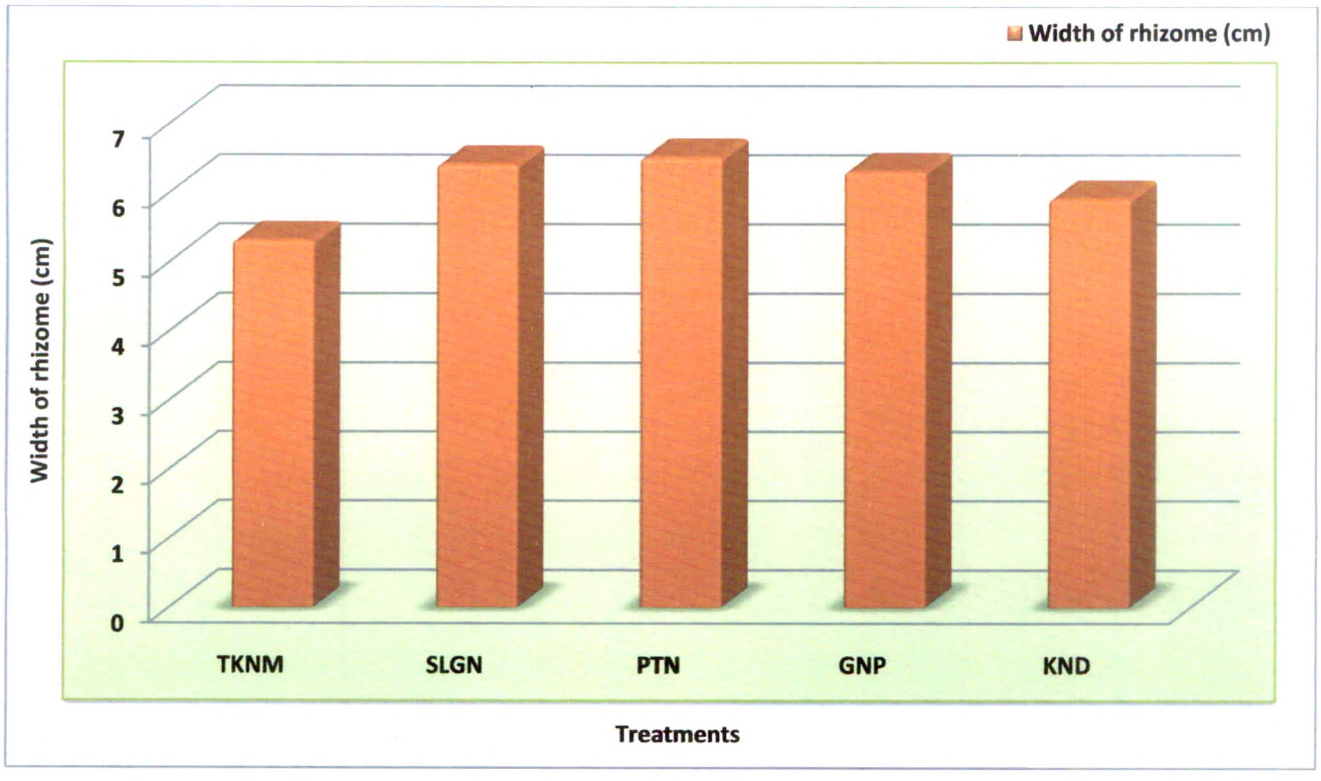


Fig.10. Width of rhizome (cm) observed in different ginger genotypes.

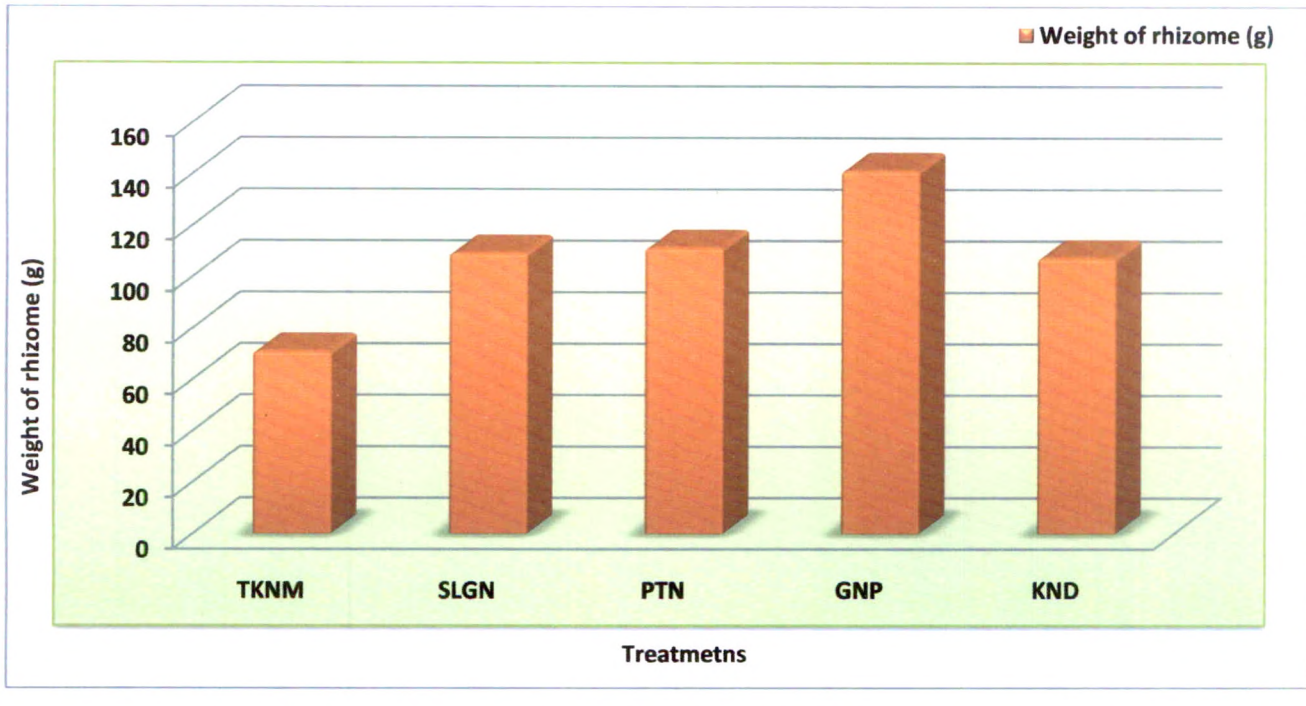


Fig.11. Weight of rhizome (g) observed in different ginger genotypes.

The data in respect to width of rhizome showed significant difference among the genotypes. Maximum width of rhizome was recorded in genotype PTN (6.50 cm) followed by genotype SLGN (6.40 cm) and GNP (6.30 cm), which were at par with each other. However, minimum width of rhizome was recorded in genotype TKNM (5.30 cm), which was at par with genotype KND (5.90 cm).

4.1.10 Weight of rhizome (g)

Data in respect of weight of rhizome was recorded after harvesting and it is presented in Table 4 and illustrated in Fig.11

The data in respect to weight of rhizome showed significant difference among the genotypes. Maximum weight of rhizome was recorded in genotype GNP (141.11 g) followed by genotype PTN (111.05 g), which were at par with each other. However, minimum weight of rhizome was recorded in genotype TKNM (70.79 g), which were at par with the genotypes KND (107.22 g) and SLGN (108.98 g).

4.2 Quality parameter

Observations in respect of chlorophyll 'a' and chlorophyll 'b' content, moisture percentage, ginger oil percentage and oleoresin percentage in ginger were recorded and data is presented in Table 5 and depicted in Fig.12,13,14.

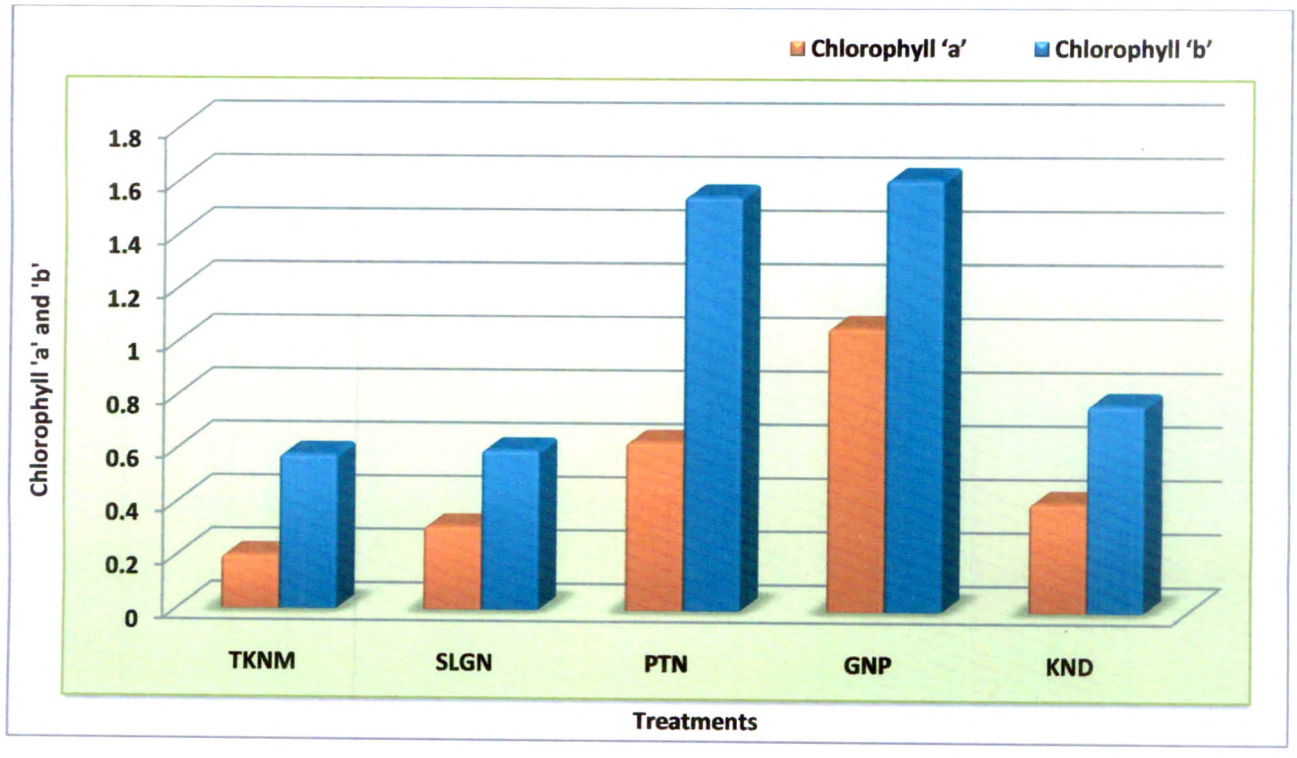


Fig.12. Chlorophyll 'a' and chlorophyll 'b' content (mg/100g) observed in different ginger genotypes.

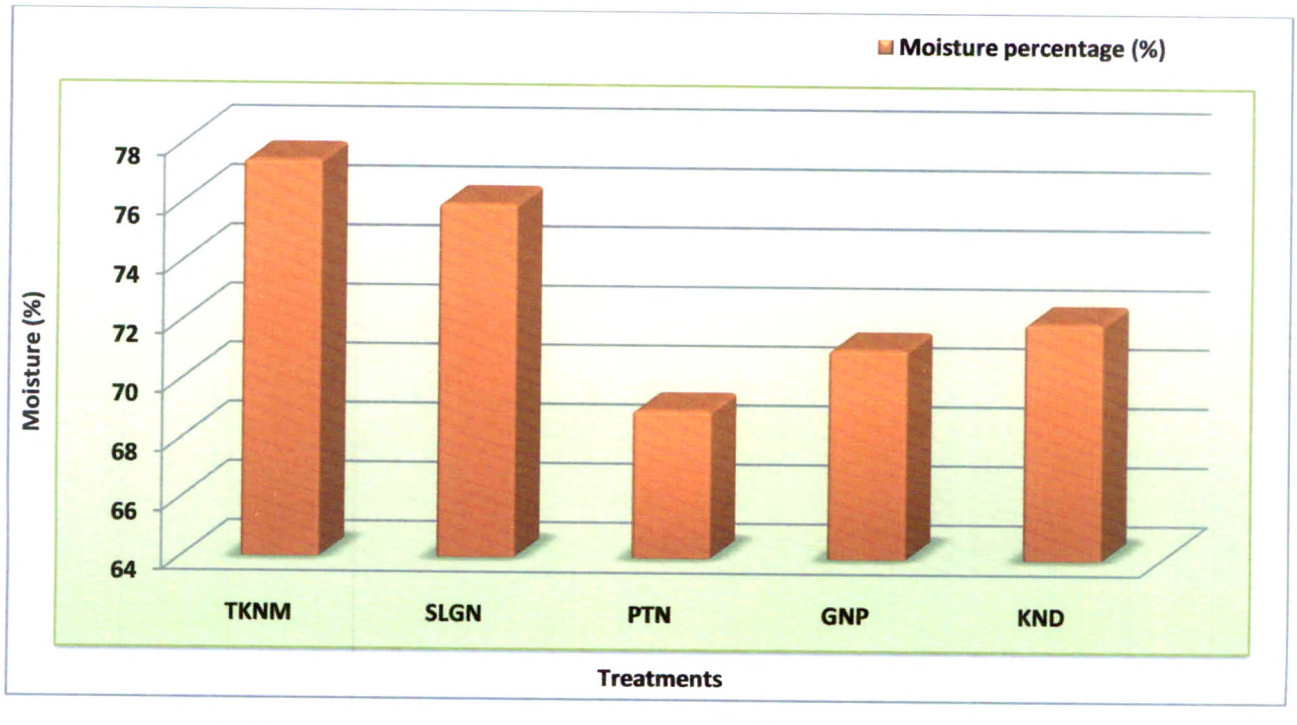


Fig.13. Moisture percentage (%) observed in different ginger genotypes.

Table 5. Different quality parameters observed in different ginger genotypes

Treatment (genotypes)	Chlorophyll 'a' (mg/100 g)	Chlorophyll 'b' (mg/100 g)	Moisture percentage (%)	Ginger oil percentage (%)	Oleoresin percentage (%)
TKNM	0.199	0.577	77.40	1.47	4.61
SLGN	0.310	0.597	75.95	1.60	5.61
PTN	0.628	1.548	69.00	2.47	10.05
GNP	1.059	1.613	71.10	1.89	7.14
KND	0.407	0.774	72.02	1.84	7.05
'F' test	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.045	0.170	0.313	0.006	0.029
CD at 5%	0.139	0.524	0.964	0.018	0.090

4.2.1 Chlorophyll 'a' and chlorophyll 'b' content (mg/100g)

The data regarding the chlorophyll 'a' and chlorophyll 'b' content from fresh leaf of ginger genotypes were estimated 90 days after planting and it is presented in Table 5 and depicted in Fig.12.

Data in respect of presented in Table 5 revealed that highest chlorophyll 'a' content was recorded in genotype GNP (1.059 mg/100g) followed by genotype PTN (0.628 mg100/g), which were at par with each other. However, minimum chlorophyll 'a' content was found in genotype TKNM (0.199 mg/100g), which were at par with the genotypes SLGN (0.310 mg/100g) and KND (0.407 mg/100g).

Data in respect of presented in Table 5 revealed that highest chlorophyll 'b' content was recorded in genotype GNP (1.613 mg/100g) followed by genotype PTN (1.548 mg/100g), which were at par with each other. However, minimum chlorophyll 'b' content was found in genotype TKNM (0.577 mg/100g), which were at par with the genotypes SLGN (0.597 mg/100g) and KND (0.774 mg/100g).

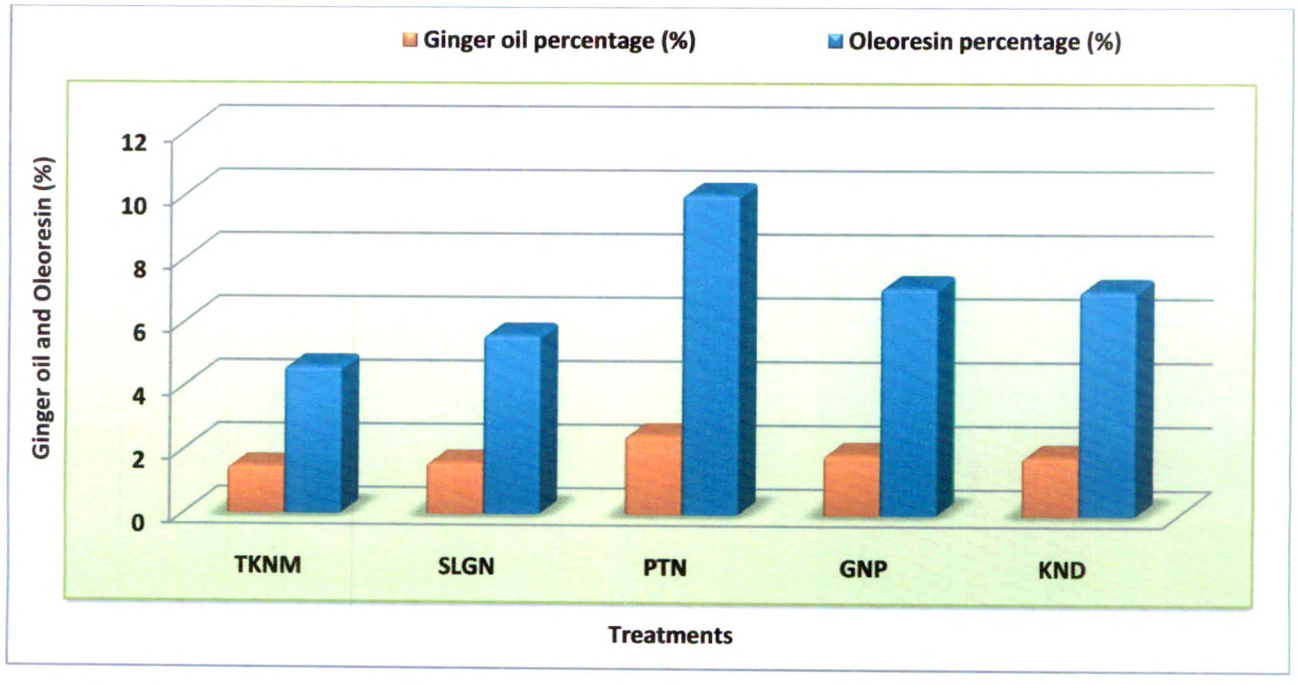


Fig.14. Ginger oil and oleoresin percentage (%) observed in different ginger genotypes.

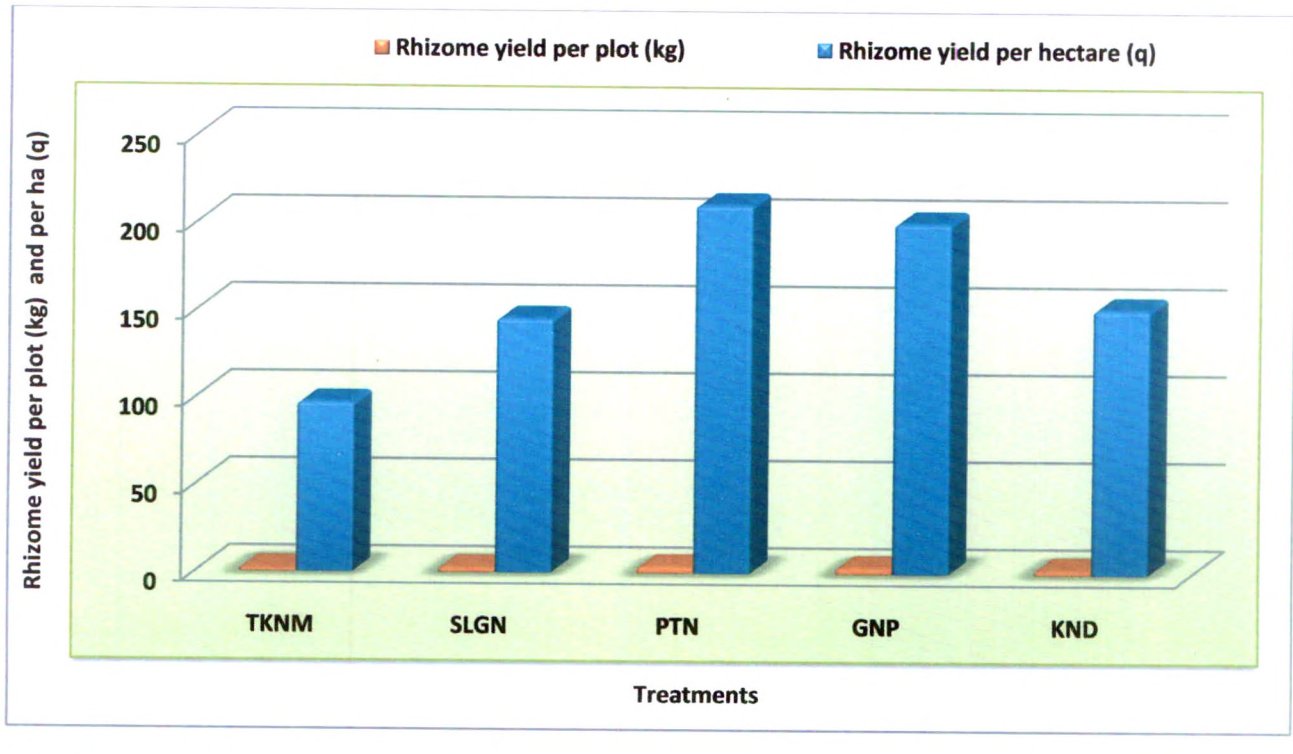


Fig.15. Rhizome yield per plot (kg) and rhizome yield per hectare (q) observed in different ginger genotypes.

4.2.2 Moisture percentage (%)

Data in respect of moisture percentage influenced by ginger genotypes was shown in Table 5 and Fig.13.

The data in respect of moisture percentage presented in Table 5 revealed that highest moisture percentage was recorded in genotype TKNM (77.40 %) followed by genotype SLGN (75.95 %), which were at par with each other. However, minimum moisture percentage was found in genotype PTN (69.00 %), which were at par with the genotypes GNP (71.10 %) and KND (72.02 %). The genotype PTN was superior over all other genotypes.

4.2.3 Ginger oil percentage (%)

Observations recorded in respect of ginger oil percentage in different genotypes is presented in Table 5 and illustrated in Fig.14

The highest ginger oil percentage in ginger was recorded in genotype PTN (2.47 %) followed by genotype GNP (1.89 %) and KND (1.84 %), which were at par with each other. However, the minimum ginger oil percentage was found in genotype TKNM (1.47 %), which was at par with genotype SLGN (1.60 %).

4.2.4 Oleoresin percentage (%)

Observations recorded in respect of oleoresin percentage in different genotypes is presented in Table 5 and illustrated in Fig.14

The highest oleoresin percentage in ginger was recorded in genotype PTN (10.05 %) followed by genotype GNP (7.14 %) and KND (7.05%), which were at par with each other, and they were significantly superior over the rest of other genotypes. However, minimum oleoresin

percentage was found in genotype TKNM (4.61 %), which was at par with genotype SLGN (5.61 %).

4.3 Yield parameters

Observations in respect of rhizome yield per plot (kg), rhizome yield per hectare (q), crop duration (days), recovery percentage were recorded and data is presented in Table 6 depicted in Fig.15,16,17.

Table 6. Different yield parameters observed in different ginger genotypes

Treatment (genotypes)	Rhizome yield per plot (kg)	Rhizome yield per hectare (q)	Crop duration (days)	Recovery percentage (%)
TKNM	1.57	97.06	235	21.75
SLGN	2.35	145.52	222	23.77
PTN	3.41	210.95	202	29.97
GNP	3.25	200.92	207	30.35
KND	2.46	152.00	216	28.40
'F' test	Sig	Sig	1.581	Sig
SE(m)±	0.056	3.489	Sig	0.489
CD at 5%	0.173	10.737	4.864	1.506

4.3.1 Rhizome yield per plot (kg)

The data regarding the rhizome yield per plot was recorded after harvesting and it is presented in Table 6 and illustrated in Fig.15

Highest rhizome yield per plot was recorded in genotype PTN (3.41 kg) followed by genotype GNP (3.25 kg), which were at par with each other. However, minimum rhizome yield per plot was found in genotype TKNM (1.57 kg), which were at par with the genotypes SLGN (2.35 kg) and KND (2.46 kg).

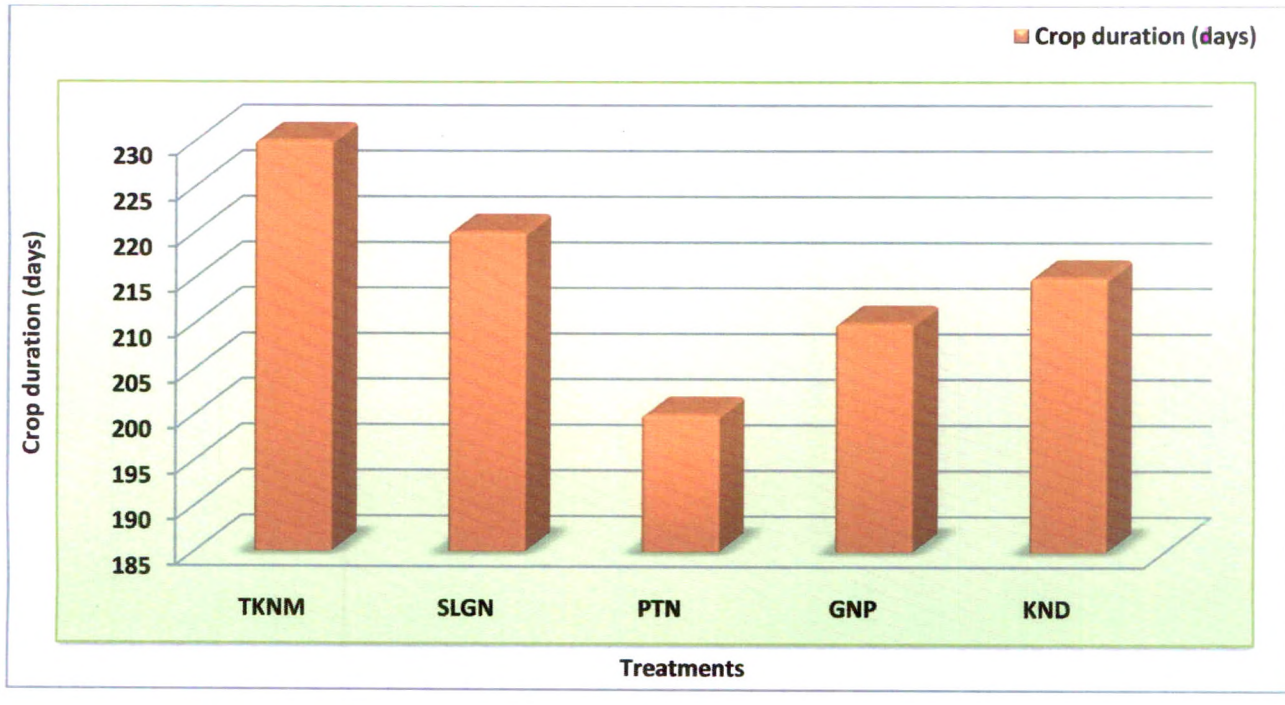


Fig.16. Crop duration (days) observed in different ginger genotypes.

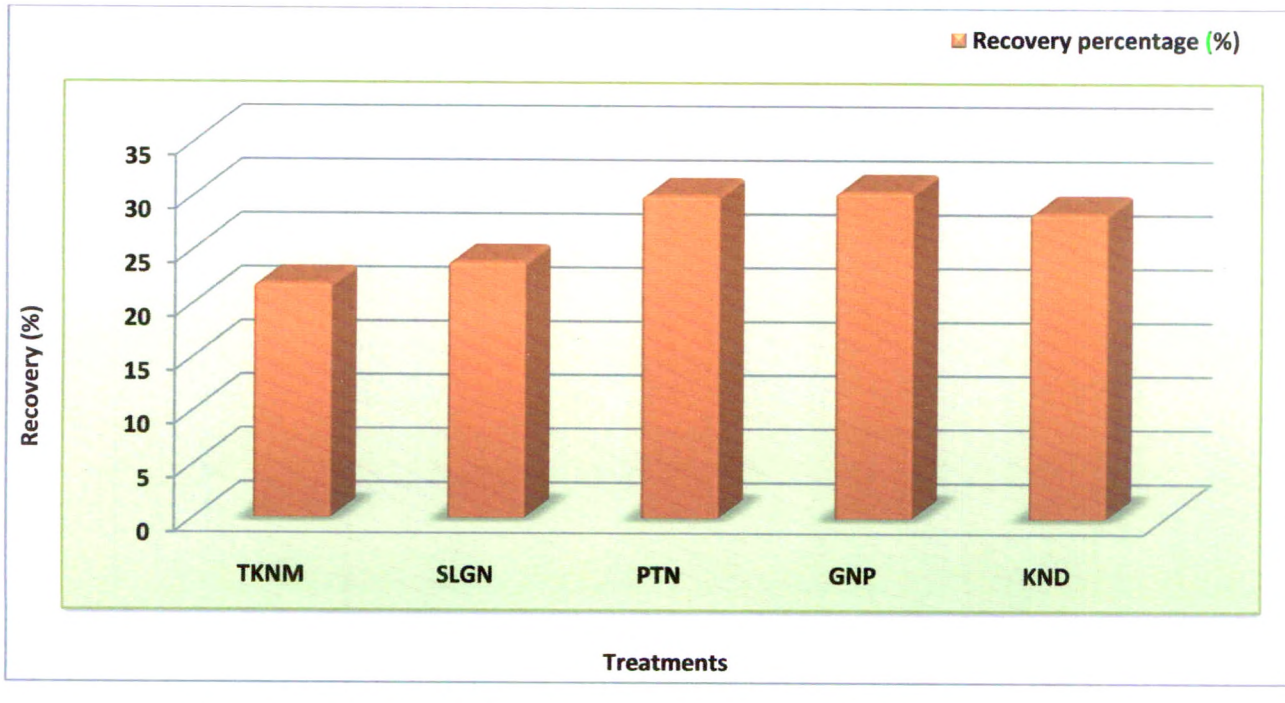


Fig.17. Recovery percentage (%) observed in different ginger genotypes.

4.3.2 Rhizome yield per hectare (q)

The data regarding the rhizome yield per hactare was recorded after harvesting and it is presented in Table 6 and illustrated in Fig.15.

Highest rhizome yield per hactare was recorded in genotype PTN (210.95 q) followed by genotype GNP (200.92 q), which were at par with each other. However, minimum rhizome yield per hactare was found in genotype TKNM (97.06 q), which were at par with the genotypes SLGN (145.52 q) and KND (152.00 q).

4.3.3 Crop duration (days)

Data in respect of crop duration influenced by ginger genotypes was shown in Table 6 and Fig.16.

Data in respect of crop duration presented in Table 6 revealed that highest crop duration was recorded in genotype TKNM (230 days) followed by genotype SLGN (220 days) and KND (215 days), which were at par with each other. However, minimum crop duration was found in genotype PTN (200 days), which was at par with genotype GNP (210 days).The genotype PTN was superior over all other genotypes.

4.3.4 Recovery percentage (%)

Data in respect of recovery percentage influenced by ginger genotypes was shown in Table 6 and Fig.17.

Data in respect of recovery percentage presented in Table 6 revealed that highest recovery percentage was recorded in genotype GNP (30.35 %) followed by genotype PTN (29.97 %) and KND (28.40 %), which were at par with each other. However, minimum recovery percentage was

found in genotype TKNM (21.75 %), which was at par with genotype SLGN (23.77 %).

Discussion

CHAPTER-V

DISCUSSION

An experiment entitled "Studies on performance of different ginger genotypes under Marathwada condition" was conducted in *kharif* season at Department of Horticulture, VNMKV, Parbhani, during 2011-2012. The observation on growth, quality and yield parameters recorded during experimentation are discussed under appropriate headings in this chapter.

5.1 Soil

The soil of the experimental plot was medium black soil of moderate fertility and good drainage.

5.2 Climate and weather condition

Parbhani is situated in the subtropical zone at 408.5 m above mean sea level. Geographically situated between latitude 19^0 16' N and 76^0 47'E longitude. It comes under assured rainfall zone area of Maharashtra. Major rains are received from South west monsoon. It starts from June and ends in October. Thus Parbhani has hot dry summer and moderate cool winter. The mean annual precipitation is 648.1 mm. During the period of investigation, the average maximum temperature ranged between 26.9 ^{0}C to 35.7 ^{0}C and average minimum temperature ranged from 5.8 ^{0}C to 23.4 ^{0}C. Almost humidity ranged from 52 to 94 per cent during morning hours and 19 to 78 per cent during evening hours.

The meteorological data in respect of maximum and minimum temperature, rainfall, relative humidity recorded at meteorological observatory,VNMKV,Parbhani during the period of experiment are furnished in Appendix-I.

5.3 Growth parameters

The observation recorded on vegetative growth of the plant during the course of present investigation are discussed under suitable headings.

5.3.1 Plant height at 30 days interval (cm).

Plant height was significantly differed in ginger genotypes at all stages of plant growth. At 150 days after planting maximum height was observed in genotype PTN (35.00 cm) followed by genotype SLGN (34.10 cm), which were at par with each other, while minimum height was found in genotype TKNM (29.90 cm). The difference between ginger genotypes in respect of plant height might be due to genetic composition in the expression of growth potential of different genotypes. These results are in agreement with the findings of Arya and Rana (1990); Saikia and Shadeque (1992); Pandy and Dobhal (1993); Ravindran *et al.* (1994) and Prasad *et al.* (1997).

5.3.2 Number of leaves per clump

The number of leaves per plant was significantly influenced by ginger genotypes at all stages of observations. At 150 days after planting the maximum number of leaves per clump found in genotype PTN (14.85) followed by genotype GNP (13.75), which were at par with each other, while minimum number of leaves per clump was found in genotype TKNM (12.75).

Similar variation in number of leaves among the different genotypes were reported by Roy and Wamanan (1990); Pandey and Dobhal (1993); Ravindran *et al.* (1994) and Prasad *et al.* (1997).

The variation in number of leaves produced by genotypes might be due to genetic factor.

5.3.3 Leaf area per plant (cm^2)

Leaf area per plant was significantly differed in ginger genotypes at all stages of plant growth. At 150 days after planting maximum leaf area per plant was observed in genotype PTN (18.93 cm^2) followed by genotype GNP (18.04 cm^2), which were at par with each other, while minimum leaf area per plant was found in genotype TKNM (16.89 cm^2).

Similar variation in the leaf area per plant among the different genotypes were reported by Mohanty *et al.* (1981); Rattan *et al.* (1988); Ravindran *et al.* (1994); Prasad *et al.* (1997) and Kandiannan (2009).

The variation in leaf area per plant produced by genotypes might be due to genetic factor.

5.3.4 Days required for sprouting

Data recorded in respect of days required for sprouting revealed significant differences among the genotypes. However, maximum days required for sprouting recorded in genotype TKNM (32.25) followed by genotype KND (32.00), which were at par with each other, whereas genotype PTN (26.75) recorded lowest days required for sprouting.

5.3.5 Sprouting percentage (%)

Data recorded in respect of sprouting percentage revealed significant differences among the genotypes. However, highest sprouting percentage was recorded in genotype GNP (86.05%) followed by genotype PTN (81.90%), which were at par with each other, whereas genotype TKNM (65.92%) recorded lowest sprouting percentage.

5.3.6 Number of sprouts per plant.

Number of sprouts per plant 30 days after planting were found significant in ginger genotypes. The data showed that 30 days after planting maximum number of sprouts were found in genotype PTN (4.25 sprouts/ plant) followed by genotype GNP (3.25 sprouts/plant), while minimum number of sprouts per plant was recorded in genotype TKNM (2.20 sprouts/plant). These results were in agreement with findings of Thangaraj *et al.* (1983); Roy and Wamanan (1990) and Saikia and Shadeque (1992).

5.3.7 Number of rhizomes per plant.

Data recorded in respect of number of rhizomes per plant revealed significant differences among the genotypes. However, maximum number of rhizomes per plant was recorded in genotype PTN (2.25) followed by genotype GNP (2.20), which were at par with each other, whereas genotype TKNM (1.45) recorded minimum number of rhizomes per plant.

5.3.8 Length of rhizome (cm)

The length of rhizome was significantly influenced by ginger genotypes. The maximum length of rhizome was found in genotype PTN (12.65 cm) followed by genotype GNP (12.35 cm), which were at par with each other, whereas genotype TKNM (10.35 cm) recorded minimum length of rhizome.

Similar variation in length of rhizome among the different genotypes were reported by Rattan *et al.* (1988) and Arya and Rana (1990).

This differential performance of ginger genotype may be due to the difference in genetic character which is naturally affected by soil, nutritional and environmental conditions.

5.3.9 Width of rhizome (cm)

The width of rhizome was significantly influenced by ginger genotypes. The maximum width of rhizome was found in genotype PTN (6.50 cm) followed by genotype SLGN (6.40 cm), which were at par with each other, whereas genotype TKNM (5.30 cm) recorded minimum width of rhizome.

Similar variation in width of rhizome among the different genotypes were reported by Rattan (1989).

5.3.10 Weight of rhizome (g)

Weight of rhizome showed significantly highest weight in genotype GNP (141.11 g) followed by genotype PTN (111.05 g), which were at par with each other. However, minimum weight of rhizome was found in genotype TKNM (70.79 g).

Similar findings were also found by Muralidharan and Shakuntala (1974); Sreekumar *et al.* (1980); Rattan *et al.* (1988) and Sujatha *et al.* (1994).

This might be due to genetic character of the genotypes and their response to particular agro-climatic condition.

5.4 Quality parameters

Data in respect of quality i.e. chlorophyll 'a' and chlorophyll 'b' content, moisture percentage, ginger oil percentage and oleoresin percentage are discussed below.

5.4.1 Chlorophyll 'a' and chlorophyll 'b' content (mg/100g)

Data regarding chlorophyll 'a'content was significantly influenced by different ginger genotypes. The significantly highest chlorophyll 'a'content was recorded in genotype GNP (1.059 mg/100g) followed by genotype PTN (0.628 mg/100g) which were at par with each other. However, significantly lowest chlorophyll 'a' content was found in genotype TKNM (0.199 mg/100g).

Chlorophyll 'b' content was significantly influenced by different ginger genotypes. The significantly highest chlorophyll 'b' content was recorded in genotype GNP (1.613 mg/100g) followed by genotype PTN (1.548 mg/100g) which were at par with each other. However, significantly lowest chlorophyll 'b' content was found in genotype TKNM (0.577 mg/100g).

Variation in chlorophyll 'a' and chlorophyll 'b' content among the genotypes grown under the same cultural and agro-climatic conditions can be attributed to the genetic factors.

5.4.2 Moisture percentage (%)

Data in respect of moisture percentage was significantly influenced by different ginger genotypes. The genotype TKNM (77.40 %) showed highest moisture percentage followed by genotype SLGN (75.95 %) which were at par with each other. However, lowest moisture percentage was found in genotype PTN (69.00 %).

The variation in moisture percentage might be due to genetic characters of genotypes.

5.4.3 Ginger oil percentage (%)

Data regarding ginger oil percentage was significantly influenced by different ginger genotypes. The significantly highest ginger oil percentage in ginger was recorded in genotype PTN (2.47 %) followed by genotype GNP (1.89 %) which were at par with each other. However, significantly lowest ginger oil percentage was found in genotype TKNM (1.47 %). Similar confirmatory results were obtained by Korla *et al.* (1993); Dutta *et al.* (2003); Sasikumar *et al.* (2003); Juliani *et al.* (2007); Singh *et al.* (2007) and Nybe *et al.* (2009).

Variation in ginger oil percentage among the genotypes grown under the same cultural and agro-climatic conditions can be attributed to the genetic factors.

5.4.4 Oleoresin percentage (%)

Data regarding oleoresin percentage was significantly influenced by different ginger genotypes. The significantly highest oleoresin percentage in ginger was recorded in genotype PTN (10.05 %) followed by genotype GNP (7.14 %) which were at par with each other. However, significantly lowest oleoresin percentage was found in genotype TKNM (4.61 %). Similar confirmatory results were obtained by Krishnamurthy *et al.* (1972); Muralidharan and Shakuntala (1974); Sreekumar *et al.* (1980); Thangaraj *et al.* (1983) and Zacharia *et al.* (1993).

Variation in oleoresin percentage among the genotypes, it is might be due to genetic factors.

The genetic character will be definitely have an impact on the oleoresin percentage which may be reason for the differential oleoresin among the genotypes under identical environmental and uniform cultural and

manurial treatments. Further, soil type, climatic conditions and cultural practices also play an important role in determining the oleoresin content in the genotype (Ravindran *et al.* 1994).

5.5 Yield parameters

Data in respect of yield contributing observations recorded and are discussed below with appropriate headings.

5.5.1 Rhizome yield kg/plot and rhizome yield q/ha

Highest rhizome yield kg/plot and q/ha were recorded in genotype PTN (3.41 kg and 210.95 q, respectively), followed by genotype GNP (3.25 kg and 200.92 q, respectively), which were at par with each other and significantly superior over rest of the genotypes. However, minimum rhizome yield kg/plot and q/ha were found in genotype TKNM (1.57 kg and 97.06 q, respectively). The probable reason for this might due to genetic make up of different genotypes and response of genotypes to the agro-climatic conditions.

These results are in conformation with the findings of Dutta *et al.* (2003); Girma and Kindie (2008); Rana and Korla (2010); Anandaraj *et al.* (2010) and Momina *et al.* (2011).

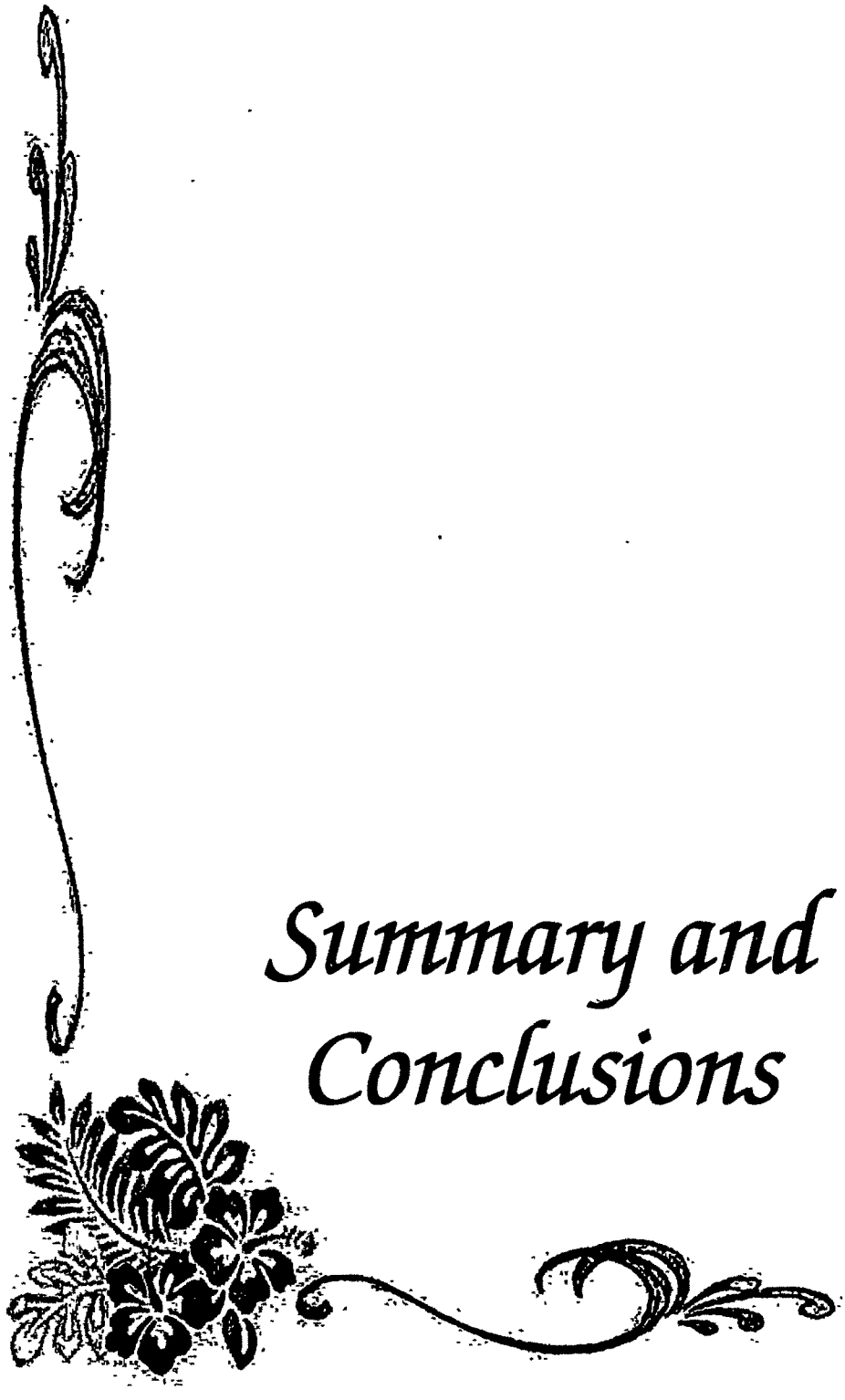
5.5.2 Crop duration (days)

Data in respect of crop duration was significantly influenced by ginger genotypes. The genotype TKNM (230 days) showed maximum crop duration followed by genotype SLGN (220 days), which were at par with each other. However, minimum crop duration was found in genotype PTN (200 days). The genotype PTN was superior over all other genotypes. Similar confirmatory results were obtained by Srinivasan *et al.* (2008).

5.5.3 Recovery percentage (%)

Data in respect of recovery percentage was significantly influenced by ginger genotypes. The genotype GNP (30.35 %) showed highest recovery percentage followed by genotype PTN (29.97 %), which were at par with each other. However, lowest recovery percentage was found in genotype TKNM (21.75 %). Similar confirmatory results were obtained by Dutta *et al.* (2003) and Srinivasan *et al.* (2008).

The variation in recovery percentage might be due to genetic characters of genotypes.



Summary and Conclusions

CHAPTER-VI

SUMMARY AND CONCLUSION

An experiment entitled ' Studies on performance of different ginger genotypes under Marathwada condition'' was conducted in *kharif* season at Department of Horticulture, VNMKV, Parbhani, during 2011-2012. The experiment was laid out in Randomized Block Design with four replications and five genotypes viz., Taklinadim, Shilegaon, Paithan, Gangapur, Kannad. Similar package of practices was followed to five genotypes in trial.

The analysis of variance revealed highly significant difference among the genotypes in all the characters. The results obtained in the present investigation in respect of growth and development, quality contributing observations and yield contributing observed in different ginger genotypes are summarized below.

6.1 Growth and Development

6.1.1 Plant height at 30 days interval (cm)

There was significant difference amongst different ginger genotypes with regard to plant height. Genotype PTN (35.00 cm) followed by genotype SLGN (34.10 cm) recorded maximum height at 150 days after planting, which were at par with each other, whereas it was minimum in the genotype KND (29.90 cm).

6.1.2 Number of leaves per clump

There was significant difference amongst different ginger genotypes with regard to number of leaves per clump. Genotype PTN (14.85) followed by genotype GNP (13.75) recorded maximum number of

leaves per clump at 150 days after planting, which were at par with each other, whereas it was minimum in the genotype TKNM (12.75).

6.1.3 Leaf area per plant (cm^2)

There was significant difference amongst different ginger genotypes in respects to leaf area per plant. Genotype PTN(18.93 cm^2) followed by genotype GNP (18.04 cm^2) recorded maximum leaf area per plant at 150 days after planting, which were at par with each other, whereas it was minimum in the genotype TKNM(16.89 cm^2).

6.1.4 Days required for sprouting

Data in respect of days required for sprouting showed significant difference among the genotypes. However, genotype TKNM (32.25) followed by genotype KND (32.00) recorded maximum days required for sprouting, which were at par with each other and genotype PTN (26.75) recorded minimum days required for sprouting. The genotype PTN was superior over all other genotypes.

6.1.5 Sprouting percentage (%)

Data in respect of sprouting percentage showed significant difference among the genotypes. However, genotype GNP (86.05 %) followed by genotype PTN (81.90 %) recorded maximum sprouting percentage, which were at par with each other and genotype TKNM (65.92%) recorded minimum sprouting percentage.

6.1.6 Number of sprouts per plant

There was significant difference amongst different ginger genotypes with regard to number of sprouts per plant. The maximum number of sprouts per plant was found in genotype PTN (4.25) followed by genotype

GNP (3.25) which were at par with each other. However, minimum number of sprouts per plant was found in genotype TKNM (2.20).

6.1.7 Number of rhizomes per plant

There was significant difference amongst different ginger genotypes with regard to number of rhizomes per plant. Maximum number of rhizomes per plant was found in genotype PTN (2.25) followed by genotype GNP (2.20) which were at par with each other. However, minimum number of rhizomes per plant was found in genotype TKNM (1.45).

6.1.8 Length of rhizome (cm)

There was significant difference amongst different ginger genotypes with regard to length of rhizome. Maximum length of rhizome was found in genotype PTN (12.65 cm) followed by genotype GNP (12.35 cm) which were at par with each other. However, minimum length of rhizome was found in genotype TKNM (10.35 cm).

6.1.9 Width of rhizome (cm)

There was significant difference amongst different ginger genotypes with regard to width of rhizome. Maximum width of rhizome was found in genotype PTN (6.50 cm) followed by genotype SLGN (6.40 cm). Which were at par with each other, whereas minimum width of rhizome was found in genotype TKNM (5.30 cm).

6.1.10 Weight of rhizome (g)

There was significant difference amongst different ginger genotypes with regard to weight of rhizome. Maximum weight of rhizome was found in genotype GNP (141.11 g) followed by genotype PTN (111.05

g). Which were at par with each other, whereas minimum weight of rhizome was found in genotype TKNM (70.79 g).

6.2 Quality parameters

6.2.1 Chlorophyll 'a' and chlorophyll ' b' content (mg/100 g)

Data in respect of chlorophyll 'a' content was influenced by different genotypes, highest chlorophyll 'a' content in ginger was recorded in genotype GNP (1.059 mg/100g) followed by genotype PTN (0.628 mg/100g) which were at par with each other, whereas lowest chlorophyll 'a' content was found in genotype TKNM (0.199 mg/100g).

Data in respect of chlorophyll 'b' content was influenced by different genotypes, highest chlorophyll 'b' content in ginger was recorded in genotype GNP (1.613 mg/100g) followed by genotype PTN (1.548 mg/100g) which were at par with each other, whereas lowest chlorophyll 'b' content was found in genotype TKNM (0.577 mg/100g).

6.2.2 Moisture percentage (%)

Observation recorded in respect of moisture percentage revealed that maximum moisture percentage was found in genotype TKNM (77.40 %) followed by genotype SLGN (75.95 %) which were at par with each other, while minimum moisture percentage was found in genotype PTN (69.00 %).

6.2.3 Ginger oil percentage (%)

Observation recorded in respect of ginger oil percentage revealed that maximum ginger oil percentage was found in genotype PTN (2.47 %) followed by genotype GNP (1.89 %) which were at par with each

other, while minimum ginger oil percentage was found in genotype TKNM (1.47 %).

6.2.4 Oleoresin percentage (%)

Data in respect of oleoresin percentage was influenced by different genotypes, highest oleoresin percentage in ginger was recorded in genotype PTN (10.05 %) followed by genotype GNP (7.14 %) which were at par with each other, whereas lowest oleoresin percentage was found in genotype TKNM (4.61 %).

6.3 Yield parameters

6.3.1 Rhizome yield per plot (kg)

Data recorded in respect of rhizome yield per plot showed significantly highest rhizome yield in genotype PTN (3.41 kg) followed by genotype GNP (3.25 kg) which were at par with each other, while minimum was found in genotype TKNM (1.57 kg).

6.3.2 Rhizome yield per hectare (q)

Data recorded in respect of rhizome yield per hectare showed significantly highest rhizome yield in genotype PTN (210.95 q) followed by genotype GNP (200.92 q) which were at par with each other, while minimum was found in genotype TKNM (97.06 q).

6.3.3 Crop duration (days)

Data recorded in respect of crop duration showed significantly maximum crop duration in genotype TKNM (230 days) followed by genotype SLGN (220 days) which were at par with each other, while

minimum was found in variety genotype PTN (200 days).The genotype PTN was superior over all other genotypes.

6.3.4 Recovery percentage (%)

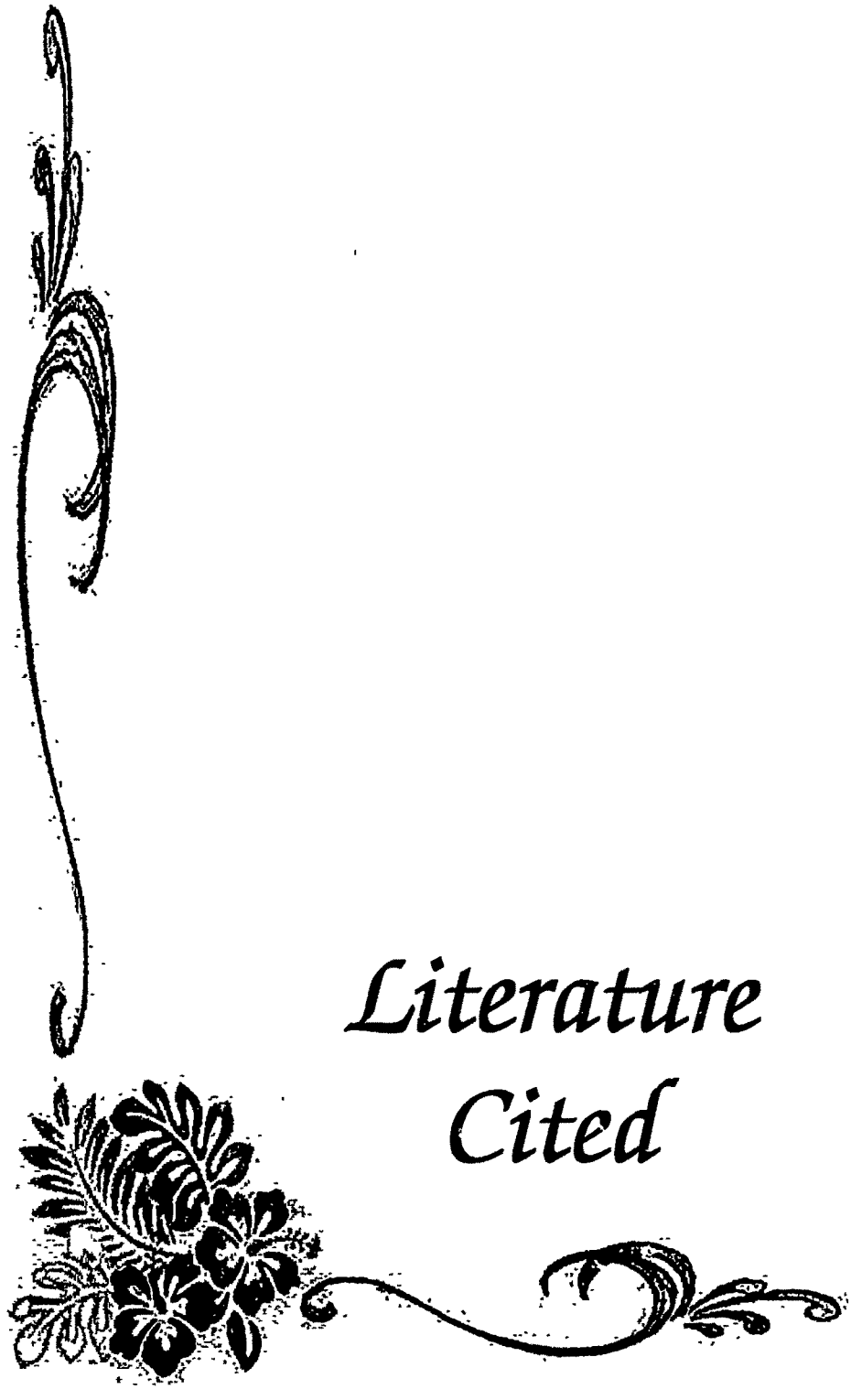
Data recorded in respect of recovery percentage showed significantly highest recovery percentage in genotype GNP (30.35 %) followed by genotype PTN (29.97 %) which were at par with each other, while minimum was found in genotype TKNM (21.75 %).

CONCLUSIONS

Based on the present investigation, it is concluded that:

1. In respect of vegetative growth genotype PTN recorded maximum plant height (35.00 cm), number of leaves per clump (14.85), leaf area per plant (18.93 cm^2), number of sprouts per plant (4.25), number of rhizomes per plant (2.25), length of rhizome (12.65 cm), width of rhizome (6.50 cm), while for all this characters GNP also showed at par result with PTN. In respect of sprouting percentage and weight of rhizome genotype GNP showed significantly highest sprouting percentage (86.05 %) and weight of rhizome (1-1.11 g) over all other genotypes.
2. Observation recorded in respect of quality parameters genotype GNP recorded maximum chlorophyll 'a' and chlorophyll' b' content (1.059 mg/100g and 1.613 mg/100g, respectively). While in respect of moisture percentage genotype TKNM showed maximum moisture percentage (77.40%). In respect of ginger oil percentage and oleoresin percentage genotype PTN showed higher ginger oil percentage (2.47 %) and oleoresin percentage (10.05%) over all other genotypes.
3. In respect of yield contributing characters highest rhizome yield kg/plot and q/ha were maximum in genotype PTN (3.41 kg/plot and 210.95 q/ha, respectively), followed by genotype GNP (3.25 kg/plot and 200.95 q/ha, respectively). Crop duration was minimum in genotype PTN (200 days). In respect of recovery percentage genotype GNP showed significantly highest recovery percentage (30.35 %) over all other genotypes.

Among the five genotypes studied the PTN (3.41 kg/plot and 210.95 q/ha, respectively), and GNP (3.25 kg/plot and 200.92 q/ha respectively), showed highest yield, which were at par with each other. Hence, on the basis of present investigation genotype PTN and GNP are most suitable for cultivation under Marathwada region. The findings obtained in the present investigation need further confirmation for final recommendation.



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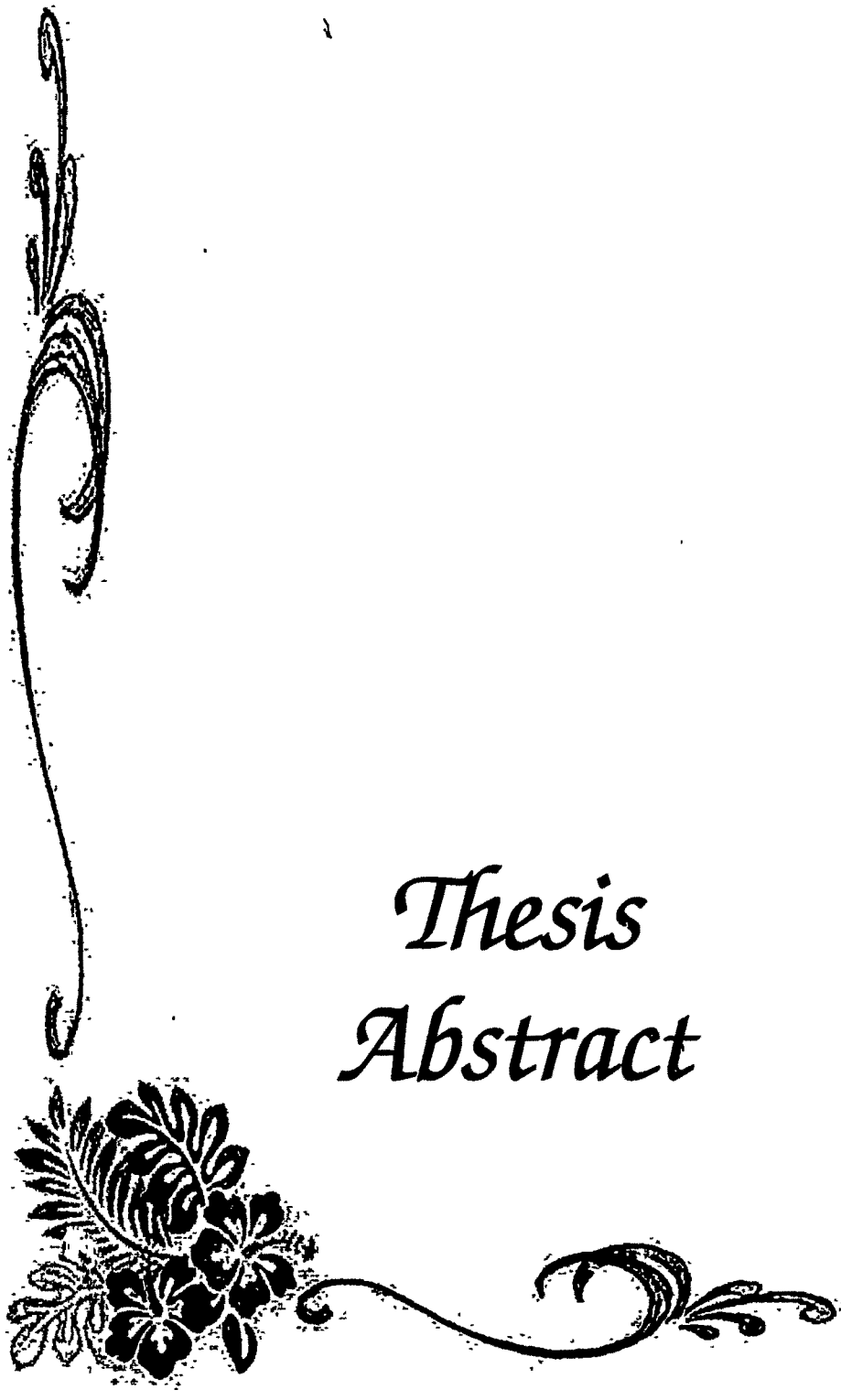


Thesis Abstract

THESIS ABSTRACT

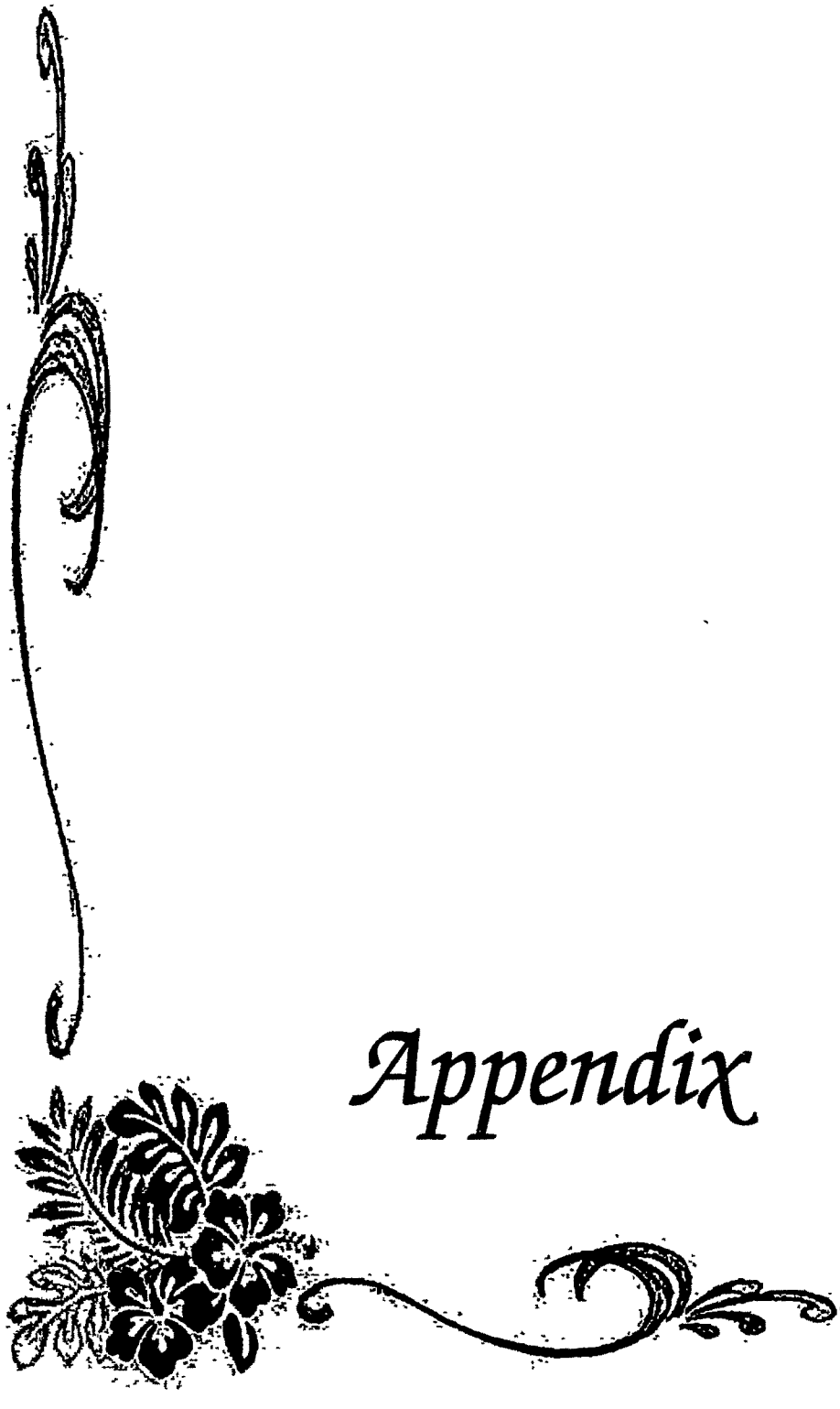
"STUDIES ON PERFORMANCE OF DIFFERENT GINGER (*Zingiber officinale* Rosc.) GENOTYPES UNDER MARATHWADA CONDITION"

Name of Student	**: Miss. R. Shanthipriya**
Reg. No.	**: 18M/2011HT**
Research Guide	**: Prof. B.G. Hiwale** **Associate Professor,** **Department of Horticulture** **MKV, Parbhani**

An experiment entitled "Studies on performance of different ginger genotypes under Marathwada condition" was conducted in *kharif* season at Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, during 2011-2012. The experiment was laid out in Randomized Block Design with four replications and five genotypes viz., Taklinadim, Shilegaon, Paithan, Gangapur, Kannad. Similar package of practices was followed to five genotypes in trial.

The Analysis of Varience revealed significant differences among genotypes in all characters. In respect of vegetative growth genotype PTN recorded maximum plant height (35.00 cm), number of leaves per clump (14.85), leaf area per plant (18.93 cm^2), number of sprouts per plant (4.25), number of rhizomes per plant (2.25), length of rhizome (12.65 cm), width of rhizome (6.50 cm), while for all this characters GNP also showed at par result with PTN. In respect of sprouting percentage and weight of rhizome genotype GNP showed significantly highest sprouting percentage (86.05 %) and weight of rhizome (141.11 g) over all other genotypes. Observation recorded in respect of quality parameters genotype GNP recorded maximum chlorophyll 'a' and chlorophyll' b' content (1.059 mg/100g and 1.613 mg/100g, respectively). While in respect of moisture percentage genotype TKNM showed maximum moisture percentage (77.40%). In respect of ginger oil percentage and oleoresin percentage genotype PTN showed higher ginger oil percentage (2.47 %) and oleoresin percentage (10.05%) over all other genotypes. In respect of yield contributing characters highest rhizome yield kg/plot and q/ha were maximum in genotype PTN (3.41 kg/plot and 210.95 q/ha, respectively), followed by genotype GNP (3.25 kg/plot and 200.95 q/ha, respectively). Crop duration was minimum in genotype PTN (200 days). In respect of recovery percentage genotype GNP showed significantly highest recovery percentage (30.35 %) over all other genotypes.

Among the five genotypes studied the PTN (3.41 kg/plot and 210.95 q/ha, respectively), and GNP (3.25 kg/plot and 200.92 q/ha respectively), showed highest yield, which were at par with each other. Hence, on the basis of present investigation genotype PTN and GNP are most suitable for cultivation under Marathwada region. The findings obtained in the present investigation need further confirmation for final recommendation.



Appendix

Appendix- I

Weekly weather data 2012

WK	Period	Rainfall (mm)	R.D.	Temperature °C		Humidity (%)		EVP	BSS (Hrs.)	W. V. (Kmph)
				Max.	Min.	AM	PM			
23	04-10 June	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
24	11-17 June	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
25	18-24 June	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
26	25-01 July	0.0	0.0	0.0	0.0	0	0	0.0	0.0	6.6
27	02-08 July	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
28	09-15 July	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
29	16-22 July	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
30	23-29 July	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
31	30-05 Aug	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
32	06-12 Aug	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
33	13-19 Aug	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
34	20-26 Aug	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
35	27-02 Sept	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
36	03-09 Sep	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
37	10-16 Sep	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
38	17-23 Sep	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
39	24-30 Sep	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
40	01-07 Oct.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
41	08-14 Oct.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
42	15-21 Oct.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
43	22-28 Oct.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
44	29-04 Nov.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
45	05-11 Nov.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
46	12-18 Nov.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
47	19-25 Nov.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
48	26-02 Dec.	0.0	0.0	0.0	0.0	0	0	0.0	7.6	0.0
49	03-09 Dec.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
50	10-16 Dec.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
51	17-23 Dec.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
52	24-31 Dec.	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0

Weekly weather data 2013

WK	Period	Rainfall (mm)	R.D.	Temperature °C		Humidity (%)		EVP	BSS (Hrs.)	W. V. (Kmph)
				Max.	Min.	AM	PM			
1	01-07 Jan.	1.0	0.0	31.7	14.9	73	36	5.0	8.4	2.7
2	08-14 Jan.	0.0	0.0	29.5	10.3	76	27	4.7	9.1	2.8
3	15-21 Jan	0.0	0.0	31.8	12.7	67	29	5.3	9.5	2.6
4	22-28 Jan	0.0	0.0	30.5	16.0	73	35	5.2	7.6	5.5
5	29-04 Feb.	0.0	0.0	31.2	#REF!	78	31	5.6	6.7	5.1
6	05-11 Feb	0.0	0.0	32.6	17.0	74	35	6.4	8.0	4.5
7	12-18 Feb.	18.5	1.0	32.1	16.2	79	36	6.0	8.6	3.4
8	19-25 Feb.	4.2	1.0	33.7	14.1	73	29	6.2	9.7	3.6