PERFORMANCE OF TURMERIC VARIETIES UNDER NAGPUR CONDITIONS

THESIS

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DECLARATION OF STUDENT

I hereby declare that, the experimental work and its interpretation of the thesis entitled, ***"PERFORMANCE OF TURMERIC VARIETIES UNDER NAGPUR CONDITIONS",*** *part thereof has not been submitted to any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or Scientific Organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.*

Place : Nagpur

Date : 29.06.02

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Certificate

This is to certify that the thesis entitled, ***"PERFORMANCE OF TURMERIC VARIETIES UNDER NAGPUR CONDITIONS",*** *submitted in partial fulfil ment of the requirements for the degree of* ***Master of Science in Agriculture (Horticulture)*** *of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by* ***Mr. Shekhar Urkuda Meshram*** *under my guidance and supervision. The subject of thesis has been approved by the student advisory committee.*

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- **Shekhar Urkuda Meshram**

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LIST OF SYMBOLS AND ABBREVIATIONS

@	-	at the rate of
ccm	-	cubic centimeter
cm	-	centimeter
conc	-	concentration
°C	-	degree celcius
et al	-	et alia (and associates)
fig.	-	figure
g	-	gram
ha^{-1}	-	per hectare
i.e.	-	that is
kg	-	kilogram
m	-	meter
mg	-	milligram
µg	-	micro gram
ml	-	milliliter
m^2	-	square meter
cm^2	-	square centimeter
/	-	per
%	-	per cent
t	-	tonne
q	-	quintals
E.C.	-	Electrical conductivity
Viz.	-	namely
Var.	-	variety
Cv.	-	cultivar
K	-	Potassium
M.T.	-	Metric tonnes
N.S.	-	Non significant
P	-	Phosphorus
N	-	Nitrogen
R	-	Layout
sq.cm.	-	square centimeter
S.E. (m)±	-	Standard error of means
C.D.	-	Critical difference
Sig	-	Significant
Temp.	-	temperature
Tr.	-	Treatment
N – S	-	North South direction

CHAPTER - I

INTRODUCTION

Spices constitute an important group of horticultural crops. India is known as the home of spices, producing a wide variety of spices like black pepper, cardamom, ginger, garlic, turmeric, chilli and a variety of free and seed species. More than 90 % of the spices produced in the country are used for domestic consumption and the rest exported as raw as well as value added products. The per caput consumption of spices in India has been estimated at 2.639 kg. During 1999-2000 compared to per caput consumption of 1.448 kg in U.S.A. (Chadha, 2001)

Turmeric (*Curcuma longa* L.) is one of the commercial spice crops which has a good demand in India and other oriental countries. India is the leading producer and exporter of the turmeric. During 1998-99, the area covered under turmeric in the country is estimated to be 1.56 thousand hectare,with an annual production of 5.98 thousand tonnes (Chadha, 2001)

In India turmeric is grown mainly in Andhra Pradesh, Tamil Nadu, Kerala, Bihar, Orissa and Maharashtra. However, Andhra Pradesh and Tamil Nadu contribute nearly 50% of the production.

Turmeric (*Curcuma longa* L.) is rhizomiferous seasonal crop belongs to family Zingeberaceae which comprises of 40 genera and 40 tropical species. It is a herbaceous perennial plant and possesses an under ground stem or rhizome which is thick and rounded, with short blunt fingers. The plant is about a meter height with a short stem and long leaves. The leaves are borne in a tuft, and are about 60 cm tall. They are thin, rather flaccid, light green in colour, lanceolate, acuminate, with a long leaf stalk. Flower is dense spike ending with couloured bracts. Calyx is short cylindrical toothed tube and corolla comprises of broad segments (Rao and Rao. 1994). Rhizomes are rich in curcumin but moderate in volatile oil.

The major quantity of turmeric produced in India is utilized as a condiments and only a small quantity is used in medicines and cosmetics. Turmeric is utilized in most of the Asiatic countries as a adjunct in many vegetables, meat and fish preparations. It is used to flavor and colour butter, cheese, pickles, margarine, fruit drinks, cakes, table jellies and other food stuffs. A pinch of turmeric powder is often added to most of our savouries to impart simultaneously an agreeable flavour and colour and to improve the keeping quality. Turmeric oil and oleoresin is also used to impart the flavor in food and perfume industries.

A medicinal value of turmeric has been recognized since time immemorial in the Indian system of Medicine, essential oil of turmeric has antimicrobial properties against a set of representative aeprophytic, plant and human pathogenic bacteria and fungi (Menon, 1975; Banergee and Nigam 1978). Turmeric and its preparations are traditional beauty aids for Indian women. Smearing turmeric paste on the face and limbs during a bath is found to clear the skin and beautif y the face specially during marriage ceremony.

The production of turmeric was 3,31,000 metric tonnes with an area of 12,300 ha during the year 1998-1999 of the total production 80 to 90% turmeric production is exported and the country gets about 10 to 12 crores of foreign exchange every year. It amounts to about 13 per cent of the spices exported from India and 10 per cent of the export earnings are from spice only (Anon, 2000)

In Maharashtra turmeric is grown under 6,191 ha having production 38,202 tonnes during 1999-2000. Vidarbha contributed 1,454 hectares of land having production 11,147 metric tonnes. In Maharashtra turmeric is mainly grown in Satara, Sangli, Kolhapur, Pune, Parbhani, Nanded, Wardha, Chandrapur, Nagpur, Yawatmal and Akola district. (Anonymous 2001).

In Nagpur district, turmeric is grown on 168 hectares of land and production ranges to 1986.30 tonnes fresh rhizomes. Bhivapur Tehasil alone occupied 140 hectares of land producing 1680 tonnes of turmeric during 1999-2000. In Nagpur region it is grown on 1.60 hectares of land producing 35.20 tonnes of fresh rhizomes. In Nagpur region it is taken as miner crop. (Anonymous 2001)

In order to fulfil the increasing demand of the people for the turmeric and improved quality, it is essential to increase the production of turmeric considerably. This object can be achieved by bringing more area under turmeric cultivation, and increasing its productivity per unit area. Lack of suitable cultivars for the particular agroclimatic condition is one of the constraints for low productivity. However, major factors contributing to low yield in turmeric are lack of sustainable high yielding variety, nutrition and layouts. Planting materials, spacing and time of planting are also the other factors which influences the productivity. (Ashokan and Radhakrishanan, 1979; Patil and Borse 1980; Ramchandran and Muthuswamy, 1984)

Though, wide genetic variability exists in this crop with regard to the growth yield and quality not much work seems to have been done on crop improvement through the selection of superior types with high yield and better quality. Systematic efforts on introduction and evaluation of improved varieties of turmeric were not undertaken in Nagpur district of Maharashtra where inferior local clones are under cultivation resulting in low productivity and less remunerative.

The scientific information of package of practices, and improved production technology of turmeric under this region is meagre. Therefore, keeping in view the inadequate information available in literature regarding various genotypes of turmeric, the present investigation in respect of "Performance of turmeric varieties under Nagpur conditions" have been planned to explore the possibilities under Nagpur conditions with the following objectives.

1. To popularize the crop in this region.
2. To evaluate the varieties of turmeric for their growth, yield and quality of rhizome.
3. To identify the variety for more yield and better quality of turmeric.

CHAPTER – II

REVIEW OF LITERATURE

Turmeric (*Curcuma longa* L) is one of the important spices grown in India, which play an important role in the national economy. In order to fulfill the increasing demand of the people for the turmeric and improved quality, it is essential to increase the production of turmeric considerably. Lack of suitable cultivars for the particular agro-climatic conditions is one of the constraints for low productivity.

Wide genetic variability exists in this crop with regard to the growth, yield and quality. Number of physiologist and horticulturist studied the performance of different varieties of turmeric (*Curcuma longa* L.) in different agro-climatic conditions. Although the scientific information of package of practices and improved production technology of turmeric under Nagpur condition is meager. Researchers indicated that there is significant variation among the different varieties of turmeric in respect of growth attributes such as plant height, leaf characters, girth of pseudostem and yield characteristics such as number of finger per clump, length, breadth of fingers, number of secondary fingers and curcumin percentage as a quality component. Therefore an attempt has been made to bring together available literature on this aspects under following titles and sub titles.

1. Effect of soil on growth and yield.
2. Effect of climate on growth and yield
   2.1 Effect of climate on growth.
   2.2 Effect of climate on yield.
3. Effect of layout on growth and yield.
4. Planting material.
5. Season / time of planting.
6. Growth parameters.

6.1 Height of plant.

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6.3 Leaf length and breadth.

6.4 Leaf area.

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7.1 Maturity / Duration of crop

7.2 Harvesting of crop

7.3 Yield of mother rhizomes and fingers

7.4 Yield of green turmeric

7.5 Yield of cured turmeric and curing percentage.

7.6 Curcumin percentage

1. Effect of soil on growth and yield :

Turmeric can be grown on soils ranging from light loam to heavy loam. A well drained, friable, sandy loam soil, rich in organic matter, is however, preferred. Light red, brown or ashy coloured sandy loam is suitable for turmeric. Alkaline soils are not suitable for its cultivation. Thankamani, *et al.* (1998) evaluated four turmeric cultivars in lateritic soil under rainfed condition at Kerala and revealed that the variation in yield and growth attributes among turmeric varieties grown under same agro-ecological conditions can be attributed to the genetic factors and reported that Suguna and Sudarshana were suited for lateritic soil of Kerala.

2. Effect of climate on growth and yield :

The vital process of plant life like manufacture of carbohydrates or protoplasm is the physiological basis for transpiration, respiration, nutrient absorption and translocation. They are affected by certain conditions owing to the climatic factors such as temperature, light, humidity etc. Some plants require a relatively high temperature for setting in motion the process known as growth, others will carry on similar process at lower point like wise light and humidity required for proper growth. Hence, there is an importance of planting date as the plants growth will be least affected by various factors during the period.

2.1 Effect of climate on growth :

Krishnamurthy, *et al.*(1975) screened 22 cvs. of turmeric and reported that the values of curcumin varied from 1.2% to 4.97% according to locality, season and cultivar. Mukhopadhyay, *et al.*(1986) during field trial analyzed the data on growth parameters from 25 germplasm types (from Southern and Eastern India) grown in west Bengal revealed significant variation for shoot / clump, leaves / shoot, plant height. Heritability estimate were moderate, being 58.7% (the highest value) for shoot / clump.

Indiresh *et al.*(1992) evaluated a total of 15 cvs. of turmeric (*Curcuma longa*) at Brahamvar for 6 morphological characters and 15 rhizome traits in order to identify a suitable type for Coastal Karnataka region. Highly significant variation were observed between the cultivars for many growth parameters. Hegde, *et al.* (1997) studied different cultivars of turmeric grown in the southern dry region of Karnataka and revealed that considering the growth traits Baglore Local, Sangli and PCT-8 can be identified as suitable cultivars for growing in open conditions of Southern Dry Region of Karnataka.

Sheshagiri and Uthaiah (1994) conducted a field experiment at Mudigere to assess the yield performance of six elite varieties under rain fed conditions and reported that BSR-1 was superior in growth attributes.

Patil, *et al.* (1995) evaluated eight turmeric varieties under rainfed conditions for two crop season at lower pulney hills, Tamil Nadu and found that Suvarna (PCT-8) had greatest number of tillers per plant but it was inferior to other varieties for other growth trials. Radhakrishnan *et al.* (1995) studied different varieties of turmeric under rain fed conditions in the high ranges of Idukki district of Kerala and revealed that growth characters such as plant height, number of tillers / plant and leaf characters varied significantly. BSR-1 was found to be tallest (48.25 cm) where as local variety showed the highest number of tillers per plant. Chandra, *et al.* (1997) evaluated 25 genotypes of turmeric from different parts of India under high humid sub-tropical condition at mid altitude (1000 MSL) in NE India and identified Sonajuli Local genotypes 1 and 2 as important genotypes for NE region of Kerala.

2.2 Effect of climate on yield :

Patil, *et al.* (1995) evaluated 8 turmeric varieties under rainfed condition for two crop seasons at lower pulney hills, Tamil Nadu and found that cultivars BSR-1 had the greatest yield (20.88 t / ha) fresh rhizomes followed by Suvarna (19.32t/ha) and Suroma (19.04t /ha). They added that BSR-1, Suvarna and Suroma were suitable for lower pulney hills of Tamil Nadu

Philip and Nair (1983) studied 19 *Curuma longa* cultivars in the plains of Kerala and revaled that ' Mannuthy Local'; ' Chayapasupa'; 'Kuchupudi' and 'Kodur' types are suitable for large scale cultivation in the plains of Kerala due to their higher yield potential. Radhakrishnan, *et al.* (1995) concluded that the variation in yield and growth attributes among turmeric

varieties grown under same agro-ecological conditions can be attributed to the genetic factors. Also added that CO – 1 is suited to the high ranges of Idukki district of Kerala State.

Pushkaran. *et al.*(1985) stated that 14 turmeric (*Curcuma longa*) cvs. grown in west coast tall coconut plantation, with the palms and found that the cv. Amruthapani Kothapetta (A) 72 gave the highest total yield of 17.36 t/ha and is recommended for intercropping. Chandra *et al.* (1999) Studied performance of 25 genotypes at Barapani, reported that PCT – 13, PCT –11, 6 L puram and PCT – 15 had higher yields indicating their suitability for cultivation under mid hill conditions of Meghalaya where as Lakadong had poor yields. Shafi., *et al.*(1994) collected fourty genotypes of turmeric from different parts of India and grown at 3 locations in North Eastern Uttar Pradesh and identified the high yielding genotypes, CLL 326 with wide adaptability and stability. Significant differences were observed due to genotypes and genotype X environment interactions.

Satyanarayana and Reddy (1986) studied 16 cultivars of *Curcuma longa* and found that the cultivar Ca 66 J was recommended for rainfed cultivation because of its lower rhizome storage losses (32.73%), compared with 52.9 % and 53.67% in CLS . 9 A and CLS – 2A respectively. Sheshagiri and Uthaiah (1994) conducted a field experiment at Mudigere to assess the yield performance of six elite varieties under rainfed conditions and found that the greatest fresh turmeric yield was produced by BSR – 1(16.57 t/ha) followed by Waigaon (15.45 t/ ha)

Indiresh, *et al.* (1992) screened total of 15 cvs. of turmeric at Brahmavar for 15 rhizome traits in order to identify a suitable type for coastal Karnataka region. Highest green rhizome yield was recorded for PCTB followed by Waigaon (32.3 and 31.6 t/ha resp.) PCTB, Waigaon and Kasturi gave the highest cured turmeric yields (6.48, 6.21 and 4.81 t/ha resp.) Hegde *et al.*(1997) revealed that considering the yield and quality traits

Banglore Local, Sangli and PCT 8 van be identified as suitable cultivars of turmeric for growing in open conditions of southern dry region of Karnataka.

3. Effect of layouts on growth and yields :-

Turmeric crop is either planted on raised beds of 1 m width and convenient length with 15 cm height or on ridges and furrows or on flat system. The growth and yield of crop affects by the type of layout in the field.

Anjaneyulu and Krishnamurthy (1979) observed significantly more plant height in ridge (30x15 Cm) and indicating thereby more favourable opportunities for plant, growth in turmeric. However, Ramchandran and Muthuswami (1984) reported number significant influences on plant hight by planting methods. The total no. of leaves per plant tiller production and yield was not affected significantly by different methods in turmeric crop.

4. Planting material: -

Turmeric (*cureuma longa* L.) is mainly propagated vegetatively using both finger and mother rhizomes. The type of planting materials used has a direct bearing on yield of the crop. The mother rhizome recorded higher green yield than that of the finger rhizomes. However Philip. (1983) reported that mother rhizomes (whole mother rhizome and halves of large and medium sized mother rhizomes) recorded significantly higher green yield than that of the finger rhizomes.

Yothasiri. *et al.* (1997) produced highest yield (3540 kg / ha) per unit area from whole mother rhizomes followed by primary rhizomes (2841 kg /ha) and the half cut mother rhizomes (2840 kg/ha). Whole mother rhizomes produced the most rapid growth and developments of plants. Maia *et al.* (1995) during the investigation reported that turmeric plants originating from primary rhizomes had a greater leaf area, total plant dry weight and a higher yield of new rhizomes than plants

originating from secondary rhizomes. The size of propagating material had no effect on the curcumin content of the rhizomes.

Humin Fu, *et al.*(1996) planted *curcuma aromatica* rhizomes at densities (40,000, 53000 and 83000 plants / ha) and reported that rhizome dry weight per plant was higher for the less dense plantings.

Rashid, *et al.*(1996) planted turmeric cultivars Sinduri and Dimla from corms or primary or secondary cormels and obtained the fresh yields were highest from corms (28.67 t/ha) and lowest from secondary cormels (19.43 t/ha). Yields were highest from Dimla than Sinduri.

5. Season / time of planting: -

Turmeric prefers a warm and humid climate. It needs a well-distributed annual rainfall of 2500 – 4000 mm for successful production as a rainfed crop. It can also be grown in area where the rainfall ranges from 120 to 150 cm during the period. However, some irrigation is required during later part of the growing period. Turmeric crop is planted within the 15 th May to second week of June.

Randhawa, *et al.*(1974) obtained the best growth and yields in rhizomes set early upto 10 May. Krishnamurthy *et al.*(1975) screened 22 cultivars of turmeric and reported that the values of curcumin varied according to locality, season and cultivar. Hoque (1995) compared Dimla and Sinduri with Local cultivar in the Kharif (Monsoon) season and reported the performance of both of the cultivars better than the local cultivar.

Barholia, *et al.*(1992) planted turmeric rhizomes on 16 Apr; 16 May or 16 June 1983 and reported the highest fresh yield of rhizomes planted on 16 May. But Hu-min Fu, *et al.*(1996) stated that all growth characters (plant height, leaf length and breath leaf number, total number of fingers, rhizome dry weight and curcumin content) were best found in planting dates from 15 March to 16 May, compared with planting on 15 June. Mishra *et al.*(1997) planted 8 turmeric cultivars during the 3rd

week of may or 1st or 3rd week of June and stated that delaying planting decreased rhizome yield.

6. Growth parameters :-

There is high variation among the different varieties of turmeric in respect of growth parameters such as plant height, number of tillers per plant, length / breath and area of leaf, girth of pseudostem. There is positively or negatively correlation of growth attributes with yield of rhizomes of turmeric.

6.1 Height of plant : -

Plant height of turmeric had positive or negative correlation with yield of rhizomes. Height of plant differ from cultivar to cultivar and it attained maximum height about 1 to 1.5 m from base to tip of leaf.

Philip and Nair (1983) studied 19 types of *Curcuma longa* and concluded that thyapasupat had maximum plant height (41.1cm) closely followed by Nandya (40.2 cm) Kuchipudi (39.8 cm) and Armoor (39.7 cm) where as lower height was recorded in aromatica type Dingrigam ca – 69 (22.1 cm) and Amalapuram (23.5 cm). Pathania, *et al* (1988); Chandra. *et al*. (1997) and Shashidhar, *et al*. (1997) showed positive and significant correlation of plant height with rhizome yield.

Radhakrishnan. *et al*.(1995) compared 6 turmeric cvs. and concluded that BSR – 1 had the tallest (48.25 cm) while Sudarshan recorded the lowest height (24.82 cm) Hegde *et al*.(1997) suggest that Banglore Local grew the tallest (45 cm) in the southern dry region of Karnataka. Thankamani *et al*. (1998) evaluated four turmeric cvs. Under rainfed conditions at Kerala and concluded that plant height increased in all cultivars up to 180 days after planting. Alleppey produced the tallest plants followed by Suvarna, Suguna and Sudarshan. Hegde *et al*.(1998) suggested that Cuddapah produced the tallest plants (57.27 cm) in 20 year old coconut plantation.

6.2 Number of leaves : -

Leaves play an important role of photosynthesis and take part in the growth of plant. The leav are vary from cultivar to cultivar.

Mohanty (1979) and Shashidhar, *et al.(1*997) concluded that rhizome yield was positively and significantly associated with number of leaves.Philip (1983) assessed 32 types of *curcma longa* and revealed that 'NBPGR / T 6' recorded the maximum number of leaves per plant (21.0) and Dingrigam had minimum number of leaves (13.4)Philip and Nair, (1983) reported that Mannuty Local had maximum number of leaves (20.6) whereas 'Aromatica' type recorded less number of leaves per plant.

The initiation of the primary finger set started at the 2 leaf stage and the order of the set increased with each new expanded leaf. Chiu *et al* (1993)Ramakrishnan. *et al.*(1995) reported that there was significant variation among the cultivars for number of leaves per plant and PCT had more leaves (10.33). Hegde, *et al.*(1997) reaveled that Banglore Local had maximum number of leaves (28.33) grown under southern dry region of Karnataka.Hazra, *et al.*(2000) found only the leaves/ clump at 180 days after planting emerged as an important rhizome yield component of turmeric.

6.3 Leaf length and Breadth: -

In turmeric the leaves are long, borne in a tuft and are about 60 cm long. They are thin, rather flaccid and light green in colour, lanceolate, acuminate, with a long leaf stalk. The length and breath of leaf varies with the cultivars.

Mohanty (1979) suggested that the genotypic and phynotypic correlation coefficients between breadth of fully opened leaf with plant shoot were significant and positive and concluded that tall plants with broader leaves are likely to produce high yielding turmeric types. But Pathania *et al.* (1981) stated that rhizome yield was positively correlated with leaf size.

Chandra. *et al.*(1999) studied 25 genotypes of *Curcuma longa* and concluded that, length, breadth of leaf were significantly and positively associated with fresh rhizome yield per clump.

Philip (1983) during an experiment reported that Amruthapani Kothapeta produced the largest leaves with maximum breadth at center (15.7 cm) where as maximum leaf length was recorded in cv. Chayapasupa. (61-90 cm) 'NBPAR / 17' recorded smallest leaves with minimum length (42.6 cm) and breadth (12.85 cm). Radhakrishnan, *et al.* (1995) showed that cultivar BSR – 1 had significantly superior with length and breadth of leaf.

6.4 Leaf Area :-

Mohanty (1979) observed that rhizome yield was positively and significantly associated with leaf area. Pathania. *et al.*(1981) that rhizome yield was positively correlated with leaf area. Shashidhar, *et al.* (1997) observed that rhizome yield was significantly and positively correlated with leaf area.

Philip. (1983) obtained the largest leaves with maximum leaf area (973.4 cm^2) in Amruthapani Kothapeta where as 'NBPGR /T 17' produced the smallest leaves with leaf area (547.9 cm^2). Hegde, *et al.* (1997) stated that Banglore Local showed the highest leaf area Index (LAI) (6.91) while PCT – 14 lowest less leaf area Index (0.75). Thankamani, *et al.*(1998) found leaf area highest in Suvarna followed by Alleppey and lowest in Sudarshan and concluded that leaf area index (LAI) increased until 5 months after planting and decreased thereafter.

6.5 Number of tillers : -

The variation among the turmeric types with regard to tillers per plant and rhizome yield is positively or negatively correlated with number of tillers per plant.

Mohanty *et al.*(1979) suggested that rhizome yield of turmeric was negatively and significantly associated with number of tillers. Shashidhar, *et al* (1997) during an investigation studied the relationship between growth and yield attributing characters of turmeric and stated that rhizome yield was positively correlated with number of tillers. Pathania, (1988) observed positive correlation of number of tillers with rhizome yield. Lynrah, *et al.* (1988) found high genetic variation and high broad sense heritability in tillers / clump.

Philip and Nair (1983) in a trial with 19 turmeric cultivars concluded that number of tillers per plant varied from 3.7 in Mannuty Local to 2.0 in Dindrigam. Mukhopadhyay, *et al.* (1986) analysed the data from 25 germplasm types and concluded that cultivar GCV Gave the highest value (58.7%) for tillers per clump. Barholia *et al.*(1992) stated that daughter and mother rhizomes of local cultivar of *Curcuma longa* planted on 16 April, 16 May or June and concluded that mother rhizomes gave the greatest number of tillers (2.62 /plant). For daughter rhizomes number of tillers decreased with later planting date. Patil, *et al.* (1995 reported in Suvarna the greatest number of tillers per plant but it was inferior to other varieties for other growth traits. Where as Radhakrishnan, *et al.*(1995) compared six turmeric cultivars and stated that CO-1 and BSR–1 showed the highest number of tillers. Hegde *et al.*(1997) investigated 12 *Curcuma longa* cultivars geneo type BSR– 1 found to produce the highest number of tillers (7 / clump).

7. YIELD CHARACTERS

7.1 Maturity / Duration of crop : -

There are variations with respect to crop duration among the different cultivars. Some varieties took relatively less number of days for maturity (7months) and they are grouped as early types. The medium, duration types matured within 8 months. Whereas, cultivars require more number of days (9 months) for maturity classified as late.

Maurya (1990) compared 10 lines of turmeric with Dholi Local and reported that RH – 10 had the shortest growth period duration (288 days). Hegde, *et al.* (1997) studied different cultivars of turmeric and revealed that PCT -13, PCT - 5, PCT - 14 and PCT - 8 respectively were found to be early duration types (193 – 208 days) where as Amalapuram, BSR – 1, cuddapah and Banglore local were grouped under Medium duration types.

7.2 Harvesting of crop : -

Philip, *et al.* (1982) in an investigation found that harvesting 270 days after planting gave the maximum yield of rhizomes, oleoresin and curcumin per unit area.

7.3 Yield of mother rhizomes and fingers : -

The fingers / mother rhizome ratio showed highly variation among the turmeric types. A higher finger / mother rhizome ratio indicates a higher percentage recovery of finger rhizome which constitutes the marketable produce in turmeric.

Philip (1983) Studied 32 cvs. of turmeric and reported the maximum finger / mother rhizome ratio in cv. ST – 17 ' (4.88) and Dindrigam (3.97). Philip and Nair (1983) obtained more number of secondary fingers per plant in Mannuthy Local

(20.9) , Chayapasupa and Armoor (19.8 each) . Where as CV. Armoor CLL – 324(7.9) and G.L. Puram-1 (8.3) produced fewer number of secondary fingers per plant.

. Jalgaokar and Jamdagni (1989) assessed yield and 11 yield related characters in 10 genotypes.and opined that secondary fingers per plant was the only character which showed a significant and positive correlation with cured turmeric yield. Chiu *et al.*(1993) stated that curcumin content was highest (0.55 %) in the mother set followed by primary finger set (0.49%) then secondary finger set (0.43 %) and tertiary finger (0.31 %) and concluded that earlier formed rhizomer were superior in quality to younger ones. Shashidhar *et al.*(1997) reported the highest correlation coefficient between leaf area / plant and circumference of secondary fingers with the yield in *C. longa.*

7.4 Yield of green turmeric : -

The yield of green turmeric varies highly with cultivars. Yield variations among the cultivars could be attributed to genetic characters of the cultivars and their response to particular agro climatic conditions.

Pusshkaran *et al.*(1985) stated that 14 turmeric (*Curcuma longa*) cvs. were grown in a west coast tall coconut plantation. The cv. Amruthapani kothapetta (A) 72 gave the highest total yield of 17.36 t / ha and the cv. Ventimetta the lowest yield of 4.78 t / ha.

Pathania *et al.*(1981) showed that rhizome yield was positively correlated with growth parameter and number of secondary rhizomes. Jalgaokar. *et al.*(1990) reported that fresh yield was significantly and positively correlated with growth parameters and secondary fingers. Shashidhar. *et al.* (1997) found highest correlation coefficient between leaf area/plant and circumference of secondary fingers.

Philip (1983) in a trial on 32 promising types of turmeric found that 'Armoor' type had maximum green yield (29-34q/ha) followed by Rajpuri (281.25 q/ha). Pujari *et al*(1987) reported that Krishna gave the highest fresh rhizome yield(427.27q/ha) followed by the cv. Duggierals with 329.22 q/ha of fresh yield, where as Rajapuri gave the lowest yield of 217.08. Jalgaokar and Jamdagni (1989) found secondary fingers per plant was the only characters which showed a significant and positive correlation with cured turmeric yield. Reddy *et al.*(1989) Obtained the highest average yields of rhizomes from PCT –13 and PCT – 14 cultivars.

Indiresh, *et al.*(1990) evaluated a total of 15 cvs. of turmeric (*Curcuma longa*) to identify suitable type for coastal Karnataka region. Highest green rhizome yield was recorded for PCTB followed by Waigaon (32.3 and 31.6 f / ha resp.). Maurya (1990) during a trial with 10 lines, RH-10 was found superior with regard to fresh rhizome yield (41.98 t / ha) of turmeric. Nandi (1990) studied and 7 yield components in 14 genotypes reported that PTS – 25 gave the highest yield of fresh rhizomes (27.5 t / ha) and yield / plant (480 g) followed by CL 89 (24.6 t and 430 g) respectively. Shasi *et al.*(1994) collected fourty genotypes of turmeric from different parts of India and identified that the high – yielding genotypes was CLL – 326 with wide adaptability and stability.

Sheshagiri and Uthaiah (1994) obtained the greatest fresh turmeric yield was produced by BSR – 1 (16. 57 t / ha), followed by Waigaon (15.45 t / ha). Radhakrishnan, *et al* (1995) concluded that found in cultivar co – 1 produced the highest yield of green turmeric (16.54 t / ha), followed by BSR – 1 (14.74 t / ha).

Ramakrishna *et al.*(1995) compared eighteen turmeric (*Curcuma longa*) lines and reported that there was significant variation among fresh rhizome yield. PCT-13 had the greatest yield of 19.15 t/ha. Pati. *et al.*(1995) reported that cultivar BSR-1 had the greatest yield (20.88t/ha fresh rhizomes) followed by Suvarna (19.32 t/ha) and Suvoma (19.04 t/ha). Rashid *et al.* (1996) planted turmeric cultivars Sinduri and Demla grown from corms or primary or secondary cormels. Fresh yields

were highest from corms (28.67 t/ha) and lowest from secondary cormels (19.43 t/ha). Yields were highest from Dimla than Sinduri.

Hegde, *et al.* (1997) reported that the Banglore local had the highest fresh yield (44.88 t/ha) followed by PCT 8 (34.03 t/ha) and Bidar (32.99 t/ha) respectively. Mishra, *et al.* (1997) planted 8 turmeric (*Curcuma longa*) cultivars in Orissa and stated that were PTS-9 and PTS-28 were the highest yielding cultivars. Lynrah, *et al.* (1998) concluded that finger rhizome yield components showed high genetic variation and high broad sense heritability. PCT-13 and VK-145 were superior genotypes for yield.

Nirmal and Yamgar (1998) evaluated eighteen new genotypes of turmeric and 2 standard varieties and identified CLS-19, CLI-320 and CLI-324 as promising varieties. Thankamani (1998) screened four turmeric cultivars under rainfed condition at Calicut and stated that yield was highest in Saguna and Sudarshan. Yield of Alleppey was low due to poor dry matter efficiency. Hazra, *et al.* (2000) concluded that leaves/clump at 180 DAP emerged as an important rhizomes yield component of turmeric.

7.5 Yield of cured turmeric and curing percentage :

Recovery percentage (driage) is an important factor as the fresh rhizomes are to be cured to obtain marketable turmeric. The variation in recovery percentage among various turmeric varieties may be due to genetic factors rather than the environment condition under which they are grown.

Philip (1983) studied 32 turmeric cultivars and the maximum curing percentage recorded in 'Dindrigram' (31.55) and low in Amruthapani kothapeta' (14.85) followed by 'NBPGR / T9' (15.0%) and Nandyal (15.15%). Pujari, *et al.* (1987) reported in trials with eight *Curcuma longa* cultivars, that Krishna gave the highest yield of cured produce (70.11q/ha) followed by the cv. Duggierals with 60.25 q/ha cured produce.

Jalgaokar and Jamdagni (1989) opined that secondary fingers per plant was the only character which showed a significant and positive correlation with cured turmeric yield. Jalgaokar, *et al.*(1990) stated that cured yield was significantly and positively correlated with yield of secondary fingers.

Shashidhar *et al* (1997) stated that rhizomes yield was positively correlated with dry matter accumulation. Chandra *et al.*(1997) evaluated 25 genotypes of turmeric and stated that the dry matter recovery was negatively correlated with rhizomes.

Reddy, *et al.*(1989) assessed 12 and 13 short duration *Curcuma longa* varieties respectively. The highest average yields of cured rhizomes were obtained from PCT-13 (5.69 t/ha) and PCT-14 (5.43 t/ha). Indiresh. *et al.*(1990) evaluated a total of 15 cvs. of turmeric (*Curcuma longa*) at Brahmavar and reported that PCTB, Waigaon and kasturi gave the highest cured turmeric yield (6.48, 6.21 and 4.81t/ha respectively).

Maurya (1990) in a trial with 10 lines and the control, variety Dholi Local, RH-10 was found superior with regard dry rhizome yield (7.53 t/ha). Shahi, *et al.*(1994) collected forty genotypes of turmeric from Mudigere to assess the yield performance of six elite varieties under rainfed conditions and reported that CL – 811 showed high dry matter content with wide adaptability and stability. Radhakrishnan, *et al.* (1995), studied different varieties of turmeric under rainfed conditions in Kerala revealed that BSR-1 registered maximum recovery percentage of 27.33 followed by Suvarna (26.33%). No Seasonal effect was noticed in the varieties with regard to driage.

Ramakrishna, *et al.*(1995), compared eighteen turmeric (*Curcuma longa*) lines and reported that curing percentage was high in Sangli 92 / 2 (34.8%) and lowest in PCT – 15 (22.7%) PCT – 13 had a low curing percentage (23.8%) but produced the highest cured turmeric yield (6.4 t/ha).

Hegde *et al.*(1997) revealed that Banglore local recorded highest cured rhizomes yield (9.72 t/ha) followed by Sangli and PCT-8 (8.32 t/ha and 8-30 t/ha

respectively). PCT-5 had highest curing percentage of 26.40 and lowest was found in Cuddapah (18.56%) and Rajapuri (18.47%). Thankamani. *et al.*(1998) evaluated four turmeric cultivars and reported that rhizome dry weight per hectare were highest with Suguna and Sudarshan.

7.6 Curcumin percentage :

Quality in terms of curcumin content is an important factor, which determines the demand and premium price of turmeric in the market. Curcumin content of turmeric varied among different cultivars of turmeric.

Krishnamurthy *et al.*(1975) screened 22 cvs. of turmeric and reported that the values of curcumin varied from 1.2% to 4.97% according to locality, season and cultivars. Mathai (1978) stated the rhizomes of *Curcuma longa* after three months of growth contained more curcumin and it had been highest in the fifth month of growth. Pathania, *et al.*(1988) suggested the environmental influence on the quality characters particularly for curcumin content.

Philip (1983) assessed 32 types of *Curcuma longa* for quality component and Mannuthy Local synthesised the maximum curcumin content (7.58%) followed by Duggirala C11-325 (7.30%). Maurya (1990) in a trial with 10 lines and Dholi Local, RH – 10 was found to be superior with regard curcumin content (8.4%). The earlier formed rhizomes were higher in curcumin content to younger ones, Chiu *et al.* (1993) But Maiya *et al.*(1995) concluded that the size of propagating material had no effect on the curcumin content of the rhizomes.

Radhakrishnan. *et al.*(1995) found the 'BSR - 1' to be superior among the varieties for curcumin content (4.4%). Lynrah *et al* (1998) concluded that yield and curcumin content were negatively correlated. Chandra, *et al*.(1999) studied 25 genotypes in which Lakadong gave poor yields but had the highest curcumin (7.33%). Hegde *et al.*(1997) estimated maximum curcumin in PCT – 8 (8.08%) followed by PCT – 14 (7.48%) and PCT – 5 (5.67%).

CHAPTER – III

MATERIAL AND METHODS

An investigation on "performance of turmeric varieties under Nagpur conditions" was carried out at College garden, College of Agriculture, Nagpur during the year 2001-2002 . The trial was laid out in Randomised Block Design (RBD) with eight treatments replicated thrice. The details of materials used and methods adopted during the course of investigation are given below under different titles and subtitles.

3.1 General :-

3.1.1 Location and climate :-

Nagpur city is situated at an elevation of 321.26 meters above mean sea level, at $21^0 10'$ N latitude and $79^0 19'$ E longitudinal and has subtropical climate. Nagpur is characterized by hot and dry summer and fairly cold winter. The area is under wide diurnal fluctuation of temperature. Minimum and maximum temperature were recorded in the range of 35.5^0c and 7.2^0c in the month of June 2001 to January 2002 during the growth and development of turmeric in the field. The rainfall received during the year 2001 to 2002 was 1020 mm is about 61 rainy days mostly from 1st June 2001 to 31st January 2002. The relative humidity ranges from 91 to 23 per cent.

The weekly meteorological data on various weather parameters recorded at meteorological observatory, of College of Agriculture, Nagpur during the year 2001 to 2002 are presented in Appendix – I .

3.1.2 Properties of soil : -

The topography of land under experiment was fairly uniform. The soil of experimental plot was well drained with uniform texture. Before laying out the experimental plot, the soil samples were collected at 25 cm depth from the field and analysed for their physical and chemical properties.

Table :

Particulars	Value	Analytical Methods used:
pH	8.8	Black man's gas electrode pH meter (Jackson, 1958)
EC	0.35m-mhos/cm	Electric conductivity meter.
Organic carbon	0.56%	Walkely and Black's rapid titration method
Total nitrogen	0.146%	Modified kjeldahl method. (Jackson , 1958)
Available Phosphorus	4.48kg ha^{-1}	Olsen's method A.O.A.C. (1955)
Available Potash	269kg ha^{-1}	Flame photometer (Jackson, 1958)

3.2 Experimental details :-

The trial was laid out in Randomised Block Design with eight treatments and three replications. The layout of an experiment is given in fig. 1 and details of experiment are furnished below.

3.2.1	Site	:-	College garden, College of Agriculture, Nagpur
3.2.2	Name of crop	:-	Turmeric
3.2.3	Botanical Name	:-	*Curcuma longa* L.
3.2.4	Family	:-	Zingeberaceae

3.2.5	Cultivars	:-	Alleppey Krishna Prabha Pratibha Sudarshan Suguna Suvarna Waigaon
3.2.6	Year of experiment	:-	2001 – 2002
3.2.7	Experimental design	:-	Randomised Block Design
3.2.8	Number of Treatments	:-	8
3.2.9	Number of replications	:-	3
3.2.10	Total numbers of plots	:-	24
3.2.11	Gross plot size	:-	1.8 x 1.2 m
3.2.12	Net plot size	:-	1.2 x 0.6 m
3.2.13	Spacing	:-	30 x 30
3.2.14	Space between two plots	:-	45 cm
3.2.15	Space between two replications	:-	1.0 m
3.2.16	Date of planting	:-	14th June 2001
3.2.17	Season	:-	Kharif
3.2.18	Total number of rows per plot	:-	4
3.2.19	Total number of plants per plot	:-	24
3.2.20	Type of layout	:-	Ridges and furrows
3.2.21	Treatments		

Treatments (Abbreviations)	:	Particulars of treatments(Varieties)
T_1	:	Alleppey
T_2	:	krishna
T_3	:	Prabha
T_4	:	Pratibha
T_5	:	Sudarshan
T_6	:	Suguna
T_7	:	Suvarna
T_8	:	Waigaon

The eight varieties were replicated three times, the total number of plots were 24. All the varieties were planted at 30 x 30 cm spacing on ridges and furrows. All the varieties offered the similar treatment.

3.3 Details of cultivation :-

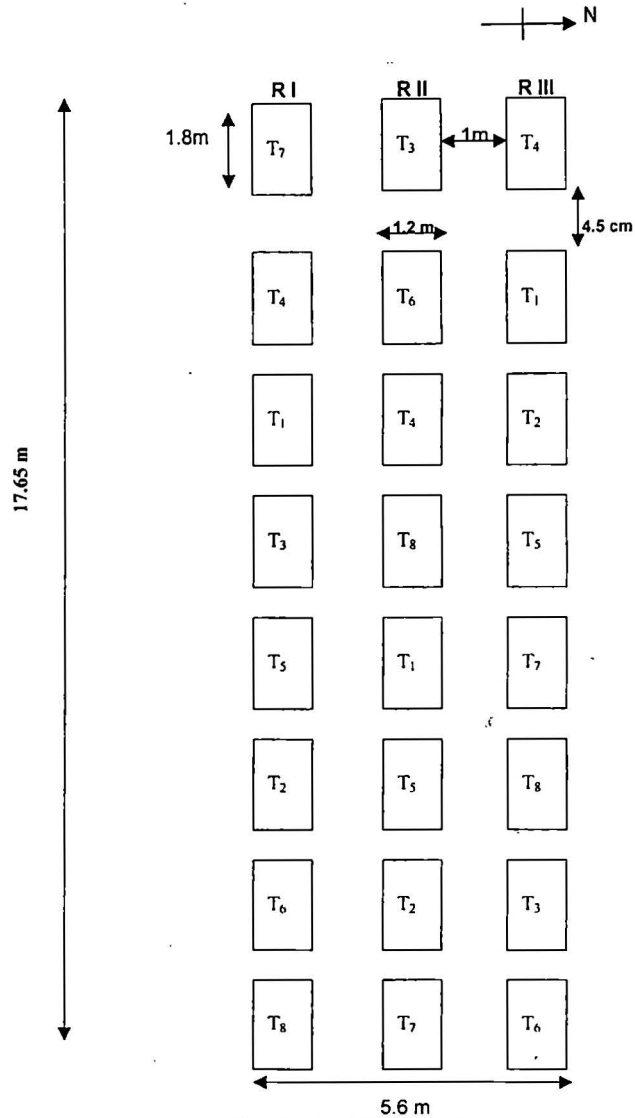
3.3.1 Preparation of field :-

The experimental field was prepared by 2 ploughing and 2 cross harrowing. 40 tonnes Farm Yard Manure per hectare was incorporated while ploughing. The field was brought to fine tilth and beds were prepared as per plan of layout. Twenty four plots were demarcated on field leaving 45 cm. space between two plots and 1m space between two replications. The demarcated plots at size1.8 x 1.2 m was prepared as per plan of layout.

I) Source and preparation of planting material :-

The mother rhizomes of the eight varieties viz. Alleppey, Krishna, Prabha, Pratibha, Sudarshan, Suguna, Suvarna and Waigaon were brought from National Research Center for Spices, Calicut in the year 2000. The eight varieties obtained from NRCS , Calicut were multiplied in this college

Fig. 1 : PLAN OF LAYOUT



Randomised Block Design

PLATE 1: TURMERIC EXPERIMENTAL PLOT

PLATE 2: MOTHER RHIZOME WITH FINGERS

and stored in underground pits. At the time of planting, the sprouted healthy and disease free mother rhizomes were taken out from the pits. The mother rhizomes weighing about 35 g were selected and treated with bavistin at the rate of 0.15 % for 15 minutes. These rhizomes were planted on 14 th June, 2001 at 30 cm spacing between rows and 30 cm plant to plant and 7.5 cm deep in the soil.

II) Cultural operation :

The experimental plots were maintained by carrying out various cultural operations.

i) **Weeding** :- Doob and other grasses were removed in order to keep the plot clean and to have good aeration. In all, five weeding s were done.

ii) **Irrigation** :- To keep the plot moist , irrigation was given at an interval of 7 to 8 days during the period of experimentation. Frequency of irrigation depends upon the weather conditionas and the moisture retentive capacity of the soil. First irrigation was given immediately after planting light irrigation 3 to 4 days before harvesting was given to facilitate easy harvesting.

iii) **Earthing up** :- After weeding and fertilization, earthing up was done to save the rhizomes from exposure to sun and also for better expansion of rhizomes.

iv) **Loosening of soil** :- This operation was carried out with sickle very carefully without damage to rhizomes to maintain proper aeration in bed.

v) **Fertilizer application :-** Chemical fertilizers were applied as per recommendation i.e. 125 :60 : 60 NPK Kg ha^{-1}. Half dose of nitrogen and full dose of P_2O_5 and K_2O was applied to the plots after sprouting of rhizomes. Remaining half dose of nitrogen was given as top dressing at 45 days after first application of the fertilizers.

vi) **Plant protection measures :-** No serious pests and diseases were noticed on the crop. However, four months after planting, there was very mild infection of leaf spot. Three spraying of Dithane M-45 @ 2.5 g in one liter of water at an interval of 15 days during the period of incidence of disease were undertaken to control the disease.

vii) **Harvesting :-** Depending upon the variety, the crop became ready for harvest within seven to nine months. At the time of maturity, all the leaves dried and hanging down. Harvesting was done as and when the variety shows the signs of maturity. The rhizomes were dug with digging fork and cleaned out of mud and other extraneous matter adhering to them.

3.4 Observation :-

Randomly, five turmeric plants were selected from each treatment for recording observations on various characters under investigation.

3.4.1 Pre harvest Observations:-

3.4.1.1 Height of plant (cm) : The height was recorded from ground level to the growing tip of leaf on randomly selected five plants of turmeric at an interval of 30 days till 180 days and averages worked out.

3.4.1.2 **Girth of pseudostem (cm) :** The girth of pseudostem at 3 cm above ground level was marked on five observational plants with white paint and the diameter was recorded with the help of Vernier Callipers from 30 days of planting till 180 days, at an interval of 30 days.

3.4.1.3 **Number of leaves per plant:** Number of leaves were counted on five plants under each treatment at an interval of 30 days till 180 days and mean values were calculated.

3.4.1.4 **Length of Leaf (cm) :** Leaf length was recorded on randomly selected five observational plants with scale in cm under each treatment at an interval of 30 days till 180 days and averages were worked out.

3.4.1.5 **Breadth of leaf (cm) :** The leaf selected for record of length was also used to measure the leaf breadth. The breadth was measured at the center of leaf where the width was comparatively more, with scale in centimeter at an interval of 30 days till 180 days under each treatment and averages were worked out.

3.4.1.6 **Leaf Area (cm^2) :** Leaves selected for record of length and breadth were subjected for this observation. Since the leaves were larger in size than the mask plate of calculating machine, they were cut into desirable sizes and arranged on mask plate of 200 cm^2 opening area in such a way that digital reading of the total area of leaf was obtained. Thus, the readings of five leaf samples averages for the mean value.

3.4.1.7 **Number of tillers per plant** : Number of tillers emerged from the plant were counted with an interval of 15 days in observational plants under each treatment. Depending upon the variety, emergence of tillers started from 80 to 90 days onwards from planting and averages worked out.

3.4.1.8 Number of days required for maturity : Depending upon the variety, the crop is matured within seven to nine months when the leaves when turned yellow and started drying. All the leaves dried and hanging down. At last the plant completely fall on the ground. Days required for maturity were counted when the crop shows the signs of maturity under each treatment.

3.4.2 Post harvest observations :

Turmeric crop became ready for harvesting in 7 to 9 months after planting depending upon the variety. During harvesting, the rhizomes were carefully lifted with a digging fork. Harvested, rhizomes were cleaned out mud and other extraneous matter adhering to them. Randomly, the rhizomes from observational plants of turmeric were selected from each treatment for recording post harvest observations on various characters under investigation.

3.4.2.1 Number of fingers per plant : From the observational plants under each treatment, the mother rhizomes and fingers were separated, cleaned and their numbers counted after harvest of crop. Average numbers of fingers per plant were worked out.

3.4.2.2 Length of finger (cm) : Five fingers from a clump of observational plants under each treatment were selected and length was measured in centimeter. Average of five fingers calculated.

3.4.2.3 Diameter of finger (cm) : Five fingers from a clump of selected plants were selected randomly under each treatment and diameter at the center portion of finger was measured in centimeter with the help of Vernier Calliper. Averages were worked out.

3.4.2.4 Yield of green turmeric per plant (g) : Yield per plant of green turmeric was recorded from observational plants randomly under each treatment and averages were worked out per plant.

3.4.2.5 Yield of green turmeric per plot (kg) : After the harvest of crop, the green rhizomes were separated and weighed from observational plants in each plot under each treatment and mean values were calculated.

3.4.2.6 Yield of green turmeric per hectare (q) : The average yield of green turmeric per hectare in quintal under each treatment was computed from the plot yield.

3.4.2.7 Weight of cured turmeric : 200 g fresh rhizomes were boiled in water for half an hour until broth and white fumes with characteristic aroma appear. They were then drained and dried in the sun for 10-15 days until they became dry and hard. The composite sample of 200 g green turmeric per treatment were subjected for weight of cured turmeric.

3.4.2.8 Yield of cured turmeric per hectare (q) : Yield of cured turmeric per hectare in quintals was worked out on the basis of average cured weight of rhizomes obtained per 200 g green turmeric under each treatments.

3.4.2.9 Weight of dried shoot per plant (g) : During maturity of plant, the leaves turn yellow and dried. At last the shoot of plant was dried and falled on the ground. The dried shoot and leaves were cut from ground level from observational plants under each treatment and weighed on electronic weighing balance.

3.4.2.10 Curcumin percentage : 200 g turmeric rhizomes of each treatment were washed, boiled, dried, polished and made to powder. The estimation of curcumin percentage of dried turmeric powder was carried out by solvent extraction and spectrophotometric measurement method (Anonymous, 1984).

PLATE 3: MOTHER RHIZOMES WITH FINGERS

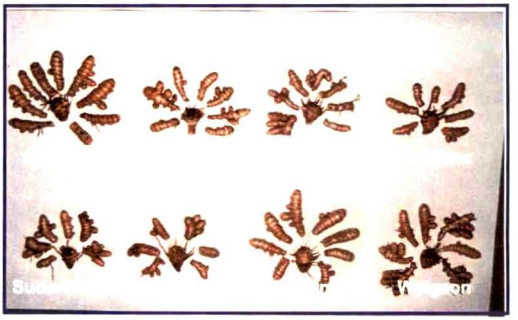


PLATE 4: MOTHER RHIZOMES AND FINGERS (Separated)

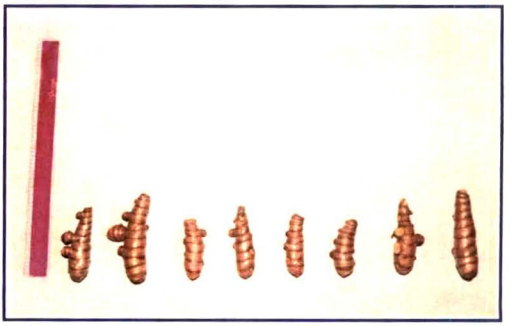


PLATE 5: FINGERS

Calculations :-

Absorbance of standard curcumin solution :-

A standard solution containing 0.0025 g/L. of curcumin gave an absorbance value of 0.42 at 425 nm.

$$\text{Absorbivity of curcumin A} = \frac{0.42}{1 \times 0.0025}$$

$$\text{Curcumin per cent in turmeric} = \frac{a \times 100}{L \times A \times M}$$

Where,

a = Absorbance of extract at 425 nm.

L = Cell in length in cm.

A = Absorbivity

M = mass / g of sample

3.5 Statistical Methods:-

The data on various observations, during the course of investigations were statistically analysed by Randomised Block Design (RBD) as suggested by Gomez and Gomez (1984). The analysis was carried out at College computer section in Q Basic language. The appropriate standard error of mean (S. Em.) and the critical difference (C.D.) were calculated at 5 per cent levels of probability. Data have been depicted by suitable graphs, figures at the appropriate tables.

CHAPTER – IV

FINDINGS AND DISCUSSION

A research project entitled 'performance of turmeric varieties under Nagpur conditions' was undertaken at College garden College of Agriculture, Nagpur during 2001-2002. The eight treatments, viz., Alleppey, Krishna, Prabha, Pratibha, Sudarshan, Suguna, Suvarna and Waigaon, were replicated three times in Randomized Block Design (RBD). Results of this investigation are given and discussed in this chapter.

4.1 Pre harvest observations :-

4.1.1. Height of plant (cm) :-

Data in respect of height of plant recorded at 30,60,90,120,150 and 180 days after planting for each treatment are presented in table1 and depicted in fig. 2

TABLE – 1 AVERAGE HEIGHT OF PLANT (cm)

Treatments	Abbre -viations	Mean height of the plant (cm)					
		30 Days	60 Days	90 Days	120 Days	150 Days	180 Days
Ileppey	T_1	13.36	24.64	48.33	74.78	89.37	99.24
Krishna	T_2	16.50	28.41	52.41	77.24	93.50	102.23
Prabha	T_3	16.80	22.13	42.26	66.14	76.90	85.31
Pratibha	T_4	19.42	28.81	48.59	72.24	86.29	96.29
Sudarshan	T_5	11.05	24.22	39.81	58.41	72.58	79.30
Suguna	T_6	12.61	26.90	41.32	66.18	78.99	86.43
Suvarna	T_7	18.58	27.09	44.29	70.77	87.44	95.56
Waigaon	T_8	13.39	24.93	46.48	72.86	89.72	98.09
GM		15.214	25.888	45.438	69.830	84.354	92.806
SE m (±)		1.034	1.799	1.807	3.579	4.179	4.265
CD at 5%		3.129	N.S	5.482	10.855	12.675	12.140

It is evident from the figures that there was progressive acceleration in height in all the treatments as the age of plant advances. However, the rate of increment in height was comparatively slow in all the varieties in between 30 and 60 days. Where as, the growth between 90 and 120 days was more which is grand growth stage and again slow down between 150 and 180 days.

The analysis of variance in respect of height of plant exhibited (Table –1) significant differences in almost all stages, i.e. 30, 90, 120, 150 and 180 days, where as the height at 60 days after planting was found non significant.

Variety Krishna possessed significantly more height in all the intervals except at 30 days where as Pratibha had significantly more height and at 60 days it had greater height than rest of the varieties. However, the varieties at par with Pratibha were abruptly changed at each intervals. Where as variety Sudarshan was found significantly inferior in almost all the intervals and there was gradual shift among the varieties those were at par with Sudarshan at every intervals. But at 60 days of planting analysis of variance found non significant and variety Prabha had attained minimum height than other varieties.

Analysis of data in Table –1 at 180 days after planting revealed that Krishna achieved maximum height and significantly superior over all the other treatments except with Alleppey, Waigaon, Pratibha and Suvarna. Variety Sudarshan, Prabha and Suguna, though at par however, recorded the height significantly lower than all other treatments.

Five varieties viz., Krishna, Alleppey, Waigaon, Pratibha and Suvarna attained the height 102.23 cm, 99.24 cm, 98.09 cm, 96.29 cm, and 95.56 cm respectively. These values were higher thatn the general mean (92.80 cm) at 180 days. Where as three varieties Suguna, Prabha and Sudarshan possessed 86.43 cm, 85.31 cm, and 79.30 cm height respectively which was lower than the general mean (92.80 cm) at 180 days.

No regular sequence in average of height of varieties was noticed during the various intervals of observation. The estimates ranged from 102.23 cm to 79.30 cm

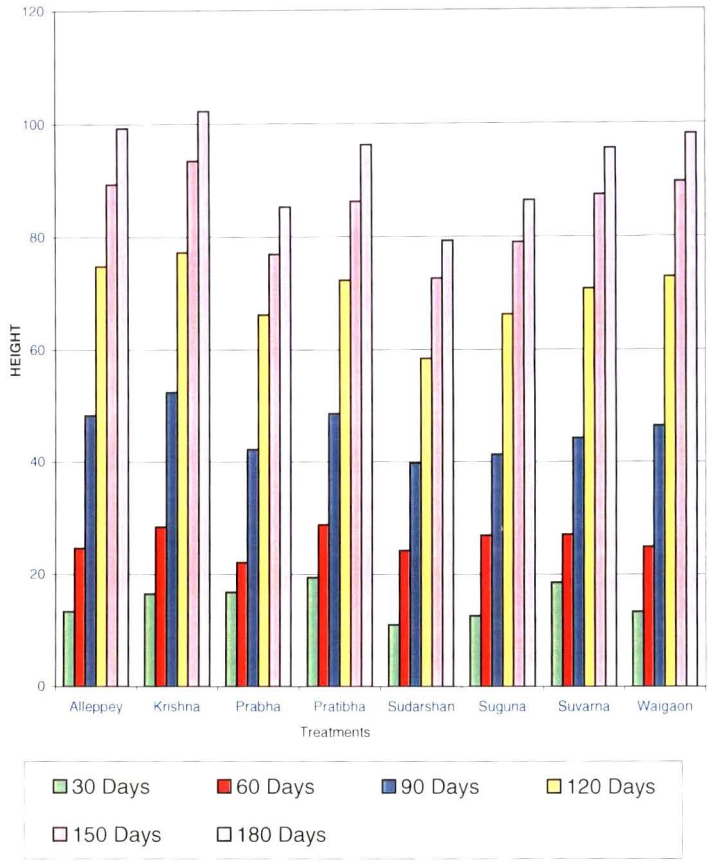


Fig. 2: HEIGHT OF PLANT (cm)

were recorded for Krishna and Sudarshan varieties respectively at 180 days after planting.

Highly significant variations were noticed among the cultivars for height (Table –1). Similar variations in the height among the cultivars under different agro-climatic conditions were reported by Philip and Nair (1983) ; Indiresh, *et al.*(1990); Radhakrishnan, *et al.*(1995) ; Hegde, [illegible] (1997) and Thankamani, *et al.*(1998). Height variations among the cultivars could be due to genetic make up of individual cultivars and their response to particular agro-climatic conditions as reported by Philip (1983); Philip and Nair (1983) and Thankamani, [illegible] (1998).

In this investigation, variety Sudarshan recorded the lowest height (79.30 cm). Similar result was reported by Radhakrishnan, *et al* (1995) as Sudarshan had 24.82 cm height over rest of the 6 cultivars. Where as Thankamani, *et al.*(1998) suggested that Alleppey produced the tallest plants followed by Suvarna, Suguna and Sudarshan under rainfed conditions of Kerala and concluded that plant height of turmeric increased in all the varieties upto 180 days after planting. This finding is in line with the present investigation. The height of Krishna plant was reported to be higher than other varieties. It may be due to the fact that variety Krishna surpassed in increase in height at every interval maintained even at 180 DAP as a result Krishna had more height than other due to its inherent characters.

4.1.2 Girth of pseudostem of plant (cm) : -

The comparison of eight varieties for their mean girth of pseudostem (cm) is presented in Table –2.

The pattern of variations of treatments could be depicted as below.

30 DAP $T_8 > T_2 > T_1 > T_7 > T_4 > T_3 > T_5 > T_6$

60 DAP $T_8 > T_2 > T_1 > T_3 > T_7 > T_4 > T_5 > T_6$

90 DAP $T_8 > T_2 > T_1 > T_3 > T_7 > T_4 > T_6 > T_5$

120 DAP $T_8 > T_2 > T_1 > T_3 > T_7 > T_4 > T_6 > T_5$

150 DAP $T_8 > T_2 > T_1 > T_4 > T_7 > T_3 > T_5 > T_6$

180 DAP $T_8 > T_2 > T_1 > T_4 > T_3 > T_7 > T_5 > T_6$

TABLE – 2 AVERAGE GIRTH OF PSEUDOSTEM OF PLANT (cm)

Treatments	Abbre -viations	Mean girth of pseudostem of plant (cm)					
		30 Days	60 Days	90 Days	120 Days	150 Days	180 Days
Alleppey	T_1	0.87	0.98	1.61	2.14	2.62	3.02
Krishna	T_2	1.59	1.90	2.37	2.92	3.25	3.56
Prabha	T_3	0.82	0.97	1.48	1.99	2.39	2.73
Pratibha	T_4	0.83	0.88	1.37	1.85	2.42	2.75
Sudarshan	T_5	0.55	0.87	1.17	1.69	2.28	2.51
Suguna	T_6	0.50	0.70	1.23	1.70	2.16	2.34
Suvarna	T_7	0.84	0.97	1.45	1.98	2.40	2.71
Waigaon	T_8	1.86	2.00	2.49	3.03	3.37	3.59
GM		0.986	1.162	1.649	2.166	2.615	2.905
SEm (±)		0.026	0.034	0.056	0.071	0.093	0.115
CD at 5%		0.078	0.105	0.169	0.215	0.282	0.348

The mean performance of the varieties in relation to girth of pseudostem (Table-2) indicated significant variation among the varieties of turmeric, in all the stages i.e. 30, 60, 90, 120, 150 and 180 days after planting. The analysis of data (Table–2) indicated significant differences in all intervals and revealed that the

variety Waigaon was significantly superior over all the genotypes and at par with Krishna at almost all the intervals till 180 days after planting except in 30 days where Waigaon was found significantly superior than others. Where as significantly inferior variety was changed it's pattern of development of Pseudostem at each intervals. However, Suguna was significantly inferior over all other varieties at all intervals except at 90 DAP and 120 DAP where Sudarshan was significantly inferior varieties rest of the at par varieties were abruptly changed.

In (Table–2) mean girth of pseudostem of plant recorded at 180 days after planting ranged from 2.34 cm to 3.59 cm. At 180 days, variety Waigaon achieved maximum girth of pseudostem (3.59 cm) and significantly higher than all other treatments and at par with Krishna (3.56 cm). While, variety Suguna showed poor girth (2.34 cm) at par with Sudarshan (2.51 cm)

Three varieties namely Waigaon, Krishna, Alleppey recorded the radial radial groth of pseudostem 3.59 cm, 3.56cm and 3.02 cm respectively, were more than the general mean (2.90 cm) at 180 days after planting. However five varieties Pratibha, Prabha, Suvarna, Sudarshan and Suguna attained the girth 2.75 cm, 2.73 cm, 2.71 cm, 2.51 cm and 2.34 cm respectively were lower than the general mean.

The varieties having maximum and minimum values over general mean were abruptly changed in rest of the intervals. Highly significant variations were observed among the varieties for girth of pseudostem. The reason for the significant variation in girth of pseudostem among the turmeric types grown under same cultural and agro-climatic conditions could attributed to the genetic factors.

The girth of pseudostem of turmeric in Waigaon, Krishna and Alleppey was at higher site right from the beginning which might have boost up and enlarged the girth of pseudostem at all the intervals of these varieties. Thus the girth of pseudostem of turmeric had increased even at 180 DAP and it was in order of Waigaon closely followed by Krishna and Alleppey varieties.

4.1.3 Number of leaves :-

The mean number of leaves per plant of eight varieties over a period six month beginning from 30 days up to 180 days after planting was computed and the values are given in table–3 .

TABLE – 3 AVERAGE NUMBER OF LEAVES

Treatments	Abbreviations	Mean number of leaves					
		30 Days	60 Days	90 Days	120 Days	150 Days	180 Days
Alleppey	T_1	3.54	6.39	7.90	9.75	11.74	12.28
Krishna	T_2	4.58	7.35	9.49	11.09	11.92	13.79
Prabha	T_3	2.58	4.77	6.41	8.21	10.19	10.84
Pratibha	T_4	3.82	5.87	7.19	9.26	10.74	12.09
Sudarshan	T_5	2.22	4.36	5.18	6.50	7.79	8.03
Suguna	T_6	2.21	3.80	5.13	6.35	7.60	7.55
Suvarna	T_7	2.38	4.29	5.77	7.41	8.71	9.66
Waigaon	T_8	4.35	6.76	7.87	9.35	11.37	12.41
GM		3.210	5.448	6.868	8.490	10.000	10.830
SE m (±)		0.146	0.346	0.403	0.567	0.652	0.755
CD at 5%		0.442	1.050	1.224	1.720	1.977	2.289

In all the varieties under study there was progressive increment in number of leaves as the age of plant advances. The data in table-3 had significant variations at all intervals of observations. In general, the mean number of leaves per plant was substantially increasing upto 120 days after planting. Subsequently, extent of leaves per plant slowed down in the rest of two intervals after four months of planting in all the varieties.

The Caverage number of leaves produced by the turmeric was 10.83 ranging from 7.55 (Suguna) to 13.79 (Krishna) of the varieties under study, five of them viz., Krishna (13.79, Waigaon (12.41), Alleppey (12.25) , Pratibha (12.09) and Prabha (10.84) possessed the average leaves per plant in turmeric more than general

mean (10.83). And two of them i.e. Sudarshan (8.03) and Suguna (7.55) had the lower the leaves that mean at the full growth of plant at 180 days after planting.

The variety Krishna was significantly superior over all the other varieties however, rest of the varieties were abruptly changed in each monthly intervals from 30 to 180 days after planting. Variety Suguna was found significantly inferior at all intervals till 180 days after planting but it was at par with Sudarshan, Suvarna, and Prabha.

At the full grown up stage of plant recorded at 180 days after planting variety Krishna produced maximum leaves (13.79). Which was significantly superior over all other treatments but at par with Waigaon (12.41), Alleppey (12.28) and Pratibha (12.09). Variety Suguna was significantly inferior over all other treatments and it was at par with Sudarshan and Suvarna, Gradual shift was found in respect of at par varieties at each intervals till full growth of plant.

Irrespective of the varieties, rate of production of number of leaves per plant borne after 4 months was higher and subsequently it reduced down. Because turmeric plant remain under vegetative phase up to 120 days. Then it shift to a stage of tuberization. Hence, rate of production of leaves for 120 DAP slowed down.

The increase in number of leaves per plant particularly by Krishna, Waigaon and Alleppey was due to the fact that in all the intervals these three varieties were superior to the other varieties and Krishna in all the months was at the top. Therefore Krishna recorded the maximum number of leaves per plant. On the contrary variety Suguna in all the intervals produced less leaves. Thus, it had less leaves at full growth. It was also inferred that more the height, more was the number of leaves per plant in turmeric. Thus Krishna, Waigaon, Alleppey and Pratibha had more leaves and Suguna Possessed the less.

Significant and positive correlation was found between number of leaves and plant height. This is in line with the finding of Pathania *et al.*(1981). Chadha (1994) found 7.38 leaves in Sudarshan cultivars. Anon (2002) reported 10 leaves in Waigaon. Comparatively similar results were recorded in the present investigation.

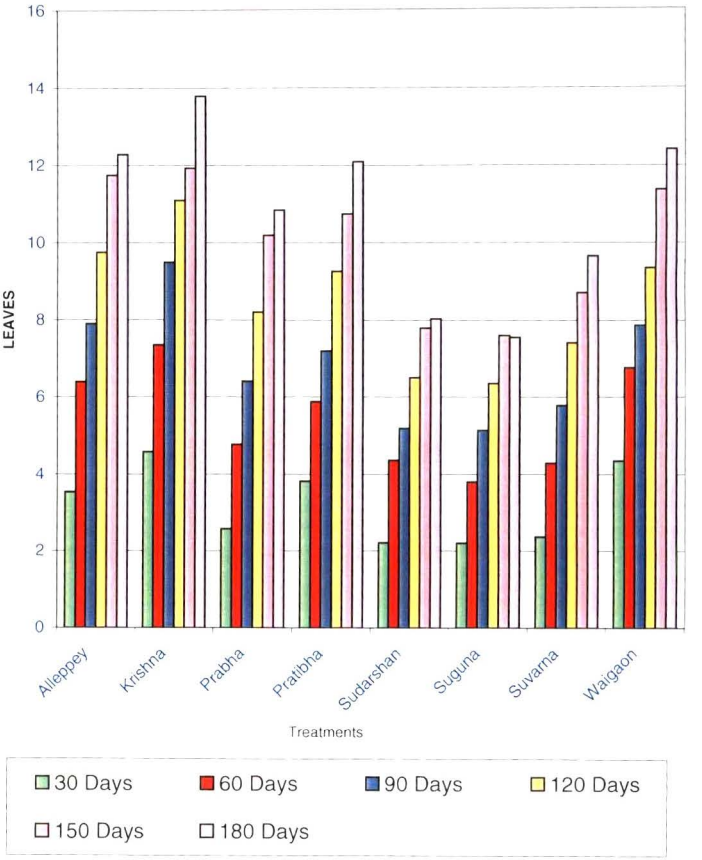


Fig. 3: NO. OF LEAVES PER PLANT

Highly significant variations were noticed among the cultivars for number of leaves (Table –3). Similar variations in the number of leaves among the different cultivars were reported by Philip (1983), Philip and Nair (1983), Reddy , *et al.*(1989); Shah , *et al.*(1982) ; Cholke (1993) ; Ramakrishnan , *et al.*(1995) and Hegde, *et al* (1997).

The number of leaves in this investigation varies to the extent from 7.55 to 13.79. These results fall in tune with that of Ramchandran and Muthuswami (1984) who obtained 12.98 number of leaves per plant of turmeric in the ridges and furrows method, 13.23 leaves per plant with 30 x 22.5 cm spacing, which is also in the range of the present investigation. Ramchandran and Muthuswami (1984) stated that the total number of leaves per plant was not significantly affected by the planting methods.

Hazra, *et al.*(2000) found only leaves per clump at 180 days after planting emerged as an important rhizome yield component of turmeric. The number of leaves showed highly significant variations among the turmeric types. The reason for this could be due to agro-climatic and genetic factors Philip and Nair (1983). The positive correlation of leaves number with yield might be due to availability of more photosynthetic area and thereby increase the rate of photosynthesis that account for higher yield.

4.1.4 Average size of leaf : -

The data in respect of length and breadth of leaf recorded at 30, 60, 90, 120, 150 and 180 days after planting for each treatment are presented in Table- 4 and 5 respectivety.

TABLE – 4 AVERAGE LEAF LENGTH (cm)

Treatments	Abbreviations	Mean length of leaf (cm)					
		30 Days	60 Days	90 Days	120 Days	150 Days	180 Days
Alleppey	T_1	5.65	15.17	25.57	40.71	49.21	55.43
Krishna	T_2	10.14	17.46	27.59	47.57	57.13	62.47
Prabha	T_3	4.63	9.52	20.61	36.72	42.86	47.89
Pratibha	T_4	9.27	16.18	28.78	48.33	57.22	61.38
Sudarshan	T_5	4.71	12.01	22.37	38.32	45.15	49.74
Suguna	T_6	7.18	17.04	23.93	45.37	53.06	59.24
Suvarna	T_7	4.48	9.42	18.81	34.87	41.05	46.04
Waigaon	T_8	10.14	16.83	30.90	49.40	57.51	62.50
GM		7.025	14.206	24.824	42.665	50.399	55.586
SE m (±)		0.462	0.889	1.765	2.393	3.828	3.878
CD at 5%		1.400	2.696	N.S.	7.258	11.612	11.762

The pattern of variation of treatments could be depicted as below.

Average length of leaf : -

30 DAP $T_2 > T_8 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$

60 DAP $T_2 > T_6 > T_8 > T_4 > T_1 > T_5 > T_3 > T_7$

90 DAP $T_8 > T_4 > T_2 > T_1 > T_6 > T_5 > T_3 > T_7$ (N.S.)

120 DAP $T_8 > T_4 > T_2 > T_6 > T_1 > T_5 > T_3 > T_7$

150 DAP $T_8 > T_4 > T_2 > T_6 > T_1 > T_5 > T_3 > T_7$

180 DAP $T_8 > T_2 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$.

TABLE – 5 AVERAGE LEAF BREADTH (cm)

Treatments	Abbreviations	Mean breadth of leaf (cm)					
		30 Days	60 Days	90 Days	120 Days	150 Days	180 Days
Alleppey	T_1	6.42	8.60	10.84	12.41	14.87	15.86
Krishna	T_2	8.63	10.45	12.07	14.08	15.68	17.16
Prabha	T_3	4.46	6.54	8.35	10.09	11.73	12.45
Pratibha	T_4	6.62	8.84	11.50	13.42	15.56	17.08
Sudarshan	T_5	4.89	6.67	8.42	10.72	12.32	13.42
Suguna	T_6	7.34	8.38	10.99	13.43	15.55	16.20
Suvarna	T_7	3.92	6.08	7.93	9.85	11.59	12.35
Waigaon	T_8	8.07	9.89	12.39	14.28	16.42	17.42
GM		6.293	8.181	10.311	12.288	14.215	15.243
SE m (±)		0.327	0.388	0.501	0.595	0.699	0.769
CD at 5%		0.992	1.177	1.520	1.805	2.119	2.333

The pattern of variation of treatments could be depicted as below.

Average breadth of leaf : -

30 DAP $T_2 > T_8 > T_6 > T_4 > T_1 > T_5 > T_3 > T_7$

60 DAP $T_2 > T_8 > T_4 > T_1 > T_6 > T_5 > T_3 > T_7$

90 DAP $T_8 > T_2 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$

120 DAP $T_8 > T_2 > T_6 > T_4 > T_1 > T_5 > T_3 > T_7$

150 DAP $T_8 > T_2 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$

180 DAP $T_8 > T_2 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$

It is evident from the figures that there was progressive increment in leaf length and breadth in all the intervals as the age of plant advances. However the rate of increment in leaf length and breadth was comparatively higher in all the variations up to 120 DAP and thereafter reduced down as evident from general mean.

Table – 4 and 5 show the analysis of variance in respect of average leaf length and breadth possessed significant differences in all the intervals except at 90 days. The leaf length was not significant. It can be seen that for increase in length and breadth of leaf no consistency was noted. There was a shift over of the varieties in intervals to come. However a definite pattern in achieving the leaf length and breadth was observed in varieties like Suguna, Prabha and Sudarshan at all stages and variety Sudarshan produced the smaller leaf.

Variety Krishna had maximum leaf size (length and breadth) and found significantly superior over all other varieties at 30 and 60 days of planting. There after Waigaon observed superiority over all other varieties till 180 days after planting in respect of length and breadth of leaf. At 90 days, analysis of variance was non significant with respect of leaf length and variety Waigaon had the leaf more elongated (30.90 cm). There was gradual shift among the treatments that were at par with significantly superior treatment at various intervals.

Both leaf length and breadth was found maximum in Waigaon and minimum in Suvarna having range pf 46.04 cm to 62.50 cm for leaf length and 12.35 com to 17.42 com in respect of leaf breadth, respectivelyAt full grown stage turmeric of plant recorded at 180 days after planting. The leaf in variety Waigaon was elongated to the tune of 62.50cm and found significantly superior over all others treatments followed by Krishna (62.47 cm), Pratibha (61.38cm) , Suguna (59.24 cm) and Alleppey (55.43cm). Whereas, Suvarna (46.04cm) was at par with Prabha (47.89 cm), Sudarshan (49.74 cm) and Alleppey (55.43 cm). In respect of leaf breadth, broader laming was noticed variety Waigaon (17.42 cm). Which was significantly superior but at par with Krishna (17.16 cm), Pratibha (17.08 cm), Suguna (16.20 cm) and Alleppey (15.86). Variety Suvarna had leaf breadth 12.35 cm and found significantly narrow leaf however at par m) and Sudarshan (13.42cm).

Under the observations of general mean, four varieties of turmeric i.e., Waigaon (62.50 cm), Krishna (62.47 cm), Pratibha (61.38 cm) and Suguna (59.24 cm) respectively the leaf was elongated and had the value more than the general mean (55.58) at full grown stage of turmeric plant recorded at 180 days after planting. Remaining four varieties Alleppey (55.43 cm), Sudarshan (49.74 cm), Prabha (47.89 cm) and Suvarna (46.04 cm) respectively values had less than the general mean (55.58 cm) at 180 days. In respect of the intervals, the behavior of the cultivars had no definite sequence and it was abruptly changed. But in respect of leaf breath the varieties viz. Waigaon, Krishna, Suguna and Alleppey had the leaf breath 17.42 cm, 17.16cm, 16.20 cm and 15.86 cm respectively which was more than the general mean (15.24 cm) at every month intervals from 30 days to 180 days after planting. Whereas Sudarshan (13.42 cm), Prabha (12.45 cm) and Suvarna (12.35 cm) had less values than general mean (15.24 cm) at each intervals till 180 days after planting.

Highly significant variations were noticed among the cultivars for leaf length and breadth. Similar variations in leaf length and breadth among different cultivars were reported by Pathania, *et al*.(1981) ; Philip (1983) ; Radhakrishnan , *et al.*

(1995), Nirmal and Yamgar (1998) ; Hegde , *et al.*(1997) ; and Philip and Nair (1983).

Philip (1983) found maximum leaf length in the type 'Chaya pasupa' (61.90 cm) and minimum leaf length in the cultivar 'NBPGR / T17' (42.6 cm). These results fall in tune with that of the present investigation. Mohanty (1979) reported that the genotypic and phenotypic correlation coefficients between breadth of fully opened leaf with shoot height were significant and positive. The tall plants with broader leaves are likely to produce high yielding turmeric types. These results are found in line with the present investigation.

Philip and Nair (1983) found leaf breath in range of 13.9 cm to 17.5 cm in the varieties Rajpuri and Amruthpani Kothapeta C11 – 317 respectively grown in the plains of Kerala. This result is in congruent with the present investigation where leaf breadth range was observed from 12.35 cm to 17.42 cm in Suvarna and Waigaon respectively.

The leaf size (length and breadth) variations among the different cultivars might be due to genetic characters of the cultivars and their response to particular agro-climatic conditions. This is in confirmity with the findings Aiyadurai (1966); Subbarayudu . *et al.*(1976); Philip and Nair (1983) and Jalgaonkar . *et al.*(1988)

4.1.5 Number of tillers per plant :-

The data on growth parameters with respect to number of tillers per plant recorded at seven intervals i.e. 90, 105, 120, 135, 150, 165 and 180 days after planting for each cultivars are presented in Table – 6.

TABLE – 6 AVERAGE NUMBER OF TILLERS PER PLANT

Treatments	Abbreviations	Mean number of tillers per plant						
		90 Days	105 Days	120 Days	135 Days	150 Days	165 Days	180 Days
Alleppey	T_1	0.48	0.76	0.83	0.87	0.99	1.21	1.33
Krishna	T_2	1.47	2.06	2.19	2.36	2.52	2.78	3.04
Prabha	T_3	0.66	0.94	1.05	1.12	1.25	1.43	1.58
Pratibha	T_4	0.98	1.33	1.44	1.53	1.68	1.82	2.08
Sudarshan	T_5	0.42	0.67	0.74	0.79	0.90	1.11	1.20
Suguna	T_6	0.76	0.66	0.73	0.79	0.87	0.96	1.12
Suvarna	T_7	1.23	1.63	1.72	1.86	2.10	2.21	2.41
Waigaon	T_8	1.60	1.74	1.87	2.07	2.38	2.51	2.87
GM		0.953	1.226	1.326	1.427	1.586	1.755	1.954
SE m (±)		0.043	0.059	0.057	0.073	0.078	0.080	0.090
CD at 5%		0.131	0.179	0.174	0.220	0.236	0.241	0.272

The pattern of variation is given below

90 DAP $T_8 > T_2 > T_7 > T_4 > T_6 > T_3 > T_1 > T_5$

105 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

120 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

135 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

150 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

165 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

180 DAP $T_2 > T_8 > T_7 > T_4 > T_3 > T_1 > T_5 > T_6$

The data in Table –6 revealed the increment in number of tillers per plant in all the varieties as the age progresses.

Significant variation was observed among the cultivars with regard to the number of tillers per plant at all the fortnight intervals from 90 days to 180 days after planting. Variety Krishna was found significantly superior over all other cultivars at almost all the observations recorded since 105 days till 180 days except at 90 days where it is replaced by Waigaon but it was at par with Krishna. There was gradual shift among the treatments that were at par with each other at various intervals.

However variety Suguna recorded significantly megre number of tillers in almost all the intervals except at 90 days where Sudarshan was significantly inferior but at par with Alleppey. The tillers emergence at 105 DAP till 180 DAP had maintained consistant sequence or pattern in order of production of number of tillers per plant.

At full grown stage of plant recorded at 180 days after planting the number of tillers indicated to extent of 1.12 in Suguna to 3.04 in Krishna. Perfuse tillering was producedly in variety Krishna and it was significantly superior over all other cultivars and at par with Waigaon,. However, less tillers were observed by Suguna but it was at par with Sudarshan and Alleppey.

Data (Table –6) showed that four varieties Krishna, Waigaon, Suvarna and Pratibha had more number of tillers 3.04, 2.87, 2.41 and 2.08 respectively at 180 days after planting and these values were higher over the general mean (1.95). Remaining four cultivars namely Prabha (1.58), Alleppey (1.33), Sudarshan (1.20) and Suguna (1.12) had the tillers lower than general mean (1.95). The same trend was observed in all the seven intervals from 90 to 180 days after planting.

The variation in emergence of tillers was 1.12 to 3.04 i.e. three fold in variety Krishna followed by Waigaon, Suvarna and Pratibha had maximum tiller per plant Similar variations in tiller numbers among different cultivars was investigated under different agro-climatic conditions. by Philip (1983), Philip and Nair (1983); Mukhopadhyay, *et al.*(1986); Lynrah , *et al.*(1998); Radhakrishnan , *et al.*(1995) and Hegde , *et al.*(1997).

Radhakrishnan, *et al* (1995) obtained 1.31 and 1.18 tillers per plant in Sudarshan and Suguna respectively which are comparatively the same with this investigation. Philip (1983) obtained 3.05 tillers per plant in cultivar Kasturi Tanuka grown in the plains of Kerala. This result is congruent with the result of Chadha (1994). Who reported 2.6 tillers per plant in Suvarna which is comparatively similar with the present investigation. Ramachandran and Muthuswami (1984) stated that the widest spacing (50 x 22.5 cm) registered the highest number of tillers and concluded that it might be due to the availability of larger foraging area for the roots and consequent greater utilization of nutrients.

The variation in number of tillers among turmeric varieties might be due to genetical characters of the cultivars and their response to particular agro-climatic conditions. This is in line with the findings of Aiyadurai (1966); Subbarayudu, *et al.* (1976); Philip and Nair (1983) and Jalgaonkar, *et al.*(1988)

4.1.6 Leaf area :-

The mean performance of the varieties in relation to leaf area recorded, at full growth stage, 180 days after planting is presented in table -7 and depicted in fig. 3

TABLE – 7 AVERAGE LEAF AREA (cm^2)

Treatments	Abbreviations	Mean leaf area (cm^2)
Alleppey	T_1	827.89
Krishna	T_2	1021.86
Prabha	T_3	551.32
Pratibha	T_4	1002.57
Sudarshan	T_5	613.31
Suguna	T_6	909.58
Suvarna	T_7	526.04
Waigaon	T_8	1033.51
GM		810.762
SE m (±)		34.753
CD at 5%		105.409

The pattern of variation of different treatments could be depicted as below.

$T_8 > T_2 > T_4 > T_6 > T_1 > T_5 > T_3 > T_7$

The mean area of the full grown leaf of turmeric plant was 810.762 at 180 days after planting which was ranger from 1033.51 cm^2 in Waigaon to 526.04 cm^2 in Suvarna varieties of turmeric. The expansion of leaf by variety Waigaon was to the extent of 1033.51 cm^2 which was significantly superior over all other cultivars and at par with Krishna (1021.86 cm^2) and Pratibha (1002.57 cm^2). Whereas variety Suvarna (526.04 cm^2) though significantly inferior to all other treatments but found at par with the varieties Prabha (551.32 cm^2) and Sudarshan (613.31 cm^2).

The varieties, Waigaon, Krishna, Pratibha, Suguna and Alleppey achieved the leaf area 1033.51 cm^2, 1021.86 cm^2, 1002.57 cm^2, 909.58 cm^2 and 827.89 cm^2 leaf area respectively and recorded higher values of leaf area than general mean (810.762 cm^2). Whereas three varieties viz. Sudarshan (613.31 cm^2), Prabha (551.32 cm^2) and Suvarna (526.04 cm^2) had less leaf area than general mean (810.762 cm^2).

Results from the table 7 indicated the significant variation among the different varieties of turmeric in respect of leaf area investigated under same agro-climatic conditions. Leaf area is a function of length and breadth. The variety possessed larger length and broader lamina naturally computed the higher area of leaf. Thus, the pattern of expansion of leaf had the pattern similar to that of length and breadth. As a result the varieties Waigaon, was followed by Krishna and Pratibha had higher leaf area. Similar results in leaf area among different cultivars investigated under various agro-climatic conditions were reported by Pathania *et al.* (1981) ; Philip (1983) ; Radhakrishnan *et al.*(1995); Nirmal and yamgar (1998) and Hegde *et al.* (1997).

Philip (1983) observed maximum leaf area 973.40 cm^2 in cultivar 'Amruthapani Kothapeta' and minimum leaf area 547.90 cm^2 in NBPGR / T17. These results fall in tune with that of this studies but the varieties were different. The leaf area variations among the different varieties might be due to genetic characters of the cultivars and their response to particular agro-climatic conditions. This result is in tune with findings of Aiyadurai (1966), Subbarayudu *et al.*(1976) ; Philip and Nair (1983) and Jalgaokar *et al.*(1988).

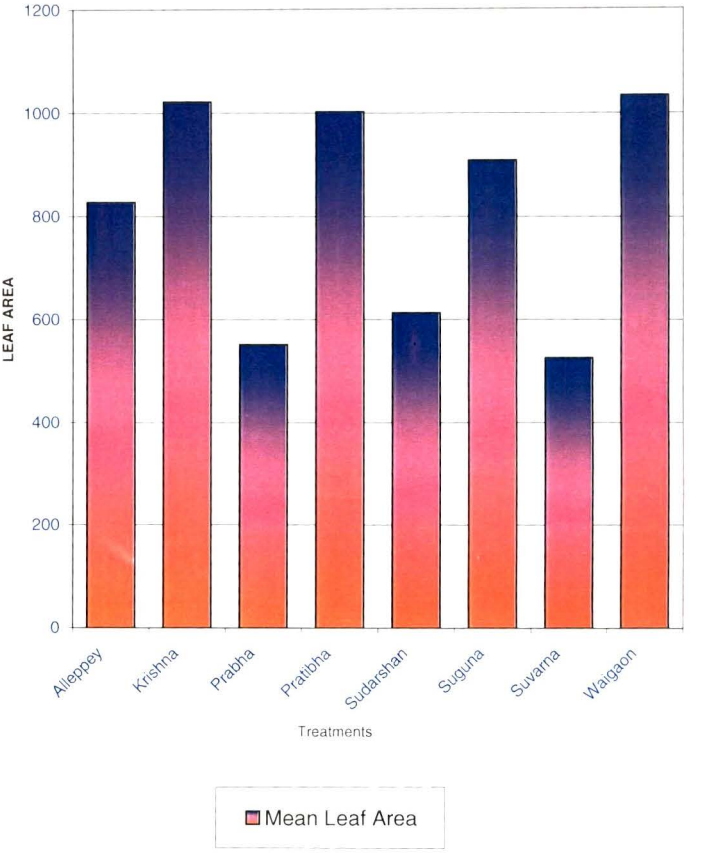


Fig. 4: AVERAGE LEAF AREA (cm^2)

4.1.7 Number of days required for Maturity : -

The data in respect of number of days required for maturity for eight treatments are presented in table –8.

TABLE – 8 NUMBER OF DAYS REQUIRED FOR MATURITY AND DRY WEIGHT OF SHOOT (g)

Treatments	Abbreviations	No. of days required for maturity	Dry weight of shoot (g)
Alleppey	T_1	243.96	19.51
Krishna	T_2	249.26	19.82
Prabha	T_3	206.20	14.29
Pratibha	T_4	225.06	18.01
Sudarshan	T_5	205.40	14.06
Suguna	T_6	192.00	14.86
Suvarna	T_7	208.93	17.69
Waigaon	T_8	229.30	19.26
GM		220.013	17.187
SE m (±)		7.331	0.497
CD at 5%		22.183	1.505

The pattern of variation of different treatments could be depicted as below.

$$T_6 < T_5 < T_3 < T_7 < T_4 < T_8 < T_1 < T_2$$

The mean performance of the varieties in relation to number of days required for maturity indicated that there is a significant variation among the different varieties. The comparison of eight varieties for the days required for maturity, a

indicator of early, medium and late and the variety Sugnna matured as early as 192.00 days and Krishna had matured around 2 months late (249.26 days).

Variety Krishna, took maximum days for maturity and it was at par with Alleppey and Waigaon. Whereas, precosity was observed in Suguna and it was also at par with Sudarshan, Prabha and Suvarna varieties of turmeric.Four varieties viz., Suvarna, Prabha, Sudarshan and Suguna could be classified early, as the values are lower than general mean (220.30 days) where as Krishna and Alleppey grouped as late. However, Pratibha and Waigaon varieties of turmeric were adjudged as medium maturity type of turmeric.

Unlike the dramatic ripening changes common to fleshy fruits. Ripening transformation in tuberous crops are relatively subtle. It is associated with marked drops in sugar content. Associate with sugar decline is an increase in other bio-chemicals.As the turmeric ripen, the arial growth frequently undergo an active senescence drying back to the ground. The matured turmeric rhizome possess superior qualities for storage. Thus the variety under shidies were grouped early viz. Suvarna, Prabha, Sudarshan and Suguna, medium as Pratibha and Waigaon and late Krishna and Alleppey due to the number of days required for maturation. Although, the variation in maturity, no doubt, due to the interaction of genetical and environmental behavior of the turmeric crops.

Hegde. *et al.*(1997) revealed that varieties Suguna (193 days), Sudarshan (206 days), and Suvarna (208) took relatively less number of days (193 to 208) days for maturity grown under southern dry region of Karnataka and they were grouped as early duration types. Similar variations and group was found in line with that of present result.

Anonymous(2002) reported that varieties Krishna and Waigaon took relatively more number of days (255 and 230 days respectively) for maturity and grouped under late duration crop. Similar result was found in line with the present investigation while Krishna required 249.26 days and Waigaon required 229.30 days for maturity.Cha dha (2001b)reported that varieties Prabha and Pratibha had

duration 205 days and 225 days respectively for maturity. This result is in congruent with the present investigation and are grouped under Medium duration type.

Table–8 showed significant variations among various cultivars. Similar variations and groups were made by Cholke (1993), Maurya (1990) and Hegde *et al* (1997).

4.1.8 Dry shoot weight :-

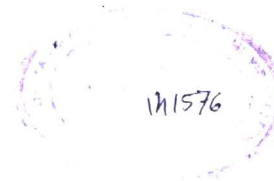
Data in respect of dry weight of shoot for different treatments is presented in Table-8 and pattern of variation depicted as.

$$T_2 > T_1 > T_8 > T_4 > T_7 > T_6 > T_3 > T_5$$

The analysis of variance showed significant differences among the eight varieties. The dry shoot weight of turmeric plant ranged from 14.06 g in Sudarshan to 19.82 g in Krishna. Krishna found significantly superior had maximum shoot dry weight and it was at par with Alleppey (19.51 g) and Waigaon (19.26 g). Variety Sudarshan had minimum shoot dry weight (14.06 g) and noted significantly inferior and at par with Suguna (14.86 g) and Prabha (14.29 g).

Varieties like Krishna (19.82 g), Alleppey (19.51 g), Waigaon (19.26 g), Pratibha (18.01 g) and Suvarna (17.69 g) achieved the higher dry shoot weight there were above the general mean (17.18 g). Where as rest of the three varieties viz. Sudarshan (14.06 g), Prabha (14.29 g) and Suguna (14.86 g) were below general mean (17.18 g) if available quste the of sink and source .

Thankamani *et al.* (1998) reported highest shoot dry weight in Suvarna followed by Alleppey and lowest in Sudarshan. This result is comparatively similar with the present findings.



4.2 Post harvest observation :-

4.2.1 Number of fingers / plant : -

The mean performance of eight turmeric varieties in relation to number of fingers per plant is presented in table-9.

TABLE – 9 AVERAGE NUMBER OF FINGERS / PLANT, LENGTH AND BREADTH OF FINGERS

Treatments	Abbreviations	No. of fingers / plant	Mean length of fingers (cm)	Mean breadth of fingers (cm)
Alleppey	T_1	8.33	8.64	2.03
Krishna	T_2	11.76	10.38	2.47
Prabha	T_3	8.61	6.26	1.83
Pratibha	T_4	10.47	8.27	1.97
Sudarshan	T_5	5.22	7.53	1.86
Suguna	T_6	6.89	6.38	1.64
Suvarna	T_7	8.39	6.47	1.71
Waigaon	T_8	10.52	10.45	2.26
GM		8.773	8.047	1.971
SE m (±)		0.655	0.423	0.106
CD at 5%		1.989	1.282	0.323

The pattern of variation of treatments in respect of number of fingers per plant could be shown as follows.

$$T_2 > T_8 > T_4 > T_3 > T_7 > T_1 > T_6 > T_5$$

Results from table-10 indicated significant variation among the different varieties of turmeric in respect of number of fingers per plant.Variety Krishna possessed 11.76 fingers per plant and found significantly excellent over all other varieties except Waigaon and Pratibha. Where as variety Sudarshan recorded 5.22 fingers per plant and found significantly Poor over all other varieties and at par with Suguna.

Data on number of fingers per plant indicated the range of 5.22 (Sudarshan) to 11.76 (Krishna). The varieties namely Krishna, Waigaon and Pratibha produced the fingers 11.76, 10.52 and 10.47 respectively and they were above the general mean (8.77) Whereas remaining varieties i.e., Prabha (8.61), Suvarna (8.39), Alleppey (8.33), Suguna (6.89) and Sudarshan (5.22) were below the general mean.

Data in table - 9 exhibited significant variation among the turmeric types. The significant variations among different varieties under different agro-climatic conditions were also found by Philip, (1983) and Philip and Nair (1983).

Cha' dha (1994) reported 4 to 7 primary fingers in variety Suguna. This result is in agreement with the recent investigation. The reason for the significant variation in number of fingers among the turmeric types grown under the same cultural and agro-climatic conditions could be attributed to the genetic factors. This result is in agreement of investigations of Sharma and Krishnamurthy (1960); Rao (1965), Aiyadurai (1966) and Subbarayudu, *et al.*(1976).

4.2.2 Length of fingers : -

Data in respect of length of finger for eight treatments are presented in table-9 and the pattern of variation could be shown as below.

$$T_8 > T_2 > T_1 > T_4 > T_5 > T_7 > T_6 > T_3$$

From the table-9 it can be seen that the analysis of variance is significant. The mean length of fingers was in between 6.26 cm in Prabha to 10.45 cm in Waigaon. Varieties viz. Waigaon, (10.45 cm), Krishna (10.38 cm), Alleppey (8.64 cm) and Pratibha had recorded the length of fingers general mean (8.04 cm). Whereas rest of varieties namely Sudarshan (7.53 cm), Suvarna (6.47 cm), Suguna (6.38) and Prabha (6.26 cm) obtained less length of finger and found below general mean (8.04 cm).

Variety Waigaon (10.45 cm) was found significantly superior over all other cultivars and at par with Krishna (10.38 cm). Whereas Prabha (6.26 cm) reported significantly inferior over all other cultivars and at par with Suguna, Suvarna and Sudarshan. Chadha (1994) reported that varieties Alleppey, Suguna and sudarshan attained the length of rhizome 7.0 cm, 6.0 cm and 8.8 cm respectively. This result is in line with the present result.

Reported by Philip and Nair. (1983) which the range of length of finger from 12.1 cm in cultivar Chayapasupa to 7.3 in Duggirala C17 – 325. This range was comparatively similar with the present result.

The reson for the variation in respect of length of finger might be due to agro-climatic and genetical factors. This conclusion is in agreement of the findings of Sharma and Krishnamurthy (1960), Rao (1965), Aiyadurai (1966), Subbarayudu . *et al* (1976) and Philip and Nair (1983).

In the investigation it was found that the length of primary finger was significantly and positively correlated with yield of turmeric. The positive correlation of the length of rhizome with the yield might because of higher weight due to higher length.

4.2.3 Breadth of fingers :-

Table-9 denoted the data in respect of breadth of finger for the different varieties. The sequence of variation of different varieties could be shown as below –

T2 > T8 > T1 > T4 > T5 > T3 > T7 > T6

The mean performance of eight varieties in respect of radial growth of fingers varied significantly. Variety Krishna possessed maximum breadth of finger(2.47cm) and found significantly superior over all other varieties and at par with Waigaon (2.26cm) where as Suguna (1.64cm) found significantly inferior over all the other varieties and at par with Suvarna, Prabha and Sudarshan .

The mean breadth of fingers of turmeric was ranged from 1.64 cm in Suguna to 2.47 cm in Krishna. Three varieties namely Krishna, Waigaon and Alleppey attained the maximum breadth of finger and they were much above the general mean (1.97) Where as Suguna, Suvarna, Prabha, Sudarshan and Pratibha possessed the thin finger and were far below general mean.

Morphologically the formation of shape organ is associated with a strong localized lateral enlargement of cells and the deposition of these cells of storage polysaccharides. Stimulation of tuber growth is due to cell enlargement where as the normal tuber growth involves cell division. These stimulus appears to be present in large amount in the leaves during the period of tuberisation. Thus it increase manifold Biran *et al.* (1972).

The progress curves of tuber growth show an exponential character. Thus the great bulk of tuber filling activity occurs very near the end of growth season. Tuber grows by roughly equal activities of cell division and enlargement. An interesting feature of tuber growth in the facility with whole material can be moved from one developing tuber to another.

The radial growth of fingers based on the number of factors which contribute higher breadth of fingers in turmeric. Since the variety Krishna and Waigaon possessed more height, tillers, leafe size and thereby contribute to the development of thick fingers.

Significant variation was found in respect of breadth of finger in different cultivars of turmeric by Philip and Nair (1983). In the investigation it was found that the different cultivars attained the significant variation in respect of breadth of finger. The reason for this might be due to agro-climatic and genetical factors. This

conclusion is in the line of investigation of Aiyadurai (1966) ; Subbarayadu *et al.* (1976) ; Jalgaonkar , *et al.*(1988) and Philip and Nair (1983).

4.2.4 Yield of green turmeric:

The mean performance of different varieties in respect of green turmeric per plant is presented in Table-10 and depicted in fig 4.

TABLE – 10 YIELD OF GREEN TURMERIC

Treatments	Abbre viations	Yield of green turmeric		
		Plant $^{-1}$ (g)	Plot $^{-1}$ (kg)	Hectare $^{-1}$ (q)
Alleppy	T_1	228.74	1.748	242.82
Krishna	T_2	376.50	2.960	411.20
Prabha	T_3	158.26	1.221	169.65
Pratibha	T_4	323.21	2.543	353.25
Sudarshan	T_5	164.95	1.312	182.21
Suguna	T_6	161.52	1.255	174.34
Suvarna	T_7	183.23	1.527	212.08
Waigaon	T_8	364.12	2.864	397.86
GM		245.069	1.928	267.926
SE m (±)		18.351	0.144	20.446
CD at 5%		55.659	0.435	62.013

The analysis of variance in respect of green yield per plant (Table-11) exhibited significant differences and the variety Krishna produced significantly higher yield 376.50 g over all other varieties except with Waigaon (364.12 g) and Pratibha (323.21 g) which was at par with each other. Where as variety prabha (158.26 g) recorded lowest yield and found to be significantly inferior than all other

varieties and the varieties viz. Suguna (161.52 g) Sudarshan (164.95 g) and Suvarna (183.23 g) move on par with Prabha.

In this experiment average production of green turmeric per plant was 245.069 g. Krishna (376.50 g) performed better than the other cultivars. Similarly Waigaon (364.12 g) and Pratibha (323.21 g) had exceed the general mean and all other varieties under studies. Varieties Prabha, Suguna, Sudarshan, Suvarna and Alleppey were found to produce yield of rhizome per plot and per hectare far below the general mean. Thus the production efficiency of Krishna exceeded more than two folds than Prabha variety of turmeric.

In table-11, Joint consideration for yield of green turmeric per plot and per hectare revealed the significant analysis of variance and observed that the yield per plot (2.960 Kg) and per hectare (411.20 q) produced by Krishna was significantly more than all the treatments. Variety Waigaon and Pratibha were at par with Krishna so far as the yield of green turmeric per plot and per hectare was concerned.

The weight of green turmeric (1.221 Kg) and (169.65 q) per plot and per hectare respectively produced by prabha were significantly lower than all the treatments. However variety Prabha was found at par with Suguna, Sudarshan and Suvarna so far as the yield of green turmeric per plot and per hectare are concerned.

In (Table –10) the yield display a good deal of variation in weight of green turmeric (fresh rhizomes) per plant, per plot and per unit area, may be plot or hectare. Interpreting the combined behavior of varieties with this attributes it appeared in general that varieties showing better performance in respect of growth parameters studied viz. plant height, girth of pseudostem, number and length , breadth of leaves, number of tillers per plant, leaf area had yield characters contributed positively. For the yield of rhizomes in this studies, it is observed that higher the magnitude of vegetative growth better the production of rhizomes per unit area and higher the yields of rhizomes. The genotypes showing superiority in growth parameters responding better for the yield of rhizomes per plant and per unit

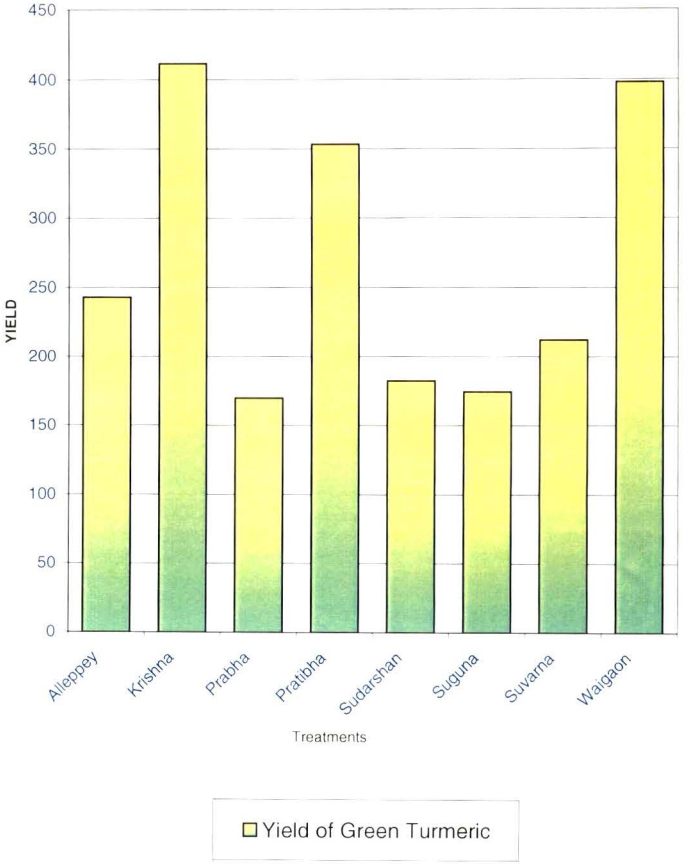


Fig. 5: YIELD OF GREEN TURMERIC PER HECTARE. (q)

area is concerned. It is very interesting to note that the varieties Krishna, Waigaon and Pratibha exhibited higher growth parameters like height of plant, number of leaves, leaf, breadth, area of leaf and number tillers observed significantly superior in yield characters like number of rhizomes, per plant, length and breath of fingers showed significantly positive correlation with yield of rhizomes.

Thus, the varieties under the studies which exceeds better for production of turmeric per plant the similar trend was also noticed for the yield per plot and per hectare. In this experiment, therefore, spectacular yield per hectare was obtained from Krishna followed by Waigaon and Pratibha.

The findings of present investigation are in congruent with the report of various research workers. Pathani, *et al* (1981); Philip and Nair (1983); Shashidhar *et al* (1997); reported positive correlation of plant height with yield of rhizomes. Mohanty (1979); Pathania (1981); Philip and Nair (1983); Radhakrishnan *et al.* (1995) and Shashidhar *et al.* (1997) observed positive correlation of leaf length, breadth and area with rhizome yield. Where as positive correlation of number of tillers with rhizome yield noticed by Pathania *et al.*(1988); Shashidhar and Sulikeri (1997). And Hazra *et al.*(2000) found that rhizome yields of turmeric was positively and significantly correlated with number of leaves.

The reason for positive correlation of rhizome yield with growth attributes was stated by Philip and Nair (1983). They reported that height of plant might be helpful for better exposure of the leaves to the sun thereby increasing the photosynthetic efficiency of the plant which account for higher yield. As well as more number of leaves, leaf might increase the photosynthetic area and thereby accelerate the rate of photosynthesis which account for higher yield.

In the finding variety Krishna was found significantly superior and produced 411.20 q / ha rhizomes. Pujari *et al.*(1987) also obtained comparatively similar yield from Krishna (427.27q/ha). Chadha (2001) recorded 391.20 q/ha green rhizome in Pratibha, which is comparatively similar with this investigation. Ramakrishna *et al.* (1995) reported 191.50 q/ha fresh rhizome yield of variety Suguna which is also similar with this study. Chadha (1994) reported 250 q/ha yield of fresh rhizome in

variety Alleppey, which is in tune with result where 242.82 q/ha fresh rhizome yield was obtained in this investigation.

Hegde *et al* (1997) obtained the yield of fresh rhizome from Sudarshan and Suguna 215.50 q/ha and 196.30 q/ha respectively under southern dry region of Karnataka also in line with this observations where Sudarshan and Suguna produced fresh rhizome yield 182.21 q/ha and 174 q/ha respectively, Indiresh etal (1990) recorded fresh rhizome yield for cultivar Waigaon 316.60 q/ha in coastal Karnataka region is in congruent with this finding.

In the investigation, highly significant variations were found between different cultivars of turmeric. Significant variations also noticed among the different cultivars for fresh yield under different agro-climatic condition by Philip (1983), Jalgaonkar *et al* (1990); Shahi *et al.*(1994); Sheshagiri and Uthaiah (1994); Radhakrishnan *et al* (1995); Patil *et al.* (1995); Hegde *et al.*(1997) ; Rashid *et al.*,(1996); Chandra *et al.* (1997); Shashidhar *et al.* (1997); Reddy *et al.* (1989); Hegde *et al.* (1997); Thankamani *et al.* (1998); Lynrah *et al.* (1998); Nirmal and Yamgar (1998) and Hazra *et al* (2000).

The variation in yield among the turmeric varieties grown under same agro ecological conditions could be attributed to the genetic factors. This is in confirmity with the observations of Sharma and Krishnmurthy (1960); Rao (1965); Aiyaduri (1966); Subbarayudu *et al.*(1976); Philip and Nair (1983); Jalgaonkar *et al* (1988); Lynrah *et al.*(1998) and Radhakrishnan (1995)

4.2.5 Yield of dried Turmeric per hectare : -

The mean performance of different varieties with respect to yield of dried turmeric per hectare, is presented in table –11 and depicted in fig 5.

TABLE – 11 YIELD OF DRIED TURMERIC

Treatments	Abbreviations	Yield of dried turmeric	
		Curing percentage	Hectare $^{-1}$ (q)
Alleppey	T_1	19.32	46.90
Krishna	T_2	16.56	68.10
Prabha	T_3	19.32	32.77
Pratibha	T_4	18.14	64.07
Sudarshan	T_5	13.51	24.62
Suguna	T_6	13.78	24.02
Suvarna	T_7	21.72	46.06
Waigaon	T_8	16.50	65.64
GM		17.356	46.522
SE m (±)		1.049	2.825
CD at 5%		3.174	8.564

The pattern of variation between different treatments could be drawn as below.

$T_2 > T_8 > T_4 > T_1 > T_7 > T_3 > T_5 > T_6$

Highly significant variations were notice among the cultivars for cured yield (Table-12). The mean performance of different varieties in respect of per hectare dried yield of turmeric were received maximum from the variety Krishna (68.10 q) and it was at par with Waigaon (65.64 q) and Pratibha (64.07 q). Where as poor recovery of turmeric was recorded by Suguna (24.02 q) which was at par with Sudarshan and Prabha.

Table 11 indicated the recovery of dried turmeric between 24.02 q/ha in Suguna to 68.10 q/ha in Krishna. Four varieties viz. Krishna (68.10 q/ha), Waigaon (65.64 q/ha), Pratibha (64.07 q/ha) and Alleppey (46.90 q/ha) exhibited higher production of dried turmeric which was above the general mean (46.52 q/ha). Rest of the four varieties, namely Suguna (24.02 q/ha), Sudarshan (24.62 q/ha), Prabha (32.77 q/ha) and Suvarna (46.06 q/ha) gave poor dried of turmeric and which was far below theaverag production. The recovery percentage (driage) is one of the important factors for the fresh rhizomes which are to be cured to obtain marketable turmeric. The recovery of dried turmeric from the variety Krishna, Waigaon, Pratibha was more than two folds than Suguna and one and half time more yield of dried turmeric than general mean. This might be due to yhe fact that basically the yield of these varieties were higher. Secondly, the percentage recovery might be more resulting into production of increased dry weight of turmeric.

Highly significant variation was observed in the different varieties of turmeric with respect to dried yield of turmeric per hectare. The significant variation in recovery percentage of different cultivars grown under different Agro ecological conditions was observed by Reddy *et al.* (1989); Philip (1983); Jalgaokar and Jamdagni (1989); Indiresh *et al.* (1990); Jalgaonkar *et al.* (1990); Maurya (1990), Shahi *et al.* (1994); Radhakrishnan *et al.* (1995), Ramakrishna *et al.* (1995); Chandra *et al.* (1997); Hegde *et al.* (1997) and Thankamani *et al.* (1998).The findings of present investigation are in congruent with the report of various research worker. Indiresh *et al.* (1990) reported that Waigaon and Kasturi gave the highest yields of cured turmeric 64.8 q/ha and 62.1 q/ha respectively.

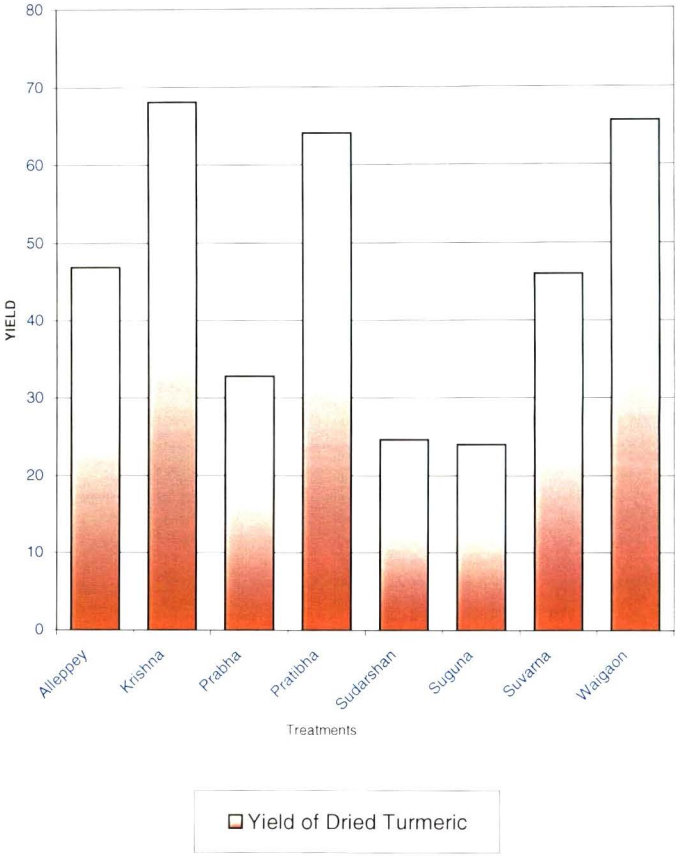


Fig. 6: YIELD OF DRIED TURMERIC PER HECTARE. (q)

The reason for higher curing percentage in Suvarna and Prabha which produced slender rhizomes can be attributed to the low moisture content in the rhizomes. This is similar to the investigation of Philip (1983) ; Philip and Nair (1983). Chadha (2001) recorded curing percentage 19.5, 18.50 and 12.0 for Prabha, Pratibha and Sudarshan respectively which is congruent with the present investigation. Pujari, *et al.*(1987) observed the highest yield of cured produce 70.11 q/ha in cultivar Krishna, Shashidhar, *et al.* (1997) stated that rhizome yield was positively correlated with dry matter accumulation.

Chadha (1994) reported curing percentage 16.4 for Krishna, Radhakrishnan, *et al.*(1995) obtained 26.33% cured yield ofturmeric under the high ranges of Idukki district of Kerala state. (2002) received 75 q/ha dried yield in variety Krishna for Vidarbha region.

The variation in recovery percentage among various turmeric cultivars could be due to genetic factors rather than the environmental conditions under which they are grown as reported by Sharma and Krishnamurthy (1960); Rao (1965); Aiyadurai (1966), Subbarayudu *et al.*(1976); Philip (1983), and Radhakrishnan *et al.*(1995).

4.2.6 Curcumin percentage : -

The mean performance of turmeric varieties in relation to curcumin percentage is presented in table –12 and depicted in fig 5. The results of the data shows highly variation in curcumin percentage as the pattern of variation is as follows.

$$T_7 > T_5 > T_3 > T_4 > T_8 > T_6 > T_1 > T_2$$

TABLE – 12 CURCUMIN PERCENTAGE

Treatment	Abbre viations	Curcumin %
Alleppey	T_1	4.38
Krishna	T_2	2.78
Prabha	T_3	6.36
Pratibha	T_4	6.17
Sudarshan	T_5	7.41
Suguna	T_6	4.82
Suvarna	T_7	8.67
Waigaon	T_8	4.97
GM		5.695
SE m (±)		0.500
CD at 5%		1.515

On an average percentage of curcumin was estimated to the extent of 5.69 % and four varieties under study contained higher percentage of curcumin Suvarna (8.67 %), Sudarshan (7.41%), Prabha (6.36%) and Pratibha (6.17%). The extent of curcumin content in rest of the three varieties Waigaon (4.97%), Suguna (4.82%), Alleppey (4.38%) had medium, however Krishna (2.78%) recorded poor meager percentage of curcumin and these values were lower than the general mean. (5.69%).

Variety Suvarna was adjudged significantly superior over all other varieties except Sudarshan. The overall values of turmeric depends upon the content of curcumin which is very important in the export of market. Chadha (1994) reported that varieties Alleppey, Suvarna, Suguna and Sudarshan attained curcumin percentage 4.4%, 8.7%, 4.9% and 7.9% respectively. This result is comparatively similar with the present investigation. Hegde, *et al.* (1997) recorded the highest curcumin content in Suvarna (8.08%) followed by Sudarshan (7.48) is congruent with the present investigation. Cholke (1993) recorded highest curcumin and

intensity of colour in Suvarna rhizomes. Anonymous (2002) found highest curcumin percentage in Suvarna (8.7%)and lowest in Suguna (4.90%) and Krishna (2.8%). This finding is congruent with the present investigation.

Highly significant variation was found in turmeric varieties in respect of curcumin percentage. Krishnamurthy *et al* (1975); Mathai (1978); Philip (1983); Pathania (1988); Maurya (1990); Chiu *et al.* (1993), Maiya *et al.* (1995), Radhakrishnan *et al* (1995); Hegde *et al.* (1997); Lynrah *et al.* (1998) had also reported highly significant variation in curcumin content among the turmeric types.

Chadha (2001) reported lowest curcumin percentage in Krishna (2.80%) howeber 6.53% and 6.21% in Prabha and Pratibha respectively. This result is comparatively similar with the present investigation. As such Krishna and Waigaon varieties of turmeric found better place exceeded the values in other parameter though did not contribute much for the higher content of curcumin.

Chiu *et al.* (1993) revealed that earlier formed rhizomes were higher in curcumin content to younger ones whereas Maiya *et al.*(1995) concluded that the size of propagating material had no effect on the curcumin content of the rhizomes. Mathai (1978) concluded that the rhizomes of *Curcuma longa* after 3 months of growth contained more curcumin and it had been highest in the fifth month of growth.

In the present investigation, it was found that curcumin percentage was negatively and significantly correlated with the fresh rhizome yield. It is very interesting to mention that the turmeric varieties performing better for the other vegetative characters including yield contributing traits parameters had poor curcumin and vice-a- versa.

From the present investigation it is observed that there is highly significant variation among the turmeric types grown under the same cultural and agro climatic conditions can be attributed to the genetic factors as reported by Hegde *et al.* (1997).

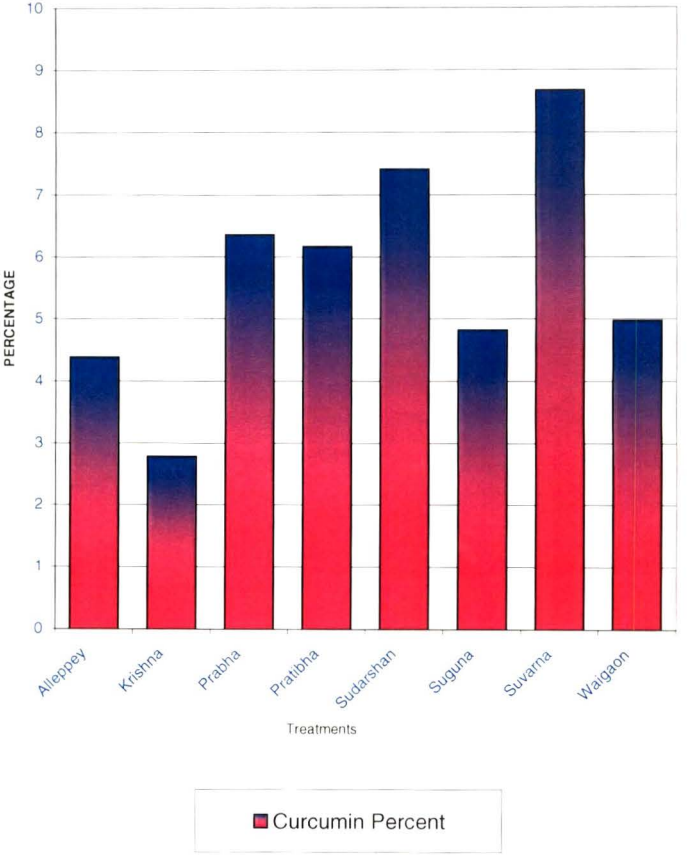


Fig. 7: CURCUMIN PERCENTAGE

CHAPTER – V

SUMMARY

An experiment entitled "Performance of turmeric varieties under Nagpur conditions" was conducted at College Garden. College of Agriculture, Nagpur during the year 2001-2002. There were eight treatments replicated thrice in a Randomised Block Design.

The analysis of variance revealed highly significant differences among the growth, yield characters and quality parameters. The results obtained in the present investigation are summarized below.

1. Among the eight genotypes of turmeric, the plants of Krishna was taller and it was followed by Alleppey. Waigaon and Pratibha. Suvarna classified as medium stature however Sudarshan was dwarf followed by Pratibha.
2. So far as, girth of pseudostem of turmeric is concerned, Waigaon and Krishna recorded comparatively larger radial growth of pseudostem. But Suguna and Sudarshan had thin pseudostem.
3. The foliage of turmeric was more in Krishna followed by Waigaon, Alleppey and Pratibha. While, Suguna, Sudarshan and Suvarna recorded significantly less number of leaves per plant.
4. As regards the measurement of turmeric leaf blade is concerned broader with elongated leaves having maximum leaf length, breadth resulting in larger leaf area was computed in Waigaon followed by Krishna and Pratibha. The genotypes, Suvarna, Prabha and Suguna recorded comparatively smaller size of leaf which had short, narrow with minimum area of leaf.
5. In respect of emergence of tillers variety, Krishna and Waigaon had more number of tillers per plant. Whereas, less tillers were noted in Suguna and Sudarshan.

6. One of the indices for earlyness is days for maturity, variety Suguna and Sudarshan took relatively less number of days for maturity.And they were grouped as early types. Waigaon and Pratibha was found medium, whereas cultivars like Krishna and Alleppey were grouped under late duration types.

7. Dry shoot weight, is an out come and as one of the indicaters for physiological activities and was found abundant in Krishna followed by Alleppey and Waigaon while, Sudarshan, Prabha and Suguna possessed comparatively less dry shoot weight.

8. The most important yield contributing character in turmeric is the number of rhizome and their size. Of the eight varieties studied substantially more number of fingers per plant was produced by Krishna and it was closely followed by Waigaon and Pratibha. However, Sudarshan and Suguna bore less number of fingers per plant.

   The bold, plumpy, thick and larger rhizomes were produced by Krishna, Waigaon and Pratibha whereas short and thin fingers were observed in Suguna, Suvarna and Prabha.

9. The yield of green turmeric per plant was remarkably high in Krishna followed by Waigaon while Sudarshan recorded lower yield of green turmeric. The yield of green turmeric per hectare followed the similar pattern as that of yield of green turmeric per plot and per plant. As such variety Krishna had surpassed in production of green turmeric as compared to Waigaon which was placed in second order as far as yield per hectare is concerned.

10. Curerd turmeric is also one of the important attributes in grading the turmeric produce for export and domestic market. An ample quantity of turmeric per hectare was obtained from Krishna (68.10 q) and it was closely followed by Waigaon (65.64 q) and Pratibha (64.07q). Varieties Suguna and Sudarshan produced considerably less quantity of cured turmeric.

11. Curcumin content in turmeric plays an important role to determine the quality for export. Although cultivars like Suvarna and Suguna recorded high per cent of curcumin but their poor yields of cured rhizome resulted into considerably less curcumin per unit area. On the other hand, varieties like Krishna, Waigaon, Pratibha and Alleppey though had less curcumin per cent however higher yield of cured turmeric, obviously, gave sufficient quantity of curcumin per unit area.

CONCLUSION :-

The results of the present study revealed highly significant variations among eight turmeric varieties studied under Nagpur conditions with regard to all of the growth, yield and quality parameters. The growth of turmeric plants had increased substantially in variety Krishna very closely followed by Waigaon which recorded marked yields of both green and cured turmeric per hectare. However the genotype Suvarna produced the maximum curcumin content.

This is the first year of experiment, which needs further studies for confirmation.

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THESIS ABSTRACT

a. Title of the Thesis	:	Performance of turmeric varieties under Nagpur Conditions.
b. Full name of the student	:	Shekhar Urkuda Meshram
c. Name and Address of advisor.	:	Dr. S.U. Gondane, Associate Professor of Horticulture, College of Agriculture, Nagpur.
d. Degree to be awarded	:	M.Sc. (Agri.)
e. Year of award of degree	:	2002
f. Major Subject	:	Horticulture
g. Total number of pages in the thesis	:	82
h. Number of words in abstract	:	168
i. Signature of student	:	Shekhar.
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ABSTRACT

Investigation on the "Performance of turmeric varieties under Nagpur conditions" was undertaken in College garden, College of Agriculture, Nagpur during 2001-2002.

The experiment was undertaken in Randomised Block Design with eight treatments with three replications. The eight varieties included under studies were Alleppey, Krishna, Prabha, Pratibha, Sudarshan, Suguna, Suvarna and Waigaon which contribute eight treatments.

Evaluation of eight cultivars of turmeric grown under Nagpur agro climatic conditions revealed that among the cultivars Krishna was found to grow tallest (102.23 cm), possessed more leaves (13.79) and emerged profuse tillers per plant (3.04). Variety Waigaon however, produced maximum radial growth (3.59 cm), elongated (62.50 cm), broader (17.42 cm) with spectacular large size of leaf (1033.51 cm^2) and it was closely followed by Krishna.

Suguna, Sudarsan, Prabha and Suvarna were found to be an early duration types (192 to 208 days) compared to Krishna and Alleppey which were matured relatively late. Waigaon and Pratibha, however, grouped under medium duration types. Krishna recorded highest fresh (411.20 q) and cured rhizome (68.10 q) per hectare yield followed by Waigaon and Pratibha. The maximum curcumin content (8.67 per cent) was found with Suvarna.

22/10/2001	28/10/2001	43	32.7	15.3	56	32	-	-
29/10/2001	4/11/2001	44	32.8	16.5	57	31	-	-
5/11/2001	11/11/2001	45	32.2	16.1	55	35	-	-
12/11/2001	18/11/2001	46	31.1	14.3	59	44	-	-
19/11/2001	25/11/2001	47	30.4	12.4	50	28	-	-
26/11/2001	2/12/2001	48	28.9	9.1	46	26	-	-
3/12/2001	9/12/2001	49	30.1	8.8	52	24	-	-
10/12/2001	16/12/2001	50	31.1	12.0	61	30	-	-
17/12/2001	23/12/2001	51	28.6	9.1	52	29	-	-
24/12/2001	31/12/2001	52	28.8	9.0	63	28	-	-
1/1/2002	7/1/2002	1	25.9	7.2	49	27	-	-
8/1/2002	14/1/2002	2	27.8	9.2	58	26	-	-
15/1/2002	21/1/2002	3	30.6	13.4	71	35	-	-
22/12002	28/1/2002	4	28.3	11.6	60	36	03.0	1
29/1/2002	4/2/2002	5	26.8	9.6	40	23	-	-
5/2/2002	11/2/2002	6	29.6	16.6	67	37	-	-
12/2/2002	18/2/2002	7	30.2	15.7	51	34	03.0	1

APPENDIX - A

Weekly Meteorological Data from June 2001 to March 2002 recorded at Observatory of College of Agriculture, Nagpur

Date/Month/Year		Number of Week	Mean Weekly Temp °C		Relative Humidity (%)		Total Rainfall In mm	No. of rainy days
From	To		Max.	Min.	Mor.	Noon		
11/6/2001	17/6/2001	24	31.1	23.2	80	68	218.8	3
18/6/2001	24/6/2001	25	32.7	23.9	70	56	1.4	1
25/6/2001	1/7/2001	26	33.3	24.5	68	58	4.0	2
2/72001	8/7/2001	27	33.7	24.6	72	54	8.8	3
9/72001	15/72001	29	29.2	22.5	88	73	99.2	5
16/72001	22/72001	29	28.5	22.8	86	81	78.0	4
23/7/2001	29/72001	30	30.7	23.5	83	66	15.6	3
30/72001	5/8/2001	31	32.0	23.3	79	64	89	6
6/8/2001	12/8/2001	32	30.4	23.8	91	71	142.3	5
13/8/2001	19/8/2001	33	28.6	23.3	86	76	139.4	5
20/8/2001	26/82001	34	28.8	23.3	85	73	65.2	6
27/8/2001	2/9/2001	35	31.9	23.4	76	54	-	-
3/9/2001	9/9/2001	36	32.8	23.9	72	51	5.9	2
10/9/2001	16/9/2001	37	34.1	22.9	75	49	5.7	2
17/9/2001	23/9/2001	38	34.0	22.6	73	47	9.9	1
24/92001	30/9/2001	39	35.5	22.6	65	33	-	-
1/10/2001	7/10/2001	40	30.8	23.1	90	73	128.3	6
8/10/2001	14/10/2001	41	31.8	23.4	85	58	2.3	1
15/10/2001	21/10/2001	42	32.8	18.0	59	33	-	-

22/10/2001	28/10/2001	43	32.7	15.3	56	32	-	-
29/10/2001	4/11/2001	44	32.8	16.5	57	31	-	-
5/11/2001	11/11/2001	45	32.2	16.1	55	35	-	-
12/11/2001	18/11/2001	46	31.1	14.3	59	44	-	-
19/11/2001	25/11/2001	47	30.4	12.4	50	28	-	-
26/11/2001	2/12/2001	48	28.9	9.1	46	26	-	-
3/12/2001	9/12/2001	49	30.1	8.8	52	24	-	-
10/12/2001	16/12/2001	50	31.1	12.0	61	30	-	-
17/12/2001	23/12/2001	51	28.6	9.1	52	29	-	-
24/12/2001	31/12/2001	52	28.8	9.0	63	28	-	-
1/1/2002	7/1/2002	1	25.9	7.2	49	27	-	-
8/1/2002	14/1/2002	2	27.8	9.2	58	26	-	-
15/1/2002	21/1/2002	3	30.6	13.4	71	35	-	-
22/12002	28/1/2002	4	28.3	11.6	60	36	03.0	1
29/1/2002	4/2/2002	5	26.8	9.6	40	23	-	-
5/2/2002	11/2/2002	6	29.6	16.6	67	37	-	-
12/2/2002	18/2/2002	7	30.2	15.7	51	34	03.0	1

APPENDIX B

Area under cultivation and yield of turmeric in different District of Maharashtra State (1990-91)

Sr. No.	District	Area (Hectares)	Yield (tonnes)
1.	Parbhani	1635	1792
2.	Sangli	1029	1418
3.	Nanded	891	1029
4.	Satara	753	1039
5.	Solapur	791	896
6.	Chandrapur	512	544
7.	Beed	335	325
8.	Osmanabad	196	250
9.	Latur	142	174
10.	Kolhapur	112	169
11.	Nagpur	101	89
12.	Akola	91	92
13.	Yavatmal	83	91
14.	Amaravati	82	97
15.	Wardha	41	42
16.	Pune	32	41
17.	Buldhana	31	33
18.	Bhandara	26	24
19.	Thane	12	9
20.	Sindhudurg	11	12
21.	Ratnagiri	4	4
22.	Gadchiroli	4	4
	Total Maharashtra	**6842**	**8174**
	Total Vidarbha	**971**	**1016**

Source :- Agricultural situation in India
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APPENDIX C

Chemical Composition of Turmeric Powder

(Shankaracharya and Natrajan 1973)

Ingredient	Quantity of ingredient present in 1.9 gm (1 teaspoon turmeric powder)
Water	110.00 mg
Food Energy	7.00 cal.
Protein	163.00 mg.
Fat	169.00 mg.
Total Carbohydrates	1328.00 mg.
Fiber Carbohydrates	313.00 mg.
Ash	129.00 mg
Calcium	3.80 mg
Phosphorus	4.94 mg.
Sodium	0.19 mg
Potassium	47.50 mg
Iron	902.00 µg.
Riboflavin	3.61 µg
Thiamine	1.71 µg
Niacin	91.00 µg
Ascorbic acid	946.00 µg
Vitamin A	31U

VITA

Mr. Shekhar Urkuda Meshram was born on 23 rd November 1974 at Umrer, Maharashtra. He passed his Secondary School Certificate examination from Jeevan Vikas Vidyalay, Umrer (M.S.) in the year 1991 and Higher Secondary School Certificate Examination (HSSC) from Nutan Adarsh Junior college, Umrer in 1995 from Maharashtra State Board of Secondary and Higher Secondary Education, Divisional Board, Nagpur respectively. He completed his B.Sc. (Agri.) degree from College of Agriculture, Nagpur, Dr. P.D.K.V. Akola in the year 2000.

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